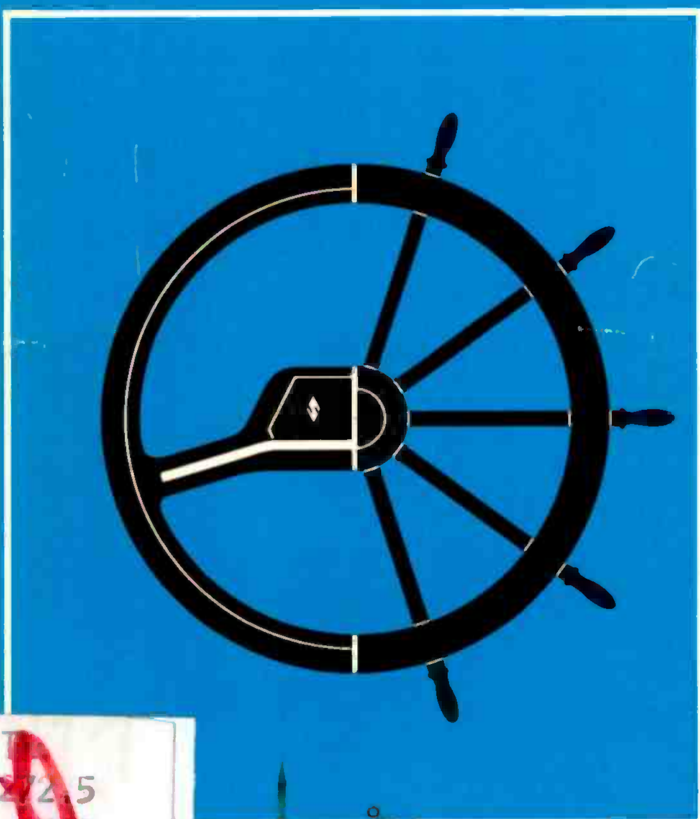
# Electronic Projects for Cars and Boats

R.A. PENFOLD



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# ELECTRONIC PROJECTS FOR CARS AND BOATS

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# ELECTRONIC PROJECTS FOR CARS AND BOATS

by
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# PREFACE

The amount of electronics found in cars and boats seems to be steadily increasing, and there appears to be a great variety of gadgets fitted as standard or available as optional extras. Despite this there are still a great many electronic projects for the car and boat that the home constructor can build and install at probably less cost than buying a commercial equivalent, and in many cases there is no commercial alternative and home-construction is the only way of obtaining the gadget concerned.

This book describes fifteen fairly simple projects for the car and boat. Each project has an explanation of how the circuit works as well as constructional details including a strip-board layout. In general the projects are simply added to the electrical system of the car or boat without any need to modify the existing wiring. Even so, it is advisable not to try to install any project unless you are sure you know what you are doing, or obtain advice from someone with the necessary knowledge and experience. The projects are designed for use with 12 volt electrical systems of the negative earth type (this is the most common form of electrical system these days), but wherever possible they have been designed so that they can also be employed with 6 volt and (or) positive earth systems. Although the projects are put forward as car projects *or* boat projects, some are of course suitable for use in both types of vehicle, and may well have uses in other fields as well.

Please take particular note of the warning included at the front of this book concerning the testing of a project before it is connected to the vehicle.

*R.A. Penfold*

## WARNING NOTE

It is extremely important to very carefully check and thoroughly test any home built project before connecting it to the vehicle battery.

It must be borne in mind that a car battery has an extremely low internal resistance and can supply very high currents. Therefore, it is possible for any errors in the wiring or construction of a unit to result in high currents flowing in the circuit, possibly causing components and/or wiring to rapidly burn out.

It is recommended that the unit is initially tested using a bench power supply having current limiting, or by obtaining a supply from ordinary dry batteries.

If the unit controls a relay then it should be possible to hear it switching "on" and "off" correctly or a continuity tester could be connected across the output to indicate the opening and closing of the contacts.

If you lack the necessary knowledge or experience to locate the correct connection points to your particular vehicles electrical system, it is recommended that you seek expert advice.

## CONTENTS

## PROJECT 1

### Simple Windscreen Wiper Controller

Windscreen wiper controllers must be the most popular of all car projects, and no excuse is made for including two circuits of this type in this book. The first of these is a simple unit that can provide a single wipe of the windscreen at a rate which is continuously adjustable from about once per second to roughly once every twenty seconds. The idea of the unit is, of course, that in light rain or mist where it is not necessary to have the wipers running continuously, the controller can be adjusted to give a suitable wipe rate. This is generally more satisfactory than leaving the windscreen wipers running continuously, and is certainly better than manually switching them on and off each time a wipe of the screen becomes necessary.

The unit is suitable for 12 volt systems, whether of the positive or negative earth type, and could also be used with 6 volt systems if a 6 volt relay is employed in place of the 12 volt type specified. The wipers must be of the self parking type, which includes virtually all cars in current use. The unit is very simple and inexpensive to construct.

*The Circuit*

Reference to the circuit diagram of Fig. 1 shows that the unit is based on the well known 555 timer IC, which is really the obvious choice for use in a unit of this type. The prototype wiper controller actually uses the CMOS ICM7555 device which has the slight advantage over the standard 555 device of having a slightly higher maximum permissible supply voltage (18 volts rather than the 16 volts of the ordinary device). This gives slightly better reliability since it is not unknown for car supply voltages to exceed the nominal 12 volt potential by a substantial amount, but the standard 555 is usable in the circuit and should prove to be perfectly satisfactory.

The 555 is used in the standard astable mode, and this is really a form of relaxation oscillator. This operates with C2 initially charging via R1, VR1 and R2 to two thirds of the

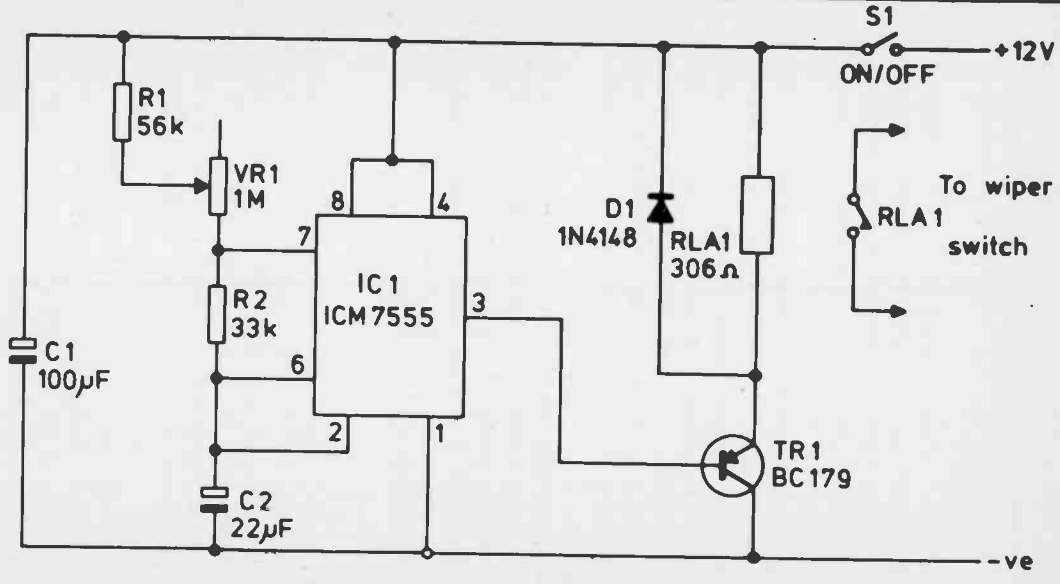



Fig. 1. The circuit diagram of the simple wiper controller.

supply voltage, at which point pin 6 of IC1 senses that this threshold voltage has been reached and triggers IC1. C2 is then discharged via R2 into pin 7 of IC1 (and an internal transistor of the 555 device). C2 continues to discharge until it reaches a charge potential of one third of the supply voltage, and pin 2 of IC1 then triggers the IC back to its original state so that C2 starts to charge up again. When the charge on C2 has reached two thirds of the supply voltage, IC1 is again triggered back to the state where it discharges C2, and the circuit continuously repeats this cycle of events.

Pin 3 is the output terminal of IC1, and this goes high (virtually equal to the positive supply rail potential) while C2 is charging, and low (practically at the negative supply rail voltage) while C2 is discharging. The output of IC1 is used to drive the relay coil by way of Tr1 which is used as an emitter follower buffer stage. The relay will be driven on when the output of IC1 is low, and switched off when the output goes high. Thus the relay is switched on while C2 is charging, and switched off while it is discharging. The wipers are operated by a pair of normally open (make) relay contacts, and will therefore be operated when the relay is driven on.

The discharge time of C2 is governed by the values of C2 and R2, and these are chosen to give a discharge time that is quite short, being less than a second. This switches on the relay and wiper motor for a sufficiently long time to reliably operate the wiper mechanism for one sweep of the windscreen, but does not give a long enough "on" period to give a double sweep of the windscreen. Incidentally, there is a switch in the wiper mechanism that connects power to the wiper motor until the end of a sweep of the screen, giving the self parking effect of the wipers. This makes it unnecessary to give the relay an on time that is accurately matched to the time taken for one complete wipe of the screen. The brief pulse which gets the mechanism started and latched is all that is required.

The charge time of C2 is governed by the values of all the timing components and can therefore be altered by adjusting VR1. In fact it is the setting of this component that largely governs the charge time due to its high value in comparison to R1 and R2. The time between sweeps of the windscreen varies from about one second with VR1 at minimum resistance to around 20 seconds with it set for maximum resistance.

S1 is the on/off switch and C1 is a supply decoupling capacitor. D1 is a protective diode, and it is quite normal to include one of these in a semiconductor circuit where a highly inductive load (such as a relay coil) is being driven. Without D1 a high voltage spike would be developed across the relay coil as it is switched off, and the magnetic field rapidly collapses around the relay coil. D1 effectively short circuits this high impedance signal, clipping it at only about 0.6 volts, and preventing any damage to Tr1 or IC1.

A tantalum bead capacitor is specified for the C2 position since these generally have tighter tolerances and lower leakage currents than ordinary electrolytics. An ordinary electrolytic component may work satisfactorily in the circuit, but it is possible that the delay times obtained will be considerably different to the nominal ones due to the relatively high tolerances and leakage currents of such components. If a high leakage component is used it is quite likely that the circuit will fail to operate at all at higher resistance settings of VR1.

The relay used in the prototype is an Omrom type having a 12 volt coil with a resistance of 306 ohms and a changeover contact having a rating of 5 amps (at 24v DC with an inductive load). The changeover contact can, of course, be used as the required make type merely by ignoring the appropriate one of the three terminals. It should be possible to use other relays with the circuit provided they have a 12 volt coil having a resistance of no less than about 185 ohms, and a contact of the appropriate type and a rating of 3 amps or more. It is advisable to use a small modern type so that the unit can be made quite small and easy to accommodate in the car.

*Construction*

Like all the other projects described in this book, the windscreen wiper controller is built on a piece of 0.1in matrix stripboard. Fig. 2 shows the component layout and underside of the board (including the locations of the four breaks in the copper strips), plus all the other wiring of the unit. The board has 12 copper strips by 19 holes, and as it is not sold in this size it is necessary to trim down a larger piece using a hacksaw. Due to the narrow spacing of the rows it is necessary to cut

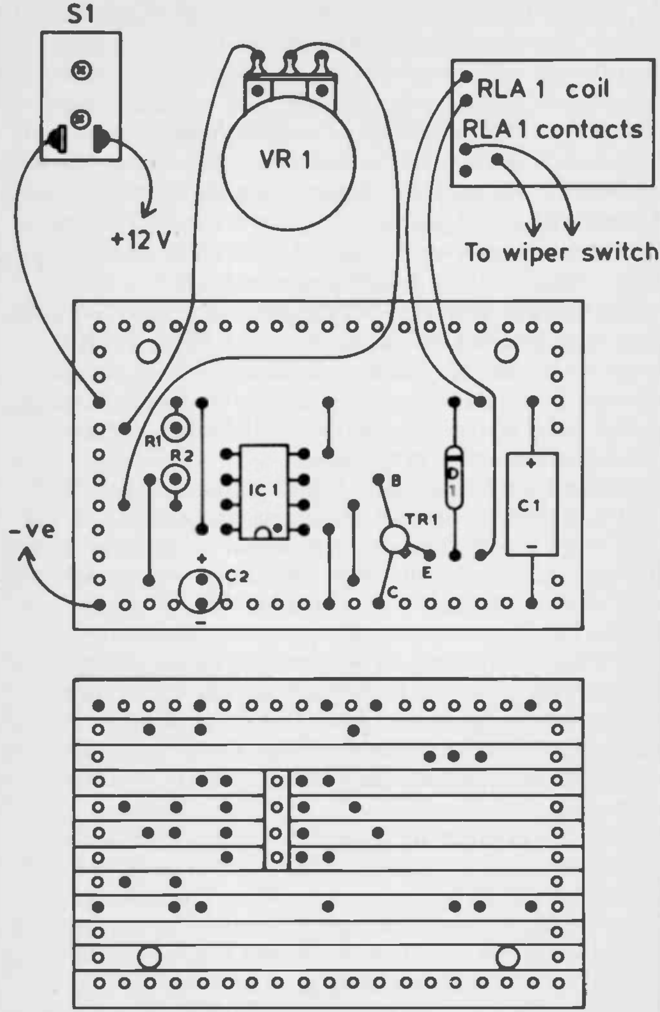



Fig. 2. Constructional details of the simple wiper controller.

down a row rather than between rows when doing this. The cut edges of the board tend to be rather rough because of this, and it is therefore a good idea to file these to a neat finish. Next the two mounting holes are drilled and these can be about 3.2 or 3.3mm in diameter and they will then accept either 6BA or M3 mounting bolts. The breaks in the copper strips should also be made at this stage, and a special tool is available for this purpose. However, it is also possible to make the cuts with a modelling knife or a small (about 3.5 to 5mm diameter) twist drill which should be hand held so that there is no tendency to bore right through the board!

The board is then ready for the components and five link wires to be soldered into place. Note that IC1 is a CMOS device, but unlike the CMOS logic family of devices it does not require any special handling precautions to avoid damage by high static voltages, due to the very effective protection circuitry incorporated in the device.

The unit can be fitted into a small plastic case with VR1 and S1 mounted at one end of the case (this end then acting as the front panel). The relay is mounted on the base panel of the case, and the relay used in the prototype was simply glued in place. With open construction relays it will probably be necessary to construct a suitable mounting bracket from about 18swg aluminium. A hole must be drilled in the rear of the case to take the two leads which connect to the wiper switch, and the supply leads. Once all the point to point fashion wiring has been completed the component panel is bolted to the bottom of the case, and the unit is ready for installation and testing.

The method of installing the unit in the car obviously depends to a large extent on the individual circumstances. It may be possible to fit the unit behind the dash board using the mounting bushes of VR1 and S1 to hold the unit in place, or some other method of fixing the unit may have to be devised. In either event, the unit is likely to be subjected to a fair amount of vibration, and the unit should therefore be strongly constructed and securely fitted in place (which is the case with any project fitted into a car).

*Components for Simple Windscreen Wiper Controller (Fig. 1)*

*Resistors*, all 1/3 watt 5%

| | |
|---|---|
| R1 | 56k |
| R2 | 33k |

*Potentiometer*

| | |
|---|---|
| VR1 | 1M lin. carbon |

*Capacitors*

| | |
|---|---|
| C1 | 100μF 25v electrolytic |
| C2 | 22μF 16v tantalum bead |

*Semiconductors*

| | |
|---|---|
| IC1 | ICM7555 or 555 |
| Tr1 | BC179 |
| D1 | 1N4148 |

*Switch*

| | |
|---|---|
| S1 | SPST toggle type |

*Relay*

| | |
|---|---|
| RLA1 | 12 volt coil with resistance of 185 ohms or more, at least one make contact having a rating of 3 amps or more at 12v DC |

*Miscellaneous*

Plastic case, 0.1in matrix stripboard, Control knob, Wire, solder, etc.

# PROJECT 2

## Improved Wiper Controller

Although simple windscreen wiper controllers of the type described in the previous section of this book usually work very well, under certain weather conditions it can be advantageous to have a controller that provides two or more sweeps of the windscreen at some preset interval, with single sweeps tending to be only partially effective and apt to smear the screen.

The unit described here is a modification of the circuit of Fig. 1, and has a second control which enables from one to about five sweeps of the windscreen to be obtained, with the time between bursts of operation being adjustable from about one second to approximately twenty seconds.

*The Circuit*

Fig. 3 shows the full circuit diagram of the Improved Wiper Controller, and the output circuitry is exactly the same as in the original circuit. It is the timing components that have been altered, with the addition of two steering diodes and an additional potentiometer (to control the number of sweeps in each burst of operation).

With the modified circuit C2 charges by way of R1 and VR1, with steering diode D2 effectively cutting R2 and VR2 out of circuit during the charge period. VR1 is thus able to be used to control the period between sweeps (or sets of sweeps) just as it did in the original circuit.

The discharge path for C2 is via D3, R2 and VR2 into IC1, also very much as in the original circuit, except the addition of VR2 enables the time during which the output of IC1 is low (and RLA1 connects power to the wiper motor) to be made considerably longer than before. This gives the required multiple sweeps of the windscreen, with VR2 being adjusted to give the required number of sweeps in each burst of operation.

