Versatile vehicle security alarm provides full protection for almost any vehicle

Jonathan Scott

This unit will protect your valuable vehicle from virtually any sort of interference — from hub-cap stealing to being towed away! It does not rely on voltage or current sensing to trip the alarm, but 'resonance microphones'. It can also protect 'perimeter accessories' like driving lights and racks. The project meets the major requirements of car alarms set down by the National Roads and Motorists Association NRMA).

CAR BURGLAR ALARMS are plentiful on the shelves of electronic and automotive stores, and designs for build-it-yourself ones abound in the archives of every electronics magazine. In fact the range is so perplexing that choosing one becomes as involved a process as buying the vehicle in the first place! Which thought brings me to an interesting question — what does one unit, a car or an alarm, or any item, have over its apparent peers? Often it is merely that some recent technical development has become available at a reasonable price. A new car may come today with a turbo-charging system, electronic braking or gear control, or intelligent suspension. Perhaps a new product has just brought together a number of discreetly-developed good design ideas, much as today's 'food processors' incorporate the functions of blenders, ordinary mixers and mincers in one appliance with reliable electronic speed control. Finally, the improvement in a product may merely be the sum total of a lot of refining effort, as is the case in computers where the operating systems are more friendly and easier to use every time a new model comes out, or in a typewriter, which appears the same as ever, but feels a little better in the push of a key, and makes a little less noise than last year's model.

ETI's new car burglar alarm which we call a Vehicle Security Alarm, for the same reasons that food processors changed their names from 'mixmasters', has some of each of the three plusses above. It uses new alarm technology which we have not seen in a home construction design before, has certain additional incorporations beyond the functions of straight burglar protection, and has some facilities to make its use convenient and foolproof.

What are the features and advantages of this new design?

1). It uses inexpensive resonance microphones to detect *interference* with the car to which it is fitted. This means firstly that it does not rely on interior light switches or any other electrical system being disturbed as do switch closure sensing or voltage/current sensing alarms. It will not therefore miss detecting intrusion via a door with no light switch; it will also detect interference with luggage bays or hatchbacks which have no light connected, or the rear of a utility or panel van which is not enclosed. It can protect a convertible or targa body vehicle, or a truck with an open load area. Voltage and current types cannot satisfactorily do this.

Secondly, it will detect a sideswipe or minor impact such as so often occurs while your car is in the car park — the kind of dent which is not worth claiming on the insurance but which surely reduces the value of a vehicle and ruins its appearance. Even children interfering with the mirrors or similar can be detected, as actual inva-

THE NRMA'S TEN COMMANDMENTS FOR VEHICLE PROTECTION

In the February 1983 issue of *Open Road*, the NRMA's journal for members, the Association reported on tests they had carried out on some 24 car alarms, 14 fitted by suppliers or agents and 10 bought in kit form. As the report said, "The extensive tests and checks revealed deficiencies in design or performance of all 24 alarms, though most of them could have been improved by minor modifications or — in the case of the supplier-fitted types — by more care in fitting."

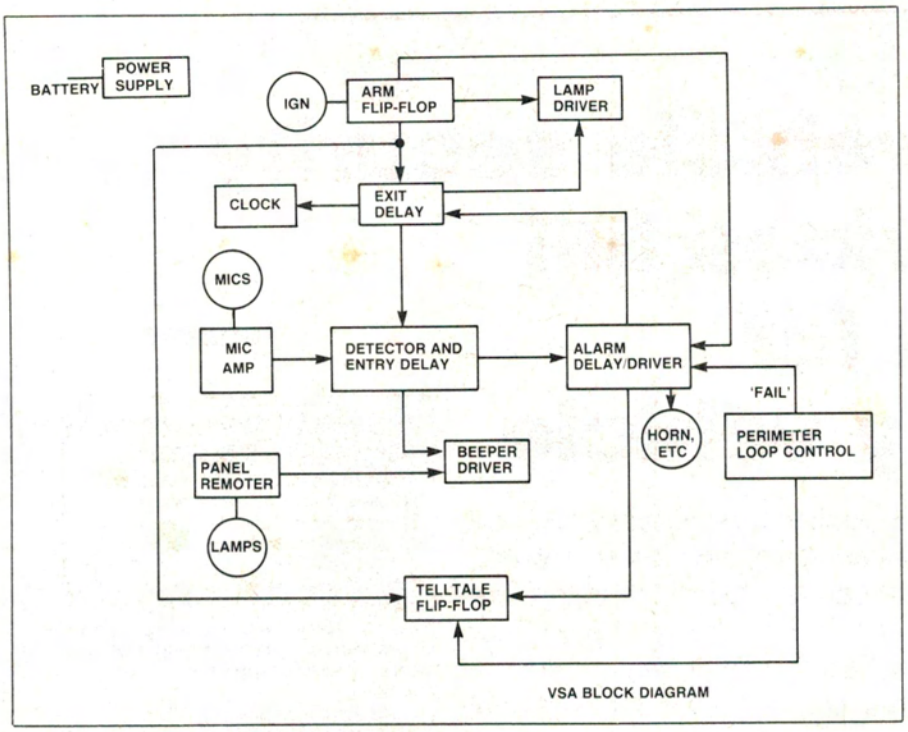
The report identified the key areas that need protection in a car. "When it comes to theft risk, 10 vulnerable points on a car are front doors, rear doors, bonnet, boot, ignition, accessories, wheels, glass and accessibility to towing and jacking," the report stated. It went on to say, "None of the alarms attempted to cover all 10 points, and some were unsuccessful in attempts to cover particular points because of poor components or poor fitting."

Based on police figures for reported thefts, you have a 1-in-50 chance of your car being stolen; if your car is a model in demand, the odds shorten considerably. The NRMA say that the fitting of a car alarm can reduce the risk of theft by deterring at least joy riders and petty thieves. Even a professional thief, seeing that the vehicle has a car alarm fitted, may move on in search of an easier mark.

The NRMA gives "10 Commandments" for buying protection:

1. The alarm should protect all the doors, bonnet and boot, at least.
2. It should operate instantly when the bonnet or boot is opened, or when the bonnet lock is released.
3. Air horns or a siren should be used, rather than the car's horn.
4. The alarm should be set from inside the vehicle, not by a key or other device from the outside.
5. Entry delay should be no more than five seconds.
6. The alarm should cut out the ignition system.
7. If the alarm obtains its power from the battery, wiring should be direct and should be positioned so that it cannot be reached from under the vehicle.
8. Horns or sirens and their wiring should be placed so they cannot be tampered with from behind the grille or from under the car.
9. The alarm duration should be about two minutes, with automatic cutout and reset.
10. Window stickers should indicate that the car is carrying an alarm system, but not the make and type.

It was this report that set in motion our quest for a car alarm project that would be versatile yet afford complete protection. We think this project can be installed so as to obey the Ten Commandments; although we disagree with No. 6. Artwork to comply with No. 10 is reproduced elsewhere in the article.



VSA BLOCK DIAGRAM

sion of the body or cabin is not necessary for detection to occur. Neither is the electronic state of the vehicle able to upset the alarm, thus eliminating false alarms due to random battery voltage variations or dash clocks drawing irregular currents.

2). The alarm is of the sensible three-delay design, but incorporates a failsafe against you forgetting it or missing one delay. By three-delay, I mean that it allows a period of time between activation and arming to allow you time to leave; a period of time between detecting possibly legal entry and sounding the alarm; and a period of time for which the alarm is sounded before resetting. Each of these is separately variable. Once activated, the warning lamp illuminates constantly; when the exit delay is over, the lamp flashes, indicating full arming. Once fully armed, a possibly legal entry/interference detection starts the second, or entry, delay. During this delay a beeping sound is emitted to quietly warn you that you have tripped the alarm (and the *thief* also that *he* has tripped it). This helps to prevent false and embarrassing blasts of the alarm noisemaker.

The final delay shuts off the alarm after a period of time, in accordance with the law of the land, not to mention the law of flat batteries! Once shut off, the system commences re-arming. This relatively 'friendly' arrangment permits full protection with minimum chance of false alarm and *no* drilling, etc of the body for installation of external switches or locks.

3). Immediate-trip perimeter inputs are provided. This facility, often missing from three-delay designs, allows the fitting of a mercury or tilt switch to the part of the car containing the battery. Without this it is relatively easy to disconnect the battery lead, killing the alarm, within the entry delay time period.

With such a mechanism connected an attempt to kill the power does at least attract a lot of attention.

