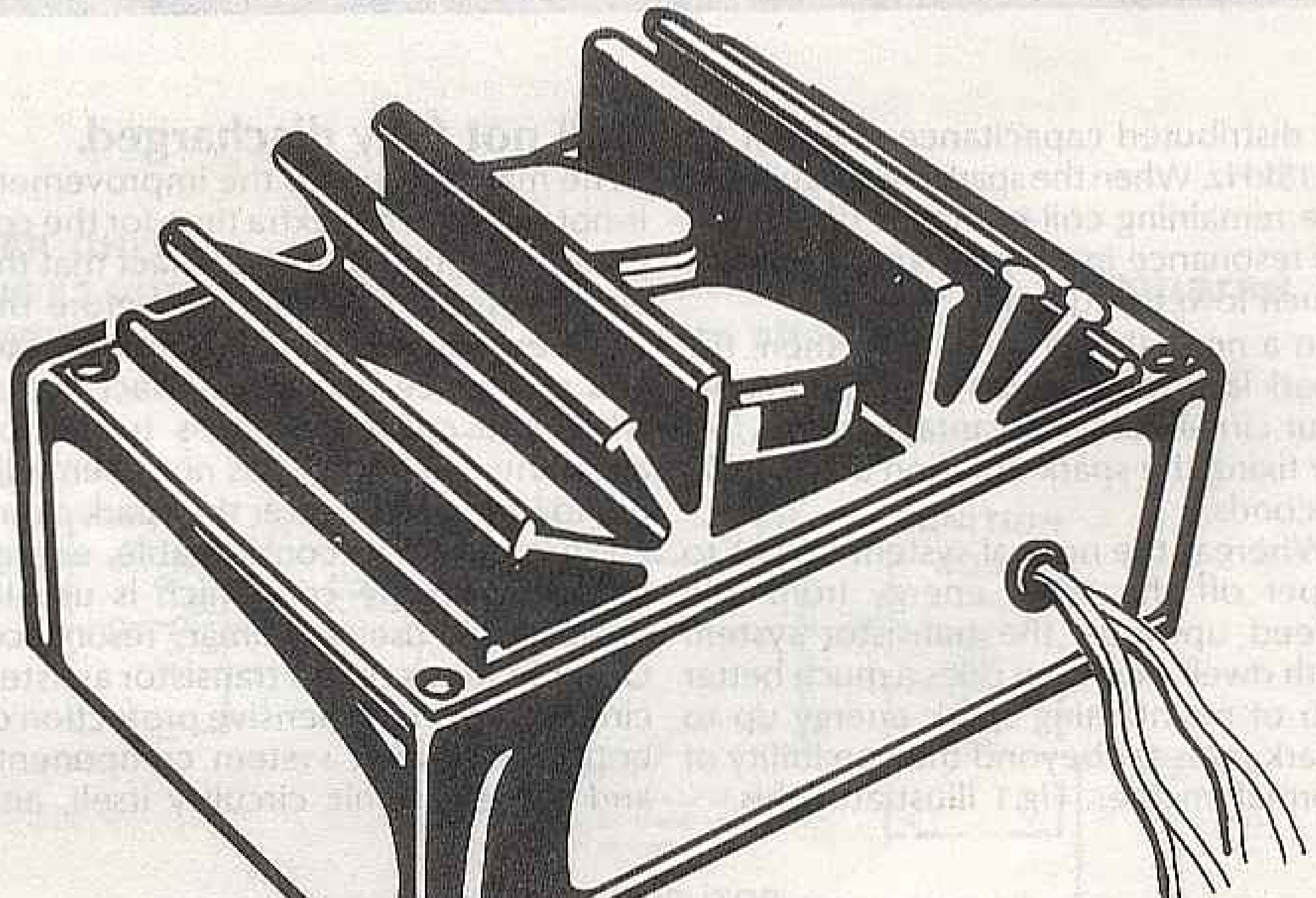
Assembly Manual for the

Transistor Assisted Ignition MkII

Cat.K-3301

PRINTED IN PART BY ARRANGEMENT
WITH ELECTRONICS AUSTRALIA
FROM THE FEBRUARY 1983 EDITION OF EA.

We present a revised version of the transistor assisted ignition system originally published in Electronics Australia December 1979. Read how it compares with the new 'high energy' ignition systems installed in the latest model cars.



Our new transistor assisted ignition system offers significant advantages over the conventional Kettering system. For a start, as with other electronic systems, it relieves the points of the heavy burden of coil current switching while still passing enough current through them to keep them clean.

This means that once the system is initially set up it will not be necessary to readjust the system until wear of the rubbing block becomes significant. In practice, this means that every 15,000 kilometres or so, the points should be regapped and the timing readjusted. So in essence the car will stay at peak tune for much longer periods than would otherwise be the case and long term economy will be improved.

Starting performance of the transistor assisted ignition system can be expected to be on a par with a freshly tuned Kettering system. However, in the conventional Kettering system starting performance normally deteriorates as the points become worn, so as time goes on, the transistor system is superior.

At low engine speeds, the spark energy of the transistor system will be comparable with a freshly tuned Kettering system with new points fitted. This is because the voltage drop across the main switching transistor is less than 300millivolts when turned on. This is comparable to the voltage drop across a typical set of points when they are reasonably new. As points become worn, the voltage drop may increase to one volt or more at maximum coil current.

As engine speed rises, the spark energy of the conventional Kettering system is reduced due to the relatively slow build-up of current in the coil primary. Our transistor assisted system maintains spark energy at a high level even up to very high engine speeds by using 'dwell extension'.

Dwell Extension.

The term 'dwell' refers to the time the points are closed and is measured in terms of degrees of distributor camshaft rotation. Our circuit provides for dwell extension by switching on the coil 0.9 milliseconds after the points open. This means that we have artificially determined the spark duration at 0.9 milliseconds.

At the instant of points opening the coil voltage rises very quickly until the spark discharge occurs, at which the voltage falls to a relatively low level while the coil secondary resonates with

Text and illustrations courtesy of Electronics Australia

PARTS LIST

Resistors

- ☐ R15 .... 10R (brn-blk-blk)
- ☐ R4 .... 220R (red-red-brn)
- ☐ R16 .... 560R (grn-blu-brn)
- ☐ R5, 8, 9......... 1k (brn-blk-red)
- ☐ R6, 7 .... 15k (brn-grn-org)
- ☐ R12, 13, 14 ..... 2R7, 1W (red-vio-gold)
- ☐ R1, 2, 3......... 150R, 1W (brn-grn-brn)
- ☐ R10, 11.......... 220R, 1W (red-red-brn)

Capacitors

- ☐ C1, 2, 3......... 0.1uF greencap
- ☐ C4.............. 0.22uF greencap

Semiconductors

- ☐ Q1 .... 2N6027
- ☐ Q2 .... BD139
- ☐ Q3 .... 2N3055
- ☐ Q4 .... BUX80
- ☐ D1, 2, 3, 4, 5 ..... 1N4002 diode
- ☐ D6, 7, 8......... 75V zener diode

Miscellaneous

- ☐ 2x.............. Transistor insulating cap
- ☐ 1x.............. Eyelet assembly
- ☐ 2x.............. Mica insulating washer
- ☐ 4x.............. Insulating bushes
- ☐ 1x.............. Cable clamp
- ☐ 1x.............. Spade plug (male & female)
- ☐ 2x.............. Utilux terminals
- ☐ 1x.............. Rubber grommet
- ☐ 4x.............. Insulated spacer
- ☐ 1x.............. PCB
- ☐ 1x.............. Diecast box
- ☐ 1x.............. Heatsink

Silicone grease, spaghetti, solder, fig.8 flex cable, screws, nuts, washers solder lugs.

its distributed capacitance at about 10 to 15kHz. When the spark is extinguished, the remaining coil energy is dissipated by resonance in the primary circuit at a much lower frequency.

