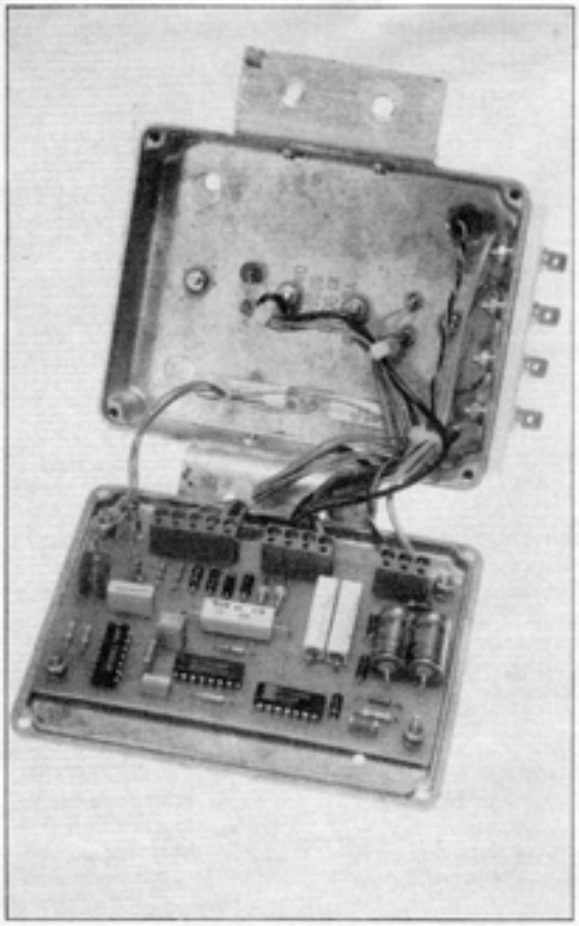


Although transistor ignition has been available for many years now, there are still millions of cars that have not been provided with the advantages of a complete solid-state ignition system. The solid-state ignition described in this article will give long and reliable service and will also extend the useful life of your spark plugs appreciably.

SOLID-STATE IGNITION

by
Hans Steeman

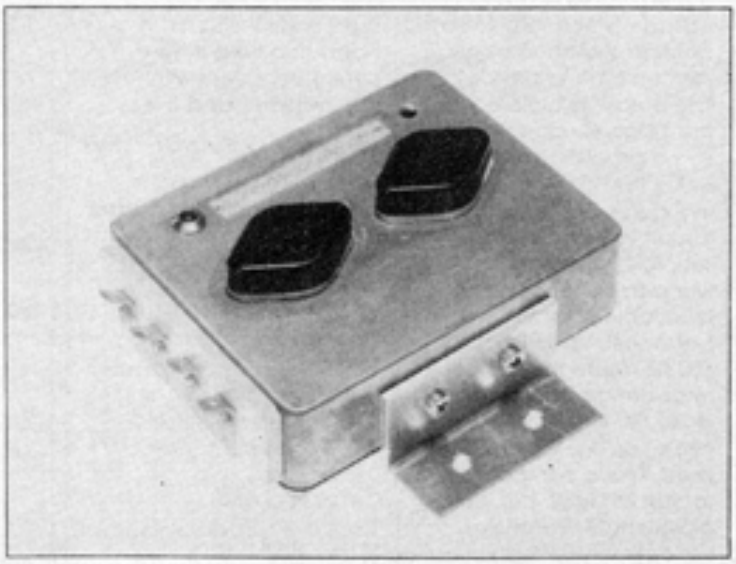
A full solid-state ignition system has many advantages over conventional systems. It will, for instance:

- enable the engine to be started readily, whether this is cold, wet, or hot — provided your battery is in good condition, of course;
- ensure that even a cold or damp engine continues to run once it has been started;
- ensure that the spark energy is constant and independent of the engine speed;
- considerably reduce carbon deposit on the spark-plug electrodes, thus allowing longer intervals between cleaning and replacement of the plugs.