In addition, connections to external driving or fog lights can be monitored and the alarm will go immediately if their earth connections are broken. These immediate loops (one normally closed, the other normally open) need not be used if not required, and if one is broken or shorted at arming time the remaining protection functions are not impaired. In addition, warning is given of a failed loop circuit, as indicated below.

4). While the state of the alarm (arming, armed, tripped, etc) is always made clear by the main lamp and the beeper, other statuses are reported by a second indicator, a 'tell-tale' LED. This glows to indicate that the alarm has gone off in your absence, and if it remains glowing after turning off the alarm by turning on the ignition, this indicates a failure in the loop circuits. Hence you are always informed as to what is going on inside the alarm circuits. The automatic rearming does not cancel the Tell-tale.

5). Alarms with automatic arming when the ignition is removed are a nuisance; conversely, an alarm which requires you to press a button to initiate arming are too open to forgetfulness. Having a concealed toggle or keyswitch is also inconvenient.

This alarm overcomes these problems by employing the usual illuminated pressbutton in an unusual mode. Turning off the ignition commences the arming cycle, *unless* the button is simultaneously pressed. Hence, normal behaviour automatically arms the system, overcoming forgetfulness, while the arming is simply overriden should you desire it by use of the button and the ignition key at once. Thus, disarming for service, etc, is facilitated. In addition, if the technique is deliberately not told to a bor- ▶

PARTS LIST — ETI-340

Resistors ..... all ¼W, 5% unless noted

R1, R38	560R
R2	33k
R3, 5, 6, 8	1k
R4	680R
R7	5k6
R9, R32	330k
R10, 11, 20, 34, 50, 53, 55, 56	100k
R12	1M
R13, 17, 27-30, 51, 52	10k
R14, 22, 25, 58	1k5
R15	56R, 1W
R16	390R
R18	1k8
R19, 47, 49	4k7
R21, 48	270R
R23, 26	150k
R24	390k
R31	680k
R33	2k2
R35	68k
R36	100R
R37	1k2
R39, R41	6k8
R42	180k
R43, 45, 46, 54	3k9
R44	180R (see text)
R57	1M2
RV1(R40)	10k vert. mount trimpot

Capacitors

C1	47µ/16 V pc mount tant. or LL electro.
C6, 14, 24, 25	100n/6 V tant.
C3, 8, 9, 10, 12, 13, 16, 17, 22, 23, 30	10µ/6 V tant.
C4	150n ceramic or greencap
C7, 11, 20, 28	47µ/6 V tant. or LL electro
C5, C15	1n ceramic or greencap
C18, 19, 27, 29	10n ceramic
C2, 21, C26	100n ceramic or greencap

Semiconductors

D1, D3	EM401, 1N4001, 1N4002 etc.
D2(LED1)	TIL220R red LED
D4, 5, 7, 8, 9	1N914, 1N4148, 1N4001, 1N4002 etc.
D6	10 V/400 mW or 1 W zener
D10(LED2)	TIL220G green LED or colour choice
IC1, 3, 6	4001
IC2, 4, 5	555
Q1	BD139
Q2, 6, 8	BC549
Q3, 4, 10	BC547/8/9
Q5	BC639 or BD139
Q7	BC559
Q9, 11	BC547

