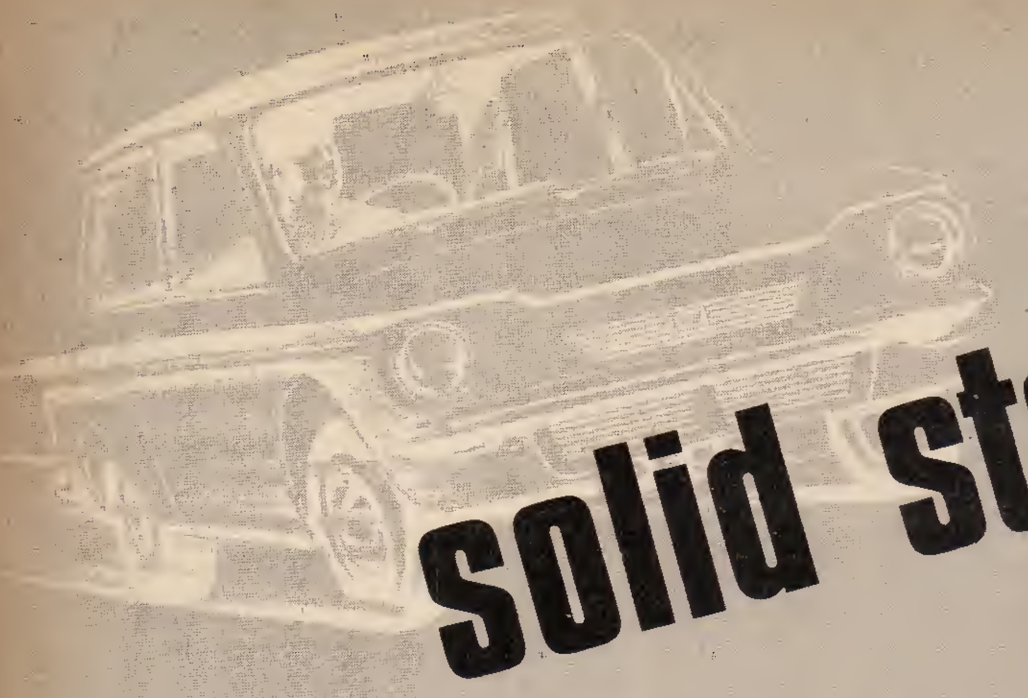


solid state

DURING recent years there has been an increasing number of electronic ignition systems offered for sale. This article sets out to enable the experimenter to build himself a system of compatible design to the commercial units but at a cost more suited to his pocket.

Before entering a detailed discussion of the relative merits of electronic ignition systems a brief description of the conventional battery/coil ignition system as used in most cars will be helpful.

CONVENTIONAL FORM

Fig. 1 shows a typical car ignition circuit. When the ignition switch is closed the battery is connected across the primary of the ignition coil while the contact breaker points are in the closed position. This allows the current through the coil to build up to a maximum value determined by the battery voltage and primary coil resistance.

When the engine is rotated the points are opened and the current ceases. The field built up around the coil by the current through it then collapses inducing a voltage in the primary. Since the primary winding is magnetically coupled to the secondary, a voltage is also developed in the secondary winding equal to the primary voltage multiplied by the turns ratio as in any normal transformer.

Typical primary values can be between 200 and 400V and secondary values between 20,000 and 40,000V. The high tension voltage is then applied to each plug in turn by the distributor. This system however has several disadvantages listed below:

(1) The high current broken causes arcing and hence a high rate of wear of the points.

(2) As engine speed increases so the "dwell" time during which the points are closed decreases. This means that the time available for the current to rise to its final value is reduced and hence the output voltage is decreased.

(3) When the points close at high engine speeds they bounce due to mechanical inertia reducing further the time available for the current to rise. The total effect of items (2) and (3) is to reduce the output voltage drastically as engine speed increases.

(4) At low speeds the system is inefficient because the current drawn from the battery is excessively high, since the points are allowing the current to flow after it has reached its maximum value. This wastes energy in heating up the coil. In fact it is well known to readers with cars that at zero engine speed with the ignition left on and points closed the coil will eventually burn out.

