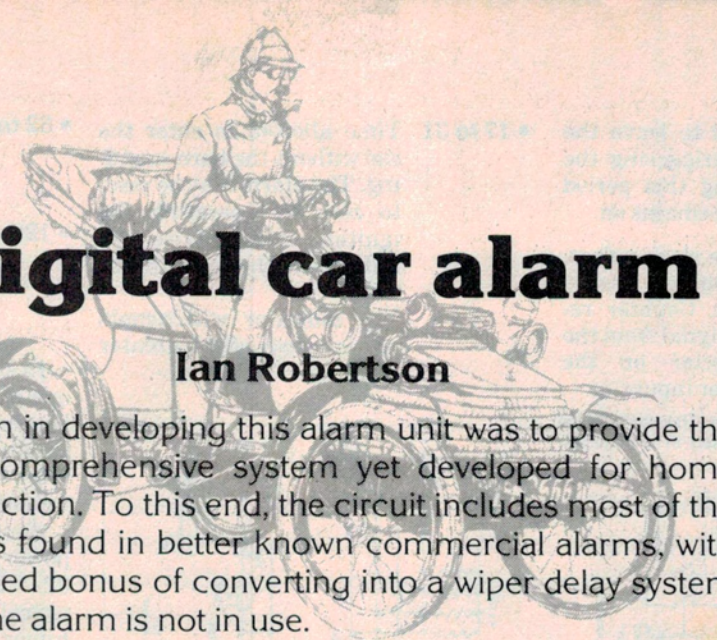


Digital car alarm

Ian Robertson

The aim in developing this alarm unit was to provide the most comprehensive system yet developed for home construction. To this end, the circuit includes most of the features found in better known commercial alarms, with the added bonus of converting into a wiper delay system when the alarm is not in use.

A MAJOR DIFFERENCE between this and other alarm circuits is the use of digital rather than analogue methods. The circuit uses a master oscillator feeding a divider chain to obtain the many time delays needed. Indeed the arrangement is in many ways similar to an electronic organ circuit.

An advantage of the digital technique is that all the delays maintain a fixed ratio to one another. They do not vary, as an analogue circuit will, due to component tolerance, leakage, temperature, etc and, by adjusting a single potentiometer in the master oscillator, all timing functions can be varied simultaneously. This means it is sufficient to check the accuracy of a single delay period to have, in effect, checked the accuracy of all delay periods. Further, by running the oscillator at, say, ten times normal frequency, a complete test that would normally take two minutes, will take under fifteen seconds.

With any alarm of this complexity the time and skill needed to carry out the installation within the car should not be underestimated. Fortunately there are a number of optional features in the system, and even if these are not used, the alarm will still be very effective. This gives each constructor the means whereby he can make the initial installation as simple or as complex as he wishes, while retaining the option of fitting the missing items at a later date.

Features

The following is a list of the main features in the system. Each item gives only a brief description. Greater detail will be found elsewhere in the text.

Flashing indicator

In operation whenever the alarm is set. Intended to deter a potential burglar, the indicator also reminds the owner to disable the system upon entering the car.

Battery detector

Sensitive to the drop in voltage occurring whenever the load on the electrical system changes. Normally opening a door, operating the brake, switching the headlights on, or a number of similar actions, will trip the detector.

Two delayed trigger inputs

Used in addition to (or in place of) the battery detector. These inputs are particularly useful in cars equipped with electric clocks, where the battery detector cannot always be successfully used. Suitable trigger inputs are the roof light, boot, bonnet and glove box lights. However, these must be powered from a circuit that remains energised at all times, even when the ignition is switched off.

Four instantaneous trigger inputs

These are suitable for the protection of driving lights, cassette player, radio, etc. In use a wire is clamped under one of the mounting bolts of the item to be protected. Should this wire become detached from the chassis, as it will if the protected item is removed, the horn will sound immediately.

Hidden switch option

Normally the alarm is cancelled by operating the ignition switch, however with this extra switch in circuit, a thief must locate both switches before he can cancel the alarm. The hidden switch will also prevent children, or curious adults, setting the alarm while the car is parked.