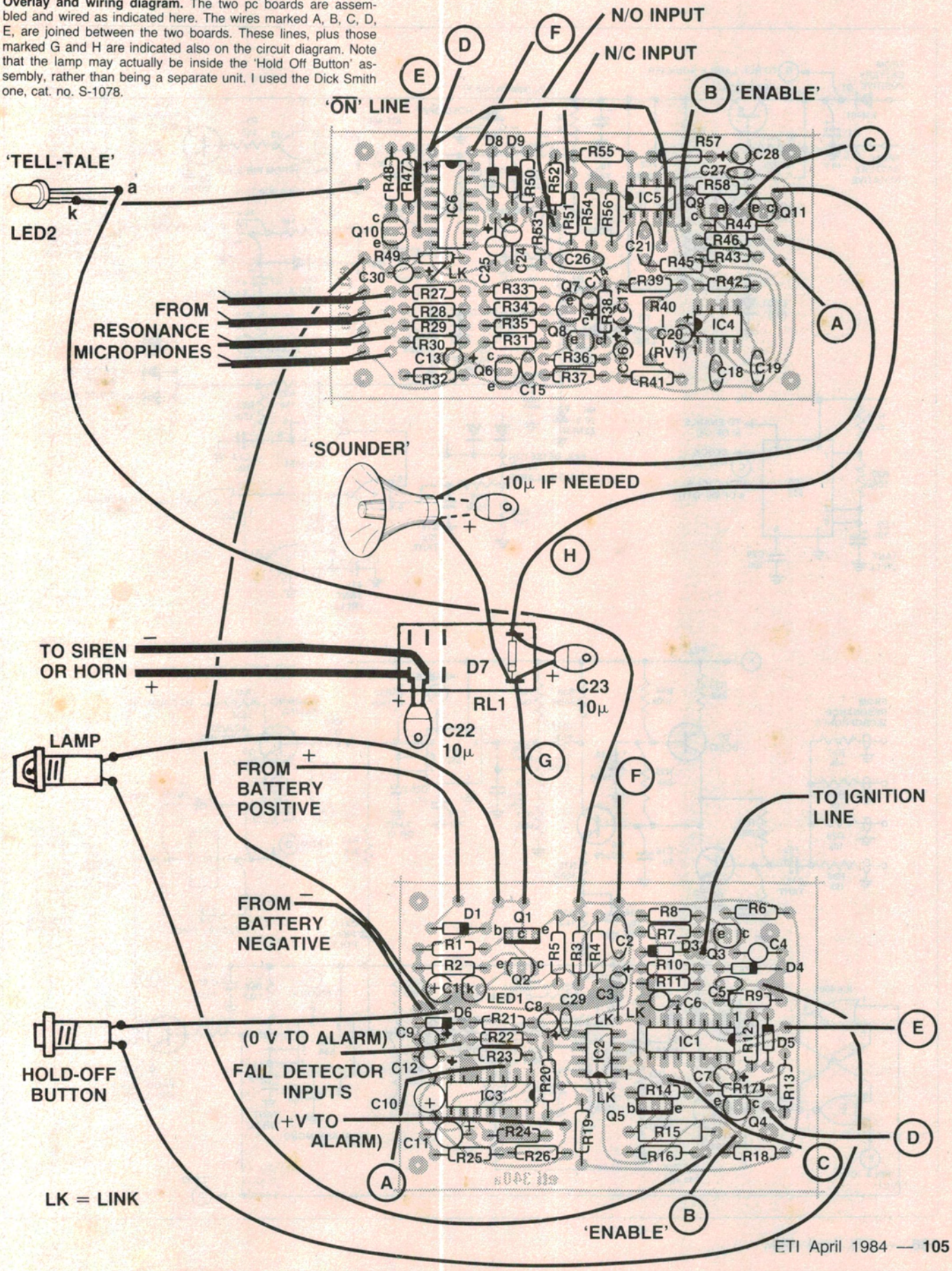
Miscellaneous

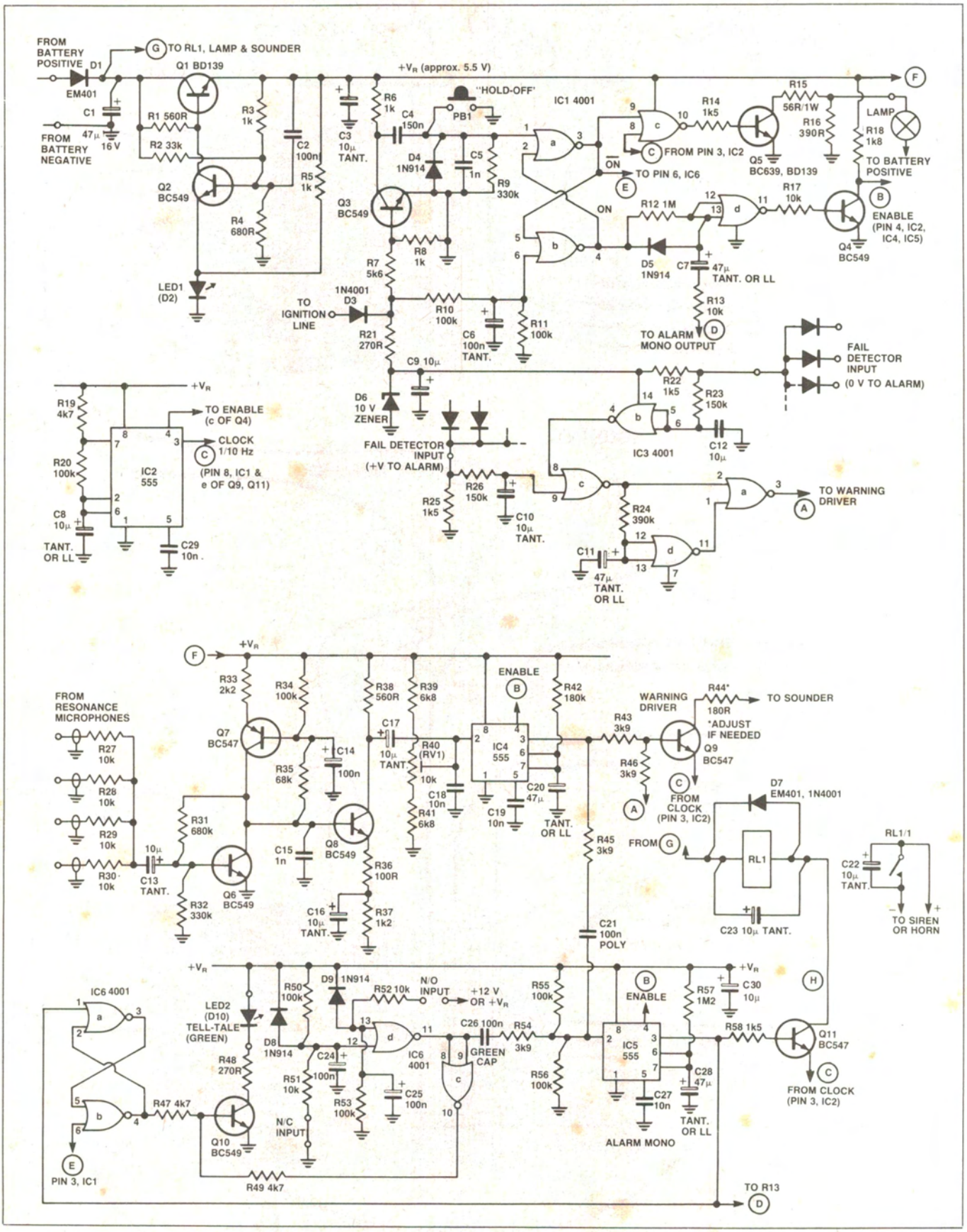
PB1 ..... Push-to-make switch. This can have the lamp indicator mounted internally if you wish (6 V globe).

ETI-340a and b pc boards; RL1 — relay with 12 V coil and contacts rated to suit horn or siren used; LED mounting bezel for Tell-Tale LED; Panel mount lamp, 6 V globe (but see PB1); Piezoelectric 'sounder' or buzzer (e.g: Altronics S5062 or D.S.E. L-7009, etc.); Up to four resonance microphones (see text); Mercury switch (e.g: glass type, Altronics S3070); Multiway male and female automotive connector — 6-pin and 9-pin or contact sets to suit (e.g: Tandy 274-226/274-236, 274-229/274-239 or similar); In-line RCA male and female connectors — number to suit number of microphones; Superglue or double-sided sticky pads; 5-minute epoxy; 4BA nuts, bolts and washers to suit; 12 mm spacers, Diecast box — 120 x 95 x 55 mm or similar; Scotchcal labels; Cable ties or insulation tape (ties preferred); Hookup wire — various colours, some 10 x 0.2 mm, some heavy duty 24 x 0.2 mm; Additional siren or horn, if needed.

Price estimate: $65-$80
(depending on optional parts)

Overlay and wiring diagram. The two pc boards are assembled and wired as indicated here. The wires marked A, B, C, D, E, are joined between the two boards. These lines, plus those marked G and H are indicated also on the circuit diagram. Note that the lamp may actually be inside the 'Hold Off Button' assembly, rather than being a separate unit. I used the Dick Smith one, cat. no. S-1078.




FROM BATTERY POSITIVE
D1
EM401
C1 47µ 16 V
FROM BATTERY NEGATIVE
G TO RL1, LAMP & SOUNDER
Q1 BD139
R1 560R
R2 33k
R3 1k
C2 100n
R5 1k
Q2 BC549
R4 680R
LED1 (D2)
+VR (approx. 5.5 V)
C3 10µ TANT.
R6 1k
C4 150n
PB1
"HOLD-OFF"
D4 1N914
C5 1n
R9 330k
Q3 BC549
R8 1k
R7 5k6
1N4001 D3
TO IGNITION LINE
R21 270R
C9 10µ
D6 10 V ZENER
IC1 4001
R14 1k5
R15 56R/1W
R16 390R
LAMP
R18 1k8
TO BATTERY POSITIVE
Q5 BC639, BD139
FROM PIN 3, IC2
TO PIN 6, IC6
ON
R12 1M
R17 10k
ENABLE (PIN 4, IC2, IC4, IC5)
Q4 BC549
D5 1N914
C7 47µ TANT. OR LL
R13 10k
TO ALARM MONO OUTPUT
R10 100k
C6 100n TANT.
R11 100k
FAIL DETECTOR INPUT (0 V TO ALARM)
R22 1k5
R23 150k
C12 10µ
IC3 4001
FAIL DETECTOR INPUT (+V TO ALARM)
R26 150k
C10 10µ TANT.
R25 1k5
R24 390k
C11 47µ TANT. OR LL
TO WARNING DRIVER
R19 4k7
R20 100k
IC2 555
TO ENABLE (c OF Q4)
CLOCK 1/10 Hz
(PIN 8, IC1 & e OF Q9, Q11)
C8 10µ TANT. OR LL
C29 10n
FROM RESONANCE MICROPHONES
R27 10k
R28 10k
R29 10k
R30 10k
C13 10µ TANT.
R31 680k
R32 330k
Q6 BC549
Q7 BC547
R33 2k2
R34 100k
R35 68k
C14 100n
C15 1n
Q8 BC549
R36 100R
C16 10µ TANT.
R37 1k2
R38 560R
R39 6k8
C17 10µ TANT.
R40 (RV1) 10k
R41 6k8
C18 10n
C19 10n
IC4 555
ENABLE
R42 180k
C20 47µ TANT. OR LL
R43 3k9
WARNING DRIVER
R44* 180R
TO SOUNDER
*ADJUST IF NEEDED
Q9 BC547
R46 3k9
FROM CLOCK (PIN 3, IC2)
D7 EM401, 1N4001
FROM G
RL1
RL1/1
C22 10µ TANT.
TO SIREN OR HORN
C23 10µ TANT.
R45 3k9
C21 100n POLY
IC6 4001
LED2 (D10) TELL-TALE (GREEN)
D8 1N914
R48 270R
R47 4k7
Q10 BC547
PIN 3, IC1
D9 1N914
R50 100k
R52 10k
N/O INPUT
+12 V OR +VR
R51 10k
N/C INPUT
C24 100n
R53 100k
C25 100n
C26 100n
R54 3k9
GREEN CAP
R55 100k
R56 100k
IC5 555
ALARM MONO
C27 10n
C28 47µ TANT. OR LL
R57 1M2
C30 10µ
R58 1k5
Q11 BC547
FROM CLOCK (PIN 3, IC2)
R49 4k7
TO R13

HOW IT WORKS — ETI-340

Though an apparently complex circuit, it can be broken down into 12 simple blocks. Referring to the block diagram first, these are Power Supply, Clock, Arming Flip-Flop, Lamp Driver, Exit Delay, Mic. Amplifier, Detector/Entry Delay, Alarm Delay/Driver, Panel Remoter, Beeper Driver, Perimeter Loop Control and Tell-tale Flip-flop. Referring now to both the circuit and the block diagram, we can discuss the function of each part discreetly.

The power supply provides approximately 5.5 volts for the electronics. Using so low a rail voltage permits the regulator to work with a large overhead, giving increased immunity to fluctuations in the battery voltage as are commonly encountered in the automotive environment. The supply consists of D1, the reverse polarity protection diode, which also serves to isolate C1 in the event that a spike on the supply drops the supply voltage below about 9 V. The supply reference consists of LED1 plus Q1 and Q2, the series pass and comparator elements, respectively, in a conventional series pass feedback regulator. Resistor R2 provides feedforward to give nearly perfect line regulation despite the low loop gain. Capacitors C2 and C3 ensure good ac load regulation (dc load regulation is not important here).