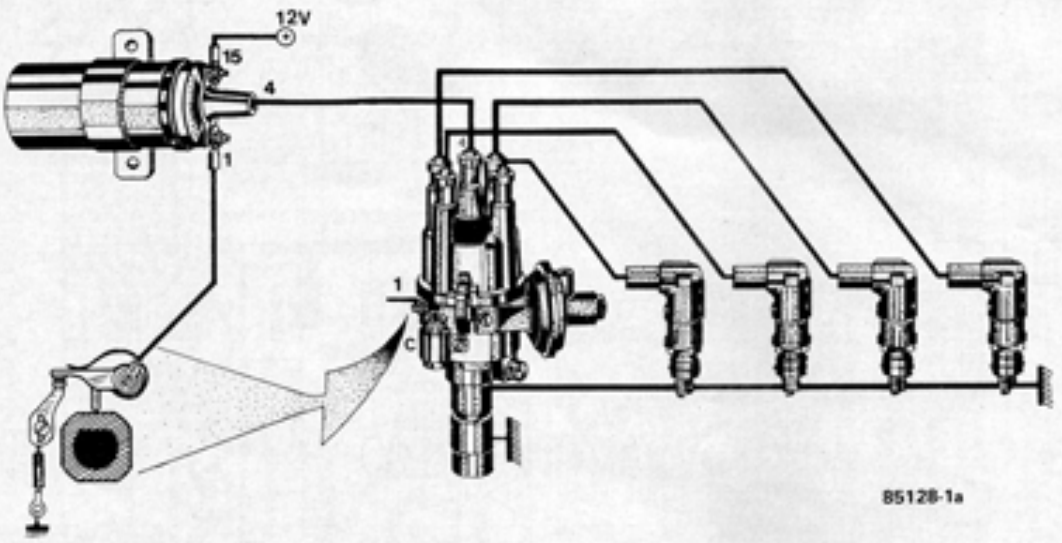
A comparision

Fig. 1 shows a conventional coil ignition system as used in most petrol engines. The contact breaker points are controlled by the distributor cam: when they open, the current flowing through the primary winding of the coil is interrupted, which causes a high potential to be induced across the secondary winding. This voltage is high enough (10 to 15 kV) to ignite the compressed charge of air and petrol vapour in the engine cylinder via the spark-plug. The distributor ensures that the high tension is applied to only one cylinder at a time. The distributor is driven by the engine at half engine speed.

In the solid-state ignition system the function of the contact breaker points is transferred to a transistor switch: the points merely serve to trigger the transistor. Because of the consequent appreciable reduction in current flowing across the points, these become virtually free of wear. The timing diagrams in Fig. 2 show the differences between the ignition pulses generated in the two systems. When the points in the coil ignition system are closed, no current flows through the primary of the coil. Note the overshoot and ringing occurring at the secondary immediately after the points have closed. These phenomena are caused by stray



1a



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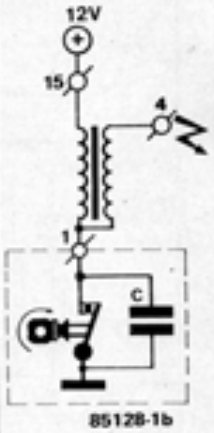

Fig. 1. Conventional coil-ignition system for petrol engines.

Fig. 2. Timing diagrams of coil ignition (left) and solid-state ignition (right).