In a normal ignition system then, the spark lasts for less than one millisecond. Our circuit takes advantage of this fact by fixing the spark duration at 0.9 milli-seconds.

Whereas the normal system begins to taper off the spark energy from idle speed upwards, the transistor system with dwell extension does a much better job of maintaining spark energy up to spark rates far beyond the capability of normal engines. Fig.1 illustrates this.

Coil not fully discharged.

The main reason for the improvement is not so much the extra time for the coil current to build up but the fact that the coil transistor is turned on before the spark extinguishes naturally and primary coil resonance occurs. The fact is that when the coil transistor is turned on again the coil energy has not been fully dissipated. In fact, after the spark extin-guishes there is considerable energy remaining in the coil which is usually dissipated in useless primary resonance. Other features of this transistor assisted circuit are comprehensive protection of both the ignition system components and the electronic circuitry itself, and the ability to drive a standard tacho-meter without any modifications.

Is there a catch to all this? Are there no disadvantages of this new transistor ignition system compared with conven-tional systems? Well there are a few side-effects of the new system but you could hardly class them as major drawbacks.

For example, because of the dwell extension feature, the coil is maintained in saturation for a much higher proportion of its operation time. So the average current passing through the coil is about 80% higher. Or, to put it another way, the coil current is increased from about 2.5 to 4.5 amps.

In addition, the transistor drive circuitry draws about 1.5 amps so the total current drain of the transistor assisted system is around six amps versus 2.5 amps for the conventionalsystem.

The extra current drain is unlikely to pose much of a problem for the cars electrical system but the extra coil current does mean that the coil runs hotter. This has not proved to be a problem for the oil filled coils on modern cars. Even so, the coil should ideally be placed so that it receives cooling air from the fan.

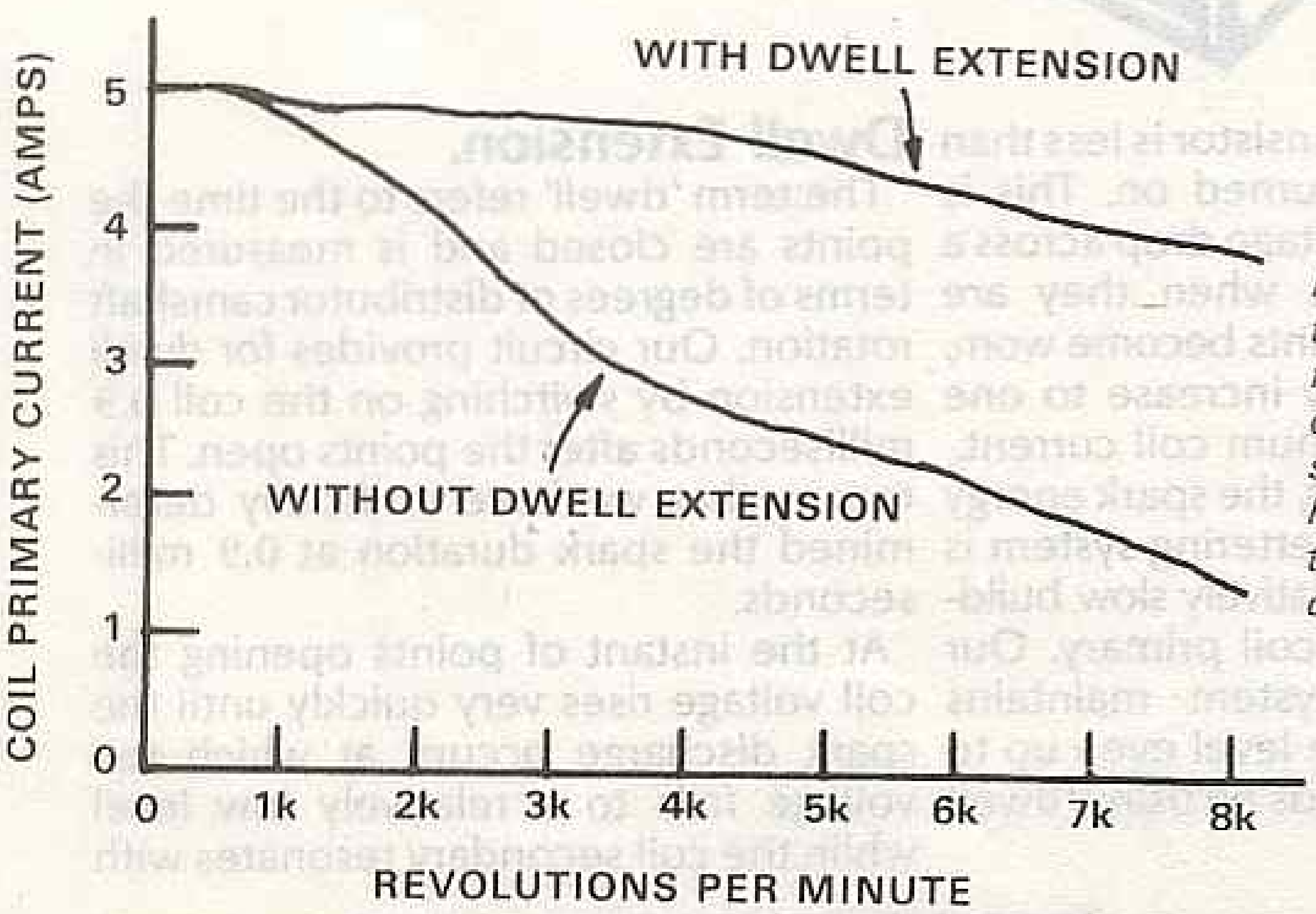


Fig.1 (left) shows how the dwell extension feature maintains coil current and therefore, spark energy up to very high engine speeds (in this case for a 6-cylinder motor).

High Energy Systems

Well, that about sums up the main features of the transistor assisted igni-tion system. How does it compare with the so-called "high energy" systems now being installed on many cars such as the Commodore, Falcon and Rover? The most important feature of these systems is not a "hotter" spark or a higher voltage output from the coil but, rather, a long spark duration, as much as two milliseconds in the case of the Commodore. This is most important in achieving reliable combustion of the generally lean mixtures used in recent model cars. The "high energy" means that the system also has the ability to refire a spark plug if it has been extinguished by turbulence of the mixture.

How do these new electronic systems achieve such a long spark duration? In any ignition system (apart from capacitor discharge types) the spark duration is determined firstly by the amount of energy stored in the coil and secondly by the resistance path presented by the spark plug.

The new high energy systems do not resort to dwell extension (as far as we know) to achieve this greater energy storage in the coil. No, they generally dispense with the ballast resistor in series with the coil and take advantage of the power transistor, which is usually a Darlington, to switch much heavier currents into the coil. Naturally, these systems are breakerless and, with no dwell extension circuitry involved, there is no risk of a coil burnout in the event of the ignition being left on while the motor is stationary. There is also the advantage of a comparatively simple circuit which should be very reliable, as seems to be the case.