The first two gates in IC1 form the 'ARM' RS flip-flop. Initially, consider that the ignition line is high, that is about +12 volts. R10 limits the current delivered into the protection diodes on the gate input, which is held near the 5.5 volt supply. Hence the gate output (ON) is low, and the system is disarmed. Because R9 holds the other gate's second input low also, its output ($\overline{ON}$) is high. Q3 is held on by current through R7. When the ignition line goes low (the car's ignition is turned off) the input of the first gate is pulled low by R11.

Two responses are possible, depending upon whether the pushbutton, PB1, is pressed or not.

If the button is not pressed, Q3 turns off and delivers a momentary positive-going pulse to the second input of the second gate, toggling the RS flip-flop. In this condition, which corresponds to the arming state of the alarm, the output of the second gate ($\overline{ON}$) goes low and is held low, while the other output is sent, and held, high.

If the button is pressed, the brief pulse is shorted out, and no change in the state of the flip-flop occurs. Hence, whenever a negative-going edge occurs on the ignition line (the ignition is turned off) the button is read to see if arming is required, the default being to arm.

Whenever the ignition line goes high, the level is conveyed to the first input of the first gate, resetting the flip-flop, irrespective of the button. The flip flop provides both the ON signal and its complement.

The Exit Delay is provided by R12, D5, C7 and the third gate in IC1. When the ON line goes high, C7 proceeds to charge toward the 5.5 volt rail via R12. For the time being consider that the output of IC5 is low. When the voltage on C7 passes about half the rail voltage, the gate output goes low, turning off Q4. The collector of Q4 is the 'enable' line, which is used to activate other blocks. This line going high signals the arrival of the armed condition, which follows the exit delay.

If the ON line goes back to 0 V, as is the case when the ignition is restored, C7 discharges via D5 and R13. Q4 is immediately turned on and the enable line pulled low. If the low on the ON line is soon returned to a high, before C7 has half discharged via R13, rearming occurs at once.

In addition to the above mechanisms, if the output of IC5 goes high, corresponding to the alarm going off, C7 will be discharged, though the enable signal is not removed because it is discharged until both of the terminals are held at about 5.5 volts. However, when the output of IC5 goes low again, when the alarm ceases, the circuit goes through its normal arming procedure re-arming the unit to detect further interference.

The fourth gate in IC1, in conjunction with Q5 and surrounding components, forms the Lamp Driver. When disarmed, the $\overline{ON}$ line is high, and the gate holds Q5 off. R16 keeps a small current flowing through the lamp (about 30 mA) to keep the filament warm. This greatly prolongs the lamp's life. When the exit delay commences, the $\overline{ON}$ line goes low and Q5 is turned on by the gate. R15 limits the current into the globe. The value shown is suitable for a 6 V/100 mA globe, as is commonly fitted to the illuminated push buttons sold for the very purpose of car alarms in the suppliers around Sydney. Lamp life is also greatly enhanced by using a globe of lower voltage along with a series resistor, and this is what I elected to do. If you use a 12 V globe, you should substitute a 10 R, ½ W resistor for R15.

The Clock signal is provided by IC2, a 555 timer. When the enable line goes high the clock line is released from 0 V and oscillates between 0 and 5.5 volts at around 0.7 Hz. That gives one lamp flash or horn blast about every second and a half. This speed may be altered by varying C8.

The power supply for IC3, the Dash Panel Remoter, is derived from the ignition line by R21, zener ZD1 and C9. Thus, this subsection of the alarm is powered up only when the ignition line is on. When on, the supply is held near 10 V.

Initially, C11 will be discharged, holding the output to the warning driver low. Thirteen seconds or so are required for C11 to reach half the supply, freeing the circuit to respond to its inputs. This ensures that no indications are given during the initial starting period.

After a few moments, C11 will have charged up to 10 volts. C12 will be held near 10 volts also, and C10 will be still discharged. The output to the warning beeper will be low. If any of the connections to the diodes joining R22 and R23 go low or any connections to the diodes meeting R25 and R26 go high for sufficient time to charge their respective filter capacitors (about one second) the output is sent high and the warning beeper sounds. After another twelve seconds, C11 will discharge and again turn off the beeper, in order not to annoy if the indication is continuous.

After that interval the unit will have drawn the driver's attention to the problem anyway.

Clearly, the circuit need not be employed if not desired as it is not interlocked to the rest of the circuit. Conversely, it could be installed in a car without the rest of the alarm. (Apart, of course, from the addition of some beeping circuit.)

The microphone preamplifier consists of Q6 to Q8 and surrounding components. Q6 and Q7 form a high gain amplifier with voltage-sample, current-sum feedback. This arrangement provides a stable gain with no crosstalk between adjacent inputs. Q7 is acting as a current source load for Q6, which is a common emitter stage. Q8 is another common emitter stage with an emitter degeneration resistor to provide current sample voltage sum feedback.

These stages give gains of around 68 and 5, or a total gain of 340. The gain must be relatively stable and constant as the trip sensitivity of the alarm is dependant upon it.

The microphone amp output is applied to the trigger input of IC4, the Entry Delay monostable. When the voltage on pin 2 falls below one-third of the supply voltage, the monostable will trigger. The dc level on this pin is set by RV40 and accompanying resistors. C18 filters any spurious spikes while C17 couples the ac signal from the resonance microphones to the trigger input. Varying the dc level changes the mount of additional signal which must be supplied by the amplifier output to initiate the entry delay. This effectively sets the sensitivity of the alarm.

When the monostable triggers, pin 3 goes high. This applies a positive voltage to the base of Q9. Whenever the clock line is low Q9 saturates, turning on the beeper. Thus the beeper pulses during the entry period, warning the driver (or thief) that the system is active.

If the positive voltage is applied to the base of Q9 by the remoter, Q9 will turn on and emit a constant beep, as the clock line will be low (disabled or 'not enabled') whenever the ignition, and hence remoter, is on. R44 is provided in case you are using a beeper rated for less than 12 volts nominal (actually about 15 volts!), or in case you find the beeper is excessively loud. It may be shorted out if you have a normal 20 volt piezo type sounder.

When the ignition line is taken high, IC4 is reset, as well as IC5, cancelling all delays, etc. If, however, the monostable times out before this happens, as is hopefully the case if some naughty thief is tampering with your pride and joy, a negative going pulse is applied to the trigger pin of IC5, yet another 555 timer. The output of this circuit is fed to the Relay Driver and the Tell-tale Flip-Flop.

For the alarm period, the relay is pulsed by Q11 in a similar fashion to how the beeper is pulsed by Q9. At this time the effectiveness of the power supply is tested as there are typically very severe electromagnetic and voltage pulses emitted by the high power circuits.

If you are using a noisemaker which is self pulsing, or some sort of sonic defence system is connected, connecting the emitter of Q11 to ground will produce a constant output for the duration of the alarm period. Once the timer times out, the re-arming cycle initiates as outlined earlier. The duration of the alarm period is set by C28; the values specified give about one minute. This is less than is often the case, but the alarm will have done its work by then anyway. In fact, 40 seconds is probably plenty. (For this use 33µ or so.)

The alarm can be triggered also by a pulse from the perimeter loop control logic via C26. Two gates from IC6 comprise the loop sensor. The normally closed (NC) connection in series with R51 keeps C24 discharged. The nromally open (NO) link in series with R52 leaves C25 discharged. If the NC link opens or the NO link closes a positive voltage is applied to one input of the first gate and its output falls, triggering IC5 immediately. The second gate turns on Q10 if the fault condition occurs, even if the reset line is low and the Tell-tale Flip-Flop is not driving the LED. This indicates the condition where one of the loops has failed. The diodes D8 and D9 provide protection in addition to the internal protection diodes of the IC to ensure that even significant voltages applied to the loop connections cannot harm the IC. C24 and C25 provide filtering to prevent extraneous pulses from upsetting the sensor.

The second two gates of IC6 form a flip-flop to remember if the alarm has been tripped in the driver's absence. It is set by the output of the alarm monostable, and drives the LED D10. It is reset by the $\overline{ON}$ line, and hence the restoring of the ignition.

rower of the car he is effectively not given the option of inhibition! (Particularly useful if you are forced to leave your keys with an attendant in a car parking station.)

6). The power supply for the alarm circuitry is a particularly 'robust' design, in order to eliminate problems which can arise if the noisemaker draws large currents or develops strong interference signals. Hence the system can handle large and fast changes in supply without complaint. This allows the use of air horns and/or backup batteries should you wish. Performance is not compromised with a sick or flattish battery.