So an improved ignition system requires that current through the points be reduced or in fact the points should be removed altogether. This is done by using an inductive pick-off to provide the trigger pulses for the electronic ignition systems of many racing cars. Secondly, the high voltage output should remain essentially constant over the entire speed range of the engine and the current drain should be reduced at low speeds. Electronic systems meet these needs quite well.

ELECTRONIC SYSTEM

Because most cars already utilise points, it is difficult (unless designing a system from scratch) to replace them, so they are retained in most available commercial systems. Most of these get over the other problems mentioned by using the points to switch the base current of a transistor which in turn switches the much greater primary coil current by its collector/emitter.

The transistor has to be capable of withstanding peak voltages of 400V or more and peak currents of several amperes. In addition a different coil with a higher turns ratio must be used to get the best results, enabling the primary voltage to be reduced and the rise time of the secondary voltage to be improved.

IGNITION

by E. BARNETT

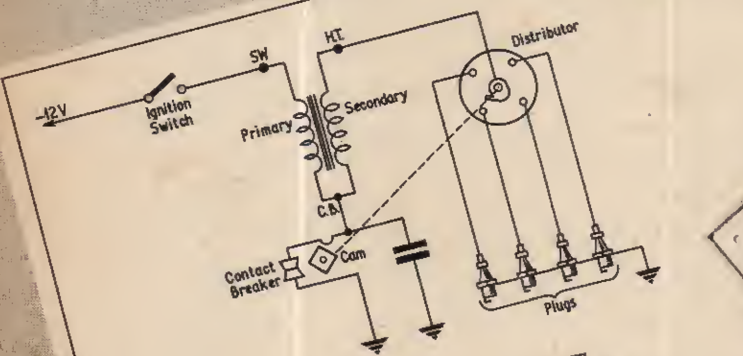
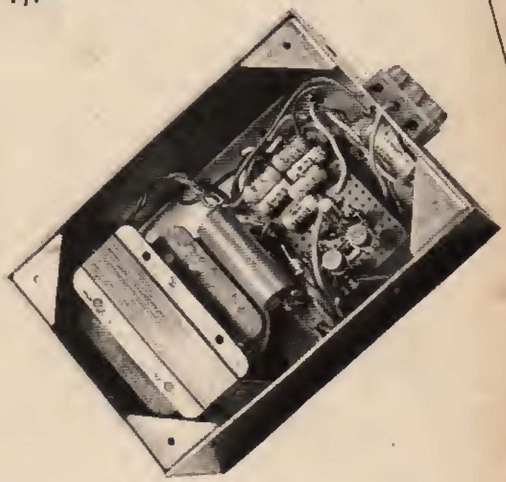


Fig. 1. Typical conventional ignition circuit



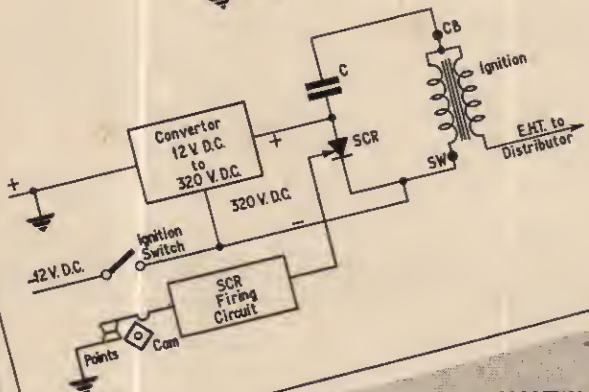


Fig. 2. Capacitor discharge system

Both of these items are costly in the single transistor and coil system.

A second approach, as used in this article, is the capacitive discharge method. Quite simply, a capacitor is charged to the required primary voltage during the "dwell" period of the points, and is then connected across the coil when the points open, thus discharging into the coil.

SYSTEM DESCRIPTION

Fig. 2 shows a schematic diagram of the capacitive discharge system. The d.c. supply for charging the capacitor is generated by a normal converter circuit which charges the capacitor to about 300V d.c.

The points are connected to a trigger circuit, the output of which is connected to the gate of a silicon controlled rectifier (s.c.r.) or thyristor. When the points open the trigger circuit applies a pulse to the thyristor causing it to "fire" and connect the capacitor across the primary of the ignition coil to discharge into the coil.

When the oscillatory current through the ignition coil reverses, allowing the thyristor to turn off and the power supply to start again the capacitor recharges.