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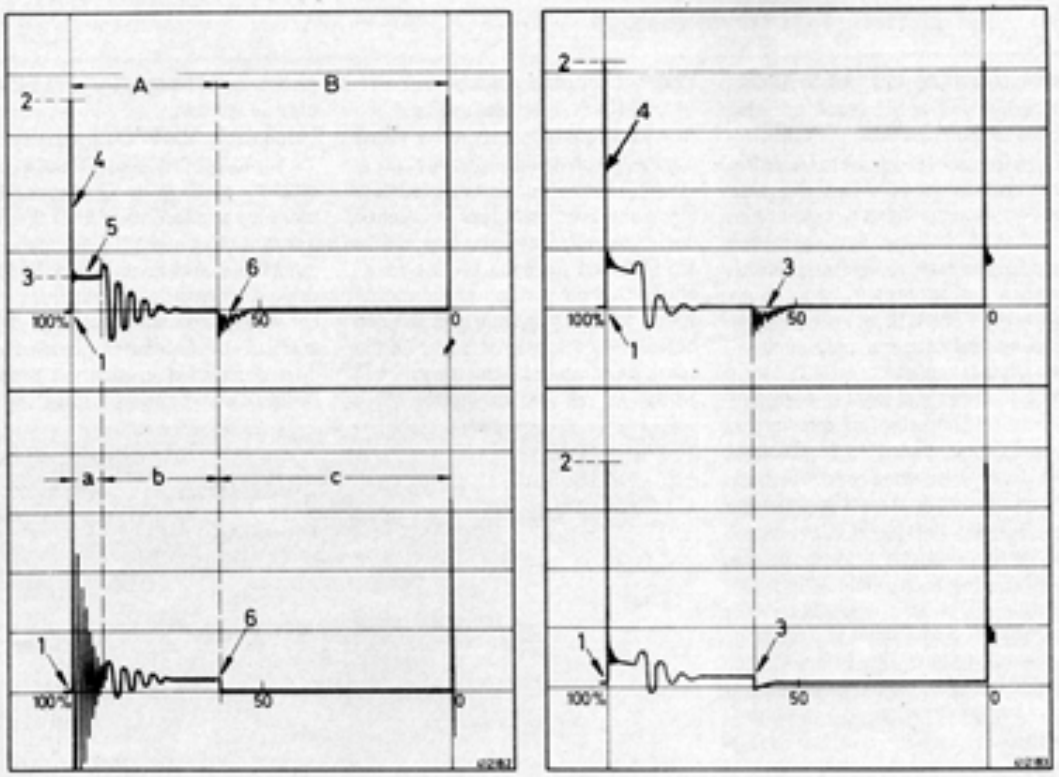

1 points open
2 ignition voltage
3 firing voltage
4 peak secondary voltage
5 firing voltage level
6 points close

A points open period
B points closed period
a spark duration
b points open period
c points closed period

1 ignition period starts; transistor switched off
2 sparking voltage; zener voltage
3 transistor switches on
4 peak secondary voltage

