Electronics in cars

measure
fuel consumption in mpg

improve
the ignition system

control
the windscreen wipers

read about
cars in the Eighties

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There are many transistor/thyristor ignition systems being produced commercially but they all seem to suffer from one disadvantage or another. In this article we describe a system which combines the most significant advantages of all the others, including the conventional type. This recipe, mixed with a few of our own ideas, results in the Elektor **transistor ignition system** — a spark for all seasons?
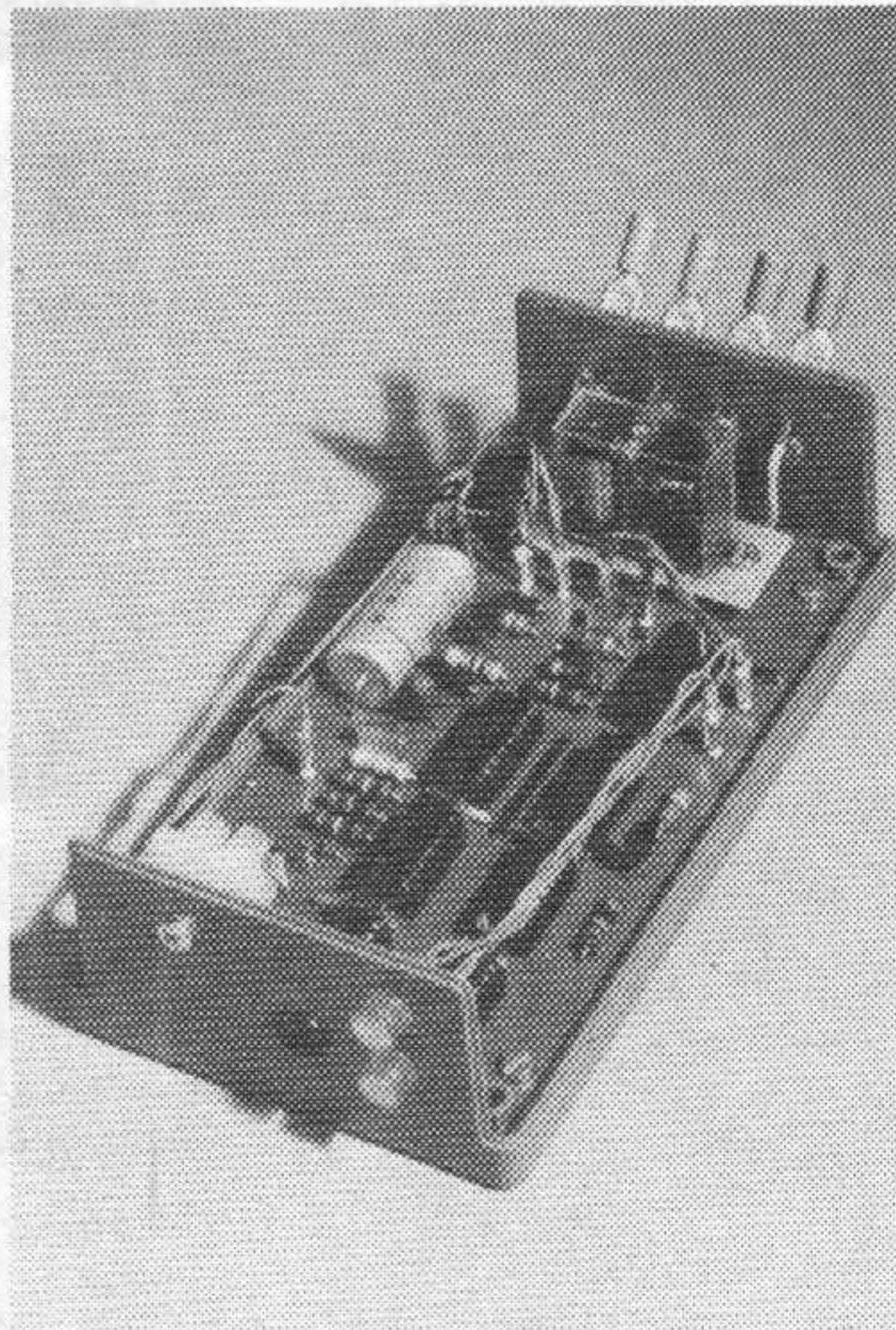
page 4-18