7). A dashboard failure warning indicator remoter is also incorporated. This is a circuit which emits a constant tone from the beeper if any crucial dash systems come on and remain on for more than 1.5 seconds. Hence, if an oil pressure warning light goes unnoticed, or the globe fails at a crucial point, a backup warning system is present.

If you ever have the fear that someone who has borrowed you car will not respond promptly to a glow in a warning panel, this is the system to relieve your nerves. Those who care to, can wire the 'low petrol' indicator to this, so that there is even more strong a warning just before you run out completely.

The remoter system waits about 20 seconds after the ignition is turned on and then starts to search the power supplies to the various connected dash indicators. If one goes active (either plus or ground as appropriate) and remains active for more than 1.5 seconds the beeper goes on for 15 seconds. Hence, in the case of the low petrol indicator, the sound only occurs when the lamp is pretty continuously on. If the alarm can protect the car when it is left alone, why shouldn't it do the same when it is being driven?

8). When installed as described, and with a main alarm noisemaker which is not accessible without violating the alarm (either a horn well concealed or a separate mechanism well away from prying hands) this alarm *meets all NRMA recommendations* for a vehicle alarm.

9). Finally, disarming occurs immediately when the ignition is applied, but immediate re-arming occurs if the ignition line does not remain on for at least three seconds. This means that a brief pulse may reset a trip but will leave the alarm armed. This can be handy in setting up, and makes it harder for inept fooling to bypass the system, or spurious glitches to cause disarming.

If the above points have not sold you on this project yet, you just don't love your car enough!

Construction

Before proceeding with details of the assembly and installation of this project let me say that a lot of care should be exercised here for three reasons: Firstly, the electronics will be stowed in some less accessible location in the vehicle making it tricky to access, even if you have the recommended connectors installed, and the sensors will be bonded solidly in various places around the body, so later corrections of errors will be painful. Secondly this is not a simple project, having two separate pc boards and a lot of interconnecting wiring in a small box, so mistakes are easier to make than normal. Lastly, sloppy or careless installation procedure can degrade the effectiveness of the whole project, possibly defeating its very purpose, so the moral is DON'T RUSH IT!

Two decisions are required before you leave the shop with the parts. The first is, namely, whether you intend to use the connectors in the cabling to permit quicker disconnection of the electronics from the fixed parts of the system. If you are dealing with a less accessible sort of car, or you cannot get a soldering iron to it easily, I *thoroughly recommend them.* Do not use the sort of connector that will work loose or corrode as these will surely cause more trouble than they save, but either go the 'whole hog', or wire directly. It will not affect operation — it is purely for your convenience. I will proceed assuming that you are going to use them, so just skip relevant parts if this is not the case.

Once you have have collected the electronic parts, unless you have bought a complete kit, you will have to go to a special supplier for the resonance microphones. The 'Microphone pickup' item on p.111 discusses places you are likely to be able to get these, though you may have to order them. They may cost from $5 to $15 each, or thereabouts, depending where you go to get them. If you have a small car, two microphones will most likely be enough. If you have a large vehicle or you wish to have 'hair trigger' sensitivity, four will be required. It is perhaps wise to get four if they are not too expensive to save another trip later, but it is also quite acceptable to get two or even only one and add more later.

Armed with all the parts, the next step is to retire to the workroom and assemble the control box. The first phase consists of preparing the box. Preferably using the blank pc boards as templates, position the two sets of mounting holes to hold the boards. I placed the smaller board against the lid and the other on the bottom of the box such that they swing apart when the lid is removed, almost using the flying leads as hinges. This makes for a neat and compact arrangement when assembled.

Only one further hole is required, being the access point for all the wires to the various parts of the car. This should be about 10mm in diameter, and preferably fitted with a grommet.

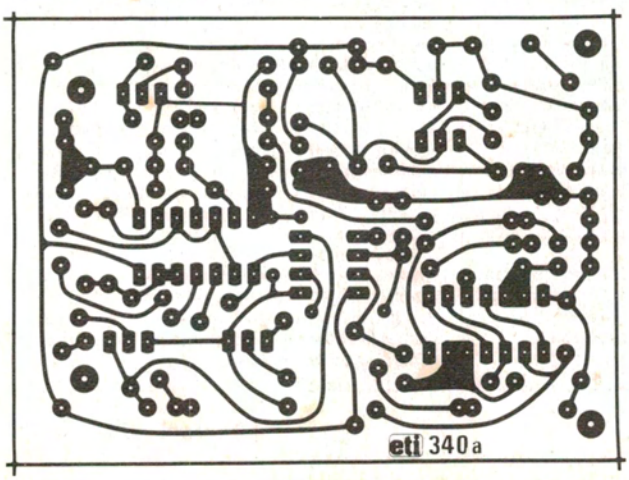
This done, assemble the boards according to the overlay diagrams. Remember, the resistors and some of the capacitors are the only parts which can be put in either way around — every other component will at least not function proplery and probably cause damage if inserted in any other way around than the correct way! It is best to insert and solder a few components at a time. Leave the ICs till last, but beyond this the order is irrelevant.

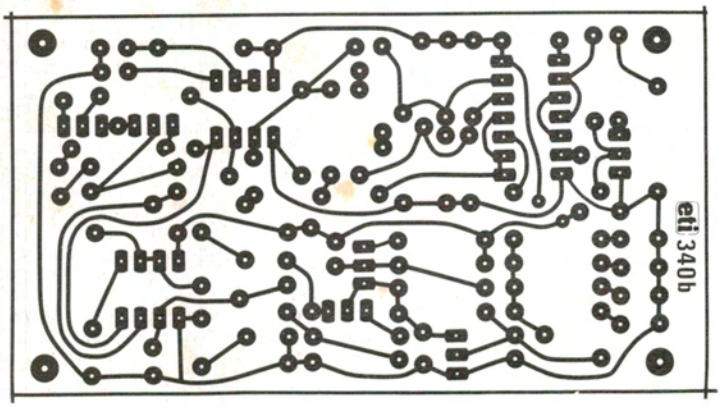
There are several links and flying leads involved, and it is perhaps best to do the links first, and flying leads last. You may like to insert each part in a logical sequence, following the circuit as you go to check the board. (The boards were fine when I last did it, but further checks cannot hurt!) Once soldered, trim the leads with side cutters, about 2 mm beyond the board surface.

If you are using connectors as recommended, leave about 250 mm of wire attached to each connection which is going to the outside of the box. Otherwise you had better leap ahead and figure out how long the wire is going to have to be!

The relay is best attached to the inside of the box with double-sided adhesive tape, such as obtained from hardware shops. This method of mounting is remarkably vibration-proof, and overcomes the fact that relays do not often have mounting holes. Gluing it to the case with silastic is also effective.

The cables running from the relay to out-





Printed circuit artwork. Reproduced full-size.

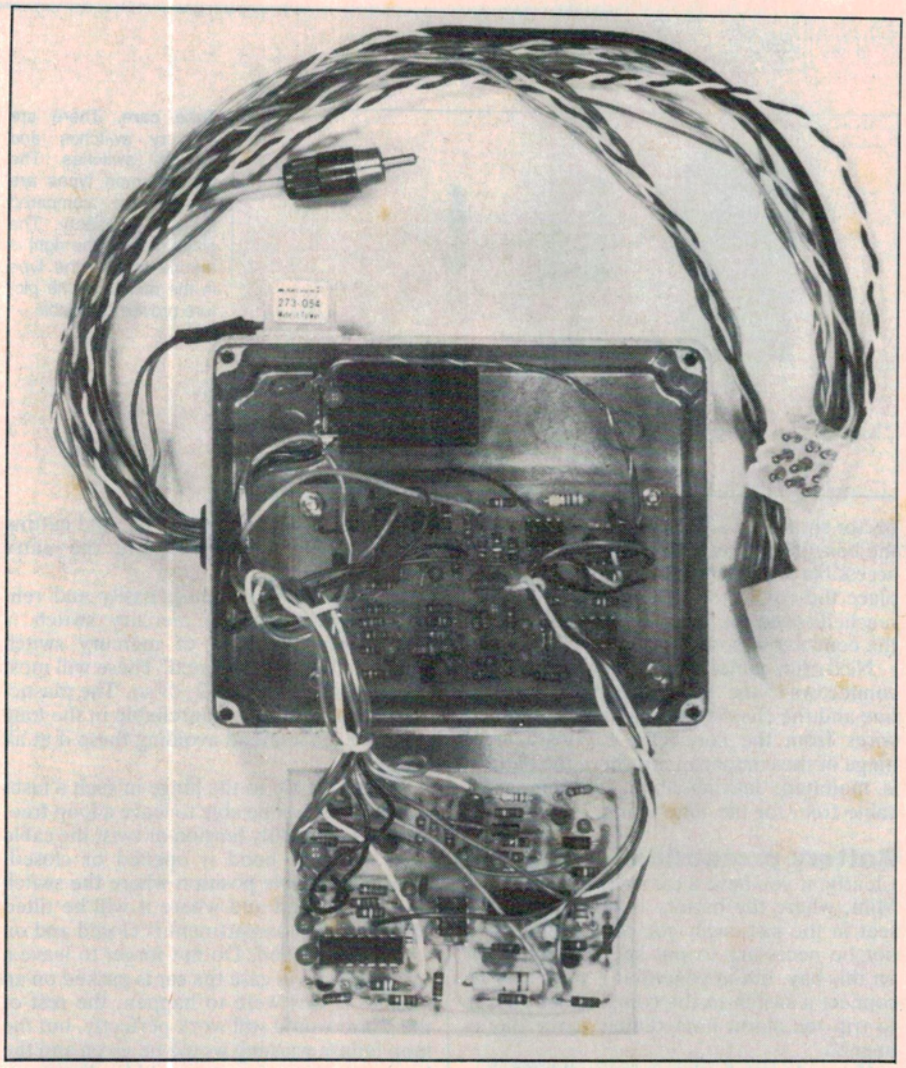
side the box should be heavy duty ones (known as '24 x 0.2 mm'), preferably of the 'automotove' sort. This merely means that both the conductor and the insulation are rather thick. Do not forget that C23 must be soldered *directly* to the *relay terminals* along with D7. These components prevent the relay generating any interference.