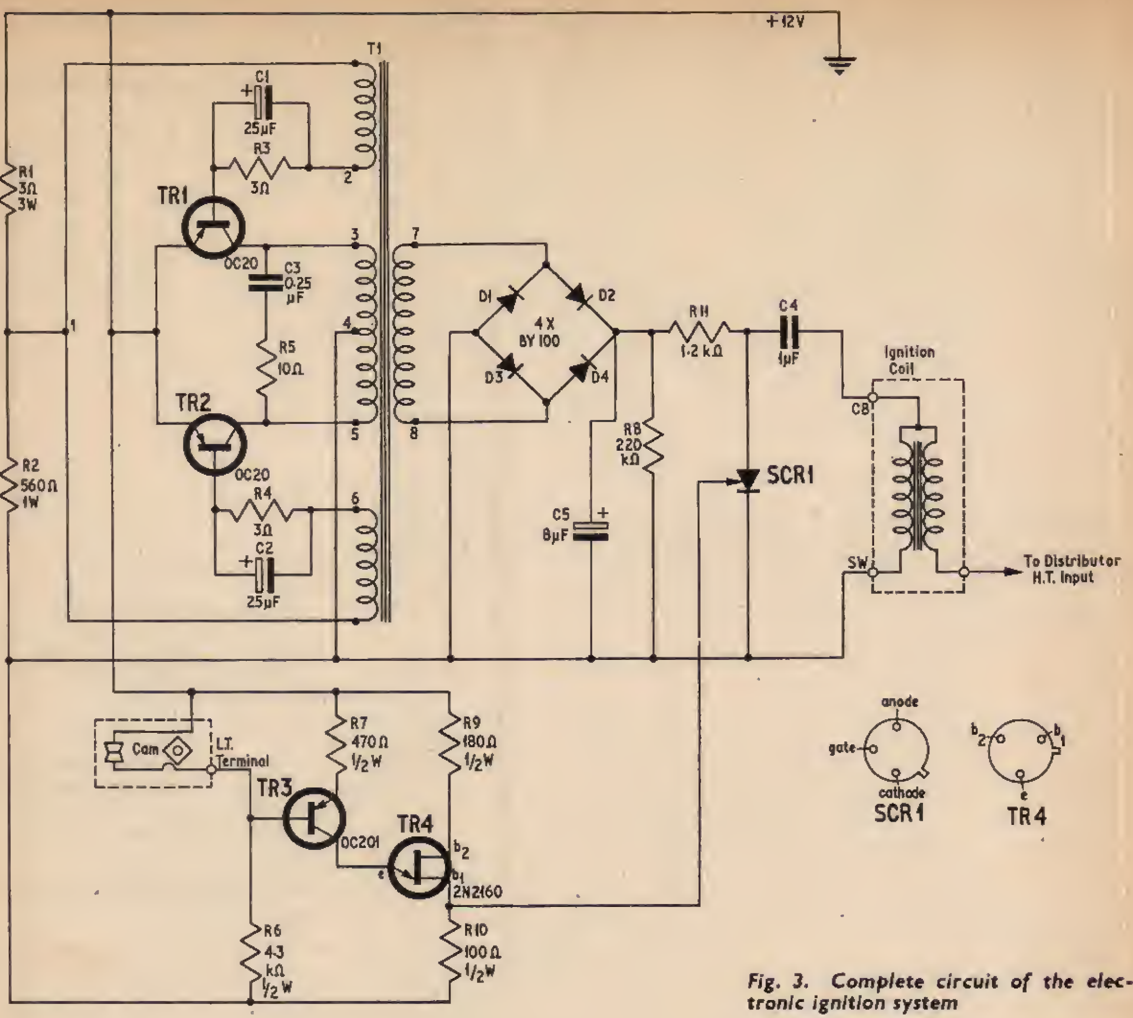


Fig. 3. Complete circuit of the electronic ignition system

CONVERTER

The heart of the converter consists of two *pnp* transistors TR1 and TR2, and the transformer T1, which together form an inverter oscillator (see Fig. 3). When the ignition switch is closed the voltage applied to the circuit causes bias current to flow through TR1 and TR2 base–emitter junctions and R2.