The use of a relay to control the wiper motor may seem to be a little old fashioned, but is has the advantage of isolating the controller circuitry from the wiper motor circuitry, and

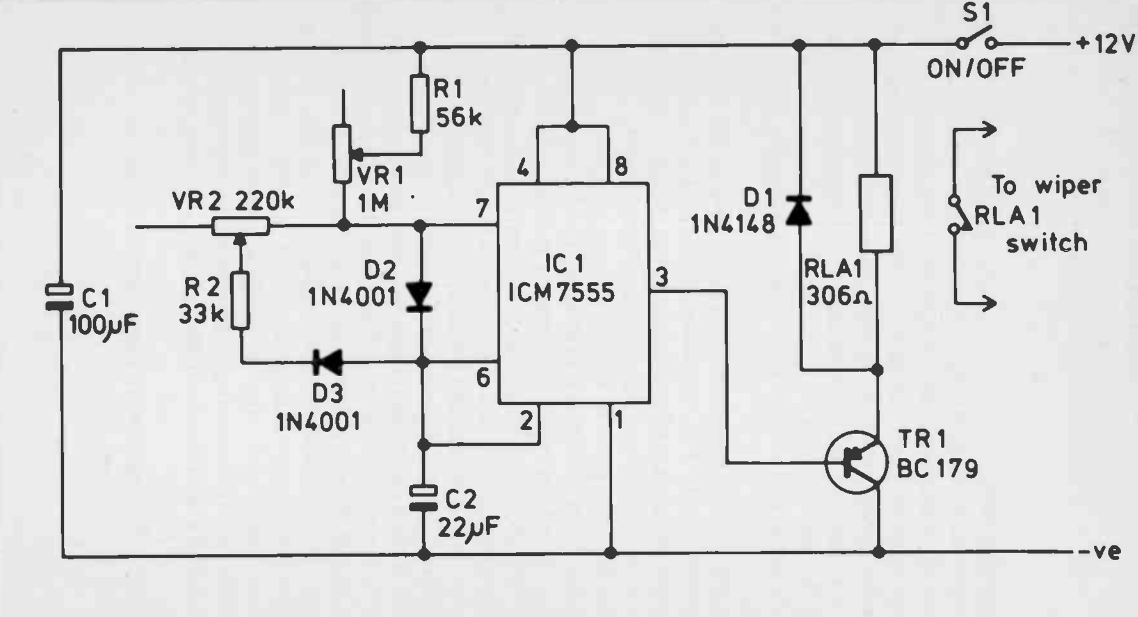



Fig. 3. The circuit diagram of the improved wiper controller.

this enables the unit to be used with positive or negative earth vehicles without the need for any modifications. Like the original circuit this one will operate from a 6 volt supply if a suitable relay is used.

*Construction*

Construction of the unit is very much along the same lines as the original unit, but there is an additional control to accommodate on the front panel and the component panel is somewhat larger. However, the unit can still be made quite small and there should be no problems in fitting it into your car. If it is necessary to make the unit as small as possible it might be beneficial to have on/off switch S1 ganged with VR1 or VR2.

Details of the component panel and wiring of the unit are provided in Fig. 4. The component panel uses a 0.1in matrix stripboard measuring 12 copper strips by 21 holes, and there are six breaks in the copper strips on the underside of the board to be made prior to fitting the components into place.

If possible, it is advisable to test the unit before connecting it to the car battery, and this is true of any car project. It should be borne in mind that a car battery has an extremely low internal resistance and can therefore supply very high currents. It is thus possible for errors in the wiring of the unit to result in very large currents flowing in the circuit, possible causing components and (or) wiring to rapidly burn out. It is therefore better to initially test the unit using a bench supply having current limiting, or an ordinary 9 volt battery such as a PP6 or equivalent is also suitable in this case. If the unit is functioning correctly it should be possible to hear the relay switching on and off after the appropriate periods, or a continuity tester can be connected across the output of the unit to indicate whether the relay contacts are open or closed.

*Components for Improved Wiper Controller (Fig. 3)*

*Resistors,* all 1/3 watt 5%

| | |
|---|---|
| R1 | 56k |
| R2 | 33k |

*Potentiometers*

| | |
|---|---|
| VR1 | 1M lin. carbon |

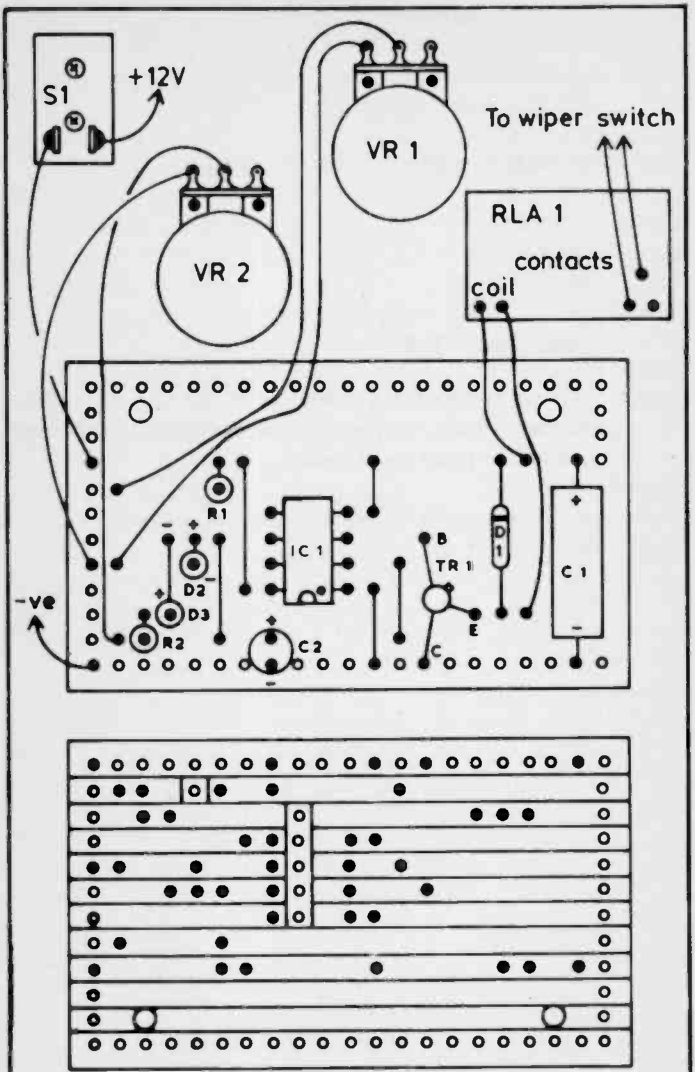



Fig. 4. Constructional details of the improved wiper controller.

| | |
|---|---|
| VR2 | 220k lin. carbon |
| *Capacitors* | |
| C1 | 100$\mu$F 25v electrolytic |
| C2 | 22$\mu$F 16v tantalum bead |
| *Semiconductors* | |
| IC1 | ICM7555 or 555 |
| D1 | 1N4148 |
| D2 | 1N4001 |
| D3 | 1N4001 |
| Tr1 | BC179 |
| *Switch* | |
| S1 | SPST toggle type |
| *Relay* | |
| RLA1 | 12 volt coil having a resistance of 185 ohms or more, having at least one make contact capable of switching 3 amps or more at 12 volts |

*Miscellaneous*

Plastic case, 0.1in matrix stripboard, Control knobs, Wire, solder, etc.

## PROJECT 3

### Courtesy Light Delay

The courtesy light of cars is usually operated by micro switches activated by the doors, with the light automatically switching on when a door is opened, and off when it is closed. You can therefore keep the light in the on condition when you are inside the car by simply leaving the door slightly open, or there is usually a manual on/off switch fitted on the light itself. However, it would often be much more convenient to have a timer unit which kept the courtesy light on for a short while after the car door is closed, switching the light off automatically (say) thirty seconds after it first switched on. This can be achieved using this very simple timer circuit which is suitable for positive or negative earth 12 volt electrical systems (but not for 6 volt systems even if a 6 volt relay is used).

The circuit of Fig. 5 shows the circuit of a normal courtesy light, and this is for a negative earth system. Positive earth systems use what is basically the same circuit – the positive and negative supply connections are merely transposed. The timer circuit is connected in parallel with the bulb (i.e. across points "A" and "C"), and the circuit closes a set of normally open (or make) relay contacts as soon as is connected to the supply. This occurs, of course, when the courtesy light is switched on by the manual switch or one of the door operated microswitches. The relay contacts are connected across points "C" and "B", and are therefore in parallel with the manual and microswitches. Thus the relay contacts will continue to supply power to the lamp and the timer circuit if the manual switch and microswitches are closed. This only lasts for about thirty seconds though, as the timer then switches off the relay, and hence also switches off the lamp and itself as well. It will be seen from Fig. 5 that the timer is an add-on unit, and does not require any modifications to the existing wiring of the car.

*The Circuit*

Fig. 6 shows the full circuit diagram of the Courtesy Light Delay unit, and it will be seen from this that the unit is based

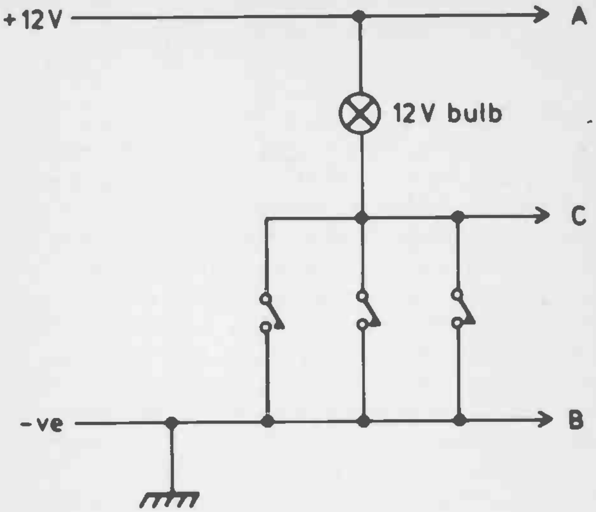



Fig. 5. The courtesy light timer circuit of a negative earth car.

on an operational amplifier (IC1).

The operational amplifier is used as a voltage comparator in this circuit, with the non-inverting input (pin 3) being fed with a potential roughly equal to two thirds of the supply voltage by means of R2 and R3. The inverting input of IC1 (pin 2) is fed from the supply lines via an R–C timing network which consists of R1 and C2. The output of IC1 assumes a state that is dependant upon the comparative input voltages, rather than what particular input voltages happen to be present. The output goes high if the non-inverting input is the one at the higher potential, and low if the inverting input is the one at the higher voltage. Initially C2 will be in an uncharged state, so that the non-inverting input will obviously be the input at the higher potential, and the output goes high. This results in Tr1 being biased into conduction by the base current it receives

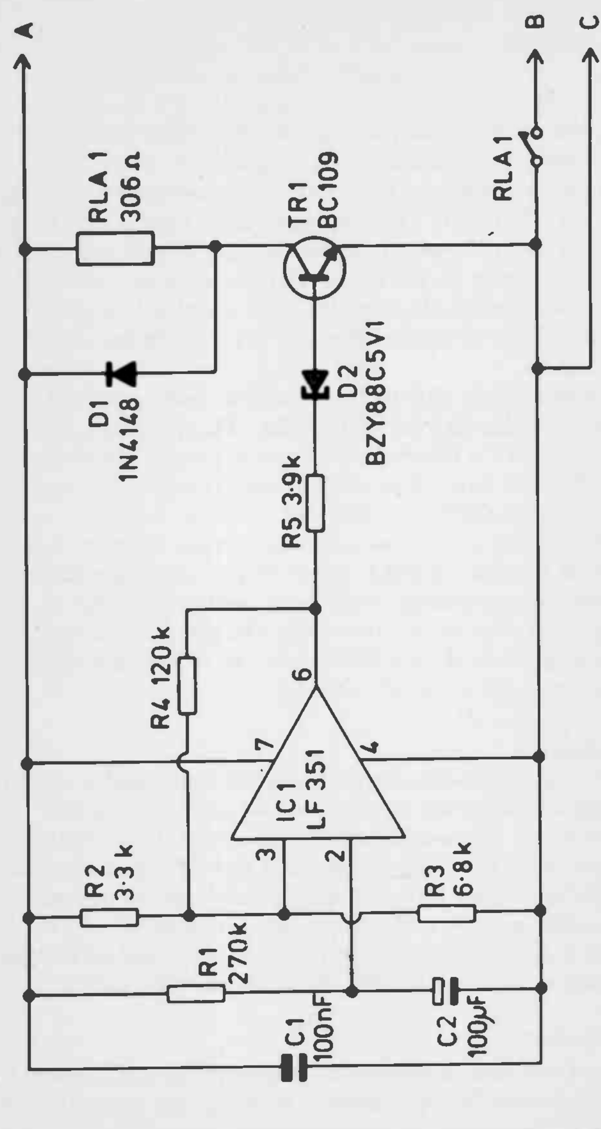



Fig. 6. The circuit diagram of the courtesy light timer.

via R5 and D2 from the output of IC1. Thus the relay is switched on in the required manner.

C2 gradually charges by way of R1 until it starts to achieve a charge voltage which is higher than the bias voltage at the non-inverting input of IC1. The output of IC1 then starts to swing low, and positive feedback provided by R4 results in the output almost instantly assuming the low state. This results in Tr1 being cut off, and the relay consequently being switched off as well. The purpose of D2 is to ensure that Tr1 is cut off when IC1's output goes to the low state, since there will then actually be about 1.5 volts at the output, and without the voltage drop through D2 there might still be just sufficient base current flowing into Tr1 to keep this device switched on.

It is possible to alter the nominal time delay provided by the unit by adjusting the value of R1. The switch-off delay is proportional to the value of this component. The delay time obtained may not be very accurate due to the component tolerances, especially the rather high tolerances of C2. However, in this application it is obviously unnecessary to have a high degree of precision in this respect. Note that C2 should be a reasonably good quality component having a low level of leakage or it may well be found that the delay time is very much longer than the nominal figure. In an extreme case the circuit could fail to switch off at all.

*Construction*

Fig. 7 shows the 0.1in matrix stripboard layout and wiring of the unit, including the locations of the four breaks in the copper strips. The board has 13 copper strips by 16 holes. IC1 has a FET input stage, but this is a JFET type rather than a MOSFET type, and so no handling precautions are necessary.

Provided a modern minature relay is used in the unit it should be possible to easily fit it into virtually any small plastic case, and construction of the unit is very straight forward.

*Positive Earth*

The unit can easily be used with positive earth cars as there is no need to modify the stripboard layout in any way. The only change to the circuit is to connect relay contact RLA1 in the

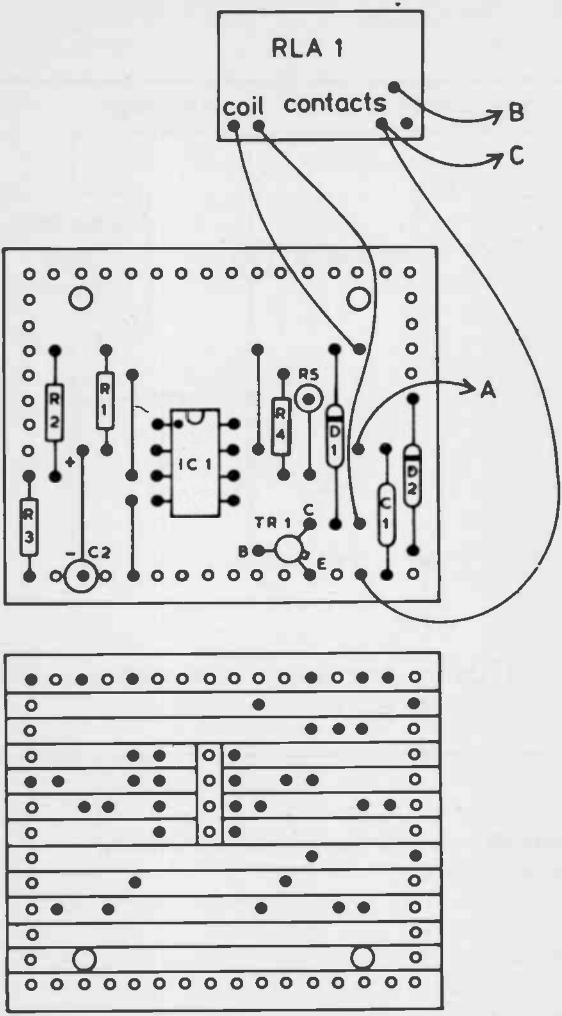



Fig. 7. Constructional details of the courtesy light delay.

positive supply to the timer unit, instead of in the negative supply rail. Fig. 8 shows how the unit is employed with positive earth vehicles.

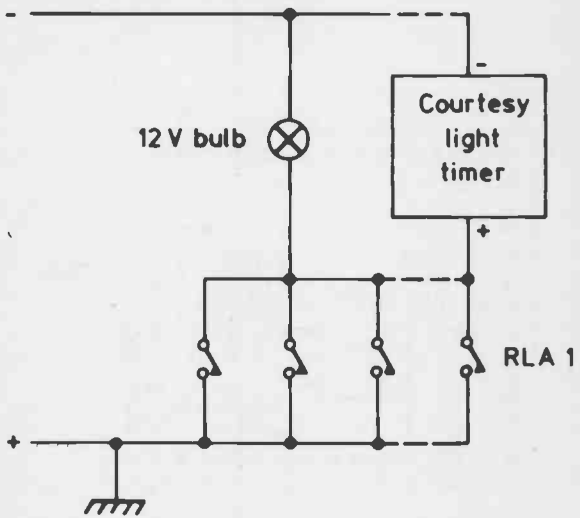



Fig. 8. Using the delay unit with positive earth cars.

*Components for Courtesy Light Delay (Fig. 6)*
*Resistors*, all 1/3 watt 5%

| | |
|---|---|
| R1 | 270k |
| R2 | 3.3k |
| R3 | 6.8k |
| R4 | 120k |
| R5 | 3.9k |

*Capacitors*

| | |
|---|---|
| C1 | 100nF polyester (type C280) |
| C2 | 100$\mu$F 16v electrolytic |

*Semiconductors*

| | |
|---|---|
| IC1 | LF351 |
| Tr1 | BC109 |
| D1 | 1N4148 |
| D2 | BZY88C5V1 (5.1 volt 400mW zener) |

*Relay*

| | |
|---|---|
| RLA1 | 12 volt coil having a resistance of about 185 ohms or more, at least 1 make contact rated at 1 amp or more at 12v DC |

*Miscellaneous*

Plastic case, 0.1in matrix stripboard, Wire, solder, etc.