If the box is to be mounted in the dashboard (see a little later) it is convenient to mount the noisemaker on the outside of the box, again with double-sided tape or with silastic (unless screw lugs are provided). If you are not sure, leave the mounting of this part until later. In any case, you will need to select the series resitor, R44, to match the noisemaker you have chosen. You will need to know how much current it draws if it is rated for operation below 12 volts maximum. I used a 5-9 volt type, and the resistor value marked on the circuit diagram was most satisfactory.

The value of the resistor is given by subtracting the working voltage from 13 volts and dividing the result by the current the thing draws at its working voltage ($R = (13-Vw)/I$).

Certain of the small noisemakers will act up if their supply impedance is not low. If you find it works on a supply of its working voltage but does little or erratic squarks when run with a resistor in series, place a 4-to-10 μF capacitor in parallel with it, at the noisemaker ends of the leads. This guarantees low supply impedance.

If it is not to be mounted in the dash, you will have to run the leads out, via a connector if it is to be installed permanently in the vehicle, or the leads must travel through a wall of the car.



INSTALLATION

With the basic electronic assembly finished, it is time to turn your attention to the vehicle. If you have a good service manual, the next step will be easy. It is necessary to determine certain connections within the vehicle's existent wiring.

The first line to identify is one which remains connected permanently to the vehicle's +12 V supply. If you cannot locate this in the paperwork which goes with the car you will have to do a lot of trial and error poking. If there is a dash clock it is likely that it will have an earth and +12 V continuous connection, as well as a line to light a globe when the car lights are on. This may narrow the field a bit, as will any appliance which remains operational when the ignition key is removed. The second line required is the ignition. This may be found near the key switch if accessible, or near an appliance which goes off with the ignition.

Horn connections

Next, the horn connections must be found. Some cars have a pair of wires leading to the horn switch, while others have only one, which is grounded when the horn is to be turned on. It does not matter whether you get into the circuit before or after the relay, if there is one, though before is clearly the desirable option. Some cars (e.g: VW) turn the horn off with the ignition. In these cars you must connect after the relay or directly to the horn. (More will be said later.)

Indicators

The above are the only necessary connections for the alarm part to be able to work by itself, but the remoter circuit will require one connection for each indicator to be monitored. I recommend that the 'charge' and 'oil pressure' lamps at least be remoted. You may wish to include 'temperature' if this is a lamp, not a gauge, or 'low petrol' or 'low oil' or 'low windscreen washer water' if you really want to cover every possibility. I think that such paranoia is unnecessary if you are not forced to let your pet out alone with other people on a regular basis. (I connected the 'low petrol' warning to annoy a lady friend sufficiently to prevent the car being returned near empty. Such measures are strong, but *eminently effective!*).

Anyway, back to the task at hand. A wire must be located (for each lamp to be remoted) which swings to rail or ground when the warning lamp illuminates. This is not hard, especially if you have the ETI-325 Auto Probe. It is best to write down each of the connections you determine. If you have a manual, write this information there, as it will be where you first look next time.

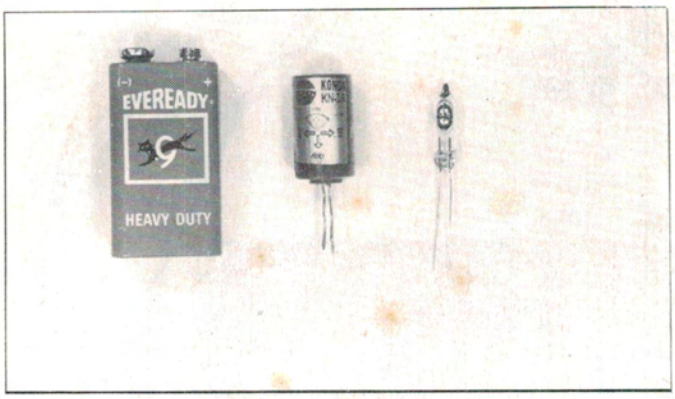
If you are in the habit of placing a circuit diagram of a project in the box along with the boards, this is also not a bad place to scribble the notes.

It may come to pass that all the lines you need to monitor with the remoter go either to ground or rail. That is, they all go to only one; in this case the part of the circuit which monitors the other option can be ignored, reducing the count of wires leaving the box by one. This will be mentioned when it comes to the wiring up.

Control box

Having located all these connections, the location of the control box can be sensibly decided. In most cases it will be more convenient for it to be located in the dashboard, but it can be in the boot or the engine bay for that matter, if it is convenient. It should be out of easy sight and away from where it might be interfered with quickly. A spot near access to the wiring harness is good, as cables will lead to various other parts of the car including the battery storage compartment, etc, and these can follow the wiring harness through the holes in the panels. Do not attach the box yet; merely sort out the location.

Given the location of the box, decide how long the wires between the box and the connectors need be. In case of failure, or the need to check wire continuity, etc, the con- ▶



Take care. There are mercury switches and mercury switches. The two common types are shown here, compared to a 9 V battery. The glass type on the right is theone to get, the type in the middle of the picture proved unreliable.

nector should be a little easier to get at than the box. If the box is to be in a location not accessible without tools, it is a good idea to place the connectors where they are easily reached (once you know where to look). Fit the connectors now.

Next, run cables from the car side of the connectors to the +12 volt line, the ignition line and the chassis (ground). Run a pair of wires from the connector to the nearest hinge of the compartment where the battery is mounted, leaving about 400 mm extra cable free, for the time being.

Battery protection

Clearly, if you have a car such as a Skoda or Mini, where the battery is stowed under a seat in the passenger compartment, it may not be necessary to put special protection on this bay, but in general it is necessary to connect a switch to the compartment cover to trip the alarm immediately if the bay is opened.

If you do not do this, it is possible to simply defeat the alarm by entering the car normally, opening the bonnet, say, and cutting the battery connection before the entry delay is over.

Such protection is most easily and reliably provided with a mercury switch. I recommend the kind of mercury switch which is glass encapsulated. These will most likely cost from $1 to $2, or so. The plastic-cased ones tend to be unreliable in the long run, so I recommend avoiding these if at all possible.

Run the cable to the hinge in such a fashion that you will be able to leave a loop free, so as not to unduly tension or twist the cable each time the hood is opened or closed. Locate a suitable position where the switch can be attached and where it will be tilted off when the compartment is closed and on when it is opened. Do not forget to leave a safety margin in case the car is parked on an incline! If this were to happen, the rest of the alarm would still work perfectly, but the loop failure warning would be given and the loop protection circuits would be disarmed.

Cut the wire to the correct length, and carefully solder on the mercury switch. Insulate the connections with small lengths of spaghetti heatshrink tubing, or insulating tape. Next attach the switch. This is best done either using tape to bind the switch to the end of the hinge bracket or perhaps using the very strong double-sided adhesive tape to stick it to the flat surface of the cover.