Alarm relay

The alarm section is fitted with a two pole relay. One contact set is used to operate the horn while the other contacts may be used to flash the headlights or disable the ignition circuit or perhaps operate a second horn installed in the boot. It helps to have a second line of defence should the horn be faulty or disconnected.

Alarm timing

- Time to exit vehicle: 15 seconds
- Time to enter vehicle: 15 seconds
- Duration of horn: 96 seconds
- Horn pulse rate: one second on, one second off
- Indicator pulse rate: half second on, half second off.

Wiper option

Whenever the alarm is not in use, the circuit converts into a wiper control unit. The output from this section is once again via a relay, it has a single changeover contact and will suit most wiper systems.

Wiper timing

The wiper control switch settings are:

- Continuous wipe (CW), normal slow speed wiper operation
- Single wipe (SW), single operation every 2, 4, 8, 16, 32 or 64 seconds.
- Multiple wipe (MW), dual operation every 8, 16, 32 or 64 seconds.

Operation

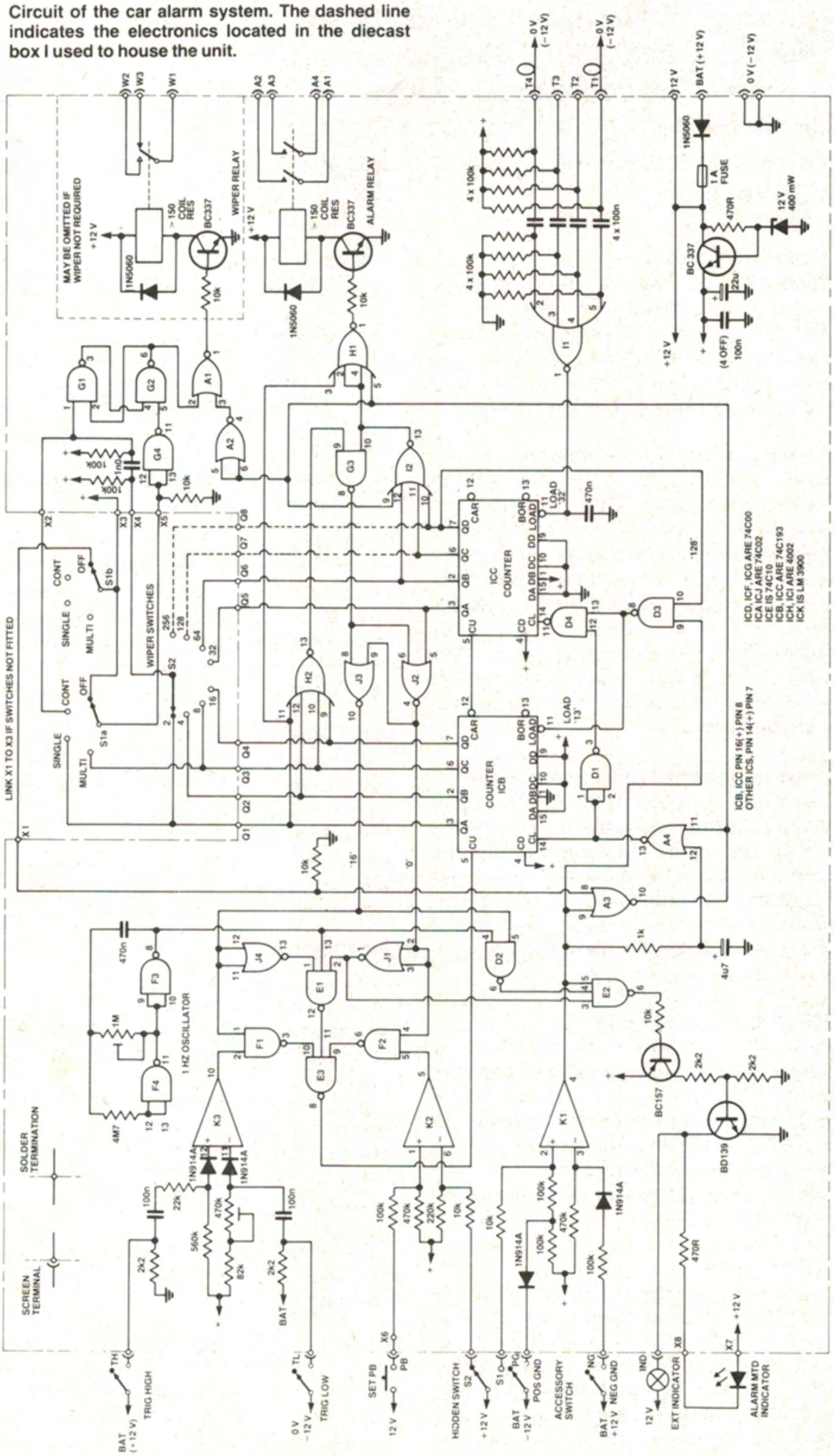
The heart of the alarm is an eight stage binary counter (ICs B & C) clocked by a 1 Hz master oscillator. By this means a delay of 256 seconds will occur whenever the counter is taken from zero count to maximum count. Shorter delays are available by using the various outputs, Q1 through Q8. In fact, any delay between one second and 256 seconds can be obtained by suitably decoding the 'Q' outputs.