Let us state, from the outset, that unless you are willing to modify the coil or ballast resistor in your system from "standard" it is not possible to gain these really long spark durations from this circuit. And in any case, we would strongly advise against doing so. Operating a normally ballasted coil without a ballast resistor will burn it out in a short time, probably within less than half an hour.

Even so, constructors who are familiar with the original circuit (cat.K-3300) will realise that the spark duration has been increased from 0.6 to 0.9 milliseconds. There is no benefit in even greater extension of the spark time because the system with standard coil does not store enough energy.

The only result of an attempt to extend the spark beyond 0.9 millisecond (by altering circuit components) will be that the spark will extinguish of its own accord at about one millisecond and the remaining energy stored in the coil will be dissipated in useless primary resonance. As outlined above, the major advantage of the dwell extension feature would be lost.

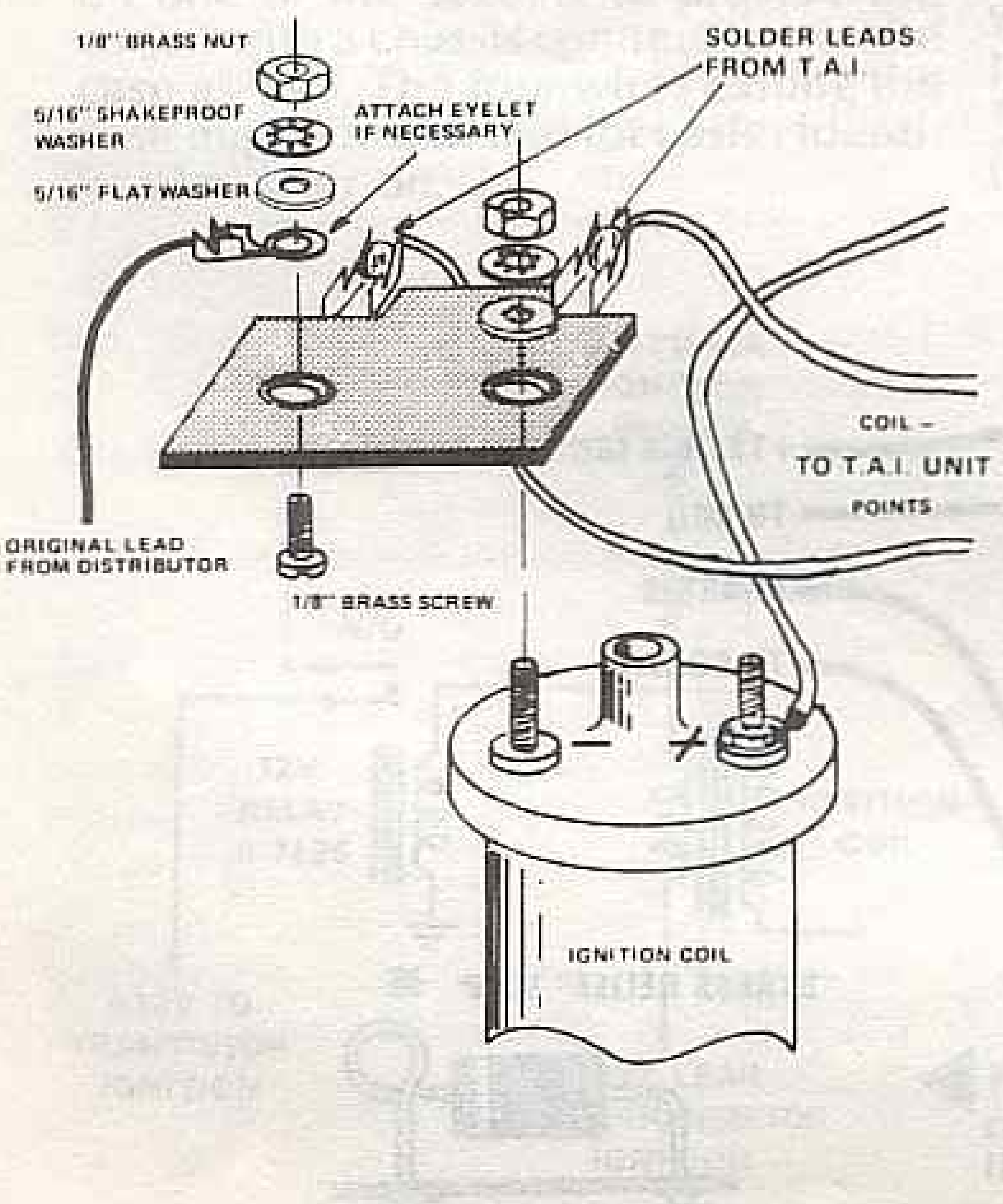
Don't open up the plug gaps

Before we leave this topic, there is one final aspect which should be noted. In the past, when fitting electronic ignition , car enthusiasts have often increased the spark plug gaps by as much as 50% to take advantage of the higher spark voltage which is usually available and thereby gain a longer spark "path".

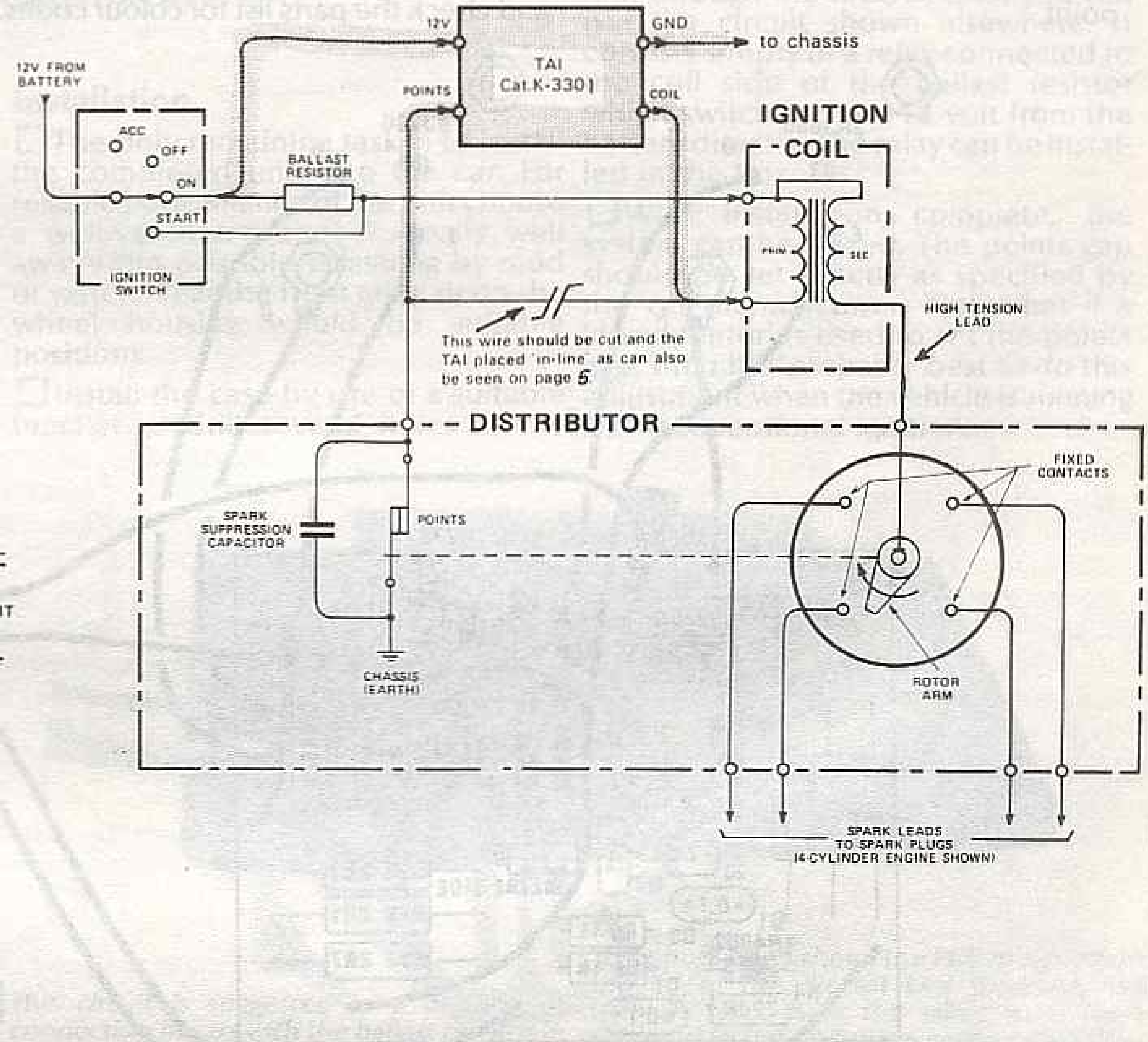
It is, however, recommended that distributor points and spark plugs be left at normal settings to allow a quick changeover to normal ignition, should this be necessary in the case of failure.