Another method involves connecting the switch to a small aluminium bracket by means of binding tape or heatshrink tubing, then screwing the bracket on with a small self tapping screw. This can be tapped into one of the structural ribs of the metalwork of the cover panel. Check that it goes open when the cover is closed, and closed when it is opened. Connect the second wire of the pair to the +12 V rail at the connector.

Accessories

Next, if you intend to protect driving lights, or some other electrical appliance using the normally grounded connection to the alarm, run a cable from the connector to the appliance. The cable can be connected immediately to the chassis at the connector if you do not need this option. At the light or whatever, connect the wire to a normally grounded point.

On a radio or similar, this is the case of the unit; on a lamp, connect to the centre (active) conductor.

When off, this cable is at earth potential, by virtue of the low cold resistance of the lamp filament. If you use the above technique to protect a lamp, you will avoid the necessity to make a separate connection to the metallic body of the lamp housing, which can be quite tricky. the only thing to note is that the loop failure indication will be given whenever the lamp is on, because the active connection will not be at ground potential.

Run the wires from the connector to the point where you intend to tap into the horn circuit, if you are using the horn. If the horn in the car is accessible from outside, or without opening the compartment previously protected on account of the battery, you may choose to use a separate noisemaker, such as a siren, rather than the car horn.

Presumably for reasons of potential tampering, the NRMA recommends that a separate siren always be employed. This is sensible, but unnecessary if you have effectively rendered the car horn tamperproof by the above measures for protecting the battery compartment. At any rate, do not actually connect the noisemaker at this stage, as there is a lot of testing to be done later, and there is no sense in crying wolf or giving yourself an earache unnecessarily.

Microphones

Now the microphones must be fitted. Each one must be glued carefully in place after the surface has been carefully prepared. The selection of the locations requires some careful consideration, and the gluing some time, so leave yourself with plenty of time for the chore.

The locations you choose should have

Front panel artwork. Full-size reproduction — covers the box used.

two properties; between them you should achieve good coverage — that is, there should be an even distribution of them all over the body. Secondly, each microphone should be secured to a fairly large piece of the body or chassis in order to get good solid sound connection to the nearby body panels. Remember that sound travels much better in solids than it does in air, and much better in rigid and hard solids than it does in soft ones. Hence, it is good to place a microphone on to a solid piece of the body framework, such as the part where the door hinges are attached, or the front wing panels just in front of the door hinges. It is unwise to secure a microphone to plastic or flimsy plates of thin metal.

While glass would otherwise be a very good choice, it is also not wise to attach to windows, because the rubber mounts which hold the glass tend to insulate the glass from vibration, and hence sound.

If you have a small car, two microphones will probably be sufficient. They may be best deployed one on either side, or perhaps one front right and one left rear will be best. It is dependent upon how the car is constructed and where solid panels are accessible.

A larger car might be dealt with by having one microphone in front of each front door, and one at the rear where the bumper bars are attached. A very large or long car might have four, one near each corner panel. A utility will need four, two near the cabin, and two at the end of the load area.

It is a wise idea to cover the driver's door more carefully as the sound of the latch being opened is less than the sound of someone scraping the front paintwork. Thus, you need to be closer to the latch than you do to the front extremity. Though it is unlikely that a thief will take time to try and unlatch the door very quietly, this also suggests the need to have microphones near the doors.

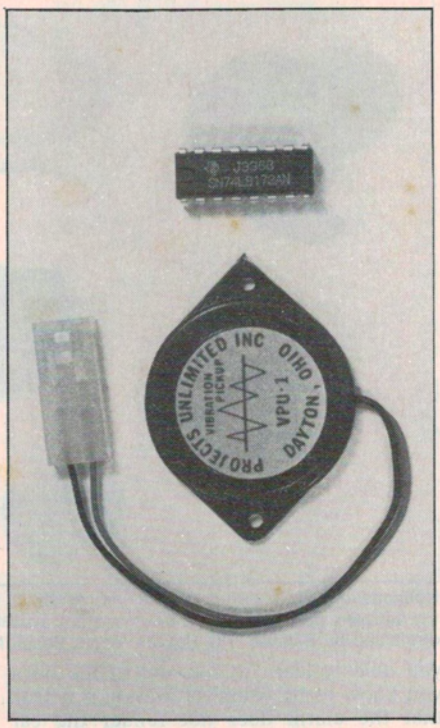
If you have access to an oscilloscope, you can employ one microphone, before attaching it permanently, as a stethoscope. Connect the microphone to the CRO and set the screen up where you can observe it while walking around the car. Get an assistant to hold the microphone against small flat sections of the body at various potentially permanent locations. Tap the car at various locations with a coin, say. (Don't scratch it!). You will observe ringing waveforms at around one kilohertz. The location which gives the biggest waveforms when the car is tapped in the area you want to protect is the best one to choose.

Having settled on the locations, clean each one carefully. Acryllic thinners proved the best solvent, but Prepsol or even methylated spirits will do at a pinch. If the area is covered with a thick antirust covering, this should be scraped back in the immediate vicinity. If the paint is gloss, not matt, this should be rubbed rough with a small piece of emery paper of 400 grade or so, in order that the glue will adhere.

For the gluing, use only an epoxy adhesive. Do not use a contact adhesive, a cyanoacrylate glue (such as 'Superglue') or any silicon rubber glues. I strongly recommend Araldite, but any epoxy type glue that sets rigid should do.

Coat the surface to be used with the glue, and press the microphone, flat face down, against the glue patch. Squeeze out any bubbles. Wedge the microphone in place and allow it to dry completely. If you move the body of the sensor just before setting, you may destroy the close mating of the microphone to the panel, reducing the effectiveness of the job quite considerably, so be sure to allow plenty of setting time. This will be longer than advertised on the packet if the weather is cold, so leave a safety margin.

When the glue is set, run the cable back to the control box and then attach the plug to the cable, if you are using it. The connection is made now rather than right at the start, because the connector would make the job of running the cable through any small openings much more difficult.



Microphone pickup. This shows a ceramic 'vibration microphone' that may be used with this alarm, compared to an IC for size. This model is available from Creative Electronics, PO Box 240, Matraville, NSW 2036. (02) 666-4000. If you use this type, reduce C13 to 100n (tant) and increase R27-30 to 47k (this may need adjusting to set correct sensitivity).

Other types of pickup, the 'resonance microphone' type, are available from Tandy Electronics as accessories for their 49-762 alarm. ▷

Lamps

Next, the connections to the lamps to be remoted must be made. You will require one diode, a 1N914 or EM401 or similar, for each lamp. If the active line of a lamp goes to ground when it is illuminated, it should be connected to the cathode of the diode, and vice versa. Then all the anodes of diodes to lamps which swing their lines to ground should be joined, and this common line run to the appropriate pin on the connector to the control box.

Similarly, all cathodes of diodes to lamps which are wired the other way should be joined, and the common connection run to the other remoter input, which should be labelled 'normally low' or 'high to alarm', or similar. If all lamps go one way, as is often the case, the other input may be ignored.

Button and tell-tale

Finally, the illuminated pushbutton and the Tell-tale LED should be installed. The location of these is up to you of course, but it is recommended that the lamp be prominent, as the flashing light does more than half of the protection involved with a car alarm. The LED should be either close to the lamp for convenience, or in some less significant location so as not to be intrusive.