An extremely annoying aspect of poor windscreen wipers is that they are fine — until you have to use them. We unfortunately are unable to do anything about that but we can help them cope with varying weather conditions. How? By designing an **intelligent wiper delay** circuit!
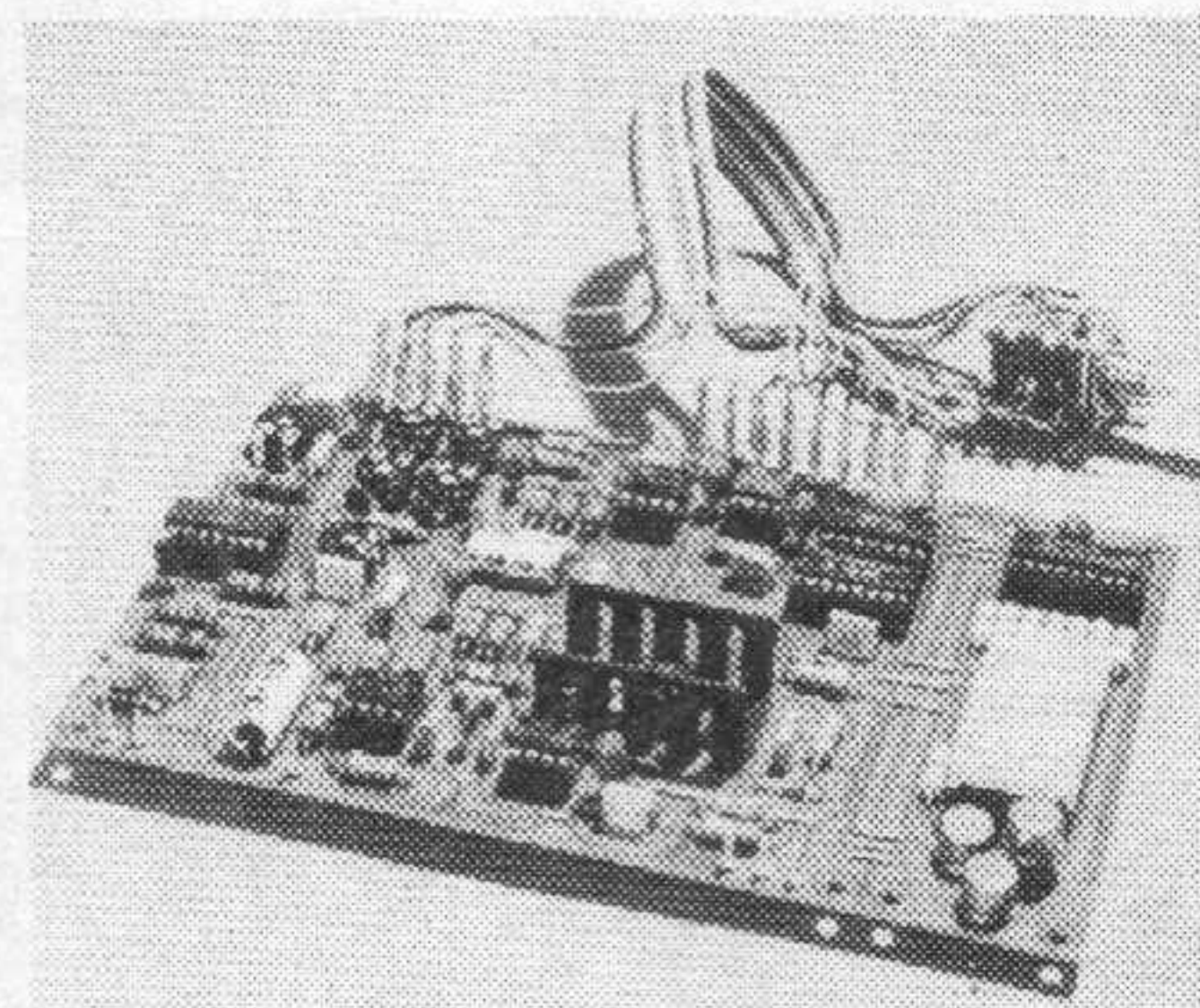
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Do you waste fuel by poor driving? For most drivers (like us) it's all guesswork. The only way to know what's really happening as you drive is to use an instant **fuel consumption meter**. A unit, in other words, that gives instant indication of your present fuel consumption in miles per gallon.