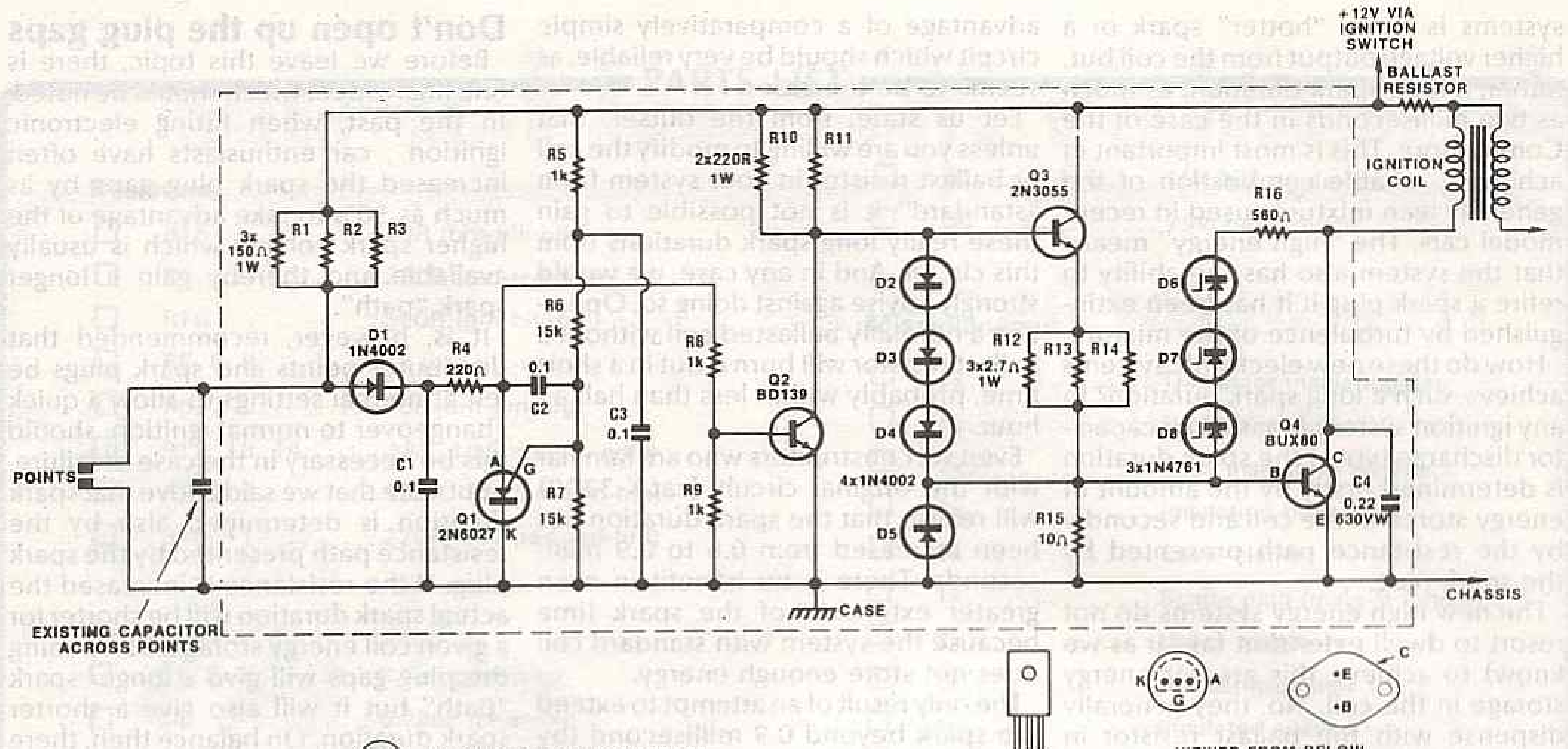
But note that we said above that spark duration is determined also by the resistance path presented by the spark plug. If the resistance is increased the actual spark duration will be shorter for a given coil energy storage. So opening the plug gaps will give a longer spark "path" but it will also give a shorter spark duration. On balance then, there is no advantage to be gained by increasing the spark plug gaps.

BEFORE INSTALLING THE UNIT IN YOUR CAR, CHECK THAT YOUR CAR'S ELECTRICAL SYSTEM IS 12 VOLT NEGATIVE EARTH. THE T.A.I. WILL ONLY WORK IN A 12 VOLT NEGATIVE EARTH SYSTEM.



Conventional Ignition and TAI Compared
(TAI system shown shaded)





TRANSISTOR IGNITION

Construction.

☐The entire transistor ignition is housed in a diecast aluminium case. It is rugged and can be made splashproof easily. All the components with the exception of the two power transistors are mounted on a small printed circuit board measuring 91 x 68mm. The two power transistors are mounted on the lid of the diecast box together with a heatsink.