Below is a list of the outputs that have been decoded and also their main functions:

- **Zero** — Interrupts the clock pulses, freezes the counter, holds the indicator off. Pressing the set pushbutton advances the counter. ▶

- **1 to 15** Time allowed to leave the car without triggering the alarm. During this period the indicator remains on.
- **16** Interrupts the clock pulses, freezes the counter, flashes the indicator. Counter restarted by a signal from the battery detector or the delayed trigger inputs.
- **17 to 31** Time allowed to enter the car without the horn sounding. The alarm may be reset to zero by operating the ignition switch (also the hidden switch should this be fitted).
  The indicator will remain on for any count greater than 16.
- **32 to 127** Alarm relay operates, pulsing the horn at one second intervals.
- **128** Returns the count to 16 where it may be retriggered should further interference to the car be detected.

Circuit of the car alarm system. The dashed line indicates the electronics located in the diecast box I used to house the unit.



In addition to the above, if at any time one of the instantaneous trigger inputs becomes detached from the chassis, the counter will set to 32 and the sequence will begin with the horn sounding immediately.

Similarly, any interruption to the power supply will set the counter to 32. This item is included to prevent cancelling of the alarm by simply removing the battery lead for a few seconds.

The conversion of the circuit from an alarm to a wiper system is under the control of the car ignition circuit:

- With the ignition and hidden switches OFF the alarm is activated, the wiper disabled
- With the ignition and hidden switches ON the wiper is activated, the alarm disabled. Or more simply, the alarm is enabled when the car is not in use, the wiper when the car is in use.

The basic requirement of any wiper control system is to pulse the wiper motor for approximately one second, then follow with a delay (variable) before the next one-second pulse. The length of the pulse is not critical, once the wiper has started to move the normal parking contacts will take over and complete the wipe cycle. Should the pulse be longer than required for a single wipe of the screen then more than one wipe will occur, and this is the method used to obtain dual wipes in the multi-wipe switch setting.

This circuit operates by allowing the counter to free run, while feeding the signal from a Q output (selected for the delay required) via a one-second pulsing network to the wiper relay. This gives a chain of one-second pulses separated by a switched delay interval. The pulse is extended to four seconds in the multi-wipe setting.

Circuit description

Readers should refer to the various logic and circuit diagrams to clarify points raised in the following description.

All system timing is developed around the eight stage binary counter (ICs B & C). Two 74C193 up/down counters are used. However, in this circuit the down-count facility is not used. This proved to be the simplest way to obtain asynchronous load and clear inputs. Other counters I considered either lacked these inputs or they were of the synchronous type.

The counters are clocked by the 1 Hz master oscillator (ICs F3 & F4). This is a standard CMOS two-gate squarewave oscillator where the frequency can be adjusted over a wide range by the 500k preset.