# PROJECT 4

## Battery Voltage Monitor

Car batteries do not have an indefinate life, and faults can develop in battery charging circuits. Unless some form of battery monitor device is fitted to your car the first thing you know about a faulty battery or charging circuit is likely to be when the car cannot be started. This simple circuit can be added to cars which do not already have some form of battery monitoring device, and it activates a warning light if the battery voltage falls below 11 volts. If desired, several circuits having different warning voltages can be made up, and together they will form a simple bargraph voltage display. The unit is very inexpensive to construct, even in its multiple monitor voltage form, and it is also very simple to add it to any vehicle having a 12 volt system since it is merely connected across the battery.

*The Circuit*

Fig. 9 shows the circuit diagram of the Battery Monitor unit, and as can be seen from this the unit uses just eight inexpensive components.

If the battery voltage is greater than about 11 volts, a current will flow through R1 – D1 – R2, and the voltage produced across R2 will be sufficient to bias Tr1 into conduction. This gives Tr1 a collector potential which is virtually at the negative supply rail potential, and in consequence Tr2, which is driven from the collector of Tr1, is cut off. Tr2 has LED indicator D2 and its series current limiting resistor (R4) as its collector load. With Tr2 cut off D2 obviously does not light up.

If the supply voltage drops below the 0.6 volts (or thereabouts) needed in order to keep Tr1 in a state of conduction, with Tr1 cut off, Tr2 becomes biased into conduction by the base current it receives via R4, and LED indicator D2 is switched on to indicate that the battery voltage has fallen below the 11 volt threshold level.

Of course, the threshold voltage will not be precisely 11 volts in practice, due to the tolerances of the components

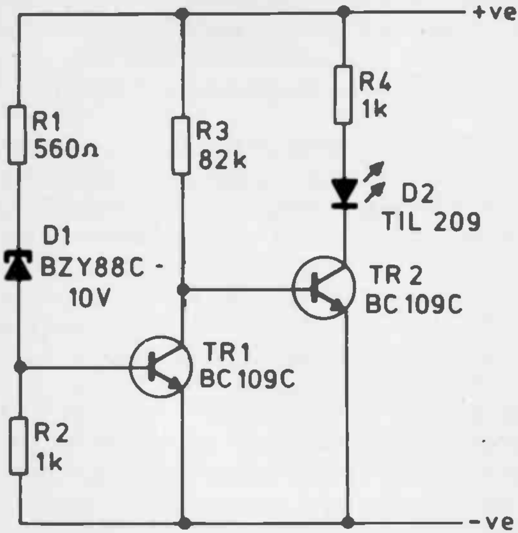



Fig. 9. The circuit diagram of the battery voltage monitor.

used in the unit, but the accuracy should be adequate for this application. The circuit does not incorporate triggering so that D2 is not necessarily switched hard on or fully off, and can take up an intermediate state. This is of no real practical importance though, provided there is a reasonably abrupt switch over as the battery voltage falls through the threshold potential. This is indeed achieved here due to the high combined gain of Tr1 and Tr2.

If you wish to build several units of this type having different threshold voltages, so that a rough indication of the battery voltage is obtained, rather than just an indication of whether the battery voltage is satisfactory or falling below an acceptable level, it is merely necessary to change the value of D1 in the additional units. The threshold voltage is approximately 1 volt more than the voltage of the zener diode used

# PROJECT 5

## Car Cassette Power Supply

A great many people like to listen to the radio or play a cassette when travelling by car, and this has led to a boom in ICE (In Car Entertainment) equipment. If a portable radio, cassette, or radio-cassette unit is already in your possession it makes sense to use this in the car as well as at home, but running this type of equipment on ordinary dry cells can be expensive, and the option of mains power is not available in the car.

One way around this problem is to run the equipment off the car battery, giving what for practical purposes can be regarded as zero running costs. However, it is not usually possible to power the equipment direct from the car battery as it is almost certain to be of the wrong voltage. Most cars have a 12 volt battery whereas most portable cassette and radio equipment is designed to operate from a 6, 7.5 or 9 volt supply. In order to use this method successfully it is therefore necessary to have some form of voltage dropper circuit in series with the supply to the cassette or radio equipment in order to ensure it does not receive an excessive voltage.

The unit described here can provide output currents of up to about 500mA, which should be sufficient to operate any radio or cassette unit. It has a nominal output voltage of 7.5 volts, but this is easily altered to 6 or 9 volts if necessary, and it is merely necessary to change the voltage of the zener diode used in the unit. The circuit incorporates output current limiting, and short circuits on the output do not damage the unit.

### *The Circuit*

Fig. 11 shows the full circuit diagram of the Car Cassette Power Supply unit, and the circuit is really just a conventional series voltage regulator.

IC1 is an operational amplifier, and this has Tr1 and Tr2 connected at its output as a discrete emitter follower, Darlington Pair, buffer stage. These have only about unity voltage gain, but give a very high level of current gain so that

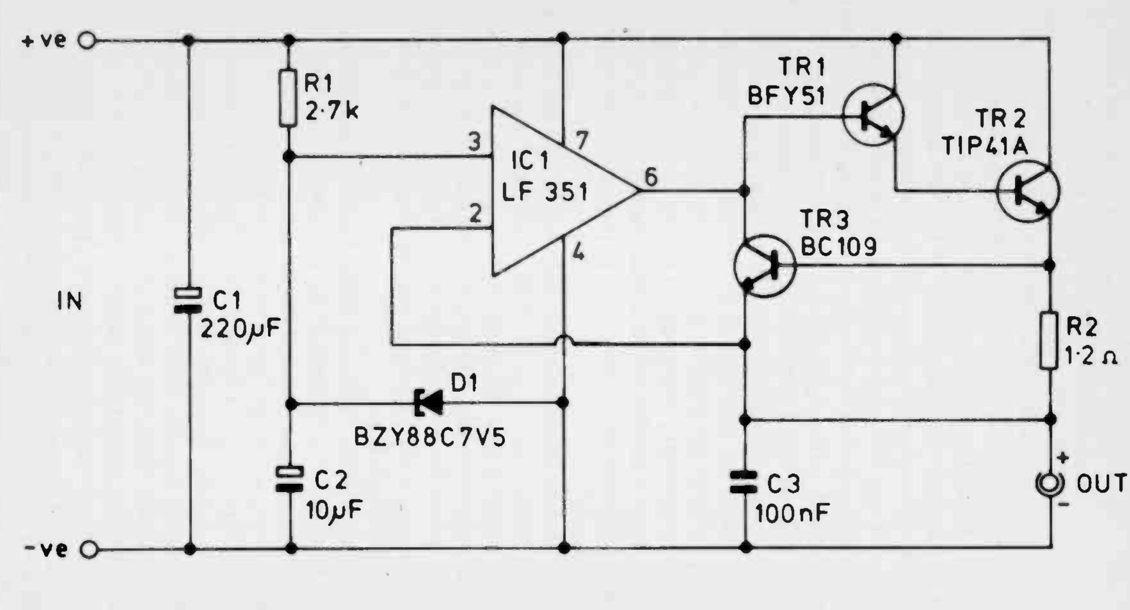



Fig. 11. The circuit diagram of the car cassette power supply.

the unit is able to supply the fairly high output current required by cassette players and recorders (these have much higher current consumptions than radios since there is an electric motor to supply in addition to the electronics). There is a 100% negative feedback loop from the output of the unit to the inverting input of IC1 (pin 2), and this gives unity voltage gain from the non-inverting input of IC1 (pin 3) to the output of the unit. Therefore, if the non-inverting input is stabilised at 7.5 volts, the output will be stabilised at the same potential. R1 and D1 form a simple zener shunt regulator which sets the output at the required potential. D1 should be changed to a 6.2 volt component if a 6 volt output is required, or a 9.1 volt component if a 9 volt output is needed. Obviously the output voltage is going to be a little higher than the required figure if the unit is built as a 6 or 9 volt version, and component tolerances could increase this error. However, it is by no means essential for the output voltage to be highly accurate, and one should bear in mind that the output voltage of a dry battery typically changes by about 20 to 25% during its operating life!

Output current limiting is provided by Tr3 and R2. Under normal operating conditions the output current (and hence the current flowing through R2) will produce a voltage across R2 that is insufficient to bias Tr3 into conduction. The current limiting circuitry therefore has little effect, since the negative feedback action will compensate for the small voltage drop that does occur through R2.

At output currents of around 500mA the voltage developed across R2 becomes sufficient to bias Tr3 into conduction. This results in some of IC1's output current being diverted to the negative supply via Tr3 and the load on the output, and tends to pull the output voltage lower. The greater the overload on the output, the harder Tr3 is biased into conduction, and the lower it pulls the output voltage. This limits the rise in output current, and even with a short circuit across the output there is a current flow of only about 520mA or so since Tr3 reduces the output voltage to practically zero.

C1, C2 and C3 are all needed to reduce noise on the output and aid the stability of the circuit. Although the unit has a negative earth rail, it can be used in positive earth vehicles provided both output rails are electrically isolated from the chassis of the car.

*Construction*

The stripboard layout for the car cassette unit is given in Fig. 12, and a board having 21 holes by 14 strips is needed. Construction of the board is quite straight forward, but note that Tr2 should be fitted with a heatsink. Small, finned, bolt-on heatsinks for this type of transistor are produced commercially, and provide adequate heatsinking. A piece of 16 or 18 swg aluminium measuring about 25 by 50mm or more also makes a suitable heatsink.

Once again, there are numerous plastic cases available which are capable of accommodating this project. It is advaisable to drill some ventilation holes in the case, above and below the heatsink of Tr2, in order to give an efficient transfer of heat from Tr2 to the air around the unit. Without any ventilation holes it is likely that the air within the case will rise in temperature by a substantial amount, effectively reducing the efficiency of the heatsink.

Many cassette units and portable radios have a power socket so that they can be used with an external power supply of the appropriate DC potential. If the unit is used with a cassette player or radio of this type it is merely necessary to have a twin output lead terminated in the appropriate type of power plug (making sure you connect the plug with the right polarity). With other cassette units and radios it may be possible to terminate the output of the unit in a battery clip which will then connect to the battery connector of the powered equipment. If this method is adopted, remember that the battery connector used at the output of the supply is being used as a power source rather than a collector, and the roles of the two press-studs are therefore reversed. Thus the positive battery clip lead connects to the negative output of the supply, and the negative battery clip lead connects to the positive output of the unit.

A third alternative is to fit a power socket to the cassette unit or radio, and then terminate the output cable of the supply in a plug of the appropriate type. However, it is advisable not to attempt even a simple modification to

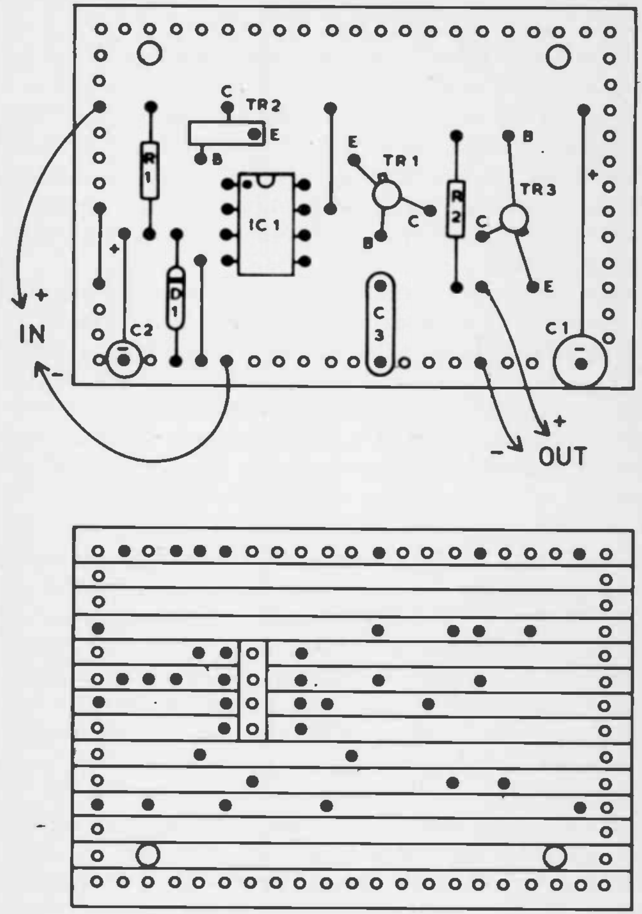



Fig. 12. Constructional details of the car cassette power supply.

commercially produce equipment unless you are absolutely sure you know what you are doing (it should also be borne in mind that such a modification might invalidate the guarantee).

*Components for Car Cassette Power Supply (Fig. 11)*
*Resistors,* all ½ watt 5%

| | |
|---|---|
| R1 | 2.7k |
| R2 | 1.2 ohms |

*Capacitors*

| | |
|---|---|
| C1 | 220µF 25v electrolytic |
| C2 | 10µF 25v electrolytic |
| C3 | 100nF polyester (C280) |

*Semiconductors*

| | |
|---|---|
| IC1 | LF351 |
| Tr1 | BFY51 |
| Tr2 | TIP41A |
| Tr3 | BC109 |
| D1 | BZY88C7V5 (400mW 7.5 volt zener – see text) |

*Miscellaneous*
Plastic case, 0.1in matrix stripboard, Heatsink for Tr2, Input lead, Output lead and plug, solder, etc.

# PROJECT 6

## Seatbelt Reminder

Most people accept as fact that the risk of being seriously injured or killed in a car crash can be significantly reduced by the wearing of seatbelts, and in some countries the use of seatbelts is compulsory. It is very easy to forget to fasten ones seatbelt though, and some form of audio alarm which serves as a reminder is a very useful car accessory.

There is more than one method of triggering an alarm signal in this application, and it would, for example, be possible to fit microswitches or reed switches to the seatbelts, so that upon entering the car the alarm sounded until the seatbelts were fastened. This would be rather awkward to achieve in practice though, and the wiring to the seatbelts could even be dangerous!

An alternative method, and the one employed here, is to have an alarm that sounds when the ignition is switched on, and which can then be cancelled by operating a push button switch. This is effective in practice and requires no wiring to the seatbelts. In fact it is merely necessary to feed the unit from the car battery via the ignition switch.

*The Circuit*

The circuit of the Seatbelt Reminder is given in Fig. 13, and this breaks down into two basic sections; a bistable multivibrator using Tr1 and Tr2, and an audio oscillator utilizing IC1. The bistable circuit controls the audio oscillator, and is arranged so that it always triggers to the state that operates the audio alarm at switch-on (i.e. when the ignition switch is operated). It can be set to the alternative state by operating push button switch PB1, and this switches the audio oscillator off. Thus the required automatic start and manual switch off is achieved. It is no good simply having an audio oscillator fed from the battery by way of the ignition switch and an on/off switch that could be used to cancel the unit, as the cancel switch would probably just be left in the "off" position, rendering the unit inoperative.

The bistable is a conventional bipolar transistor circuit

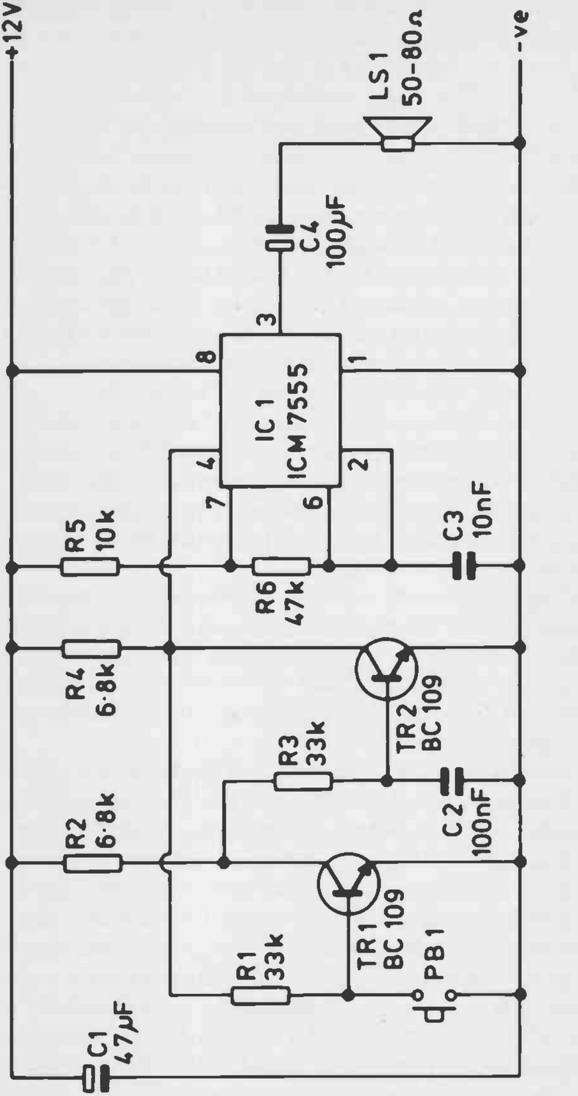



Fig. 13. The circuit diagram of the seatbelt alarm.

except for the inclusion of C2, which ensures that it always assumes the correct state at switch-on. When power is first applied to the circuit both Tr1 and Tr2 will be biased into conduction. Tr1 is biased by R4 and R1, while Tr2 is biased by R2 and R3. C2 has the effect of delaying the build-up in voltage at Tr2's base, and Tr1 therefore conducts more heavily initially. Its collector voltage therefore tends to remain rather low, starving Tr2 of base current via R3. This in turn keeps the voltage at Tr2's collector quite high, so that Tr1 receives a strong base current via R1. This results in Tr1 becoming switched hard on, so that its collector voltage falls to practically zero. Tr2 then receives no base current at all via R3 from Tr1's collector, and is therefore cut off. The output of the bistable (Tr2's collector terminal) is initially in the high state.

The audio oscillator uses an ICM7555 device in the standard astable configuration. Timing components R5, R6, and C3 are chosen to give an operating frequency of roughly 1kHz, and the output from pin 3 of the device is coupled to a high impedance loudspeaker by C4. A low impedance loudspeaker should not be used in the unit.