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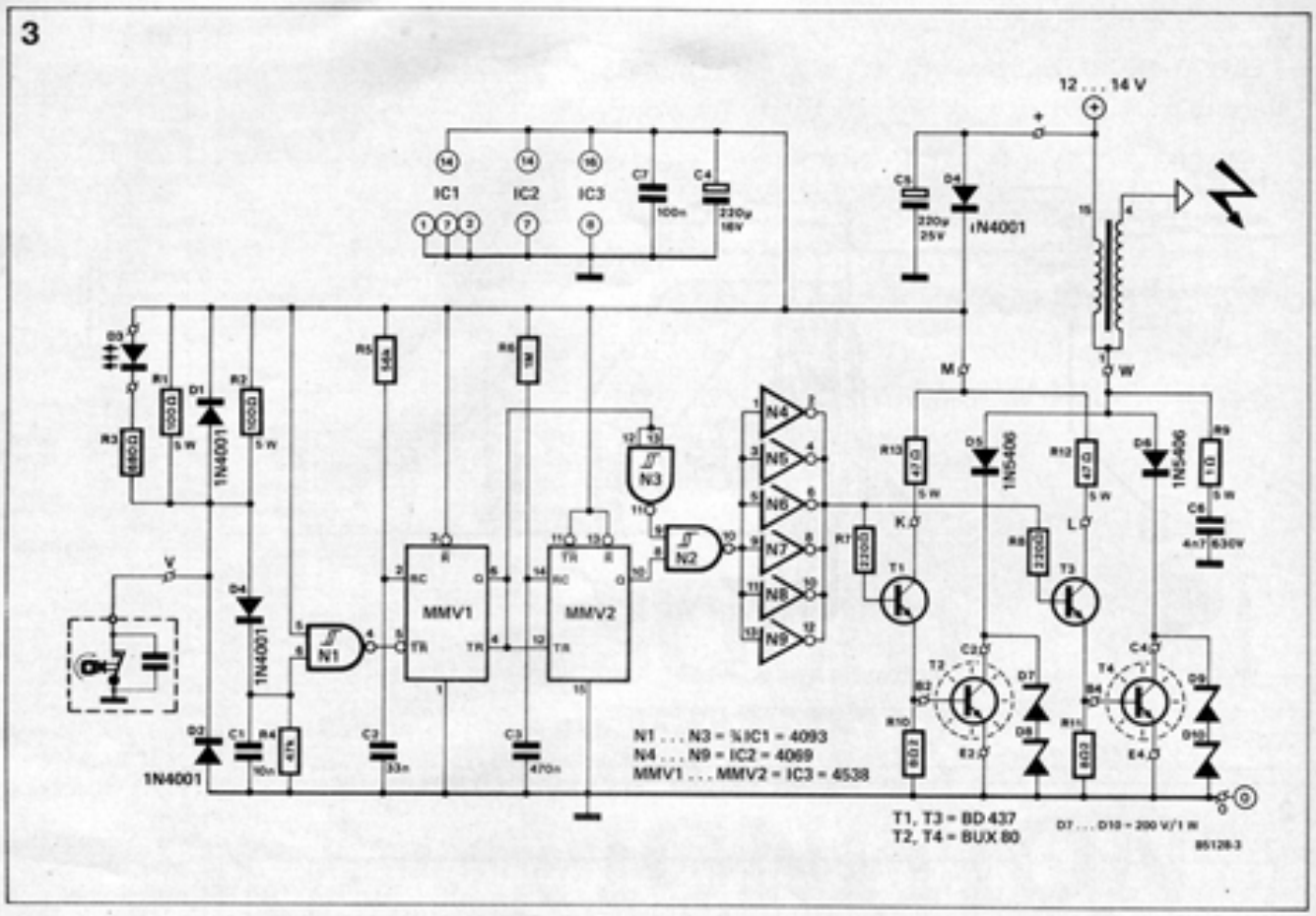


Fig. 3. The circuit diagram of the solid-state ignition system.

capacitance and inductance which, since the coil is not replaced, also occur in the solid-state system.

When the points are open, i.e., at the moment the high tension is induced, the two systems behave in an unlike manner. A voltage similar to the peak secondary voltage just before the spark-plug fires — 4 in both diagrams — exists across the primary winding and dies out only after ignition has taken place.

Once the required level of high tension is reached, the air gap in the sparking plug becomes conductive, and a spark jumps across the gap. Therefore, during the actual ignition, the full secondary voltage exists across the plug electrodes. At the primary side in the solid-state system, there is no longer the characteristic overshoot and ringing of the coil system. The energy in the secondary winding declines until it is no longer sufficient to sustain the spark, and this then dies out.