Selective decoding of the counter outputs is carried out by the gates shown above the counter (main circuit); decoded are 0, 16, › 32 and 128.

Normally the counter will free run unless the clock pulses are interrupted by gates E1 & E3, and this will occur at counts 0 and 16. If the count is stopped at zero it may be restarted by a pulse from the set push button, if stopped at 16 may be restarted by a pulse from the battery detector, trigger high or trigger low inputs.

Any counter greater than 32 will operate the horn via the horn relay and gate H1. Note also that gate H1, and therefore the horn, is pulsed on and off by output Q1 on counter B.

Various gates below ICs C and B are used to clear and load the counters. These inputs, as mentioned earlier, are synchronous and may be operated at any time, even during periods when the clock is halted. The way these inputs have been used needs explanation.

Turning the ignition on resets both counters, and this in turn interrupts the clock and holds the alarm in the standby position.

A signal from one of the four instantaneous trigger inputs will set the counter. In this instance a count of ⩾ 32 will be loaded, causing the horn to sound, and continue to sound, while the counter steps through to 128. In a similar manner, the capacitor on the load terminal of C will force the output to ⩾ 32 for each power up of the circuit.

Reaching a count of 128 resets the counters to 13 which involves clearing counter C while loading 13 into counter B. Loading 13 will silence the horn while giving three counts for the electrical system to settle before the battery detector is rearmed at a count of 16.

Most input signals are buffered by the LM3900 quad op-amp. Keep in mind that this device compares input currents whereas the conventional op-amp compares input voltages. Using resistors to convert voltages to currents, standard operational amplifier circuitry can be realised, but note when testing that both inputs are clamped to within 0.5 V of negative by the base-emitter junction of the input transistors.

Nonetheless, the circuit operation is straightforward with K1 handling the accessory switch inputs (positive or negative ground systems), K2 buffers the set push button, while the hidden switch feeds both K1 and K2. The low value (10k) resistors used in the switch circuit can override any other input signal and will prevent the alarm being set in position S2 or cancelled in position S1.

A short RC delay network is fitted in one line from the output of K1, which resets the counters each time the accessory switch is turned off, thereby ensuring the alarm sequence will start from zero and overcome a problem that occurs if the ignition is switched off with the wiper running.

Section K3 functions as the battery drop detector while also functioning as the trigger high/low input buffer. Figure 10 shows the battery detector in a simpler form. Both inputs are fed from a common voltage, but the lower value resistor feeding the inverter input drives the output low.

If a negative pulse occurs on the battery line it will be coupled into the inverting input by the 100n capacitor. This will reverse-bias the inverting input resulting in the op-amp output going high and developing a pulse to advance the counter one count. In the final circuit a diode is included in series with the op-amp input, this means the diode and not the inverting input is driven negative, and prevents possible damage to the IC.

Delayed trigger inputs TL and TH operate in a similar fashion. Note that in this instance the TL input feeds a negative pulse into the inverting input while the TH input is somewhat different as it feeds a positive pulse into the non-inverting input. The result however, is the same — a positive pulse at the output of K3.

The instantaneous trigger inputs (T1 and T4) are quite different. Normally, the four inputs are held at earth potential so that, should any input be detached, a pulse will enter the NOR gate via the appropriate RC network. A negative-going pulse occures at the output of the gate, loading 32 into the counter, thereby enabling the horn sequence. Unused inputs can in practice be left floating, as they respond to the change in voltage not the voltage level.

An important feature is the indicating light. This may be a LED or lamp and is operated by a two transistor driver stage, under the control of gate E2. The indicator may be off, illuminated or flashing and the sequence is as follows:

- Off when wiper operation selected
- Off for standby mode, counter zero
- Flashing when armed, count of 16
- Illuminated for all other counts.

The ICs are supplied via a series pass transistor and the function on this stage is not primarily as a regulator. The intention is to limit the voltage fed to the ICs to below the rated maximum of 15 V. In order to limit dissipation in the series transistor a 12 V zener is used. This means that the transistor is hard on with a nominal 12 V rail and will not start to regulate until the input voltage is some volts above this value.