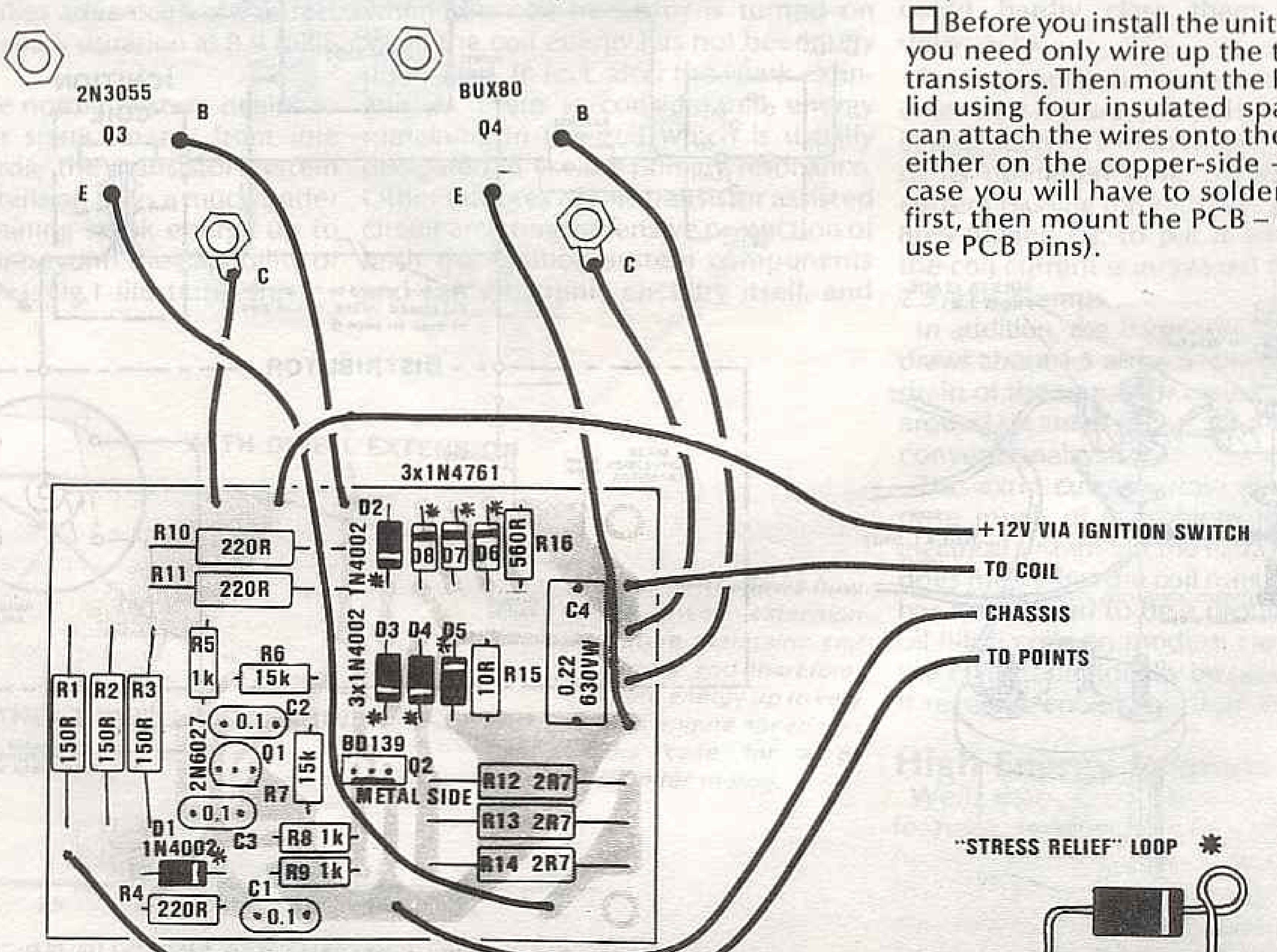
☐You should first drill the necessary holes for the power transistors using a mica washer as a template. Drill the heatsink first, then mark out the hole positions on the lid of the case and drill. After drilling, remove any burrs by using a large diameter drill. Mounting holes for the PCB should also be drilled at this point.

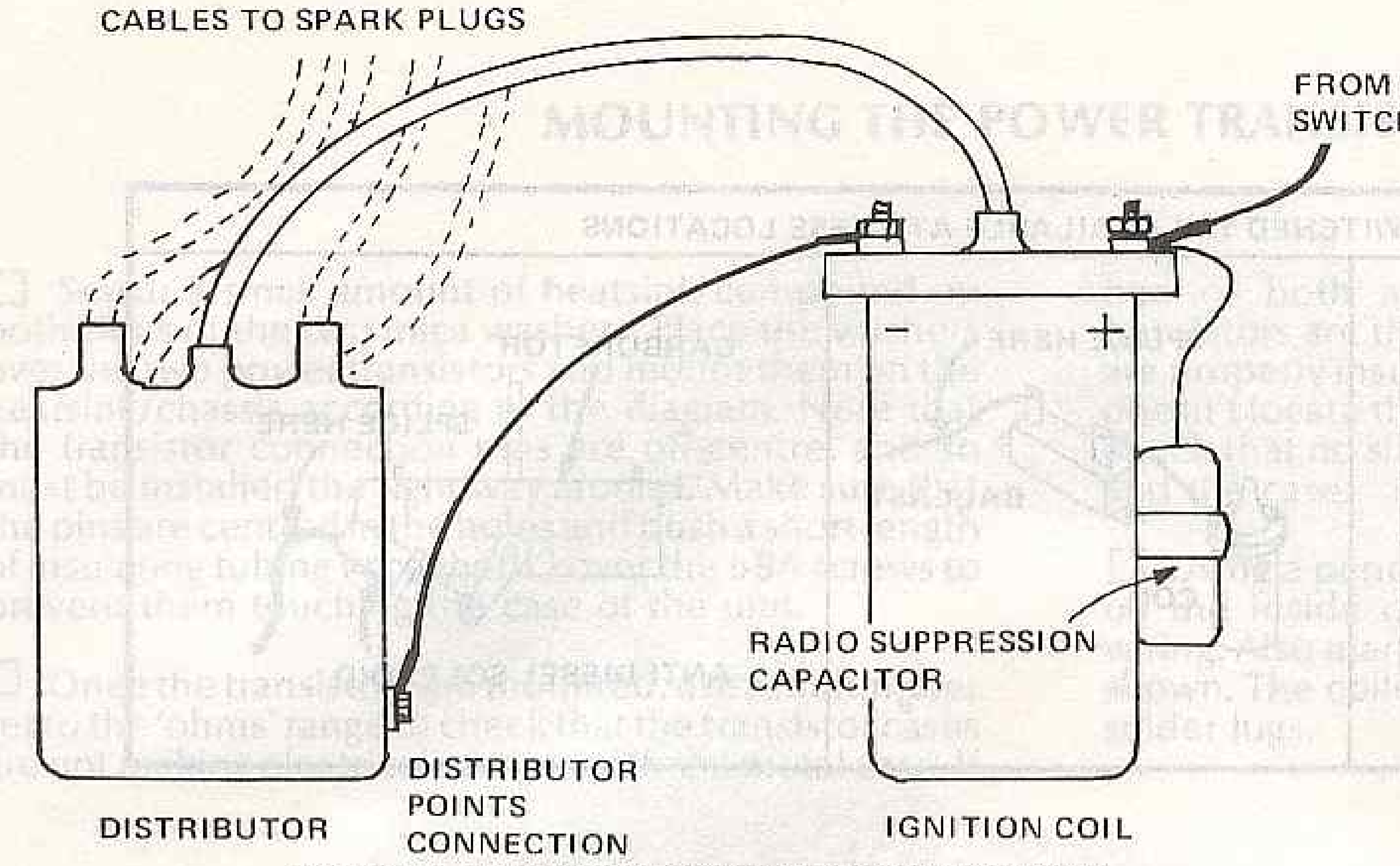
☐With the diecast box and the heatsink free from any metal shavings or other grit, a thin layer of silicone grease can be applied to the area underneath the transistors and on the mica washer. Apply the compound carefully with a cotton bud and avoid skin contact with it. Mount the transistors with the mica insulating washers and plastic bushes in position and then check that the case of both transistors is insulated from the lid and heatsink using a multimeter or other continuity checker.