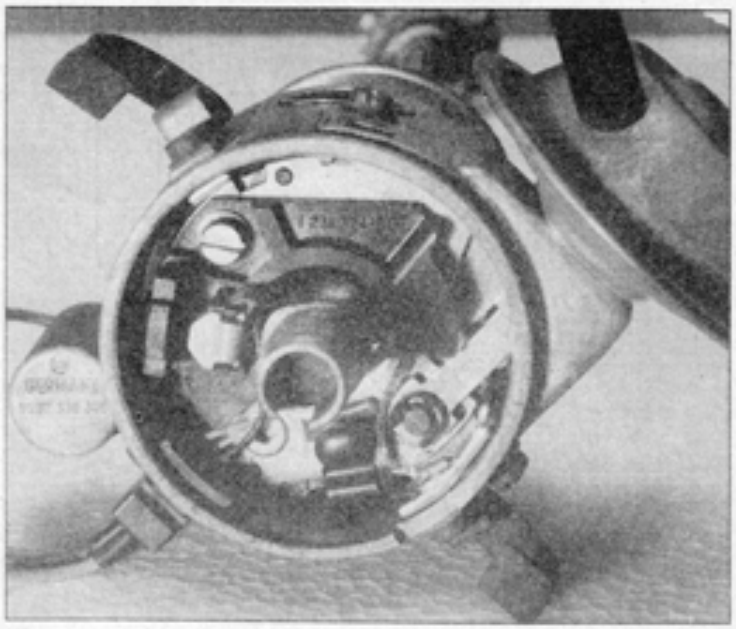
Circuit description

The voltage pulses provided by the contact breaker are reshaped by Schmitt trigger N_1 — see Fig. 3 — and then applied to monostable MMV_1. This stage has been arranged such that it provides pulses of about 1.8 ms at its Q output (pin 6). This corresponds exactly to the required spark duration.

In a four-stroke, four-cylinder petrol engine, each cylinder is ignited at every second engine revolution. Since the four cylinders must each fire at regular intervals, two sparks are required for each engine revolution. This means that at an engine speed of 6000 rev/min the interval between two sparks is 5 ms. As the spark duration is 1.8 ms, the coil has 3.2 ms to restore its energy. This period is, of course, longer at lower engine speeds.

Monostable MMV_1 is triggered at its TR input (pin 4) every time it provides a pulse at its Q output. This pulse is applied via NAND Schmitt triggers N_3 and N_2 to parallel-connected inverters N_4 to N_9 that drive the power output stages.

For safety, the output stages T_3-T_2 and T_3-T_4, have been duplicated and then connected in parallel. Diodes D_5 and D_6 and zeners D_7 to D_{10} pro-



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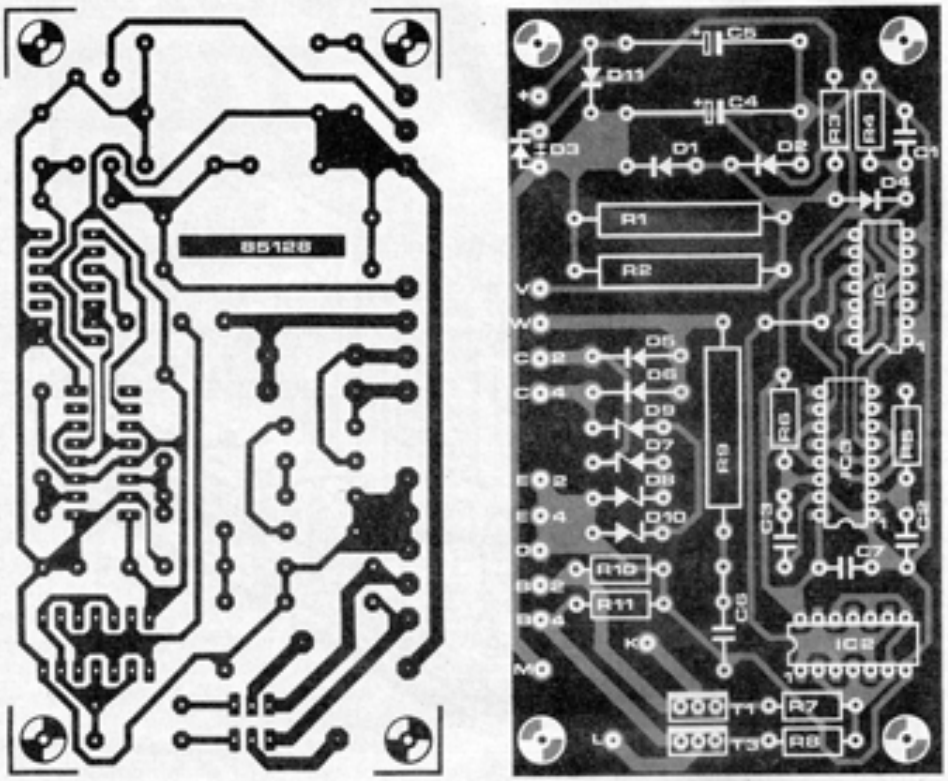