Due to the slight differences that usually exist even between matched transistors, one of the two transistors conducts more than the second. The one which conducts more current (via its collector–emitter junction through its relevant half of the transformer primary winding) induces a feedback voltage in a positive direction to its own base and turns itself on. At the same time it induces feedback voltage in a negative direction to the second transistor, causing that transistor to turn off.

The current in the first transistor rises linearly with time, whilst the voltages across its half of the primary feedback winding and the secondary winding remain constant, i.e. square wave output. The primary voltage is derived from the 12V battery supply, whilst the secondary provides a stepped up voltage determined by the turns ratio to approximately 320V peak.

The current eventually reaches the saturation level of the transformer core and/or the conducting transistor "bottoms". Whichever occurs first, there is no longer any increase in collector current of the conducting transistor to maintain a magnetic field about the transformer.

At the instant of saturation the current in the conducting transistor rises sharply to a value limited by the gain of the transistor multiplied by its base current, so the transistors used are quite robust electrically. The field about the transformer collapses, reversing the voltages previously induced in the transistor feedback windings and causing the second transistor to turn on and the first to turn off. The process then repeats cyclically. The transformer output voltage is fed into a bridge rectifier, the d.c. output of which is used to charge C4.

CAPACITOR DISCHARGE

While the contact breaker points are closed the thyristor presents a high resistance in its forward direction and C4 remains charged to the maximum output of diode bridge D1–D4. When the points open, the firing circuit applies a trigger pulse to the thyristor gate electrode. When it fires the thyristor discharges C4 into the primary of the ignition coil. A high voltage, with a waveform like that shown in Fig. 4, is induced in the secondary of the ignition coil, where it is applied to one of the spark plugs via the distributor.

The thyristor is turned off when C4 has fully discharged into the ignition coil. The field built up around the coil collapses causing the voltage on terminal SW on the coil to swing negative with respect to that on the CB terminal (point "a" in Fig. 4). At this point the current through the thyristor falls to zero causing the thyristor to be reverse biased and hence turn off. At the end of the negative voltage swing across the coil, the capacitor retains a small positive charge (point "b" in Fig. 4). Most of the energy in the field around the coil has been dissipated by this time and the converter starts up again quickly recharging C4.

FIRING CIRCUIT

The requirements of a thyristor gate firing circuit are that it should provide a pulse of very fast rise time, short duration and of amplitude great enough to fire the thyristor under all conditions, yet be less than the gate maximum ratings. The unijunction transistor (u.j.t.) has been developed specifically for this purpose.

The "earthy" side of the points in most British cars is connected to the positive side of the battery via the engine and bodywork (positive "earth" car electrical systems) and so the trigger circuit has been designed to work from this type. *This system will not operate on negative "earth" systems.* When the points are closed the base of TR3 is held positive with respect to its emitter holding the transistor cut off. With TR3 off the emitter–base one (b_1) of the u.j.t. is non-conducting due to the high "off" impedance between TR3 collector and emitter. Only the interbase (b_2 to b_1) bias current of a few milliamps flows through R9 and R10, the voltage across R10 thus being negligible.

When the points open the positive bias is removed from TR3, which is turned hard on by its base–emitter current through R6 and R7. Due to the negative resistance characteristic of the u.j.t. emitter–base one (b_1) junction, the voltage at the u.j.t. emitter rises rapidly to approximately six to eight volts before it conducts, producing a short pulse across R10 firing the thyristor.

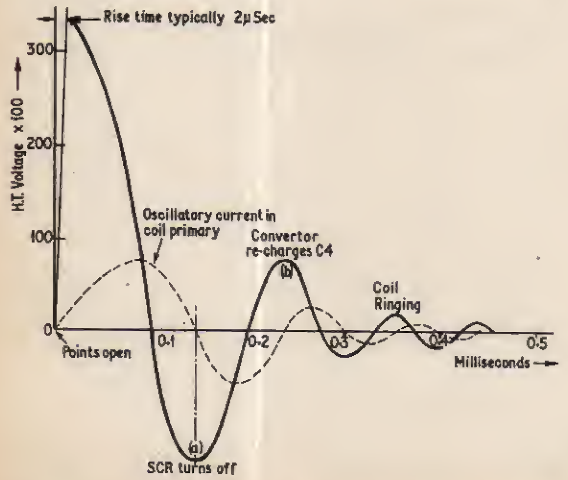


Fig. 4. Voltage induced in the coil secondary winding

COMPONENTS . . .