☐When you are satisfied that there are no shorts to the box, you can start work on the PC board. Firstly mount all the resistors; follow the overlay carefully and check the parts list for colour codes. Note that parallel combinations of resistors have been used in three instances. This is because 1 watt resistors' temperature rise is not as great as wirewound five watt resistors'. Even so, one watt resistors can still become quite warm, so mount them slightly off the board!

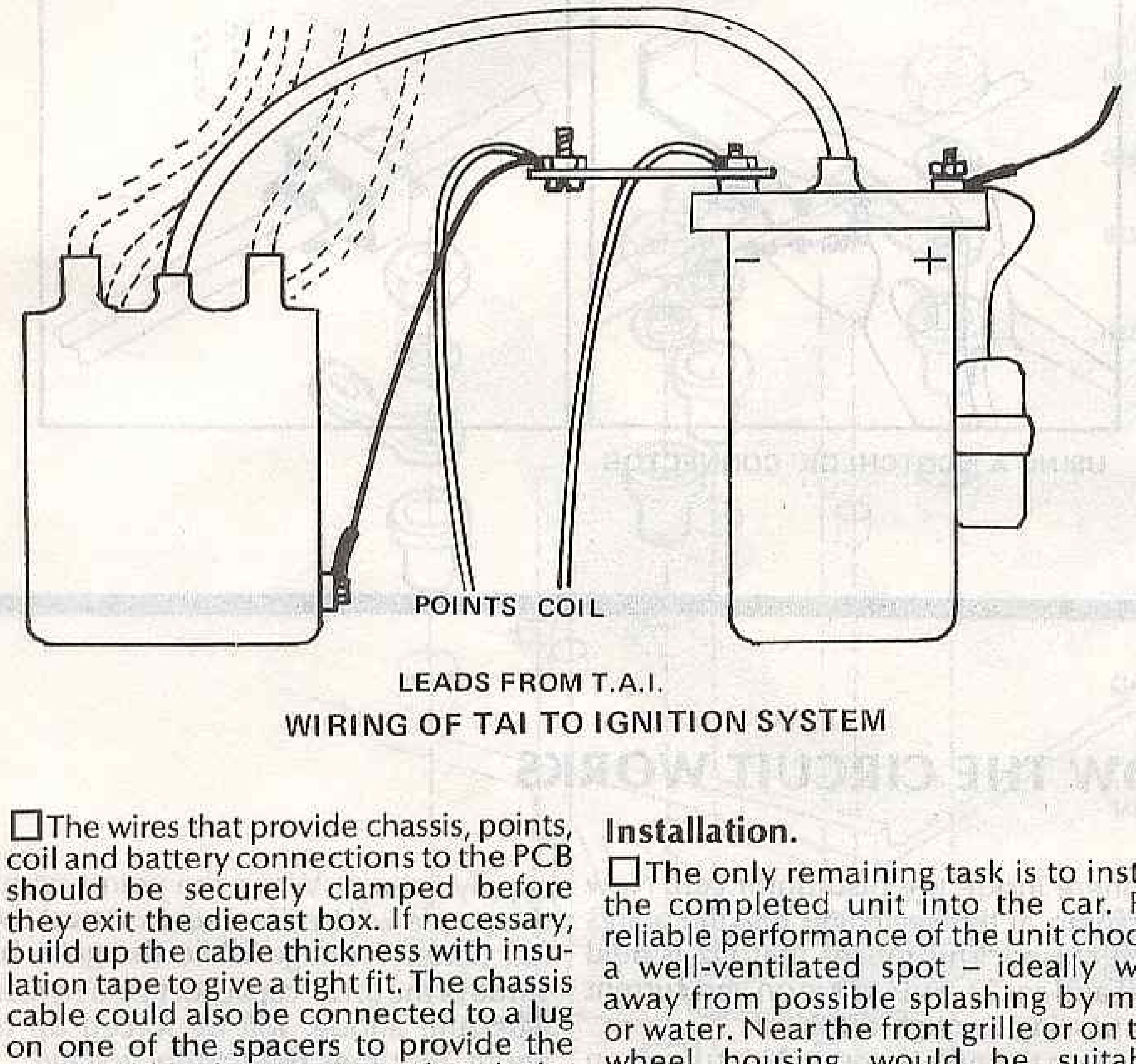
☐Next mount the greencaps, followed by the diodes. Note that the diodes should all be installed with a "stress relief" loop at one end, as shown on the overlay. Also pay special attention to their orientation. The two last components on the PC board are the 2N6027 PUT (Programmable Unijunction Transistor) and the BD139 transistors – make sure you install these the right way round.

☐Before you install the unit in your car you need only wire up the two power transistors. Then mount the PCB on the lid using four insulated spacers (you can attach the wires onto the PC board either on the copper-side – in which case you will have to solder the leads first, then mount the PCB – or you can use PCB pins).





NORMAL IGNITION SYSTEM CONNECTIONS



WIRING OF TAI TO IGNITION SYSTEM

☐The wires that provide chassis, points, coil and battery connections to the PCB should be securely clamped before they exit the diecast box. If necessary, build up the cable thickness with insulation tape to give a tight fit. The chassis cable could also be connected to a lug on one of the spacers to provide the circuit with a chassis connection via the case as well. The four wires exiting the case might be labelled for easier identification later on.

Installation.

☐The only remaining task is to install the completed unit into the car. For reliable performance of the unit choose a well-ventilated spot – ideally well away from possible splashing by mud or water. Near the front grille or on the wheel housing would be suitable positions.

☐Install the case by use of a suitable bracket or drill several holes in the bottom of the case and secure it to the vehicle. With the unit mounted, the various connections to the cars electrical system can be made.

☐For this purpose, we recommend the use of the eyelet/solder lug assembly. This sits on what is normally the points connection of the coil but which now is connected to the collector of Q4. The remaining connection point of the solder lug assembly connects the points wire from the distributor back to the "To Points" lead in the transistor ignition.

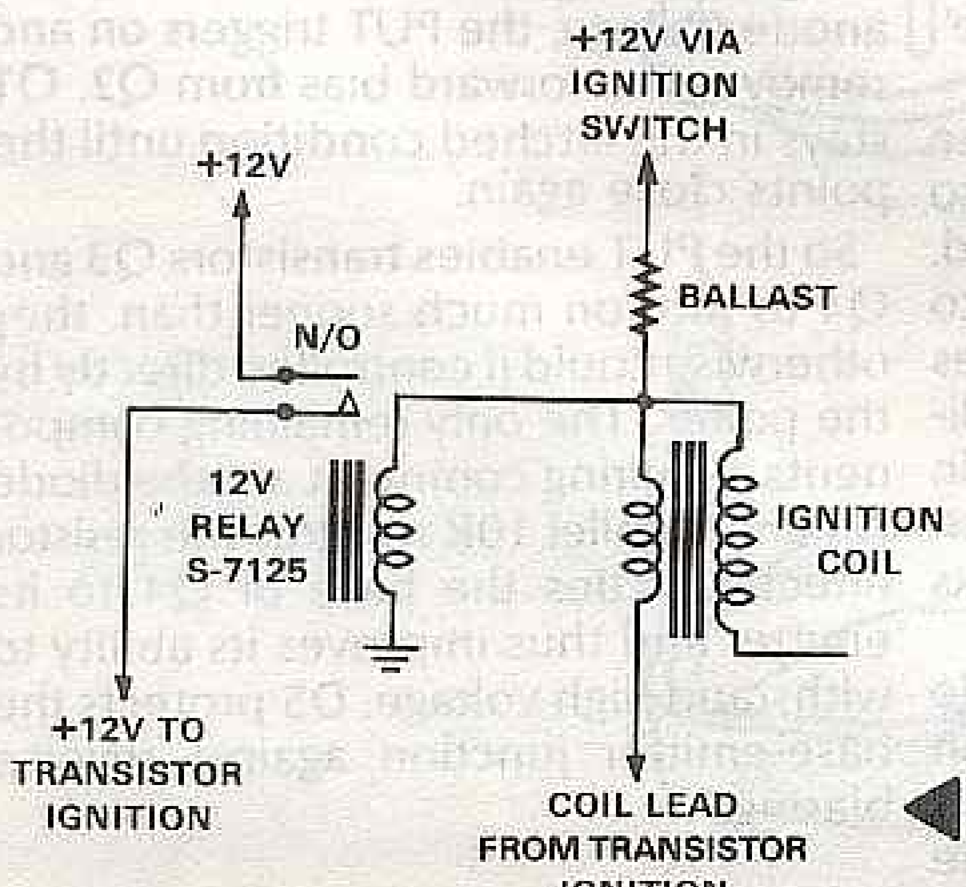
☐The other connection to the coil remains as standard because it is the same whether transistor or conventional ignition is being used. In this way it is simply a matter of swapping leads to the eyelet assembly on one side of the coil, if a changeover is necessary.