Conversion into a wiper control unit requires that the counters free run, and to obtain this the load and clear inputs must be overridden and the gates decoding 0 and 16 must be blocked. This is under the control of the ignition switch. A logic '0' on the output of K1 sets the circuit as a wiper control and a logic '1' at this point sets the alarm function.

The free-running counter will give a squarewave signal from the various 'Q' outputs. The period in seconds given at each stage is two at Q1, four at Q2, eight at Q3, extending through to 256 at Q8. By means of an RS flip-flop (cross-coupled gates, G1 and G2) the squarewaves are converted into an asymmetrical wave having one second ON periods and switch-selectable OFF periods.

Diagram 12 shows Q3 with a period of eight seconds setting the RS flip-flop, while the inversion of Q1 resets the same flip-flop every two seconds. The resulting output, one second on seven seconds off, is clearly shown.

On the multiple wipe setting the flip-flop is reset by the inversion of Q3, not Q1, and this will give a pulse four seconds long in lieu of the previous one-second pulse. Depending on the speed of individual wiper motors two or three wipes will occur during this period.

Construction

Construction is fairly straightforward, however there are two forms this may take. The first is to build only the alarm, the second is to built the alarm/wiper combination. There are points for and against either approach and these are covered in the installation notes. In the construction there is little difference between systems, although in units without the wiper option, one relay, two switches and a couple of minor components can be omitted.

(Note that this article is not intended as an ETI constructional project and thus no pc board details are given.)

Testing

A completed unit should operate with a minimum of adjustment, however I recommend setting up the test circuit (Figure 9) to check out the alarm before fitting it into the car.

Simple faults may be located with a multimeter, but for more elusive faults an oscilloscope will be required.

The 12 V for testing may be obtained from the car's own battery, in situ, or more conveniently from a battery on the work bench. Alternatively a bench power supply may be used with the restriction that it may not test the battery detector circuit in all respects.

Steps for testing using Figure 9 are:

- Set preset potentiometers to approximately mid-way ▶

- With the power and accessory switches on, all other switches off, check that the indicator light, alarm relay and wiper relay are all off
- Move the wiper switch to continuous wipe (CW) and the wiper relay will pick up and remain up
- Move to the single wipe position (SW) and the relay will pulse at an interval determined by the second wiper switch. By adjustment of the 1M oscillator preset, the interval can be matched to the times marked on the switch. Reducing the resistance of the preset too far (frequency increasing) will stop the oscillator
- The multiple wipe setting (MW) is similar to the single wipe setting, however the relay pulse will be longer (four seconds) and switch settings 2 and 4 will give the same timing as position 8
- Turn the wiper and accessory switches off and the indicator, alarm relay and wiper relay should be off
- Momentarily operate the push button. This will set the alarm, and light the indicator for a period of 15 s (exit time)
- After the exit time the indicator will flash at one second intervals showing the alarm is set
- The alarm may now be triggered by means of the battery detector, opening a car door if the car battery is being used, or with a bench supply momentarily reducing the voltage by about three volts. If a bench battery is being used, connect a load, say a 15 W lamp, across the battery terminals. For correct operation the 470k sensitivity preset may need adjustment as maximum sensitivity is obtained with maximum resistance in circuit. Slowly rotate the preset until the indicator latches on, back off 1 mm, reset circuit (using accessory switch and the push button) and then try again
- The 15 s entry delay will occur, followed by the horn relay pulsing at one second intervals for a period of just over one and a half minutes. The circuit will reset with the indicator flashing
- The alarm may also be triggered by either the TH or TL switch and these operate in the same manner as the battery detector
- At any point during the above sequence, closing the accessory switch should cancel the alarm, forcing the relay and indicator off
- Close the instantaneous trigger switch (T1). Reset the alarm using the accessory switch and push button. Opening switch T1 will cause the horn relay to operate, pulsing for the normal 1½ minute horn period
- Momentarily opening the power switch will also cause the horn relay to operate
- Other switches can be added for a more detailed test. Add the hidden switch, PG, T2, T3, T4 switches and with either an ohmmeter or lamp, check the alarm relay contacts, wiper relay contacts and also the indicator output.