As this month's cover illustrates, this issue is devoted to cars. More specifically, electronics in cars. We have a feeling that at least some of the ideas presented here will find their way into the cars of the future. But why wait? They can all be built and installed now!

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Automative electrics in the 'Eighties'

As we enter the 1980's the motorists of Europe — often led by over-optimistic motoring journalists — are waiting impatiently for the great breakthrough in battery technology which will come in the next few years, will sweep away the world's dependence on oil with all its political implications, and will herald the age of the electric passenger car. Unfortunately, as experts from many areas point out, the prospect is not quite so exciting as that.

Constant development

The first fact to remember is that as in most technologies, 'breakthroughs' seldom come in dramatic form and all at once. Although a hundred years old, the conventional lead-acid battery which we all use in our cars has been the subject of progressive breakthroughs during most of its life. These developments have accelerated during the past two decades, and although the battery you buy today may *look* similar to those on the market twenty years ago, in practice it is different in almost every detail. Its container, its seperators, the design and configuration of its vents, the design of its plates and the composition of the alloys used to make them, have all dramatically changed — mainly in the interests of improved life and reliability, and above all to obtain the greater power for less weight and size, on which modern car designers insist.

Lead acid has by no means yet reached the end of the road, and there is plenty of room for creative technical development, enabling the designer to emphasise whatever performance characteristics are required by the motoring public at the time — currently, low maintenance, which will be prominent in the Motor Shows of 1980 and 1981 and which will be dealt with in more detail later in this article.

The electric car

But such developments to this conventional arrangement of internal-combustion engine plus lead-acid battery for starting, lighting and other services will not satisfy the eager motorist who wants to see an all-electric car, to reduce the world's dependence on politically-unstable and increasingly expensive oil supplies.

There is a great deal of historical logic in this. Electric cars competed very successfully with petrol-engined designs in the early days of motoring — they even held the world's land speed record, and 'electric broughams' were the carriages of Royalty and the aristocracy.

Problems of power supply

Professor Bird went back to the familiar petrol hose on the garage forecourt, as a base from which to begin his study, and some frightening figures emerged.
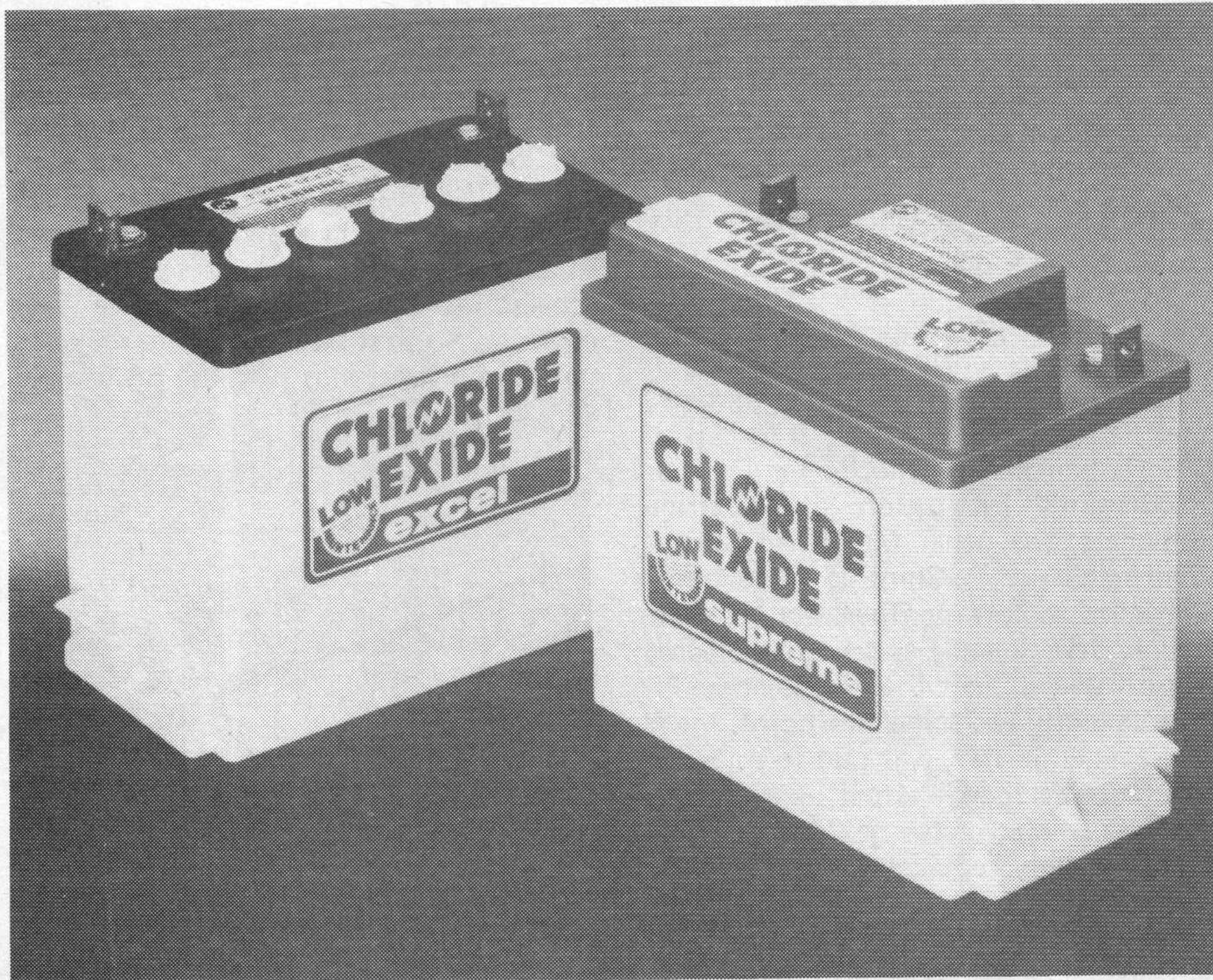
Les us examine what happens in terms of energy and power when a petrol tank is filled. If it is assumed that it takes one minute to fill a ten-gallon tank and that one gallon of petrol contains 45 kWh of energy, when the total energy transfer which occurs during that one minute at the petrol pumps is 450 kWh, and the