☐Apart from the ignition coil and points it is also necessary to connect the +12 volt lead to the battery via the ignition switch.

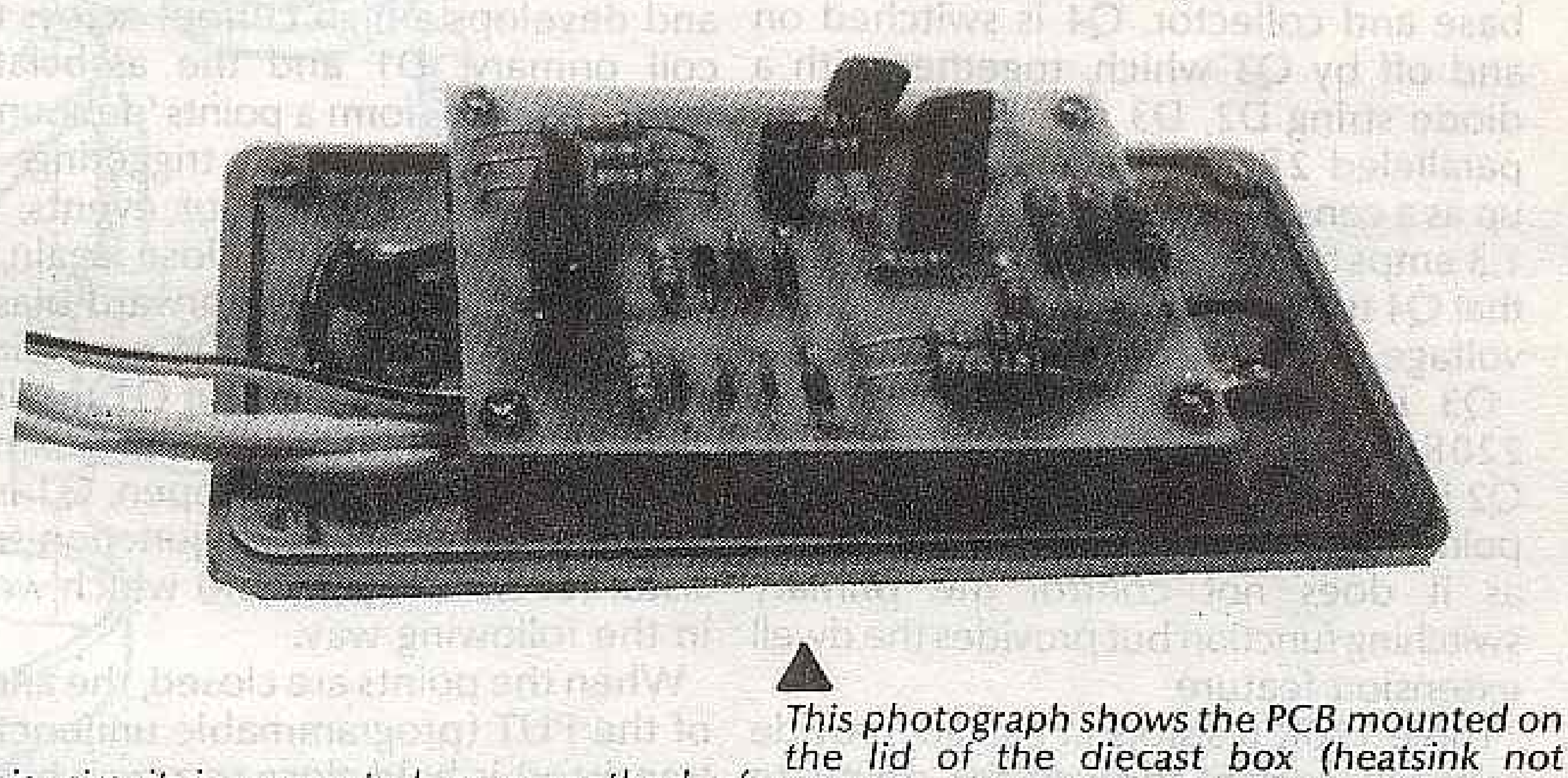
☐If your car has a seperate ballast resistor then it is a simple matter to connect to the ignition switch side of the resistor. Some cars, though, use a ballast wire, which complicates the situation because it is then necessary to guide the +12 volt lead from the transistor ignition through an appropriate hole in the firewall to the actual ignition switch itself.

☐Alternatively, if you do not wish to drill through the firewall then you can use the circuit shown elsewhere. It consists simply of a relay connected to the coil side of the ballast resistor which switches the +12 volt from the battery directly. The relay can be installed in the box.

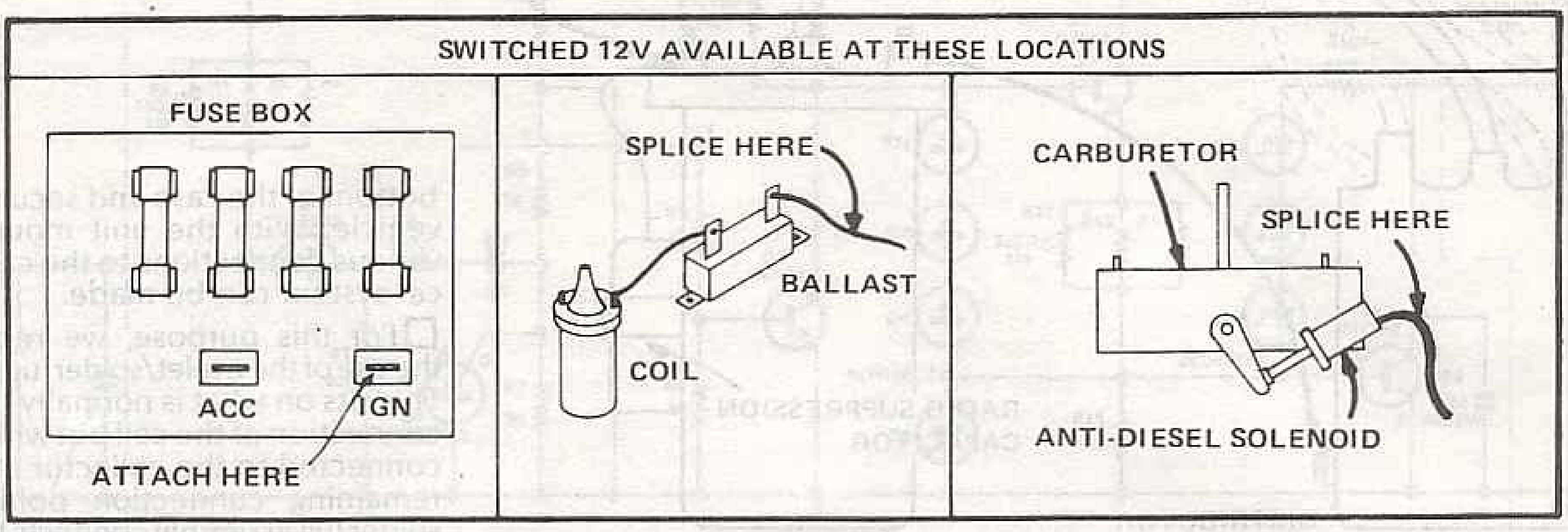
☐With installation complete, the system can be tested. The points gap should be set exactly as specified by the car manufacturer. Note that if a 'dwell meter' is used to set the points gap, then it is probably best to do this adjustment when the vehicle is running with conventional ignition.