Normally pin 4 ot IC1 would be connected to the positive supply rail so that the oscillator operated continuously while the supply was present, but in this circuit the oscillator is controlled by a signal fed (from the output of the bistable) to this terminal. Pin 4 is taken high to activate the oscillator, and low in order to mute it.

As mentioned earlier, the output of the bistable is initially in the high state, and the oscillator is therefore activated when the ignition switch is closed, producing the required audio alarm tone. If PB1 is briefly depressed, Tr1's base is short circuited to the negative supply rail so that this device is cut off. Its collector voltage therefore goes to practically the full positive supply potential, biasing Tr2 hard into conduction due to the base current it receives via R3. The collector voltage of Tr2 then falls to practically zero, and the audio oscillator is muted. With Tr2's collector at a low voltage, Tr1 will not be biased into conduction by way of R1 when PB1 is released, and so the circuit latches in this new state.

When the ignition switch is set to the off position power is removed from the circuit, and it is ready to start from the beginning again when the ignition switch is next operated. The circuit will consume power whenever the ignition switch is in the "on" position, but the current consumption of the unit is only about 2mA and is far too low to have any noticeable effect on the battery.

*Construction*

The unit is assembled on a 0.1in matrix stripboard measuring 24 holes by 13 copper strips using the component layout shown in Fig. 14. The component panel is constructed using the normal techniques.

The unit is housed in a small plastic case with PB1 and the loudspeaker mounted on the front panel. A grille is needed for the loudspeaker, and this can simply consist of a neat matrix of small holes drilled in the front panel. Unfortunately it is highly unlikely that the loudspeaker will have provision for fixing screws, and it will almost certainly be necessary to glue it in place. However, it is essential to use a really good quality adhesive (an epoxy type for example) or vibration is likely to dislodge the speaker.

*Components for Seatbelt Reminder (Fig. 13)*

*Resistors,* all 1/3 watt 5%

| | |
|---|---|
| R1 | 33k |
| R2 | 6.8k |
| R3 | 33k |
| R4 | 6.8k |
| R5 | 10k |
| R6 | 47k |

*Capacitors*

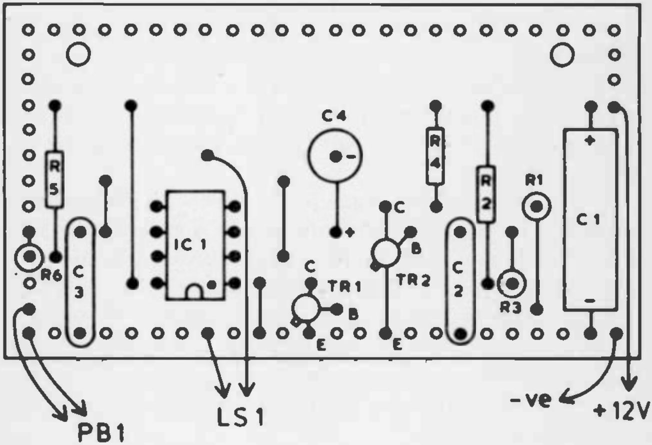
| | |
|---|---|
| C1 | 47µF 25v electrolytic |
| C2 | 100nF polyester (C280) |
| C3 | 10nF polyester (C280) |
| C4 | 100µF 25v |

*Semiconductors*

| | |
|---|---|
| IC1 | ICM7555 |
| Tr1 | BC109 |
| Tr2 | BC109 |

*Switch*

| | |
|---|---|
| PB1 | Push to make, release to break type |



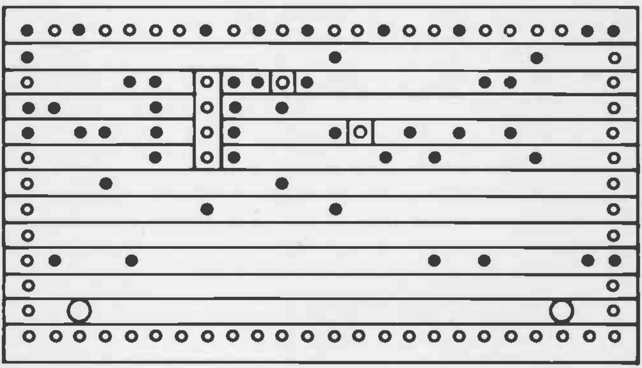



Fig. 14. Constructional details of the seatbelt alarm.

*Loudspeaker*

LS1 Minature speaker having an impedance in the range 50 to 80 ohms

*Miscellaneous*

Plastic case, 0.1in matrix stripboard, Wire, solder, etc.

## PROJECT 7

### Lights Timer

It can sometimes be handy to have the car headlights remain on for a short while after you have left the car, so that your way from the driveway to the front door is well lit and to help you find your keys easily, for example. This can be achieved using a simple timer such as the one described here, which will switch on the headlights for a nominal period of 30 seconds (this can be altered if desired) by operating a push button switch. Thus, before leaving the car the lights and ignition are switched off in the normal way, and then the push button is activated in order to switch on the lights for the nominal 30 second period.

The circuit controls the lights via a relay, and it can therefore be used with positive or negative earth vehicles. It can also be used with 6 volt electrical systems if the specified relay is changed for one having a 6 volt coil.

*The Circuit*

This is another application where a 555 IC is the obvious choice as the basis of the unit, and as can be seen from the circuit diagram of Fig. 15, the unit is indeed based on a 555 IC (or the ICM7555 CMOS 555 to be precise).

IC1 is used in the monostable mode on this occasion, and the length of the positive output pulse at pin 3 is governed by timing components R1 and C2. The output pulse length is 1.1CR seconds, or about 29.7 seconds with the specified values (which is obviously close enough to the required figure of 30 seconds). In practice the actual output pulse may be significantly different to this figure due to the tolerances of the timing components (especially C2) and IC1. This is not of any great importance in this application though, where the precise length of the output pulse is hardly critical. Of course, it may be that a longer output pulse than the nominal 30 second one is required, and this can be achieved by raising the value of R1 accordingly. C2 must be a reasonably high quality component having a high insulation resistance or leakage

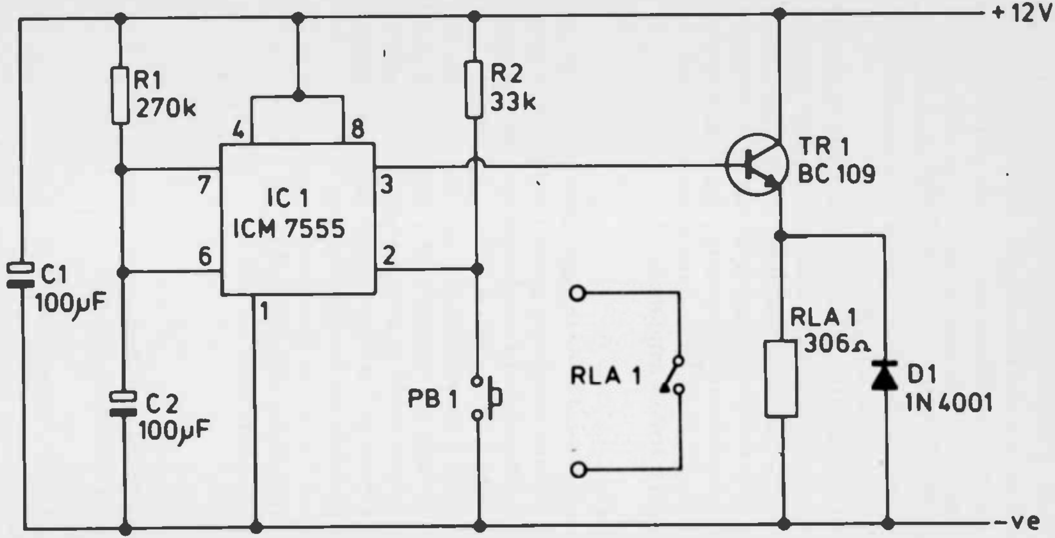



Fig. 15. The circuit diagram of the lights timer.

currents could well greatly extend the output pulse, or even prevent it from ending at all!

R2 is used to take the trigger input of IC1 (pin 2) to the high state under normal conditions, but depressing PB1 takes pin 2 low and triggers IC1. The relay is then operated via emitter follower buffer stage Tr1. D1 is the usual protective diode. A normally open (make) contact of the relay is used to switch on the headlights while the relay is activated.

Of course, the circuit must be fed direct from the battery and not by way of the ignition switch, or it would not be able to function. This does mean that it will be drawing current from the battery all the time, but as the current consumption of the circuit is a mere 100μA or so this is not really going to have an adverse affect on the battery which will have a capacity of a few tens of amp/hours.

*Construction*

The unit is constructed along the same lines as previous projects, and the 0.1in matrix stripboard layout for the unit is shown in Fig. 16. This also shows the small amount of point to point style wiring. The board measures 24 holes by 10 strips, and it is possible to buy 0.1in stripboard in this size, although the board can obviously be trimmed from a larger piece if preferred.

The headlight switch does not normally obtain power via the ignition switch, and so relay contact RLA1 can simply be wired in parallel with the headlight switch.

*Components for Lights Timer (Fig. 15)*

*Resistors*, all 1/3 watt 5%

| | |
|---|---|
| R1 | 270k |
| R2 | 33k |
| *Capacitors* | |
| C1 | 100μF 25v electrolytic |
| C2 | 100μF 25v electrolytic |
| *Semiconductors* | |
| IC1 | ICM7555 |
| Tr1 | BC109 |
| D1 | 1N4001 |
| *Switch* | |
| PB1 | Push to make, release to break type |

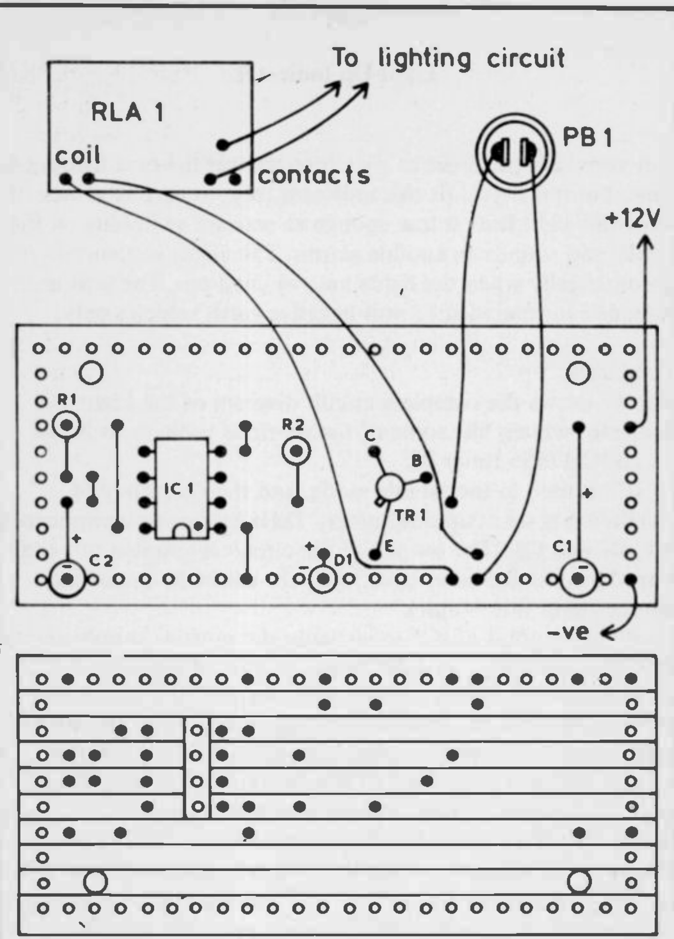



Fig. 16. Constructional details of the lights timer.

*Relay*

RLA1 12 volt coil having resistance of 185 ohms or more, and at least one make contact rated at 5 amp or more at 12V DC

*Miscellaneous*

Plastic case, 0.1in matrix stripboard, Wire, solder, etc.

# PROJECT 8

## Light-Up Indicator

It is very easy to forget to switch on the car lights at lighting up time, but not if you fit this indicator to your car. It senses when the light level is low enough to warrant switching on the lights, and sounds an audible alarm. The alarm is silenced automatically when the lights are switched on. The unit is intended for use with 12 volt negative earth vehicles only.

*The Circuit*

Fig. 17 shows the complete circuit diagram of the Light-Up Indicator which, like some of the previous projects, is based on an ICM7555 timer IC.

IC1 is used in the astable mode, and the frequency of oscillation is set at approximately 1kHz by timing components R1, R2 and C2. The output of the circuit is coupled to a high impedance loudspeaker by C3 (do not use a low impedance speaker with this circuit).

R3 takes pin 4 of IC1 to virtually the positive supply voltage, enabling the circuit to oscillate in the normal way, but the collector of Tr1 is also connected to pin 4 of IC1 and it is possible to mute the oscillator by turning on Tr1. The base terminal of Tr1 is fed from the supply lines via a potential divider which is comprised of R4, PCC1 and R6. PCC1 is a cadmium sulphide photo resistor which has a resistance of only about 100 ohms under bright conditions, but exhibits a resistance of at least 10 megohms when in total darkness.

The base voltage fed to Tr1 (and thus whether this device is switched on or off) obviously depends upon the light level received by PCC1, and also on the resistance setting of R6. If PCC1 receives a high light level it will have a low resistance and Tr1 will be switched on, thus muting the oscillator. If PCC1 is subjected to only a low light level it will have a very high resistance and Tr1 therefore switches off and enables the oscillator to operate and indicate the low light level. In practice R6 is given a setting that results in the oscillator cutting in at a suitable light level.

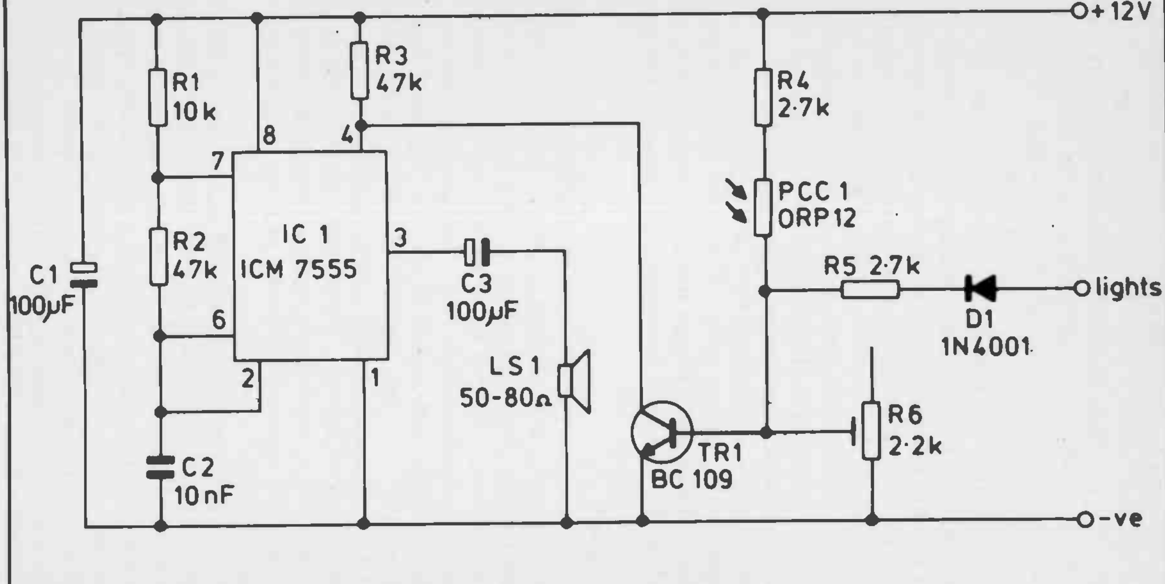



Fig. 17. The circuit diagram of the light-up indicator.

The anode of D1 connects to the junction of the lights switch and the bulbs in the sidelights. With the lights switched off, this point is connected to the (negative) chassis by way of the side light bulbs. This has no effect on the circuit since D1 blocks any current flow to earth from Tr1's base via R6 and the sidelight bulbs.

When the lights are switched on, the anode of D1 is connected to the positive supply via the sidelight switch. This biases Tr1 into conduction due to the bias current that flows through D1 and current limiting resistor R5. This cuts off the oscillator, even if the resistance of PCC1 is insufficient to do so. Thus, if the alarm is sounding, switching on the sidelights cancels it. Switching on the sidelights before the alarm has activated prevents it from sounding unnecessarily.

The 12 volt positive supply line for the unit must be obtained via the ignition switch. This is not just a matter of preventing unnecessary battery drain, but is necessary in order to prevent the alarm from sounding when the car is not in use.

*Construction*

Fig. 18 shows the 0.1in matrix stripboard layout for the unit and this requires a board having 12 copper strips by 25 holes.

Construction of the unit is basically straight forward, but it will be necessary to have PCC1 mounted somewhere where it will receive the ambient light level. This means it must be remotely located from the rest of the unit. The three inputs of the unit ("+", "–" and "lights") and the two connections to PCC1 can be made via a five way terminal block mounted on the exterior of the unit. These blocks are normally only available in twelve way lengths, and so it will be necessary to cut down a five way block from one of these using a sharp modelling knife.

It is not necessary for the photocell to be fitted on the exterior of the car, and satisfactory results should be obtained if it is fitted behind the windscreen or rear window with its sensitive surface (the one opposite the leadout wires) facing towards the screen or window. Of course, it must be mounted in such a way that light is not significantly impeded from reaching the sensitive surface of the cell. It seems to be acceptable to glue the cell in place using a good quality clear adhesive.