rate of transfer of this energy — i.e. the power flowing through the filler hose — is 27 MW. Thus filling a petrol tank on a garage forecourt can be equated to taking the entire output of a 27 MW power station for one minute and it can be said that a motorway forecourt with 20 petrol pumps represents the energy equivalent of a 550 MW power station.

This is clearly a significant calculation for electric transport and contains a host of engineering implications. It is valuable to look at this energy equivalence from a different viewpoint. If a vehicle is plugged into the domestic 13 A mains for 12h overnight, a maximum energy transfer of 37 kWh occurs, which can be equated to the energy content of less than one gallon of petrol.

The implications are obvious. To obtain an electric vehicle which has similar characteristics to the i.c.-engined vehicles is extraordinarily difficult, and the use of electricity for transport purposes could be expected to require a radically different engineering approach in order to achieve a satisfactory performance.

The industrialist's view

The industrial view, expressed by Mr. Burnet, is equally forthright, though he naturally saw the problem from the practical point of view of the Motor Industry and its customers.

The effect of the energy crisis is likely radically change the design of cars, which in turn will have an important influence on battery design. However, with an electric car or truck costing approximately twice the price of its internal combustion equivalent and with the internal combustion engine having such advantages of convenience, flexibility and economy for ordinary motoring, the public will continue to use it in most circumstances. Many battery manufacturers are deeply involved in development work on electric vehicles with the belief that the performance of electric vehicle batteries for commercial trucks can be increased by 50%. This, plus the necessity to reduce urban pollution and the need to save energy, may well cause electric vehicles to capture 10% of the 1 - 5 ton road transport market by the end of this century.

Unfortunately, traffic conditions, performance and other requirements have all changed since and electric power *for private motoring* is no longer viable — nor does it seem likely in the foreseeable future.

A number of prominent designs have appeared in the past ten years, some of

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which are still in the early stages — ranging from an experimental car by Fiat, with front wheel drive and room for two passengers and 20 kg of luggage, to a much more ambitious town car now being developed in America, with thermostatically controlled heaters to facilitate fast charging of a specially designed lead-acid battery. But they are all restricted to a cruising speed of about 50 mph and a range of about 50 miles, which although acceptable in a town delivery vehicle is of little use to the ordinary business or family motorist.

Two points of view

The present situation of the electric vehicle has recently been analysed in depth by two leading authorities, one, a scientist — Prof. B.M. Bird, M.Sc. Chairman of the Power Division of Britain's Institution of Electrical Engineers; the other Mr. David Burnet, Chairman of Chloride European Automotive Battery Operation. It is not always that Science and Industry agree, but on this subject they both homed in on to exactly the same viewpoint.

The academic view was that in spite of a substantial research effort, it is unlikely that the lead acid storage battery will be substantially replaced by advanced technology (such as sodium sulphur) much before the end of the 20th century. The industrial one was that most people in the motor industry, as well as motorists, are likely to see the internal combustion engine's dominance

continue throughout their working and motoring lives.