Installation

The alarm may be installed with or without the wiper components. The combined alarm/wiper system must be mounted within reach of the driver, and this can mean the unit is more accessible if the car is broken into. By foregoing the wiper control the electronics may be hidden, and by using extended leads, the push button and indicator may still be fitted in the dash. I, however, advise against mounting the wiper switches outside the alarm as the circuit could be effected by noise pulses introduced by the connecting cables.

Keep the wattage of the indicator down and use a high output LED or a low power lamp. Each time the indicator turns on it attempts to trip the battery detector. This in turn is set less sensitive, and if taken too far the system may not respond in an emergency. The roof light must be not less than four times the wattage of the indicator.

In mounting the alarm, each constructor must determine the most suitable position in his car.

Wiring should be carried out in stages, starting with the basic circuit (Figure 1 or Figure 2) followed by the optional items (Figure 3 to Figure 8). As each stage is fitted, the circuitry may be tested and the faults found. Testing stage by stage is possible with this alarm circuit because careful design has eliminated the need to bridge unused terminals to override the redundant function.

Care is required to select the correct horn circuit as this should match the existing wiring whilst also taking into account the current demand of the horn(s) to be driven. The wiring must suit the currents involved. As a guide the cables used for the relay contacts (also the 0 V and BAT circuits) should have approximately the same area as the horn wiring already fitted in your car. The remaining runs can be any standard hook-up wire and the size can be chosen for mechanical rather than electrical reasons.

During the alarm installation it is easy to overlook the part played by the wiring, for it is often the wiring and not the alarm that is most vulnerable. Take particular care to conceal the cable runs and to ensure all connections are sound and will not cause intermittent operation at a later date.

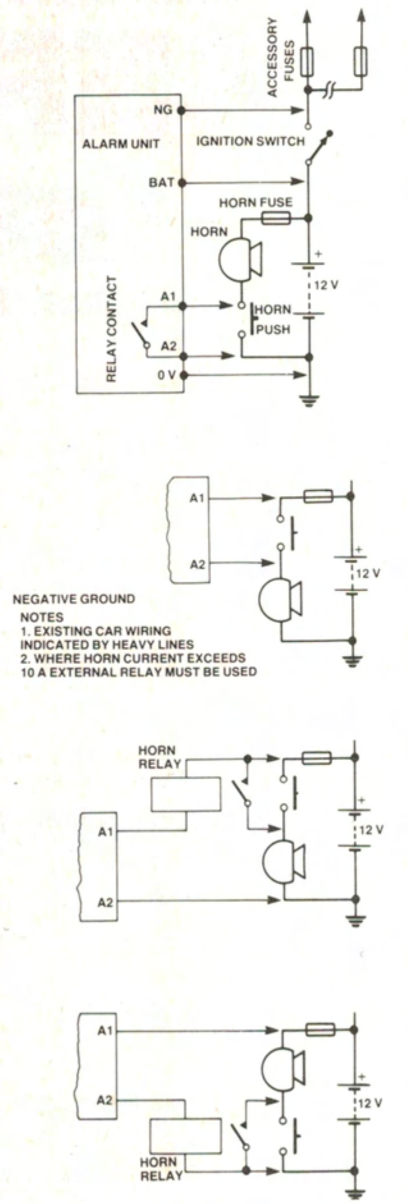


Figure 1. **Basic alarm system, negative ground, with variations to the horn circuit.**