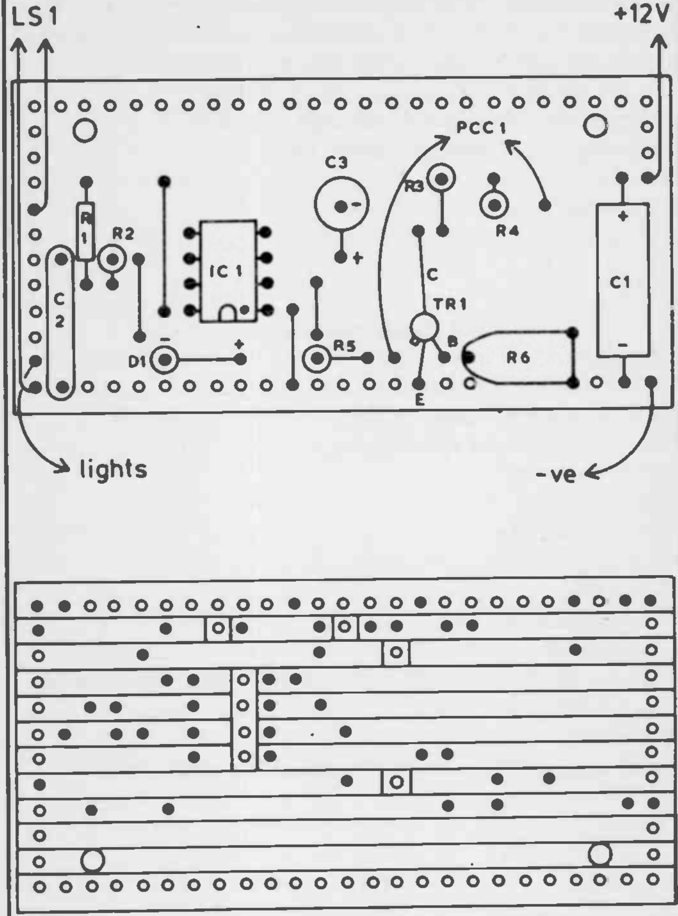



Fig. 18. Constructional details of the light-up indicator.

The easiest way of adjusting R6 correctly is to wait until the ambient light level is at the point where the unit should sound the alarm. Start with R6 set in a fully clockwise direction, and then back it off in an anticlockwise direction just far enough to cause the oscillator to be activated.

*Components for Light-Up Indicator (Fig. 17)*

*Resistors*, all 1/3 watt 5% except R6

| | |
|---|---|
| R1 | 10k |
| R2 | 47k |
| R3 | 47k |
| R4 | 2.7k |
| R5 | 2.7k |
| R6 | 2.2k 0.1 watt horizontal preset |

*Capacitors*

| | |
|---|---|
| C1 | 100μF 25v electrolytic |
| C2 | 10nF polyester (C280) |
| C3 | 100μF 25v electrolytic |

*Semiconductors*

| | |
|---|---|
| IC1 | ICM7555 |
| Tr1 | BC109 |
| D1 | 1N4001 |

*Photocell*

| | |
|---|---|
| PCC1 | ORP12 |

*Loudspeaker*

| | |
|---|---|
| LS1 | Minature speaker having an impedance in the range 50 to 80 ohms |

*Miscellaneous*

Plastic case, 0.1in matrix stripboard, Wire, solder, etc.

## PROJECT 9

### Flasher Warning Unit

Although most vehicles now have automatic turn indicator cancelling and the flasher unit produces a "clicking" sound inside the car when it is operating, it is by no means uncommon for people to drive along with a turn indicator inadvertently left in the "on" position. This is due to the fact that the degree of movement of the steering wheel is not always enough to operate the automatic cancelling facility, and the "clicking" sound produced inside the car by the flasher unit is usually not very loud and can easily be missed.

This problem can be eliminated by adding an audible alarm which produces a tone when one of the turn indicator lamps is switched on. Unlike the "clicking" sounds of the flasher unit, this tone is made reasonably loud and is a more noticeable signal anyway. The possibility of accidentally leaving a turn indicator switched on is thus eliminated.

*The Circuit*

Fig. 19 shows the circuit diagram of the unit, and the circuit is just an audio oscillator having its output fed to a high impedance loudspeaker.

The circuit, like some of those described earlier in this book, uses an ICM7555 device used in the astable mode and operating at a frequency of a few hundred Hertz. C3 couples the output to the loudspeaker, and the volume provided is quite sufficient to ensure that the signal is not overlooked while not being so high as to be an annoyance in use. C1 is a supply decoupling capacitor.

*Construction*

A 0.1in matrix stripboard having 24 holes by 10 copper strips is used to accommodate the components with the only exception of the loudspeaker which is glued to the front panel of the case behind a suitable speaker grille. It is possible to buy a board of the specified size, but it can of couse be cut down from a larger piece if preferred, or a suitable off-cut may

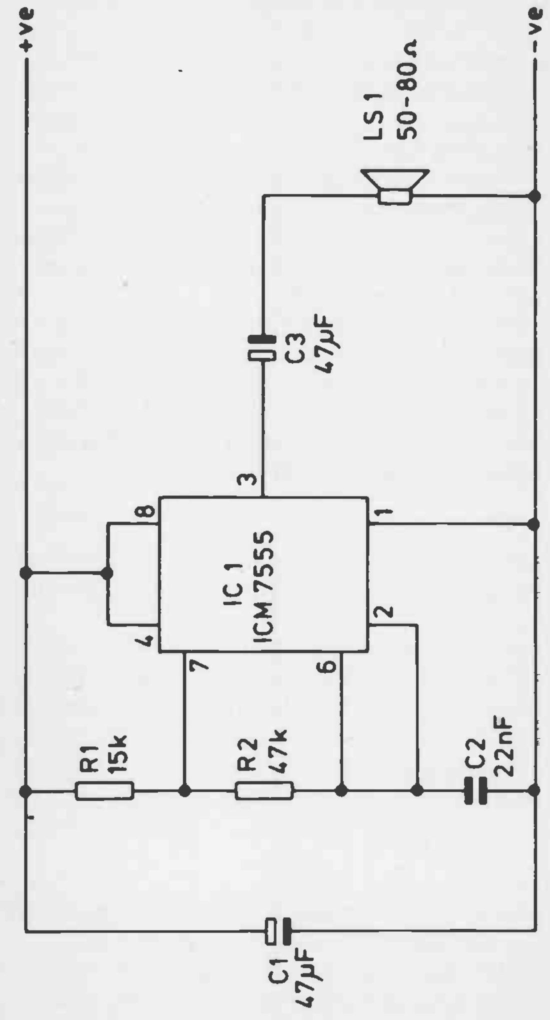



Fig. 19. The circuit diagram of the flasher warning unit.

well be to hand. Details of the component panel are given in Fig. 20, and construction of the unit is extremely simple and straight forward.

The unit can be used with negative or positive earth vehicles, and will work with 6 or 12 volt supplies (although the volume

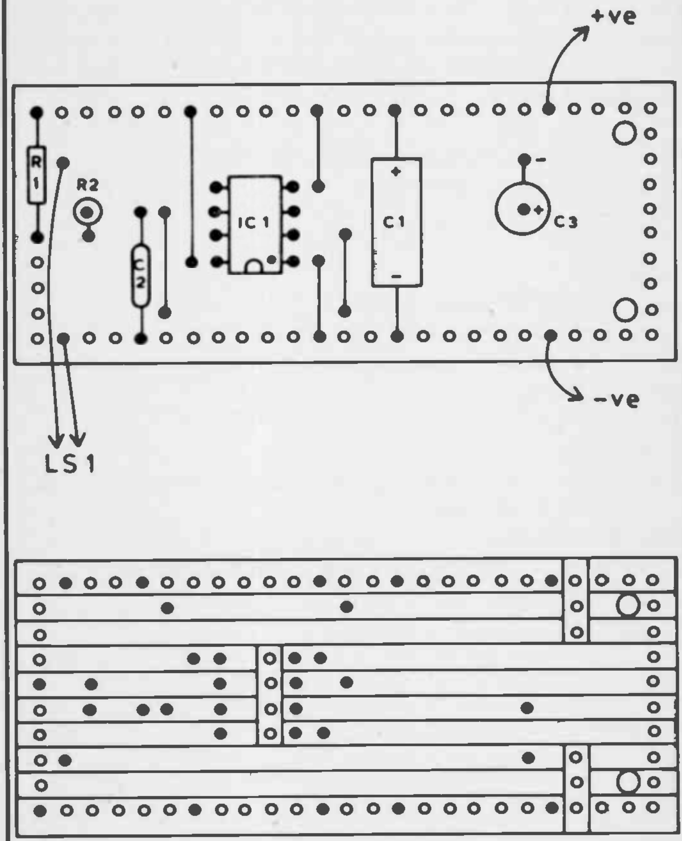



Fig. 20. Constructional details of the flasher warning unit.

will be substantially lower if the unit is employed with a 6 volt system). The appropriate supply rail of the circuit is earthed to the chassis of the car at any convenient point, while the other supply lead must connect to a point which is supplied with power in unison with the turn indicators. Some cars have just one turn indicator lamp on the dashboard, and in this case the non-earthy supply lead simply connects to the appropriate side of this bulb. It is quite common to have two indicator lamps on the dashboard though, and it will then be necessary to experiment to find a terminal on the flasher unit that gives the desired effect.

*Components for Flasher Warning Unit (Fig. 19)*

*Resistors*, both 1/3 watt 5%

| | |
|---|---|
| R1 | 15k |
| R2 | 47k |

*Capacitors*

| | |
|---|---|
| C1 | 47μF 25v electrolytic |
| C2 | 22nF polyester (C280) |
| C3 | 47μF 25v electrolytic |

*Semiconductor*

| | |
|---|---|
| IC1 | ICM7555 |

*Loudspeaker*

| | |
|---|---|
| LS1 | Minature speaker having an impedance in the range 50 to 80 ohms |

*Miscellaneous*

Plastic case, 0.1in matrix stripboard, Wire, solder, etc.

# PROJECT 10

## Audio Power Booster

Despite the fact that there is a fair amount of noise inside most cars when they are under-way, many car radios and tape players have rather modest maximum output powers. One reason for this is probably the fact that it is not possible to obtain a great deal of power using a 12 volt supply and a modern transformerless output stage into a 4 or 8 ohm loudspeaker. The maximum possible output swing is nominally 12 volts peak to peak. No output stage gives an output voltage swing equal to the supply voltage as there are inevitably voltage drops through the output transistors. On the other hand these are counteracted to some extent by the fact that a car battery usually has an actual voltage which is somewhat more than its nominal level. In terms of RMS voltage this limits the maximum output to only about 4.25 volts, which gives only about 2.25 watts RMS into an 8 ohm speaker, or 4.5 watts RMS into a 4 ohm type.

There are ways of obtaining increased output, and the method used in this add-on power booster is to use a bridge amplifier circuit. The booster is simply connected between the car radio or tape player and the loudspeaker and it gives an output power of about 9 watts RMS into an 8 ohm load or 18 watts RMS into a 4 ohm type.

A bridge amplifier really consists of two power amplifiers with the loudspeaker being driven from the two outputs; neither speaker lead being connected to earth. The two amplifiers are arranged so that under quiescent conditions their outputs are at the usual level of about half the supply voltage, and there is no significant voltage present across the loudspeaker. The amplifiers are arranged to have output signals that are in anti-phase, so that a positive change in the ouput potential of one is matched by a similar but negative change in the output voltage of the other. Thus when one amplifier has its output fully positive, the output of the other one is fully negative. This gives about 12 volts across the loudspeaker. On signal peaks of the opposite polarity the two output states are reversed so that 12 volts is again developed across the loudspeaker, but the polarity of the output signal has changed. Thus the amplifier can give up to ± 12 volts across the loudspeaker, or a peak to peak voltage swing of 24 volts in other words. This is double that obtained with a normal amplifier, and gives a maximum output current that is also doubled. Thus the output power for a given speaker impedance is boosted by a factor of four when compared to an ordinary amplifier.

*The Circuit*

The unit is based on two TDA2006 audio IC power amplifiers, as can be seen from the circuit diagram of Fig. 21.

IC1 is used as what is virtually a straight forward non-inverting amplifier, with the non-inverting input of the device being biased to half the supply voltage by R2 and R3. R5 provides 100% negative feedback from the output to the inverting input of IC1 at DC so that the circuit has unity voltage gain and the output is biased to the required level of half the supply voltage. C2 and R4 remove some of the feedback at audio frequencies and this gives a voltage gain of about 18 times at these frequencies. This is far more than is actually needed, and a voltage gain of little more than unity is in fact sufficient. It is necessary to remove a substantial amount of feedback though as instability is otherwise likely to occur. R1 is used at the input of the amplifier to reduce the sensitivity to a more suitable level, and C1 simply provides DC blocking at the input.

IC2 is used in virtually the same configuration, but its non-inverting input is not fed with an audio signal, and only receives the DC bias signal from R9 and R10. R2, R3, R9 and R10 are all close tolerance components so as to ensure a reasonably small voltage difference across the outputs of the two amplifier stages under quiescent conditions, and consequently a small and insignificant quiescent current through the loudspeaker.

R11 couples the output signal of IC1 to the inverting input of IC2, and the value of R11 is chosen to give IC2 an effective voltage gain of unity. However, as the input signal is coupled to IC2's inverting input there is a phase inversion through this section of the amplifier, giving the required anti-phase

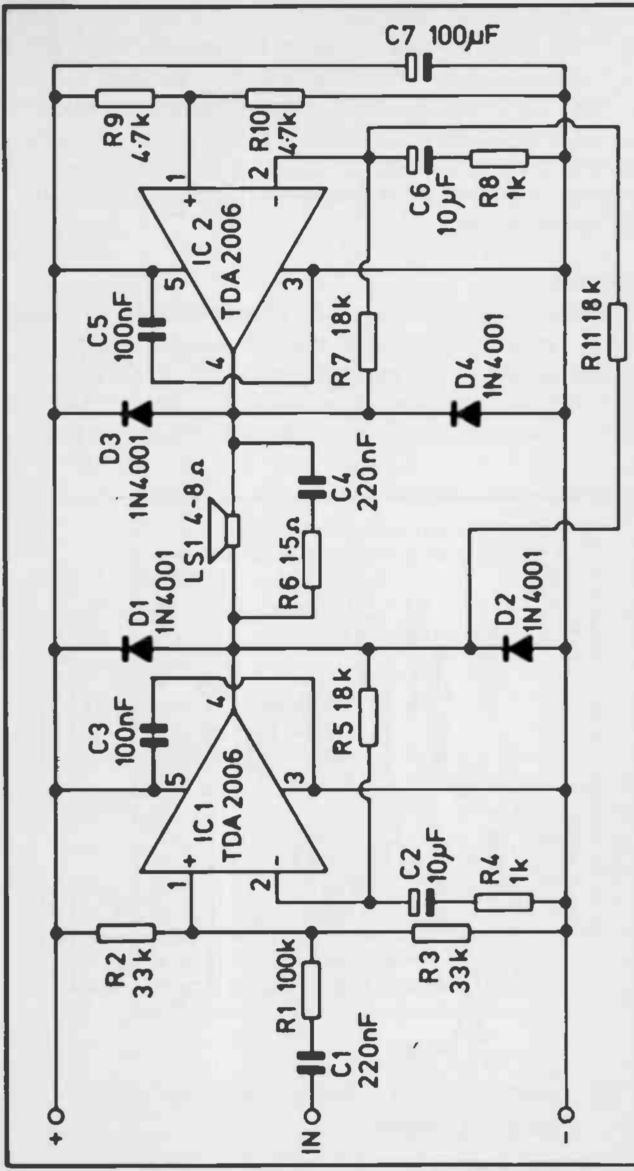



Fig.21. The circuit diagram of the audio power booster

relationship at the two outputs.

D1 to D4 are protection diodes for the two ICs, while R6 plus C4 form a Zobel network which helps to prevent instability. C3, C5 and C7 are all supply decoupling capacitors. It was not found to be necessary to include filters in the two bias networks in order to prevent noise on the supply lines from being coupled to the non-inverting inputs of the two ICs via the biasing circuits.

*Construction*

A 0.1in matrix stripboard having 18 copper strips by 17 holes is used to accommodate most of the components, and the component layout of this board is given in Fig. 22. There are no breaks in any of the copper strips incidentally. The two ICs are modern types which physically resemble plastic power

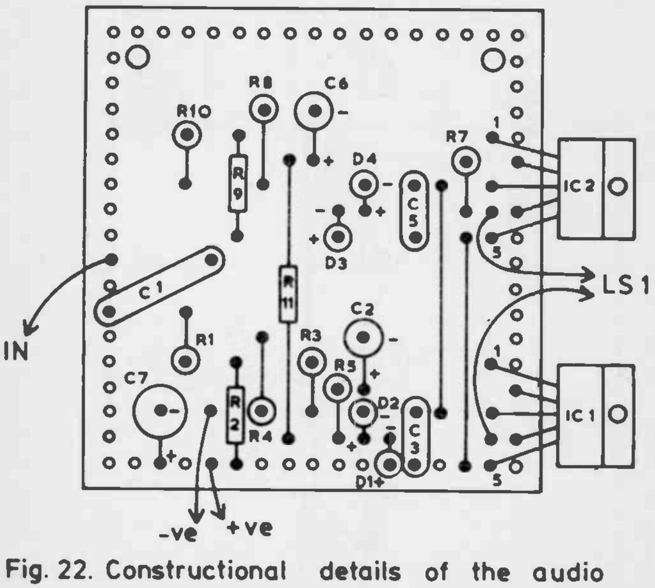



Fig. 22. Constructional details of the audio power booster.

transistors, but they have five rather than three leadouts. These must be carefully bent outwards slightly in order to fit these devices into this layout. Ensure that you do not omit the two link wires, and it is probably best to solder these in place before adding the components. Be very careful to connect the polarised components with the correct polarity, especially the four rectifiers as these could be damaged if connected incorrectly.

The two ICs should be bolted to a substantial heatsink. If the unit is used in a negative earth vehicle it can be fitted into a metal case which can be used as the heatsink, but it will probably be necessary to use an aluminium bracket to provide a thermal path from the ICs to the case. A suitable bracket can easily be produced from 18 swg aluminium.