Fig. 4. The printed-circuit board for the solid-state ignition system.

tect the power stages from negative pulses and over-voltages.

Monostable MMV2 is triggered by the output pulses of MMV1 and generates for each of these a pulse of about 0.5 s at its Q output (pin 10). The duration of this pulse is determined by the time constant R6-C3. The pulse ensures that gate N2 remains open to accept control pulses. When the engine stops, the contact breaker no longer provides control pulses, and the gate closes after 0.5 s. This ensures that the ignition coil cannot burn out when the engine is not running. In that condition, parallel-connected resistors R1 and R2 allow a current of about 250 mA to prevent the contact breaker points from corroding.

Construction

When the printed-circuit board — see Fig. 4 — which is available through our Readers' services, is used, no construction problems are envisaged.

Collector resistors R12 and R13 get quite hot and must, therefore, be glued onto the inside of the lid of the metal case.

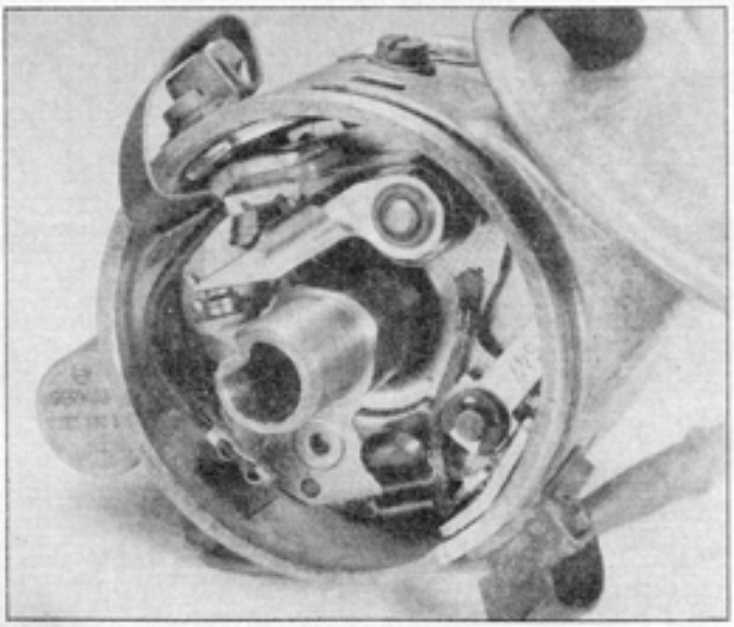
The remainder of the construction should broadly follow the lines suggested in Fig. 5. If you cannot get a cast enclosure, fit the power transistors on suitable heat sinks. Do not skimp on the heat conducting paste!

Before the ignition is fitted into the vehicle, it should be checked with an ohmmeter to make absolutely certain that it is free of short-circuits.

As shown in Fig. 5, one of the sides of the enclosure should be provided with four insulated car-type male terminals onto which the interconnecting cables are push-fitted by means of mating receptacles. These male and female connectors are available from most motorists' shops. It is advisable to fit the receptacles with insulating sleeves.

The case should be fitted under the bonnet in a position where it is reasonably well protected from water ingress.