Resistors

R1	3·3Ω	3W	wire wound	R6	4·3Ω
R2	560Ω	2W	carbon	R7	470Ω
R3	3·3Ω	3W	wire wound	R8	220kΩ
R4	3·3Ω	3W	wire wound	R9	180Ω
R5	10Ω			R10	100Ω
R11	1·2kΩ	2W			

All resistors 10%, ½W carbon except where otherwise quoted

Capacitors

C1	25μF	elect.	25V
C2	25μF	elect.	25V
C3	0·25μF	paper	150V
C4	1·0μF	polyester	400V
C5	8μF	elect.	400V

Transformer

T1 Repanco Type TT51

Semiconductors

TR1, TR2 OC20 (Mullard) (2 off)
TR3 OC201 (Mullard)
TR4 2N2160 (International Rectifier, Hurst Green, Oxted, Surrey.)
SCR1 2N1599 (Davis & Whitworth Ltd., 220–4, West Road, Westcliff-on-sea, Essex.)
D1–D4 BY100 (4 off)

Miscellaneous

Chassis 6in × 4in × 2in with cover plate
Veroboard, 2in × 2¼in, 0·015in hole matrix
Heat sink compound (International Rectifier)
Terminal block strip, bushes and mica insulators
Solder tags

CONSTRUCTION

The majority of the circuitry is mounted on Veroboard which is housed in a small aluminium box chassis measuring 6in × 4in × 2in deep along with the converter transformer T1.

The converter transistors TR1 and TR2 are chassis mounted; it is important that all burrs are removed after drilling the mounting holes as it is so easy to puncture the mica insulator that is used to insulate collector from chassis. Heat sink compound (silicon grease) should be applied to the undersides of the power transistor to effect a good heat transfer to the chassis. In view of the degree of vibration that the unit will experience, locking or shakeproof washers should be used under all nuts.

There should be no difficulty with the wiring and component layout if Figs. 5 and 6 are followed; however it should be noted that the silicon rectifiers D1–D4 and the higher wattage resistors should be mounted about ¼in away from the board to allow maximum air circulation.

The simplest form of stand-off mounting for the board is a section of terminal block with a 4BA; ¾in screw holding the board and block to chassis with a nut and lock-washer fixing.

PRELIMINARY CHECKS

If possible it is wise to test the various parts of the circuit before attempting to instal it in the car.

To check converter output, join a wire link from the centre connection of the terminal block (2) to chassis; apply a 12 volt d.c. source to the circuit board with negative to terminal block 1 and positive to chassis. The output from the d.c. side of the diode bridge D1–D4 should be approximately 300 to 350 volts.

Next, to check the thyristor and trigger circuit operation, connect a 100 kilohm resistor in series with a small neon indicator lamp between chassis and connection 3 of the terminal block; keep the wire link that was used in the first test. Switch on the 12V power supply and open the wire link. The neon should flash once at the instant of opening the link. Immediately afterwards turn off power supply.

INSTALLATION

When installing the unit it is most important to mount it in the coolest place possible. A cable run of 4ft is permissible and it may be possible to use more according to the user's individual experiences. For front-engined cars the space between the front grill and

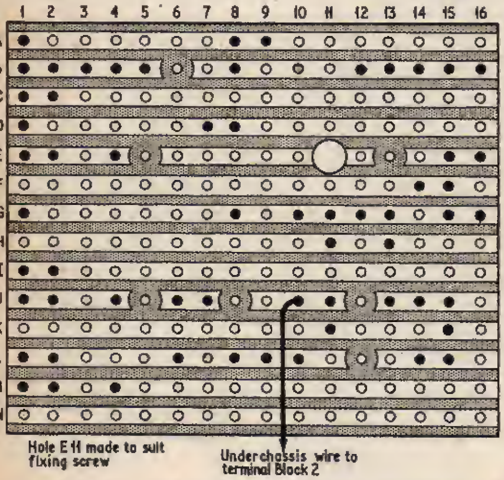


Fig. 5a (above). Underside view of the component board showing the copper strip breaks and connections