In positive earth vehicles this is not really advisable since the heat-tabs of the ICs connect internally to their negative supply leadouts. This would result in the case connecting to the negative supply, and the likelyhood of a short circuit between the case of the booster and the positive chassis of the car. Of course, insulation sets can be used to insulate the heat-tabs from the case, but this must be done well and reliably so that the vibration to which the unit will inevitably be subjected does not cause the insulation to be breached. Alternatively the unit could be housed in a plastic case, and a heatsink for the two ICs could be fitted inside the case. If the heatsink is bolted in place it is advisable to insulate the two ICs from the heatsink. The exposed heads of the mounting bolts on the exterior of the case will then be electrically isolated from the vehicle's electrical system, and there will be no danger of them short circuiting to the chassis.

R6 and C4 are not mounted on the component panel, but are wired across the output socket or terminals of the unit.

When installing the booster remember that neither output lead should be allowed to come into contact with the chassis of the vehicle. The TDA2006 incorporates output short circuit protection circuitry and thermal overload shutdown circuitry, and accidental contacts between the output leads and the chassis (or each other) should not damage the unit.

Ideally the supply for the unit should be taken from the supply rails of the radio or tape player with which the booster is employed, as it will then be switched on and off in sympathy with the main item of equipment. However, the unit can of course have its own on/off switch added into whichever supply lead is not earthed. The input for the booster is taken from whichever output lead of the radio or tape player is not earthed, and the correct lead can be found simply by connecting the two leads, in turn, to the input of the unit to see which one provides the desired result.

If the unit is used with a radio or tape player that has only a very limited output power it may be necessary to reduce R1 in value somewhat in order to fully drive the booster.

*Components for Audio Power Booster (Fig. 21)*

*Resistors,* 1/3 watt 5% except where noted otherwise

| | |
|---|---|
| R1 | 100k |
| R2 | 33k 2% |
| R3 | 33k 2% |
| R4 | 1k |
| R5 | 18k |
| R6 | 1.5 ohms |
| R7 | 18k |
| R8 | 1k |
| R9 | 4.7k 2% |
| R10 | 4.7k 2% |
| R11 | 18k |

*Capacitors*

| | |
|---|---|
| C1 | 220nF mylar or C280 |
| C2 | 10µF 25v electrolytic |
| C3 | 100nF polyester (C280) |
| C4 | 220nF polyester |
| C5 | 100nF polyester (C280) |
| C6 | 10µF 25v electrolytic |
| C7 | 100µF 25v electrolytic |

*Semiconductors*

| | |
|---|---|
| IC1 | TDA2006 |
| IC2 | TDA2006 |
| D1 to D4 | 1N4001 (4 off) |

*Miscellaneous*

Case, 0.1in matrix stripboard, Heatsink, Sockets, wire, solder, etc.

## PROJECT 11

### Vehicle Immobiliser

The number of car thefts these days is quite alarming, and it is advisable to fit security devices to vehicles to deter would-be thieves. There are quite a number of burglar alarms and deterents that can be used, many of which are electrical or electronic devices that can be constructed by the home-constructor.

A simple and popular type of burglar deterent is a vehicle immobiliser of some kind. In its most simple form this can merely consist of a switch or switches connected across the points, or in series with the ignition switch. These switches are placed at points in the car where they are well concealed and are not easily found by anyone trying to steal the vehicle. When the car is left unattended and switches across the points are set to the closed position so that the points are short circuited and the car will not start. Similarly, any switches in series with the ignition switch are left in the open position so that power is not available for the ignition system when the ignition switch is closed, and the car cannot be started.

Unfortunately, this system does not always work since car thieves are very expert at finding the switches and setting them appropriately to enable the vehicle to be started. An alternative type of immobiliser, and one that is likely to be more effective in practice, is one which enables the car to be started, but halts the engine soon afterwards. This leads the thief to believe that no immobiliser is fitted to the car, and that the problem is a fault in the vehicle. The thief therefore gives up and searches for a better vehicle!

*The Circuit*

Fig. 23 shows the circuit diagram of a simple vehicle immobiliser of this type. S1 is closed in order to bring the immobiliser into action, but the supply for the unit is obtained via the ignition switch and the unit is not supplied with power until this switch is closed.

When power is initially received by the circuit C1 will be in

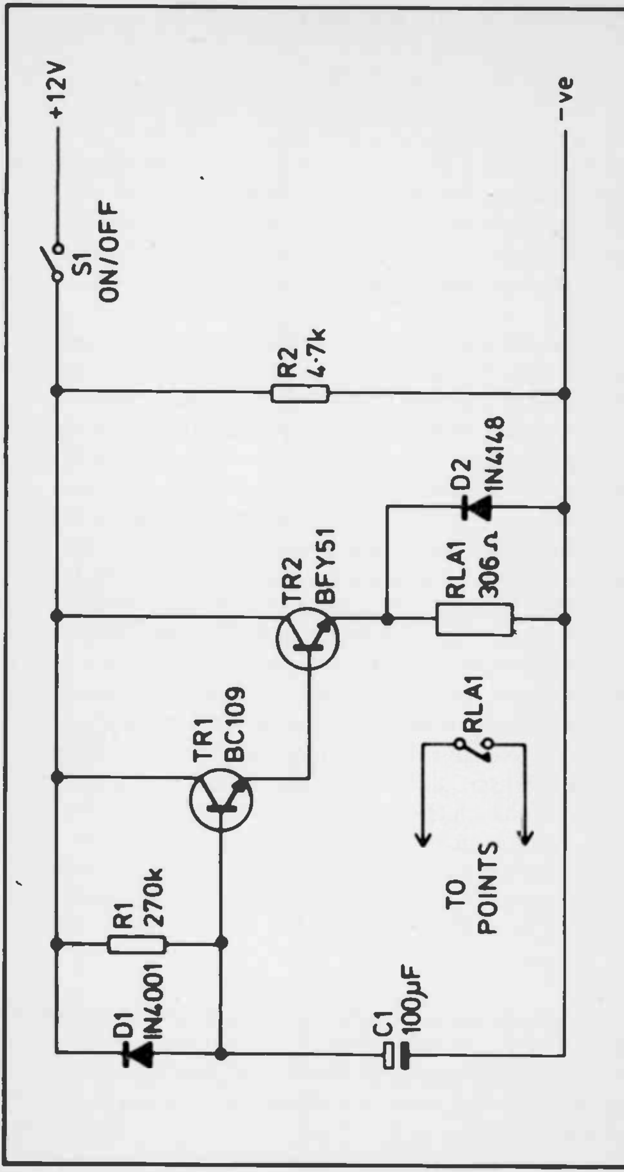



Fig 23. The circuit diagram of the vehicle immobiliser.

an uncharged state, and the emitter follower Darlington pair formed by Tr1 and Tr2 will therefore be cut off, and no power will be fed to the relay coil which forms their emitter load. The normally open relay contacts are connected across the points, and at this stage the relay contacts will obviously be open circuit and will not have any effect on the ignition system.

C1 charges by way of R1, and the input voltage to the Darlington pair therefore rises steadily, causing a similar rise in potential at the emitter of Tr2. A Darlington pair is used in order to give a very high input impedance to the buffer stage so that the voltage across C1 is free to rise to almost the full positive supply potential, and loading effects do not limit the charge potential to just a few volts. Thus the voltage across the relay eventually becomes sufficient to switch on this component. The relay contacts then close and short circuit the points, preventing the ignition system from operating properly and stopping the engine.

If the ignition is switched off, power is removed from the circuit and D1, which was previously reverse biased, now becomes forward biased by the charge on C1 and discharges the latter quite rapidly through R2 (and any other DC path across the supply lines). The circuit is then ready to operate once again when the ignition is switched on again; enabling the engine to run, but not for long.

The values of R1 and C1 give a delay of about 25 to 30 seconds before the relay is activated, although component tolerances might produce quite large errors in the actual delay time obtained. If necessary, R1 can be raised in value to give a longer delay, or reduced in value to give a shorter one, although the precise length of the delay is obviously not too critical. C1 must be a reasonably good quality device having a low leakage current or the timing period will be greatly lengthened, and the relay could even fail to operate at all in an extreme case.

*Construction*

The 0.1in matrix stripboard layout for the unit is given in Fig. 24, and this requires a board having 14 copper strips by 11 holes. There are no breaks in the copper strips.

The unit is very simple and straight forward, and there

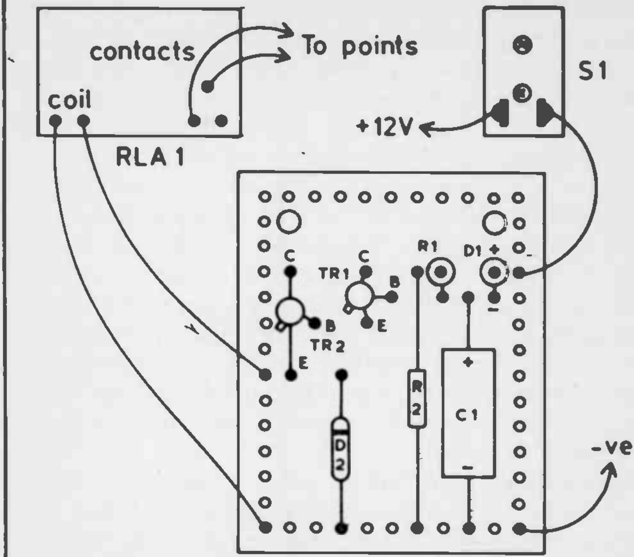



Fig. 24. Constructional details of the vechicle immobiliser.

should be no difficulties with the construction of this project. The relay can be glued to the case using a powerful adhesive such as an epoxy type. As with any car project it is advisable to use multistrand wire rather than single core wire when wiring it to the car's electrical system, since single core wire is likely to break when subjected to vibration. It is also advisable to fit grommets into any holes that are made in metalwork to permit wires to pass from one part of the vehicle to another, as it is otherwise likely that the metal will eventually cut through the insulation of the wire and a short circuit could easily result.

The circuit is shown as a negative earth one, but the unit can be installed in positive earth vehicles if the on/off switch is inserted in the negative supply rail rather than the positive one.

*Components for Vehicle Immobiliser (Fig. 23)*

*Resistors*, both 1/3 watt 5%

| | |
|---|---|
| R1 | 270k |
| R2 | 4.7k |
| *Capacitor* | |
| C1 | 100μF 25v electrolytic |
| *Semiconductors* | |
| Tr1 | BC109 |
| Tr2 | BFY51 |
| D1 | 1N4001 |
| D2 | 1N4148 |
| *Switch* | |
| S1 | SPST toggle type |
| *Relay* | |
| RLA1 | Omron 306 ohm 12 volt coil, heavy duty changeover contact or similar (available from Maplin Electronic Supplies). |

*Miscellaneous*

Plastic case, 0.1in matrix stripboard, Wire, solder, etc.

# PROJECT 12

## Car Burglar Alarm

Many car burglar alarms necessitate the fitting of an on/off switch on the exterior of the car so that the alarm can be switched on after the occupants have left the vehicle and closed the doors, and can be switched off before opening a door and entering the vehicle. This avoids having to activate the alarm (which is triggered by door switches) when entering and leaving the car, but reduces security in that even if the switch is a key type and is well hidden, it will still be vulnerable and quite possibly ineffective against an experienced car thief.

A better method is to have exit and entry delays built into the system so that the on/off switch can be fitted inside the car. The exit delay simply provides a short delay between the circuit being switched on and it actually coming into operation, so that the occupants of the car can get out of the car without triggering the alarm. The entry delay does not prevent the alarm from being triggered, but does prevent the alarm from being sounded until a short while after triggering has occured. This gives you time to enter the car and switch off the alarm before the alarm is sounded.

This system is obviously not perfect in that it is possible for a thief to enter the vehicle and switch off the alarm before it sounds, but this is unlikely to happen in practice. For one thing the thief will probably be unaware that an alarm is fitted, and will not even try to switch off the alarm. Also the alarm is installed in such a way that it would not be easy for a prospective thief to switch off the unit. For example, the on/off switch should be positioned where it is well concealed and where it would not be easy for anyone to tamper with the wiring which connects to it. It is also advisable to use a key switch.

This alarm circuit is easy to install as it is activated by the existing door switches which operate the courtesy light. It has both exit and entry delays, and additionally it has a timer circuit which automatically silences the alarm after about 3 to

4 minutes of operation so that the unit causes a minimum of annoyance if it should be triggered, and does not drain the car battery unnecessarily.

*The Circuit*

Fig. 25 is the circuit diagram of the unit, and it should be noted that this alarm is only intended for use with 12 volt negative earth electrical systems. The courtesy lamp and door switch (which in practice would be two or more switches in parallel) are of course part of the car's electrical system, and not part of the alarm circuitry proper.

The circuit is based on IC1 which is a 555 timer device used in the monostable mode. The specified values of R2 and C1 give a positive output pulse of around 200 seconds in duration at pin 3 of IC1 when the trigger input at pin 2 is taken low. Due to component tolerances the actual output pulse length may be significantly different to the calculated length, and is likely to be somewhat longer. However, this is not of great importance since the length of this output pulse merely determines the length of time that passes before the alarm is automatically silenced. D1 and R1 are included in series with the input to pin 2 of IC1 to prevent an excessive input current from flowing when the unit is switched off (bearing in mind that the input would still connect to the positive supply rail through the courtesy lamp). These components do not prevent IC1 from being triggered when one of the door switches closes though.

Tr3 and its associated components give the exit delay. When the unit is initially switched on C3 will be uncharged, and therefore charges by way of R5 plus R6 and the base-emitter junction of Tr3. The current that flows in the base circuit of Tr3 switches this device hard into the on state, taking pin 4 of IC1 low and blocking the operation of IC1. After about 20 seconds the charge current for C3 is insufficient to hold Tr3 in the on state, and R4 takes pin 4 of IC1 high so that the monostable is then able to function properly and will trigger if one of the door switches should close.

When the car is entered this does of course happen, and C2 starts to charge via R3 from the high output of IC1. The voltage across C2 is coupled to the relay coil by way of a

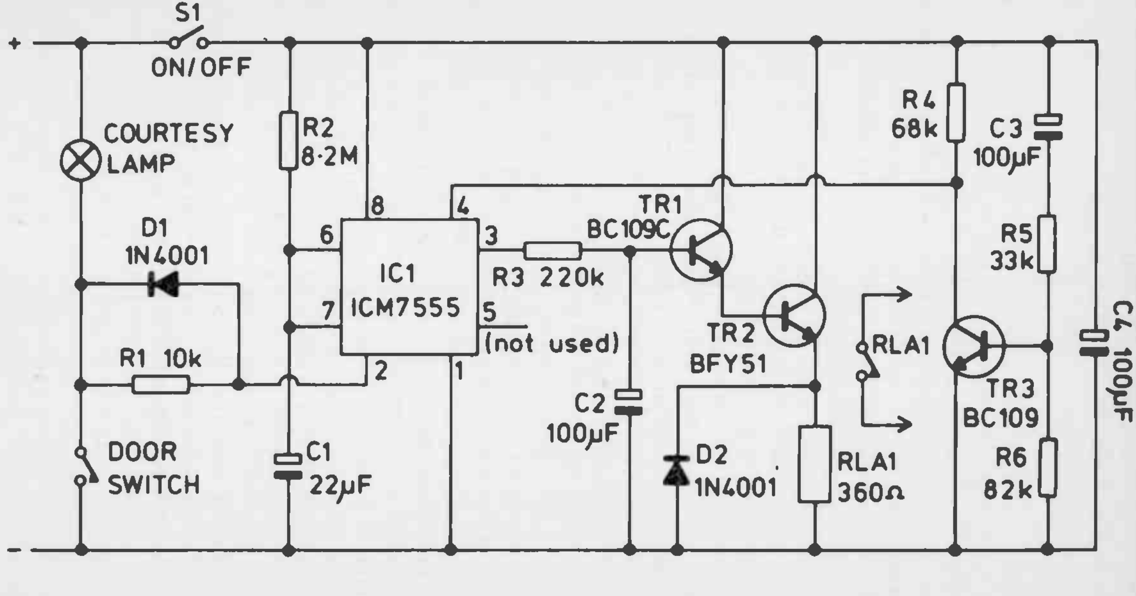



Fig 25. The circuit diagram of the car burglar alarm.

buffer amplifier which utilizes Darlington pair emitter follower Tr1 – Tr2. The voltage across C2 and the relay steadily rises and after roughly 30 seconds becomes sufficient to switch on the relay. A pair of normally open relay contacts are used to switch on the alarm generator, and the latter can simply be the car horn. Of course, provided S1 is switched off before the relay is activated the alarm will fail to sound.

*Construction*

The 0.1in matrix stripboard for the burglar alarm is illustrated in Fig. 26, which also shows the small amount of point to point style wiring. As in the previous projects which incorporate a relay, this component is not fitted on the component panel but is glued to the case as firmly as possible.

The unit should be fitted in a tough plastic case having a screw fixing lid rather than a clip-on type. It is advisable to fit the unit where it is not easily found, and preferably so that it is not easy to tamper with the three leads that connect the unit to the car's electrical system. It is necessary to use ones initiative here.