It should normally not be necessary to alter the ignition timing. This timing can be checked roughly with the aid of diode D3, which should light when the points are closed. However, if in any doubt, the timing



Parts list

Resistors:
R1;R2 = 100 Ω;5 W
R3 = 680 Ω
R4 = 47 k
R5 = 56 k
R6 = 1 M
R7;R8 = 220 Ω
R9 = 1 Ω;5 W
R10;R11 = 8.2 Ω
R12;R13 = 47 Ω;5 W

Capacitors:
C1 = 10 n
C2 = 33 n
C3 = 470 n
C4 = 220 µ;16 V
C5 = 220 µ;25 V
C6 = 4.7 n;630 V
C7 = 100 n

Semiconductors:
D1;D2;D4;D11 = 1N4001
D3 = LED; red
D5;D6 = 1N5406
D7 to D10 = zener diode 200 V;1 W
T1;T3 = BD437
T2;T4 = BUX80
IC1 = 4093
IC2 = 4069
IC3 = 4538

Miscellaneous:
Heat sinks for two TO-3 transistors; not required if a die-cast aluminium box is used
Insulating plates — preferably Teflon — for mounting the power transistors
2.5 mm² stranded wire as required
4 car-type male terminals and mating receptacles for fitting with M3 size self-tapping screws
four insulating bushes for use with M3 size screws
metal — preferably die-cast — case 120 × 95 × 30 mm; if a die-cast case cannot be obtained, use thick aluminium sheet
PCB 85128