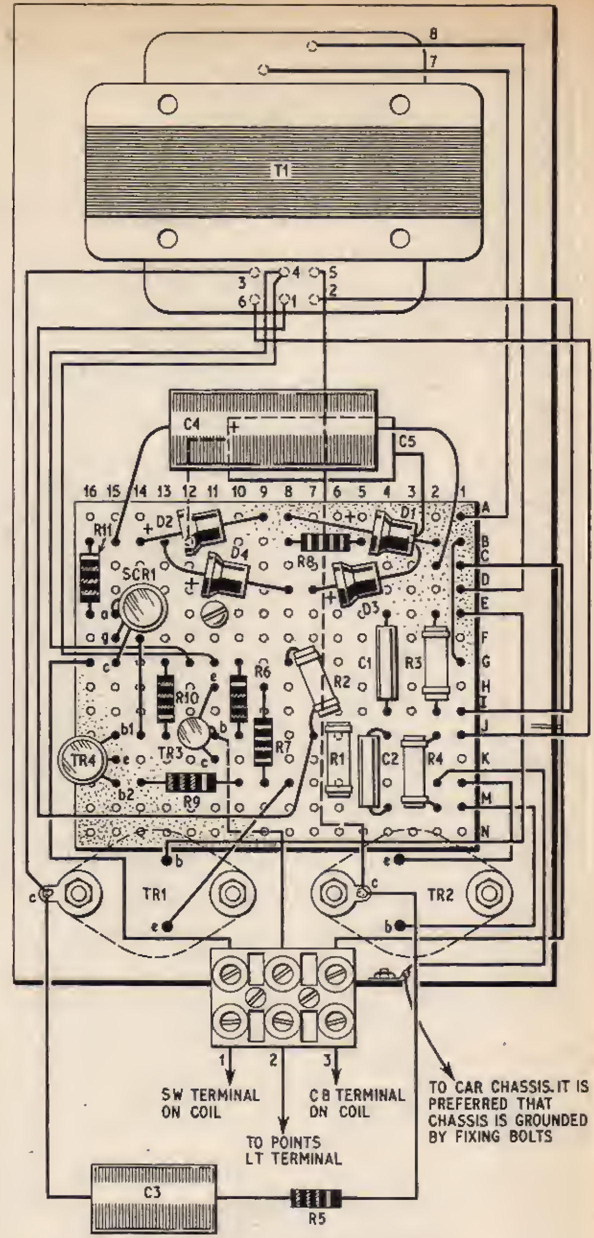


Fig. 5b (right). Layout of the complete circuit in the chassis box. TR1 and TR2 are mounted on the outside of the chassis; connections are as viewed underneath

radiator can be used where the airflow is maximum. On rear-engined cars the unit can be mounted beneath the rear so that the airflow keeps it cool.

For good heat transfer from the unit to car chassis; bolts or screws with generously dimensioned washers should be used so that the washers transfer any heat away from the transistors and chassis; locking washers under the fixing nuts will provide a shakeproof mounting.

The chassis of the unit is at earth potential (i.e. + ve battery) so ensure a good connection exists between it and the car bodywork by cleaning away any paint or rust before tightening up the fixing nuts.

To connect the unit into the existing system is a very simple operation. A cable-form of three 7/·0076 p.v.c. covered wires must be made up and fixed to the "terminal" block on the ignition unit. The following steps are then carried out with reference to Fig. 6.

(a) Remove the lead from the "CB" terminal on the ignition coil and connect it to terminal block position 2.
(b) Connect terminal 3 to the "CB" terminal on the ignition coil.
(c) Connect terminal 1 to the "SW" terminal on the coil.

PERFORMANCE

Improvements in overall petrol consumption will depend upon many things: manner of driving, the size, condition and efficiency of the engine. But if only a 2 m.p.g. improvement is obtained over 9,000 miles on a car which normally does 30 m.p.g. the total saving more than covers the cost of the unit.

Needless to say the life of the contact breaker points is virtually the same as that of the car and although financially this improvement is small, in convenience it is worthwhile.

When the starter turns the engine over slowly the greater efficiency of the unit will provide a far better spark. Also the plugs will remain cleaner and last longer. In fact the plugs that would normally be rejected for use with a conventional ignition system should work perfectly well with this system. ★