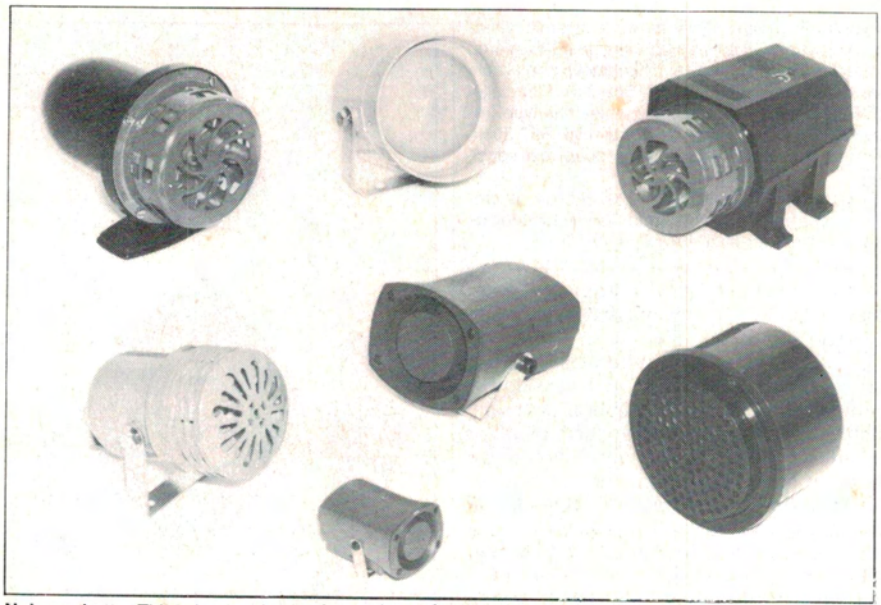
Where fitted to a motor bike, the considerably smaller battery may present problems. In this case, where the bright lamp is less of a vital concern, because it will be easier to see, certain power reduction measures can be taken. The lamp may be replaced by an LED. In this case the 390R resistor (R16) should be placed in series with the LED, rather than in parallel with the lamp it replaces. Current drain is then reduced to approximately 30 mA, or 40 mA (armed) at most. On the other hand, motor bikes can usually be kick-started, circumventing flat battery problems, whereas a car is typically not provided with a crank, as all once were!

An interesting side effect here is that the usage which the alarm makes on the battery can prolong its life. Batteries like to be used. If your car is one that regularly starts on the first turn, the battery is getting almost no use at all.

A previous ETI project — the Expanded Scale Ammeter (ETI-329) — clearly evidences the fact that the car's alternator can replenish the energy used to start the engine in 15 to 30 seconds. In fact, the more sophistocated car electrical systems coming out of Europe these days are actually organised to use the battery, permitting its partial discharge under some circumstances, such as night driving. This deliberate forcing of the battery to deliver power over a period of time improves its chances of being able to do it when needed at short notice, or so the theory goes.

Special protection techniques

The main complaint levelled at car burglar alarms is that they merely make a little noise, of which no-one takes any notice. This is generally not the case, as people love to see whose alarm has gone off, although they have little intention of acting on the information. In itself, this is good protection because thieves rely upon being inconspicuous. In addition, many people are rarely out of earshot of their own cars, and ▶



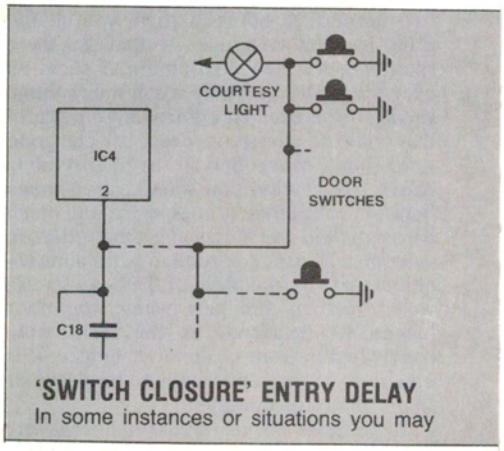
Noisemakers. This picture shows the variety of noise makers you can use if you decide not to use the vehicle's own horn. And all of these are available from one firm! This range (30-XXXX series) is distributed by Benelec, PO Box 21, Bondi Beach, NSW 2026. (02) 665-8211.

you quickly learn to respond to the horn you know to be yours! However, it is true that the alarm does not render the car unstealable.

Several tacks can be taken to enhance effectiveness, even strictly within the law. The first consists of installing a latching relay which isolates the ignition or starter relay supplies.

In some cars it is easier to hotwire the ignition by placing a patchcord directly from the battery to the coil. In this case interrupting the ignition wires is *hopeless*, as they are all bypassed immediately anyway. Where the battery is in the engine compartment this technique is so easy as to make the effort wasted, if another jump is tried, so turn your attention from the ignition to the starter system.

The wire running to the starter solenoid is the best to interrupt, as few thieves bother push-starting. The circuit modifications required to implement such a system are shown in the adjacent circuit diagram. It is necessary either to remove and replace the battery connection with the ignition on, or to have a concealed reset switch, in order to reset the interlock, but then that is not a large price to pay and is unlikely to be tried by a thief endeavouring to quickly and quietly slip away with the car.



'SWITCH CLOSURE' ENTRY DELAY

In some instances or situations you may

It is necessary to have a relay with two contact pairs in the alarm itself if you are using this circuit, as well as the additional relay.

Mount the isolator relay in a concealed area, so as not to make its presence too obvious. Try to cut the appopriate wire where it is not plainly visible, in case the thief notices this and bypasses it at once. The relay you use need not be rated to switch more than two amps or so, even if the solenoid is rated much higher, as the relay will probably never actually interrupt the supply while it is on.

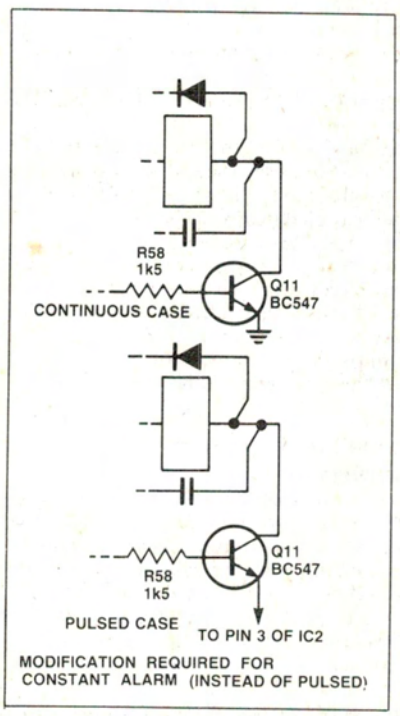
These methods are, however, a bit messy, and do not stop the thief pinching things from the cabin. They are merely a hindrance to taking the whole car, and also represent a lot of fiddling with the car's electrics, with possible reliability problems. A favoured idea in certain foreign climes consists of putting a *very loud* noisemaker actually inside the cabin. The idea behind this is simply to drive the thief out by sheer sonic power.

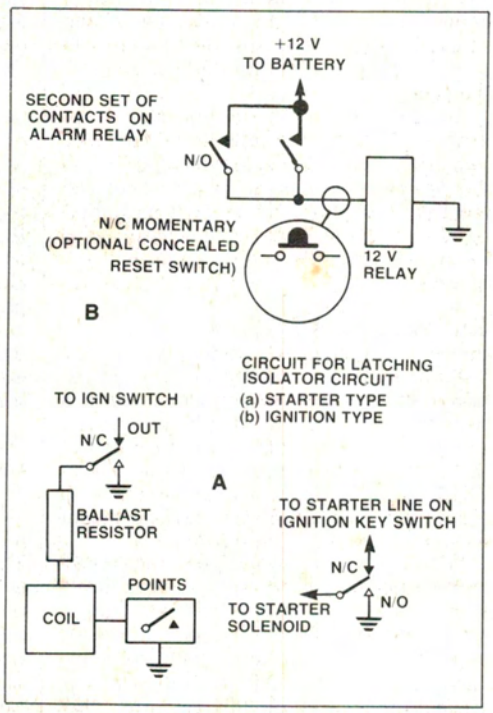
Air-type sirens can be purchased which deliver sound levels of 120 dB at one metre. These are ideal for the job. The rear parcel shelf of a sedan is a suitable place to mount such a mechanism. It can be connected in place of the horn as the central sound generator, because sufficient noise leaks out of the cabin to attract attention, even with closed windows and doors.

If you need it to run continuously, rather than in a pulsed fashion, a small modification is needed to the alarm circuitry. Return the emitter of Q11 to the 0 V line, rather than the clock line. This will cause the alarm relay to remain latched rather than pulse for the alarm duration. This modification is details in the accompanying circuit.

If you do not mind the warning buzzer set for continuous rather than pulsed operation as well, the modification is quickly implemented by changing the flying lead from the emitters of Q9 and Q11 from the other pc board to the 0 V line (ground).

If thieves get away with your car after all this — wish them good luck and go see your insurance firm! ●





consider it desirable to have a switch closure activate the entry delay, rather than trip the alarm immediately. An example would be using the 'courtesy' light switch in a door. Some cars have door catches which don't make much noise (a noisy catch tripping the alarm) or have doors which are heavily sound-damped, such as is the case with Rovers, Mercedes', Rolls Royces (. . . we like to cover *all* our readers!) and some Peugots, etc.

Using the courtesy light switch to set off the normal entry delay is illustrated in the circuit here. All you need to do is link pin 2 of the 555 entry delay timer (IC4) to the 'lamp' side of the door switches via a diode.