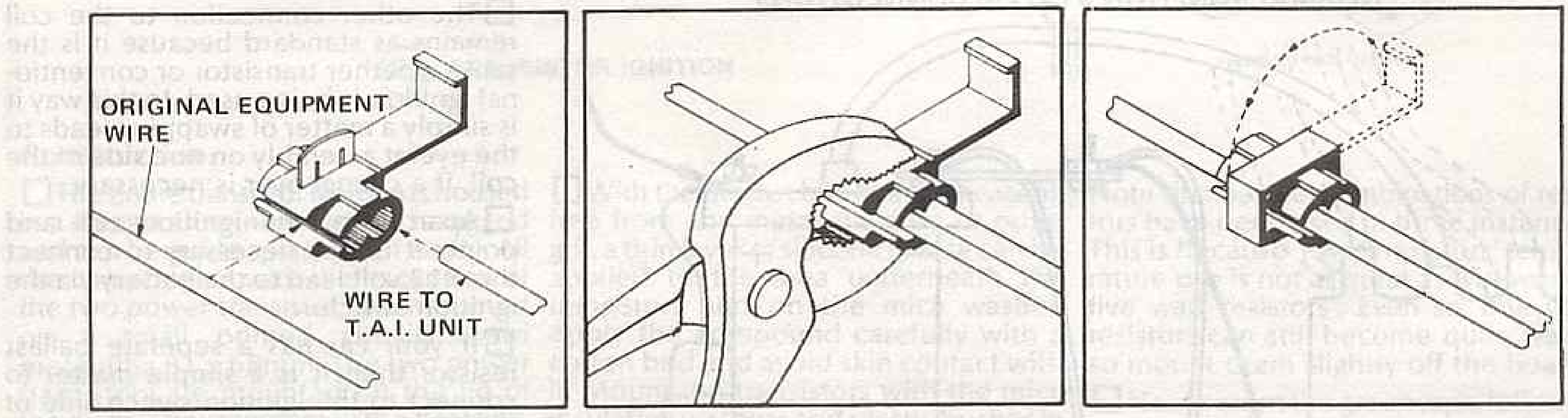


This circuit is suggested as a method of connection in cars with the ballast resistor in the wiring harness.



This photograph shows the PCB mounted on the lid of the diecast box (heatsink not visible). Note how the wires have been soldered to the underside of the board. You may, however, decide to use PCB pins.





USING A 'SCOTCHLOK' CONNECTOR

HOW THE CIRCUIT WORKS

The heart of the circuit is Q4 which is arugged transistor especially intended for use in converters, switching regulators and automotive ignition systems. Q4 does the arduous job of switching the coil current. It is protected against excessive voltages by a 0.22uF capacitor and by a string of three 75V zener diodes and a 560R limiting resistor between base and collector. Q4 is switched on and off by Q3 which, together with a diode string D2, D3 and D4 and three paralleled 2R7 emitter resistors, is set up as a constant current source to deliver 1.3 amps to the base of Q4. This ensures that Q4 turns on hard and has a saturation voltage of around 300 millivolts or less.

Q3 is biased on by two paralleled 220R resistors and controlled by Q2. Q2 is turned on and off by the distributor points via D1. Ignore Q1 for the moment, as it does not control the primary switching function but provides the dwell extension feature.

Three 150R resistors in parallel provide 'wetting' current through the points to keep them clean in the fumeladen atmosphere inside the distributor cap. Now assume, at the beginning, that the points are closed. This means that Q2 is held off and so Q3 and Q4 are on and current is passing through the coil.

When the points open, Q2 is turned on by the base current via D1 and the three 150R resistors. Thus Q2 turns off Q3 and Q4 which interrupts the coil current and develops a high current across the coil primary. D1 and the associated 0.1uF capacitor form a points 'debounce' circuit to prevent erratic triggering.

In the normal course of events, the points will eventually close again, so that D1 ceases to be forward-biased, turning Q2 off and Q3, Q4 on again to recommence the cycle. But Q1 modifies that cycle by turning Q2 off 0.9 milliseconds after the points open. Q1 is, in fact, a programmable unijunction transistor (or anode gate SCR) which works in the following way.

When the points are closed, the anode of the PUT (programmable unijunction transistor) is held close to zero while its gate is held at a little less than half the supply voltage. When the points open, the anode will be lifted up to almost the full battery voltage while the gate, by virtue of the 0.1uF capacitor tied between gate and anode, will be forced up to about 1.5 times the battery voltage.

This 0.1uF capacitor then discharges via the voltage divider made up of two 15k resistors and a 1k resistor. When the capcitor is discharged to the point where the gate voltage is 0.6 volts less than the anode voltage, the PUT triggers on and removes the forward bias from Q2. Q1 stays in the latched condition until the points close again.

So the PUT enables transistors Q3 and Q4 to turn on much sooner than they otherwise could if controlled directly by the points. The only remaining components requiring comment are the diode D5 and parallel 10R resistor. The resistor effectively ties the base of Q4 to its emitter and thus improves its ability to withstand high voltage. D5 protects the base-emitter junction against reverse biasing.

MOUNTING THE POWER TRANSISTORS

☐ Smear a small amount of heatsink compound on both sides of the two mica washers. Place the washers over the two power transistors and mount them on the heatsink/chassis according to the diagram. Note that the transistor connection pins are off-centre, and so must be installed the right way around. Make sure that the pins are centred in the holes and push a short length of insulating tubing ('spaghetti') over the 6BA screws to prevent them touching the case of the unit.

☐ Once the transistors are mounted, use a multimeter set to the 'ohms' range to check that the transistor cases are not making electrical contact with the metal case. If one or both are making contact, check that the transistors are the right way around and that all screws are properly insulated and centred in their holes. If this doesn't locate the problem, remove the transistors and check that no sharp filings are between the transistors and the case.

☐ Using a pencil, write the numbers of the transistors on the inside of the case to avoid confusion when wiring. Also mark their emitter and base (E & B) pins as shown. The collector (C) connections are made to the solder lugs.