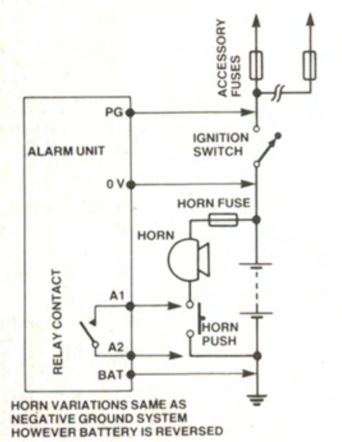


Figure 2. **Basic alarm system, positive ground.**

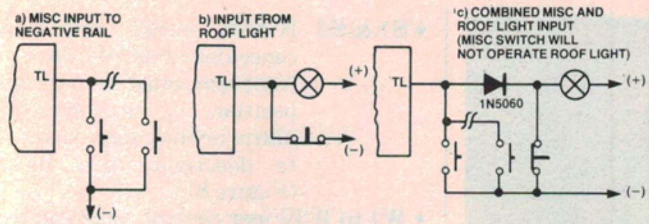


Figure 3. **TL input: using added switches or roof light.**

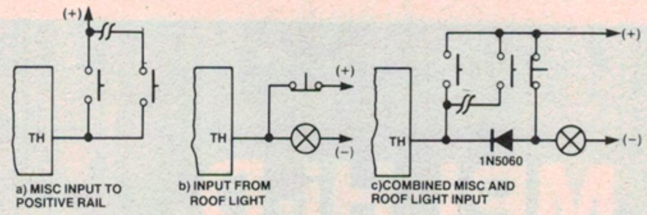


Figure 4. **TH input: using added switches or existing roof light.**

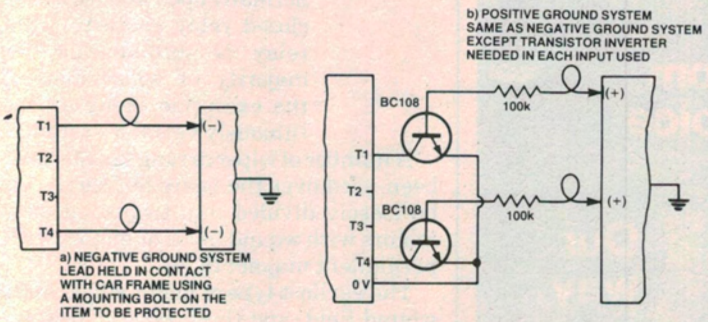


Figure 5. **T1 to T4 inputs: for driving light and radio protector.**

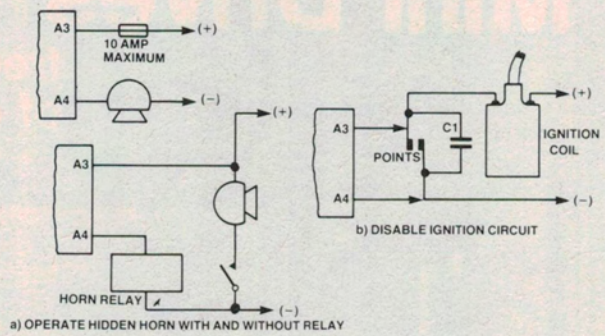


Figure 6. **A3 and A4 alarm relay contact; giving extra protection.**

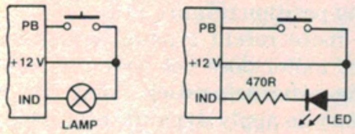


Figure 7. **PB and IND terminals: external pushbutton and indicator.**

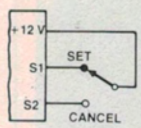


Figure 8. **Wiring a hidden switch.**

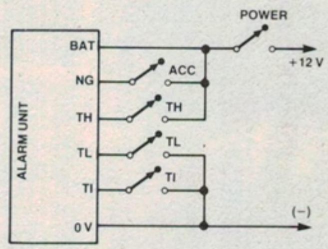


Figure 9. **Basic test circuit.**

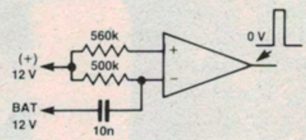


Figure 10. **Simplified battery-drop detector.**

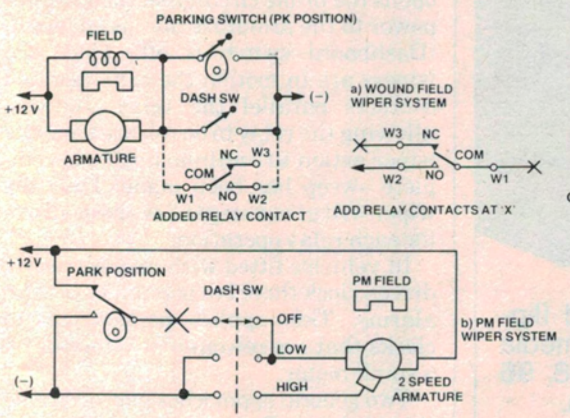


Figure 11. **Wiper operation.**

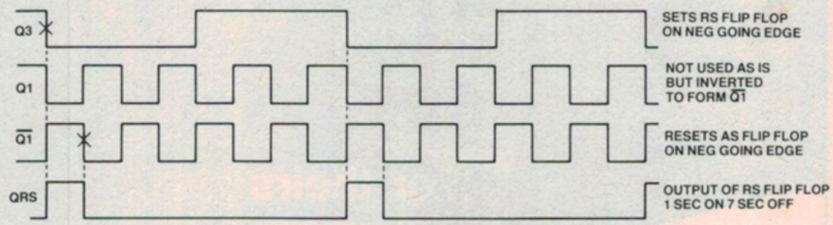
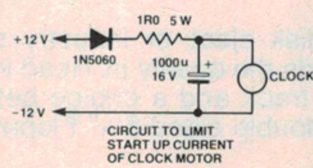


Figure 12. **Wiper circuit timing diagram.**



◁ *Figure 13.* **Clock circuit modification to prevent tripping of alarm.**

Included are a number of diagrams and these show how to wire the optional features.

- **TH & TL** Delayed inputs for connection to the roof light circuit may also be fed from any number of additional points. Possible switch positions are rear doors, tail-gate or glovebox (Figure 3 & 4).
- **T1 to T4** Instantaneous inputs are clamped under driving lights, cassette, radio, etc and will sound the horn as soon as the connection is broken. A transistor inverter stage will be necessary in vehicles with a positive ground system, however this stage should only be fitted to inputs that are actually used (Figure 5).
- **A3 & A4** Spare contacts on alarm relay may be used for a number of auxiliary functions. The contacts have a current limit of 10 A and larger currents require a horn or lamp relay to be fitted (Figure 6). ▶

- **S1 & S2** Hidden switch, normally concealed under the dash or front seat, must be in the set position to activate the alarm or the cancel position to deactivate the alarm (Figure 8).