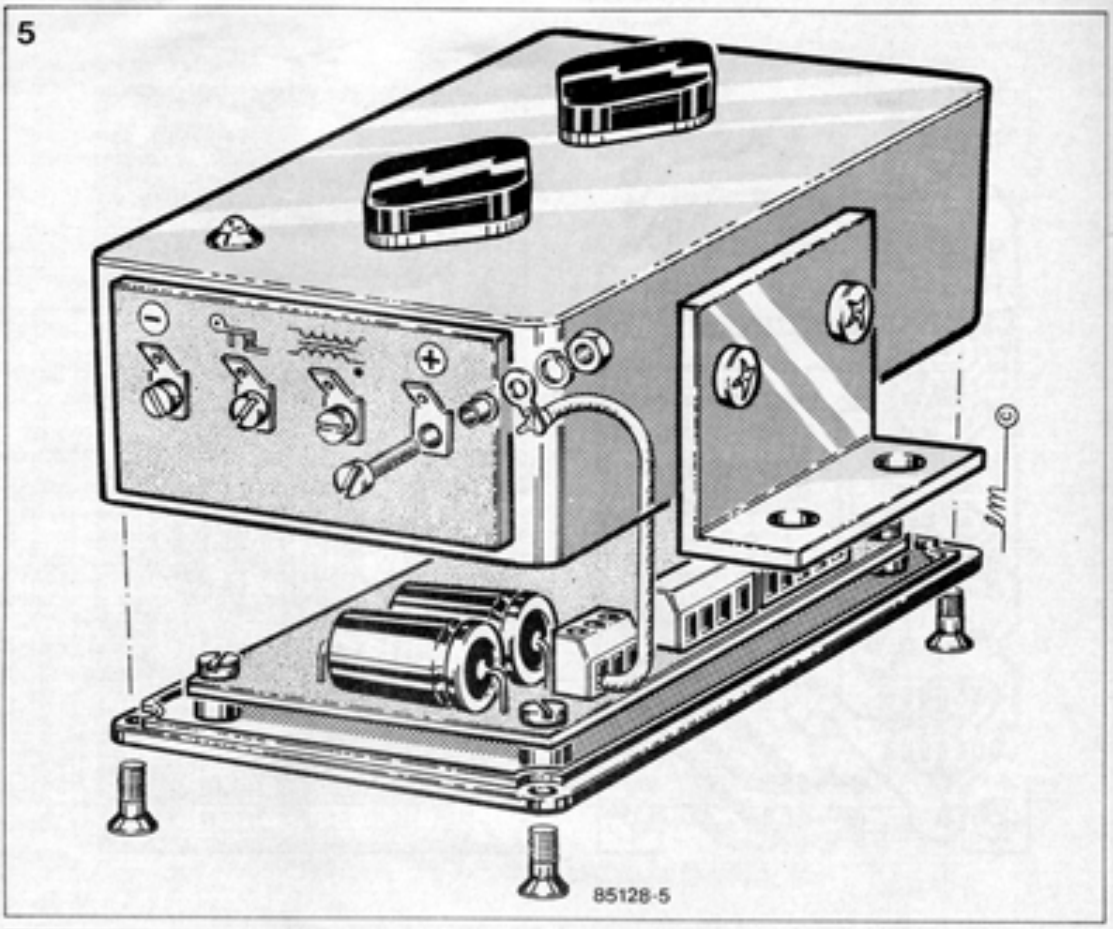
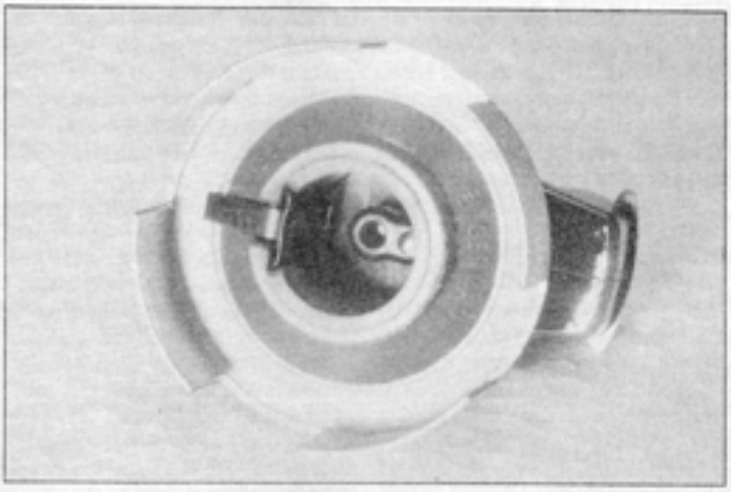
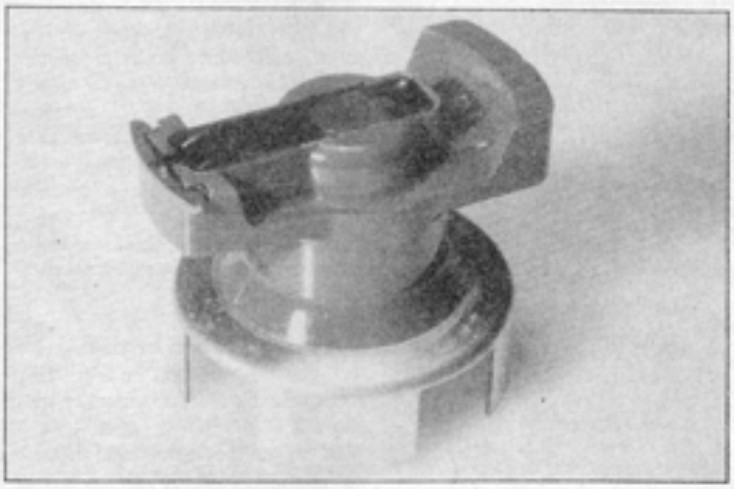


Fig. 5. Artist's impression of how the solid-state ignition system may be constructed and housed.





should be checked properly with a stroboscope with the engine turning over at constant speed.

In some cars, a resistor is connected in series with the ignition coil. This resistor, which is shorted out when the engine is started, must not be removed. Apart from the connection to terminal 1 of the coil, i.e., that to the contact breaker, all wiring in the car remains as before. If the car is fitted with a revolution counter, this should remain connected to terminal 1 of the ignition coil.

FINALLY A WARNING: WHEN THE ENGINE IS RUNNING DO NOT UNDER ANY CIRCUMSTANCES TOUCH THE TERMINALS OR COMPONENTS OF THE IGNITION SYSTEM. BECAUSE THE HIGH TENSION PRESENT AT VARIOUS PLACES MAY BE FATAL.