*Components for Car Burglar Alarm (Fig. 25)*

*Resistors,* all 1/3 watt 5% (10% over 1M)

| | |
|---|---|
| R1 | 10k |
| R2 | 8.2M |
| R3 | 220k |
| R4 | 68k |
| R5 | 33k |
| R6 | 82k |

*Capacitors*

| | |
|---|---|
| C1 | 22μF 25v electrolytic |
| C2 | 100μF 25v electrolytic |
| C3 | 100μF 25v electrolytic |
| C4 | 100μF 25v electrolytic |

*Semiconductors*

| | |
|---|---|
| IC1 | ICM7555 |
| Tr1 | BC109C |
| Tr2 | BFY51 |
| Tr3 | BC109 |
| D1 | 1N4001 |

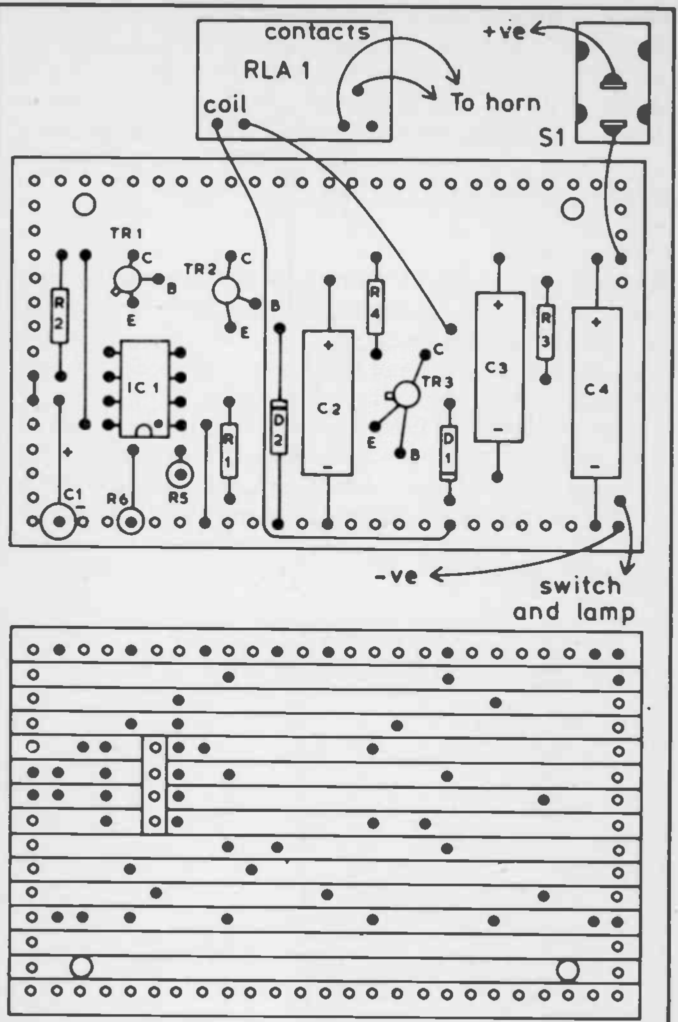



Fig. 26. Constructional details of the car burglar alarm.

D2 1N4001

*Switch*

S1 SPST toggle or key type

*Relay*

RLA1 306 ohm 12 volt coil, heavy duty changeover contacts (Omron, available from Maplin Electronic Supplies).

*Miscellaneous*

Case, 0.1in matrix stripboard, Wire, solder, etc.

# PROJECT 13

## Gas and Smoke Alarm

Bottled gas is used extensively in boats, mainly to power cookers, and occasionally other items of equipment such as refridgerators as well. This type of fuel is not without dangers, and even a small gas leak can eventually lead to a dangerous concentration of gas building up. Correct ventilation of the appropriate compartments of the boat help to minimise the danger, as does regular checking of the gas installation. A gas alarm such as the one described here is also beneficial and a very worthwhile addition to a craft which has a bottled gas installation, as it should give warning of a leak before the gas reaches an explosive concentration.

The unit utilizes a sensor which will respond to virtually any inflammable gas, including methane, propane, carbon monoxide, most smoke and methylated spirit vapour. The unit runs from a 12 volt supply and has a current consumption of about 140mA. It emits an audio tone when gas or smoke are detected.

*The Circuit*

Fig. 27 shows the circuit diagram of the unit, and it is basically just a two transistor audio oscillator which drives a loudspeaker. However, the biasing of the oscillator is controlled by a potential divider circuit which incorporates the gas sensor, and this blocks the oscillator until a concentration of an appropriate gas or vapour is detected.

The oscillator uses two common emitter amplifiers, one of which is based on Tr2. This has the loudspeaker as its collector load and is biased by R6. The other stage is centred on Tr1 and has R4 as its collector load. It is biased by R2, but only if the gas sensor circuitry detects gas or vapour. Under normal conditions Tr1 is cut off and the oscillator is blocked. C3 couples the output of Tr1 to the input of Tr2, and positive feedback is obtained via C4 and R5. C2 and C5 are needed to prevent high frequency instability which would make the oscillator unreliable.

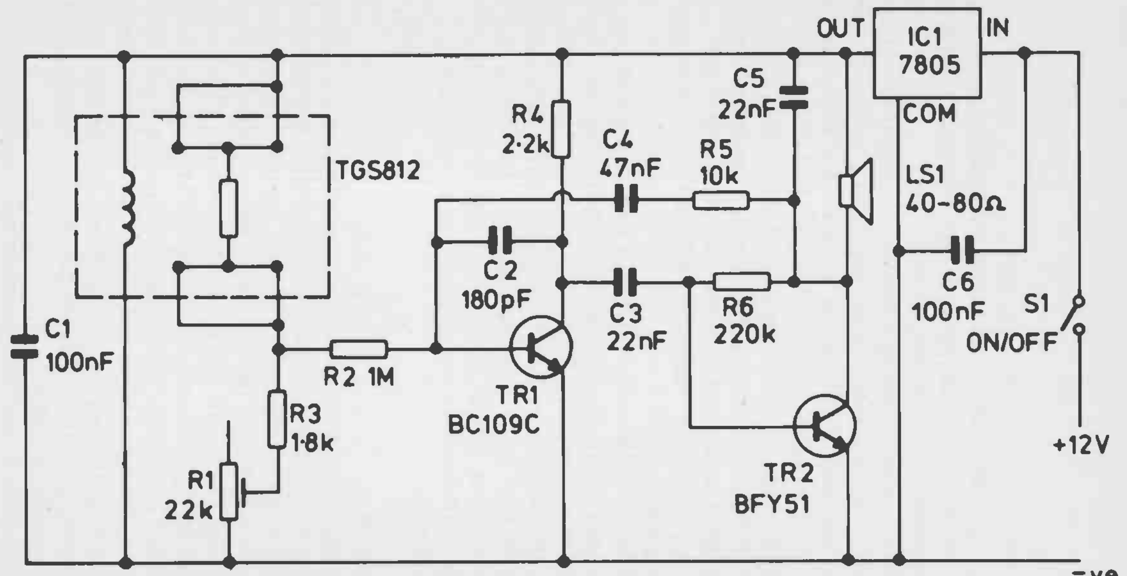


Fig 27. The circuit diagram of the gas and smoke alarm.

The gas sensor consists of two main sections, a heating element and a semi-conductor sensing element. The heating element oxidizes the semi-conductor material and the sensing element thus has a high resistance under normal operating conditions. If an inflammable gas or vapour comes into contact with the semi-conductor material it has a reducing (deoxidizing) effect, and causes a very substantial decrease in the resistance of the sensing element.

R1, R3 and the sensing element are connected in a potential divider circuit across the supply lines. R1 is adjusted so that under quiescent conditions the voltage fed to R2 is not quite sufficient to bring Tr1 into conduction, and the required blocking of the oscillator is produced. Of course, when the sensor is subjected to a suitable type and concentration of gas or vapour its resistance falls, and the voltage fed to R2 increases to the point where Tr1 is biased into conduction and the alarm is sounded.

The heating element requires a 5 volt supply, and this is produced from the 12 volt battery supply using a monolithic voltage regulator (IC1). C1 and C6 are supply decoupling capacitors which are needed to prevent IC1 from becoming unstable, but these are the only discrete components that this device requires. The stabilised 5 volt supply is also used to supply the other circuitry, and helps to ensure reliable operation.

*Construction*

The front panel of the case should be drilled with a matrix of small holes to act as a speaker grille, and then the loudspeaker is glued in place behind this. The gas sensor can be mounted on the front panel of the unit in the special holder, or it can be remotely located if this is more convenient. If this is done it is not necessary to use a screened lead to connect the sensor to the rest of the unit, and ordinary twin cable is satisfactory. However, it is advisable to add a capacitor of about 220nF in value from the junction of the sensor, R2 and R3 to the negative supply rail to decouple any electrical noise picked up in the connecting cable.

Apart from S1 and the gas sensor the components are all fitted onto a 0.1in matrix stripboard which has 20 holes by 13 copper strips, and the component layout and other details of this board are provided in Fig. 28. This diagram also shows the very limited amount of point-to-point fashion wiring. At the supply currents encountered in this design IC1 does not generate sufficient heat to warrant a heatsink.

If R1 is adjusted for maximum resistance (set in a fully clockwise direction) and the unit is switched on, the alarm tone should be emitted from the loudspeaker. If the tone is not obtained you should switch off immediately and thoroughly recheck all the wiring. Assuming the tone is obtained, leave the unit for a minute or two while the gas sensor stabilises, and then back off R1 just far enough to cause the tone to be muted. Do not back R1 off too far or the unit will have reduced sensitivity, but do not be tempted to take the setting of R1 right to the verge of oscillation or the unit may become unreliable and apt to produce false alarms. Just back it off very slightly from the setting which causes the unit to break into oscillation.

*Components for Gas and Smoke Alarm (Fig. 27)*

*Resistors,* all 1/3 watt 5% except R1

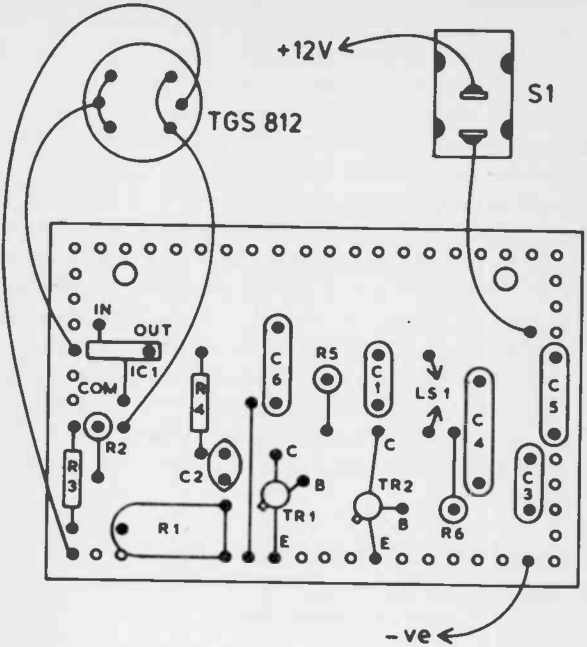
| | |
|---|---|
| R1 | 22k 0.1 watt horizontal preset |
| R2 | 1M |
| R3 | 1.8k |
| R4 | 2.2k |
| R5 | 10k |
| R6 | 220k |

*Capacitors*

| | |
|---|---|
| C1 | 100nF polyester (C280) |
| C2 | 180pF ceramic plate |
| C3 | 22nF polyester (C280) |
| C4 | 47nF polyester (C280) |
| C5 | 22nF polyester (C280) |
| C6 | 100nF polyester (C280) |

*Semiconductors*

| | |
|---|---|
| IC1 | 7805 (5 volt 1A voltage regulator) |
| Tr1 | BC109C |
| Tr2 | BFY51 |
| Gas sensor | TGS812 (Watford Electronics) |



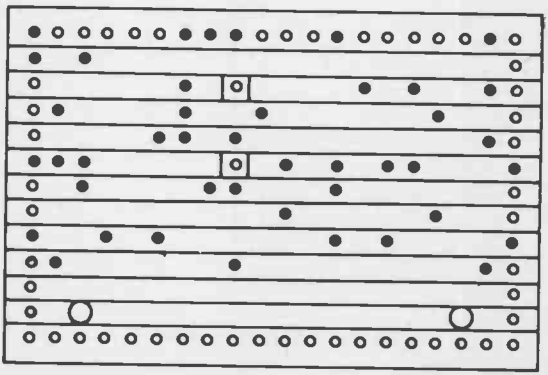



Fig. 28. Constructional details of the gas and smoke alarm.

*Switch*

S1 SPST toggle type

*Loudspeaker*

LS1 Minature type having an impedance in the range 40 to 80 ohms

*Miscellaneous*

Plastic case, 0.1in matrix stripboard, Holder for gas sensor (Watford Electronics), Wire, solder, etc.

# PROJECT 14

## Depth Alarm

Many small craft are equipped with a depth sounder these days, and instruments of this type are certainly a very useful navigational aid and help to reduce the risk of running aground. A useful feature of some depth sounders is an alarm which is sounded automatically if a reading provided by the unit drops below some predetermined level. This avoids having to keep a constant watch on the instrument to check that the depth of water does not drop below some critical level.

Of course, many echo sounders do not have this facility built-in, but it is possible to fit an add-on depth alarm to some units. These are the type that have a depth scale with a moving light which indicates the appropriate depth reading. The depth alarm is a sort of light activated switch which has the light sensor placed on the dial at the depth where it is desired that when it senses the light from the scale indicator it triggers an audible alarm which continues to sound until the unit is reset by pushing the reset button. Thus the addition of the depth alarm does not necessitate any modifications to the depth sounder, but the latter must obviously be one of the correct type, and could not be a digital type for example.

*The Circuit*

The circuit consists of two main sections; a bistable multivibrator and an audio oscillator. Fig. 29 shows the full circuit diagram of the depth alarm unit.

The bistable is a standard bipolar design using Tr1, Tr2 and R2 to R5. At switch-on the bistable goes to the state where Tr1 is switched on and Tr2 is switched off, or it is manually set to this state by briefly operating reset switch PB1.

The audio oscillator uses an ICM7555 device in the astable mode, as in several of the projects described earlier in this book. It has pin 4 controlled by the output of the bistable, and under normal conditions Tr2 is switched on and pin 4 of IC1 is at virtually zero volts. This mutes the audio oscillator, and no tone is emitted from loudspeaker LS1.

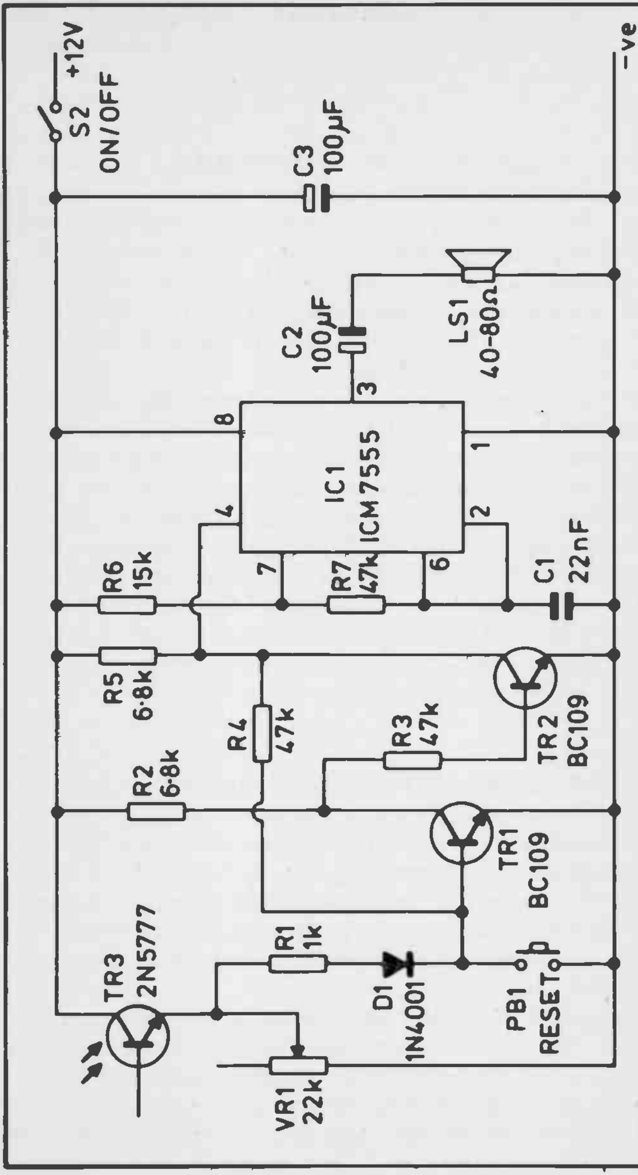



Fig 29. The circuit diagram of the depth alarm.

A photo-Darlington transistor (Tr3) is used as the photocell in this circuit, and devices of this type offer high sensitivity and moderately fast response time. A 2N5777 device is employed in the prototype, but any similar photo-Darlington transistor should also be suitable. In this circuit the emitter – collector terminals of the device are used as a sort of sensitive photo-resistor, and the base terminal is not connected into circuit. The collector – emitter impedance of the device falls as the light level it receives is increased. Tr3 is connected in series with VR1 to produce a potential divider across the supply lines, and the voltage at the junction of Tr3's emitter and the wiper of VR1 therefore rises and falls as the light level received by Tr3 rises and falls.

VR1 is adjusted so that under normal operating conditions the voltage fed to the input of the bistable from the photocell circuit (via D1 and current limiting resistor R1) is not sufficient to switch on Tr1 and trigger the bistable to the other state, but is sufficient to do so if Tr3 receives the light from the scale indicator lamp. With the bistable triggered to the other state the collector of Tr2 goes high and activates the audio alarm. Due to the inclusion of D1 at the input of the bistable the photocell circuit can switch Tr1 on, but cannot switch it off again. Thus the circuit latches in this state until it is manually reset by briefly depressing PB1.

*Construction*

The unit is quite straight forward from the constructional point of view; Fig. 30 shows the component panel and point to point wiring of the unit. This requires a 0.1in matrix stripboard having 14 copper strips by 26 holes, and Tr3 is obviously not mounted on the component panel, but is fitted into a sensor unit which fits over the display of the depth sounder and couples to the main depth alarm unit via a two way cable.