- **W1 to W3** Wiper control relay contact with W1, W2, W3 corresponding to the common, normally open and normally closed relay contacts. This relay is suitable for the majority of wiper motors, the exception being a continuously variable system.

A number of wiper arrangements have been used over the years but these can be loosely divided into two categories, motors with wound fields or motors with permanent magnet fields.

The earliest type of motor employed a wound field, and these were characterised by a good self-braking action. All that is required for control is a simple on-off switch. Self parking is achieved by a mechanically linked parking switch which keeps power applied in all but the parking position (Figure 11a).

The more recent type of permanent magnet motor does not have the same braking characteristics, and it is necessary to apply dynamic braking by placing a short across the armature. Here a changeover self-parking contact is used which either applies power to the armature or places a short across it (Figure 11b). The added relay contact opens the brake circuit and then applies power to the armature low speed brush. (Dashboard switch is off.) Once the wipers are in motion the cam-operated contacts parallel the relay contacts, allowing the relay to be released and the wiper action to continue until one complete sweep has been made. Thus the wiper will give a single low speed stroke for each relay operation.

In vehicles fitted with an electrically driven clock there is a possibility of false alarms. This applies particularly to clocks that are rewound at intervals by a small motor.

Two general approaches may overcome this problem. Reduce the sensitivity of the battery detector or limit the starting current of the clock motor.

The sensitivity of the battery detector is adjusted by the 470k preset, while the start-up current can be reduced by the network shown in Figure 13. The component values are a guide only and in certain instances a series resistor may be found to be all that is required.

If all else fails the alarm may be triggered by the TH or TL inputs via the roof light circuit. Hopefully the battery detector can still be set to operate with the brake light or similar high current circuit. ●