The construction of the sensor requires a little ingenuity, and this must fulfil two main requirements. It must be possible to fit the sensor securely over the desired section of the scale, and extraneous light must be excluded as far as possible. The light output of the indicator lamp is not usually very great, and if a large amount of ambient light is allowed to find its way onto

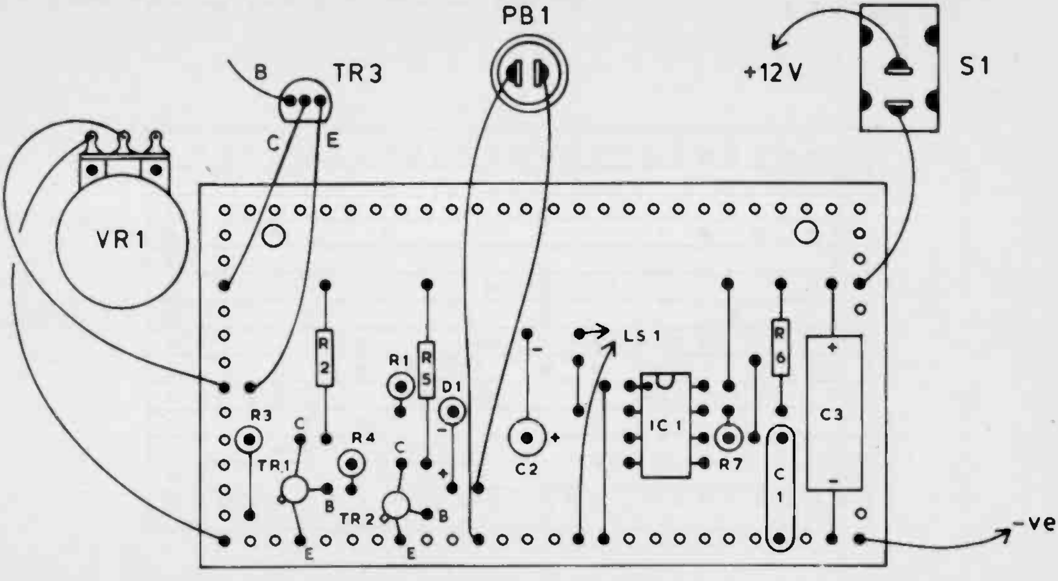



Fig. 30. Constructional details of the depth alarm.

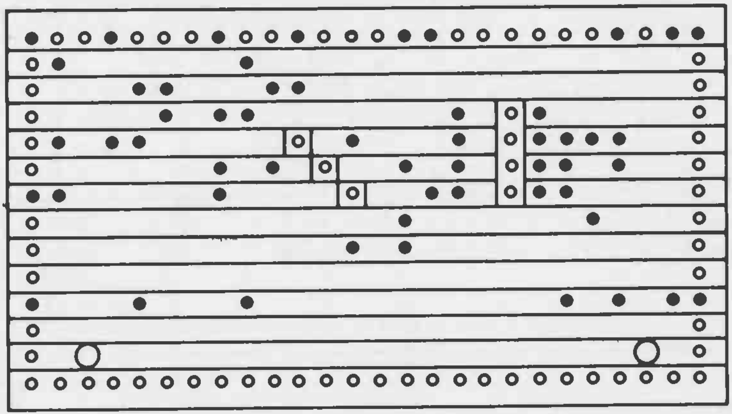


Fig. 30 a. Underside of board shown on Fig. 30.

the photocell it will swamp the light from the lamp and prevent the alarm from operating properly. The sensitive surface of the 2N5777 device is the curved surface at right angles to the leadout wires, and the sensor unit must obviously be arranged so that this surface is aimed towards the scale of the depth sounder and the indicator lamp.

One possibility is to simply fit the photocell into a lump of Bostik Blue-Tak, leaving a hole for the sensitive surface of the photocell to "look" through. This should readily stick to the dial of the depth sounder and will largely cut out extraneous light provided a suitably large piece of Blue-Tak is used.

Of course, more sophisticated arrangements can be used if preferred, and it should be possible to fabricate from wood a simple sensor unit to push onto to viewing hood of the depth sounder, or one that clips onto the hood using a crocodile clip or something of this nature.

VR1 is given a suitable setting by trial and error, and any setting that gives reliable operation is satisfactory. However, it is advisable not to have VR1 adjusted for a sensitivity that is much higher than absolutely necessary (i.e. it should be set no further in a clockwise direction than is absolutely necessary) as this could result in false alarms under very bright ambient lighting conditions.

The sensitivity of the unit can be adjusted over a very wide range by means of VR1, and the unit should function properly with any sounder of the appropriate type. If necessary the sensitivity of the unit can be raised slightly by adding a fixed resistor in series with VR1, or reduced by shorting the base of Tr3 to its emitter terminal, but it is highly unlikely that either course of action will prove necessary.

*Components for Depth Alarm (Fig. 29)*

*Resistors*, all 1/3 watt 5%

| | |
|---|---|
| R1 | 1k |
| R2 | 6.8k |
| R3 | 47k |
| R4 | 47k |
| R5 | 6.8k |
| R6 | 15k |
| R7 | 47k |

| | |
|---|---|
| VR1 | 22k lin. carbon potentiometer |

*Capacitors*

| | |
|---|---|
| C1 | 22nF polyester (C280) |
| C2 | 100$\mu$F 25v electrolytic |
| C3 | 100$\mu$F 25v electrolytic |

*Semiconductors*

| | |
|---|---|
| IC1 | ICM7555 |
| Tr1 | BC109 |
| Tr2 | BC109 |
| Tr3 | 2N5777 or similar photo Darlington device |
| D1 | 1N4001 |

*Switches*

| | |
|---|---|
| S1 | SPST toggle type |
| PB1 | Push to make, release to break type |

*Loudspeaker*

| | |
|---|---|
| LS1 | Minature type having an impedance in range 40 to 80 ohms |

*Miscellaneous*

Plastic case, 0.1in matrix stripboard, Control knob, Wire, solder, etc.

# PROJECT 15

## Shaver Inverter

Most small craft have a 12 volt (battery powered) electrical system, and do not have a generator that enables the use of 240 volt mains equipment on board. One way of overcoming this problem is to use an inverter unit to give a 240 volt AC output from the 12-volt battery supply. However, this system is normally only usable when very low powered equipment is involved since the current drain from the battery would otherwise be very high and the battery would soon be exhausted.

The inverter described here is primarily intended for use as shaver inverter to enable a 240 volt AC shaver to be operated from a 12 volt DC supply. The unit can provide an output of just a few watts, and this makes it unsuitable for use with most other items of equipment, although it might be possible to operate small items of equipment such as a soldering iron from the inverter.

The unit has a current consumption of several hundred milliamps with the output unloaded, and the current drain increases to over 1 amp under load. As the unit is only likely to be used briefly and intermittently this fairly high level of current consumption is perfectly acceptable and should not prove to be troublesome.

*The Circuit*

Circuits of this type operate by pulsing the primary winding of a step-up transformer with pulses from the 12 volt DC supply so that the required high voltage AC output is produced. Although one might think that applying these pulses to the secondary winding of a 12 volt mains transformer would give the required 240 volt output, closer examination of the situation will reveal that this is not the case. A mains transformer will usually operate very well when used in reverse as a step-up type, but it must be remembered that the 12 volt secondary winding (which now becomes the primary winding) has a rating of 12 volts RMS, whereas a 12 volt battery gives

12 volts peak to peak when fed to the transformer via a switching circuit. As 12 volts peak to peak is only about 4.5 volts RMS, the AC output voltage obviously falls somewhat short of the required figure.

Obviously this slight snag can be overcome simply by using a 4.5 volt mains transformer rather than a 12 volt type, but suitable transformers would seem to be relatively scarce and difficult to obtain. An alternative method, and the one employed in this design, is to use a bridge circuit to drive the transformer. This uses an arrangement which is basically the same as that utilized in the "Audio Power Booster" described earlier in this book, so that the peak to peak output voltage applied to the load is doubled to 24 volts peak to peak, or about 9 volts RMS in other words. This enables a readily available 9 volt mains transformer to be used.

The output voltage of the unit is still likely to fall a little short of 240 volts RMS, and this is due to the use of a mains transformer in reverse. Although in theory the ratio of primary turns to secondary turns is the same as the ratio of primary volts to secondary volts, in practice the secondary voltage falls slightly short of the calculated figure due to defficiences in practical transformers. In order to compensate for this additional turns are used on the secondary winding. In this application where the transformer is used in reverse, the additional turns are on what is now the primary winding rather than on the secondary one, giving slightly reduced output voltage.

Fortunately the output voltage only seems to fall marginally short of the required figure, and is close enough for practical purposes (bearing in mind that most equipment for use on the UK mains supply has a voltage rating of 220/240 volts and slightly less than 240 volts will be perfectly acceptable anyway). Also, it is better to slightly under-power the load than to risk applying an excessive voltage to it, since the input voltage to the inverter could well be significantly in excess of 12 volts on occasions, and an excessive output voltage could damage the powered equipment and be dangerous.

Fig. 31 shows the complete circuit diagram of the inverter. IC1 is used as an oscillator providing a squarewave output which can be set at a frequency of 50 Hertz by means of R5.

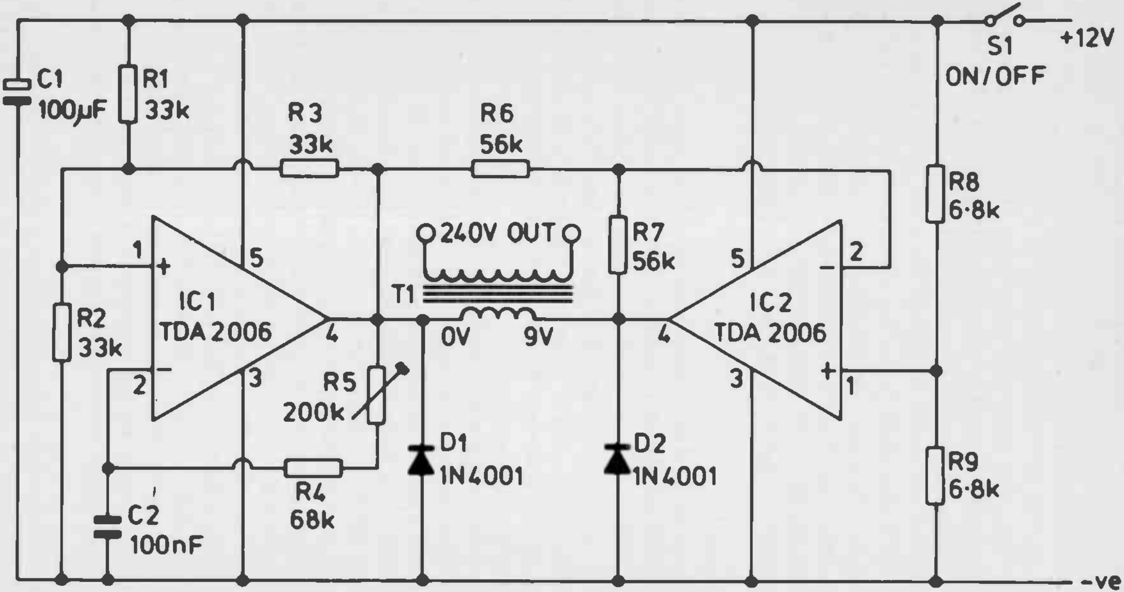



Fig 31. The circuit diagram of the shaver inverter.

IC2 is used as a unity voltage gain inverting amplifier having its input connected to the output of IC1. This gives antiphase signals at the outputs of IC1 and IC2 with both signals having a peak to peak amplitude virtually equal to the supply voltage. As the TDA2006 integrated circuit has a Class B output stage capable of sourcing or sinking quite high currents, the outputs can be applied direct to the primary winding of T1.

Although the signal applied to the input of T1 is a squarewave, the limited high frequency response of a mains transformer severely attenuates the harmonics on the output signal, giving something approaching a sinewave signal, and a signal that is certainly perfectly acceptable in practice. D1 and D2 are protection diodes for IC1 and IC2 respectively.

*Construction*

The unit is housed in a plastic case having S1 and a mains outlet (into which the shaver is plugged) fitted on the lid. T1 is mounted on the base of the case and has its secondary winding (i.e. the 240 volt winding) connected to the "L" and "N" terminals of the mains outlet. There is no earth connection of course, and shavers do not normally have an earth connection anyway, but use double insulation instead.

The other components are fitted onto a 0.1in matrix stripboard panel having 15 copper strips by 15 holes, as shown in Fig. 32. IC1 and IC2 require a substantial heatsink in order to ensure that they do not overheat in use, and suitable commercially produced heatsinks are available. Alternatively a piece of 16 or 18 swg aluminium measuring about 75mm x 100mm will suffice. The heat-tabs of both ICs connect to the negative supply rail, and it is not necessary to insulate them from the heatsink (although the heatsink must obviously be kept electrically isolated from the rest of the circuitry).

Give all the wiring two or three thorough checks before connecting the finished unit to the battery supply and switching on, since wiring errors or accidental short circuits could easily result in very large current flows and consequent expensive damage to the unit.

Initially R5 should be set at about half resistance or a little less. Many electric shavers only seem to operate efficiently if they are fed with an AC supply which is very close to the 50

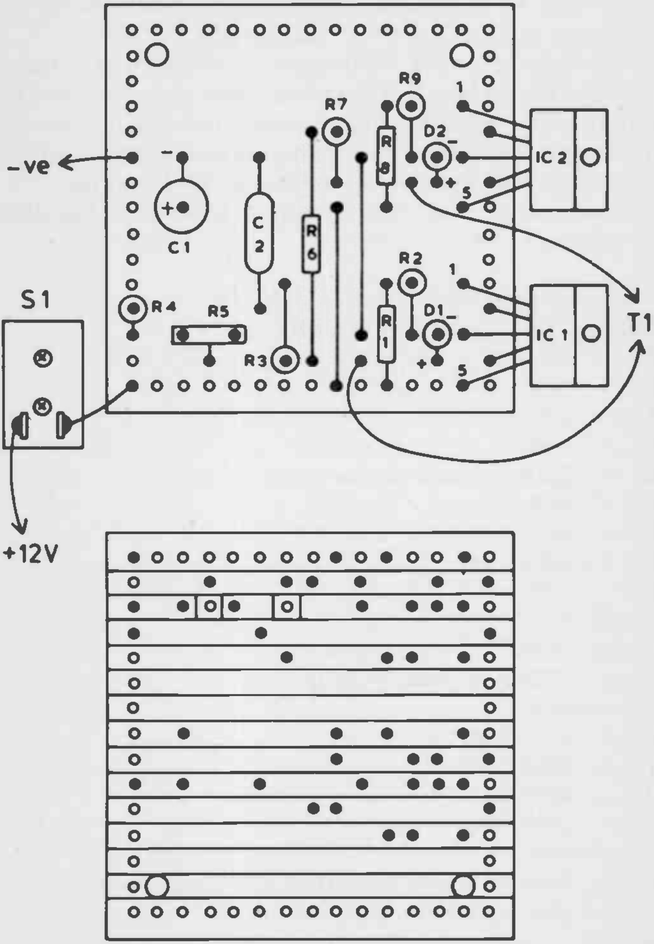



Fig. 32. Constructional details of the shaver inverter.

Hertz mains frequency. R5 is therefore adjusted to give an output frequency that gives efficient operation from the shaver. Of course, if suitable frequency measuring equipment is available, this can be used to monitor the output frequency of IC1 while R5 is adjusted to give the appropriate operating frequency.

Although the output of the unit is by no means as dangerous as the mains supply as it is at a much higher impedance and can provide only a relatively modest current, the output of the unit is nevertheless capable of delivering a substantial electric shock and the unit should be used and handled with the appropriate care. Therefore this project is **NOT RECOMMENDED** for beginners.

*Components for Shaver Inverter (Fig. 31)*

*Resistors*, all 1/3 watt 5% except R5

| | |
|---|---|
| R1 | 33k |
| R2 | 33k |
| R3 | 33k |
| R4 | 68k |
| R5 | 220k 0.1 watt vertical preset |
| R6 | 56k |
| R7 | 56k |
| R8 | 6.8k |
| R9 | 6.8k |

*Capacitors*

| | |
|---|---|
| C1 | 100$\mu$F 25v electrolytic |
| C2 | 100nF polyester (C280) |

*Semiconductors*

| | |
|---|---|
| IC1 | TDA2006 |
| IC2 | TDA2006 |
| D1 | 1N4001 |
| D2 | 1N4001 |

*Transformer*

| | |
|---|---|
| T1 | Standard mains primary, 9 volt 1 amp secondary (used in reverse, see text) |

*Switch*

| | |
|---|---|
| S1 | SPST toggle |

*Miscellaneous*

Plastic case, 0.1in matrix stripboard, Heatsink, Mains outlet, Wire, solder, etc.

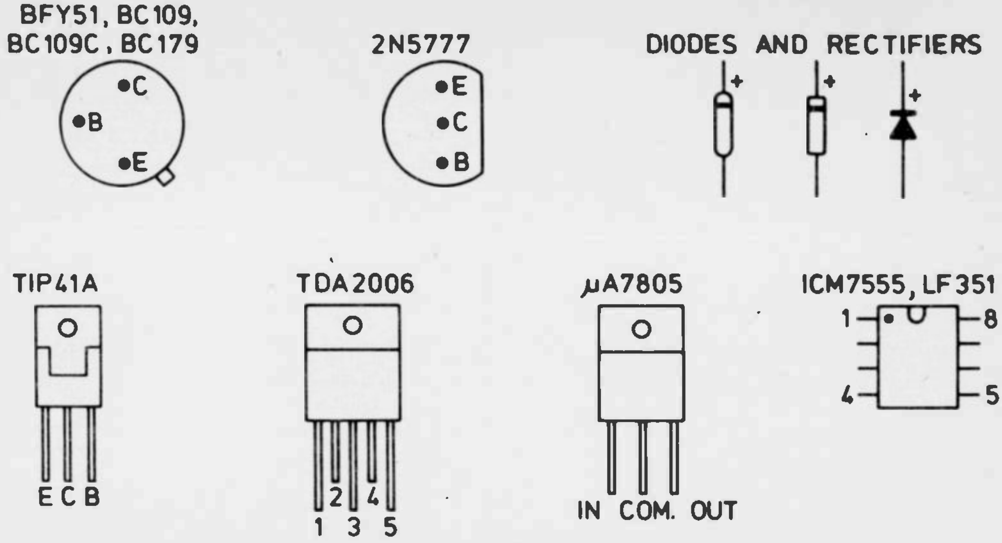



Fig 33. Semiconductor leadout diagrams (transistor base views and IC top views).

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