The reasons for this unanimity between two sides of the fence, which do not always see eye to eye with each other, was clearly spelt out by both.

Remembering that electric delivery vehicles have already proved to have great practical advantages in safety, silence and flexibility and are already in extensive use, points the way to significant developments.

Granted that new battery technologies are not going to transform road transport overnight, then what is the energy crisis likely to do to the Motor Industry?

Petrol at £ 2 a gallon in a Mini is no more expensive than £ 1 a gallon in a Rover 3.5. It has taken us seven years to get from 30 pence a gallon petrol to a pound a gallon yet it seems reasonable to believe that it is not going to take us too long before we get to £ 2 a gallon in the 1980s. In the next decade we are going to see a very rapid trend towards smaller and much lighter cars with fewer accessories in order to improve fuel economy so that buyers have to make as few compromises as possible on vehicle size.

Chloride Automotive Batteries Limited.

(538 S)

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Spectacular boost in semiconductor sales

According to a 323 page report published in two volumes by Frost & Sullivan Inc. there will be a terrific increase in sales of semiconductor memories on the European market. The turnover during 1978-1982 will increase by 230% (from 210 million dollars in 1979 to 494 million in 1982) and production is expected to rise from 2.88 billion bits in 1978 to 17.7 billion in 1982. These figures correspond to Elektor's predictions on IC memories in this year's January issue. The enormous increase in sales over the next five years will be remarkable and the general trend will be for bits to drop in price. Now it will be possible for IC memories to be adapted on an even larger scale. As we mentioned once before, this will cause the rate of development, in audio technology especially, to accelerate.

Table

Expected developments on the West European market in semiconductor memory sales per sector (turnover in millions of dollars):

	1979	1980	1985	1990
Computers	238	298	650	1136
Industry	13	18	54	113
Private Enterprise	7	10	30	109
Others	4	6	24	62

Until 1985 production in dynamic and static RAM's will soar and at the same time, the introduction of double pole memories will be more wide spread. CCD's and bubble memories, however, will only gradually take on more importance. The F & S report once again confirms the fact that American companies completely dominate the semiconductor memory market. Intel Corporation takes the lead by owning 25% of the shares. In Europe, Texas Instruments comes second with 18%, while Mostek, having 13.3%, has rapidly gained third place. As far as the Japanese are concerned, only Nippon Electric Corporation (NEC) have managed to reach the top ten.

For further information, contact:

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104-112 Marylebone Lane,
London W1M 5FU.

(542 S)

electronics in the car of the eighties

The recent progress in electronic technology has been extremely rapid but, however, the motor industry has been rather slow on the uptake. At a time when awareness of the energy crisis is ever increasing, automobile designers are, at last, turning to microelectronics in an effort to increase the efficiency of motoring in many aspects — not the least of which is engine control.

Electronics in the engine

Saving fuel is undoubtedly the most significant factor in today's motoring and is almost certain to remain so in the foreseeable future. A flexible and 'intelligent' control system will enable the engine to remain fully efficient while catering for the many and various motoring conditions which occur. One example of this is an electronic ignition control system of the type that is currently gaining more widespread use (mainly in the performance car market). After the initial developments such as the transistor ignition and fuel injection systems under mechanical or analogue-electronic control, an important step forward was recently taken by Bosch designers with their introduction of digital motor electronics or 'motronics'. It consists of an integrated digital control system governing both the ignition and fuel injection. At the heart of this system lies — what else? — a microcomputer.

Figure 1 gives the block diagram of an engine control unit which will be familiar to the electronics designer. A row of sensors, pulse generators, pulse shapers or analogue-to-digital converters, enables the microcomputer to gather the necessary information about the state of the car at any instant in time. Information on the position of the crankshaft, manifold depression, and the carburettor butterfly is fed to the microcomputer.

According to the assembled data, sampled at a rate of up to 400 times a second, the requirements of the ignition and fuel injection systems are calculated. Data concerning the correct moment of ignition and fuel metering are read by the computer from its memory. This has the following advantage: the computer's built-in program determines the type of control required. Thus, the circuit can be adapted for different levels of engine power and different types of fuel (methanol, for instance).

Figure 2 shows the ignition characteristics stored in memory at the time of ignition as compared with a 'normal' range of characteristics found in a transistor ignition system (figure 2b). How the various adaptations affect the engine is noticeable in the amount of fuel consumed.
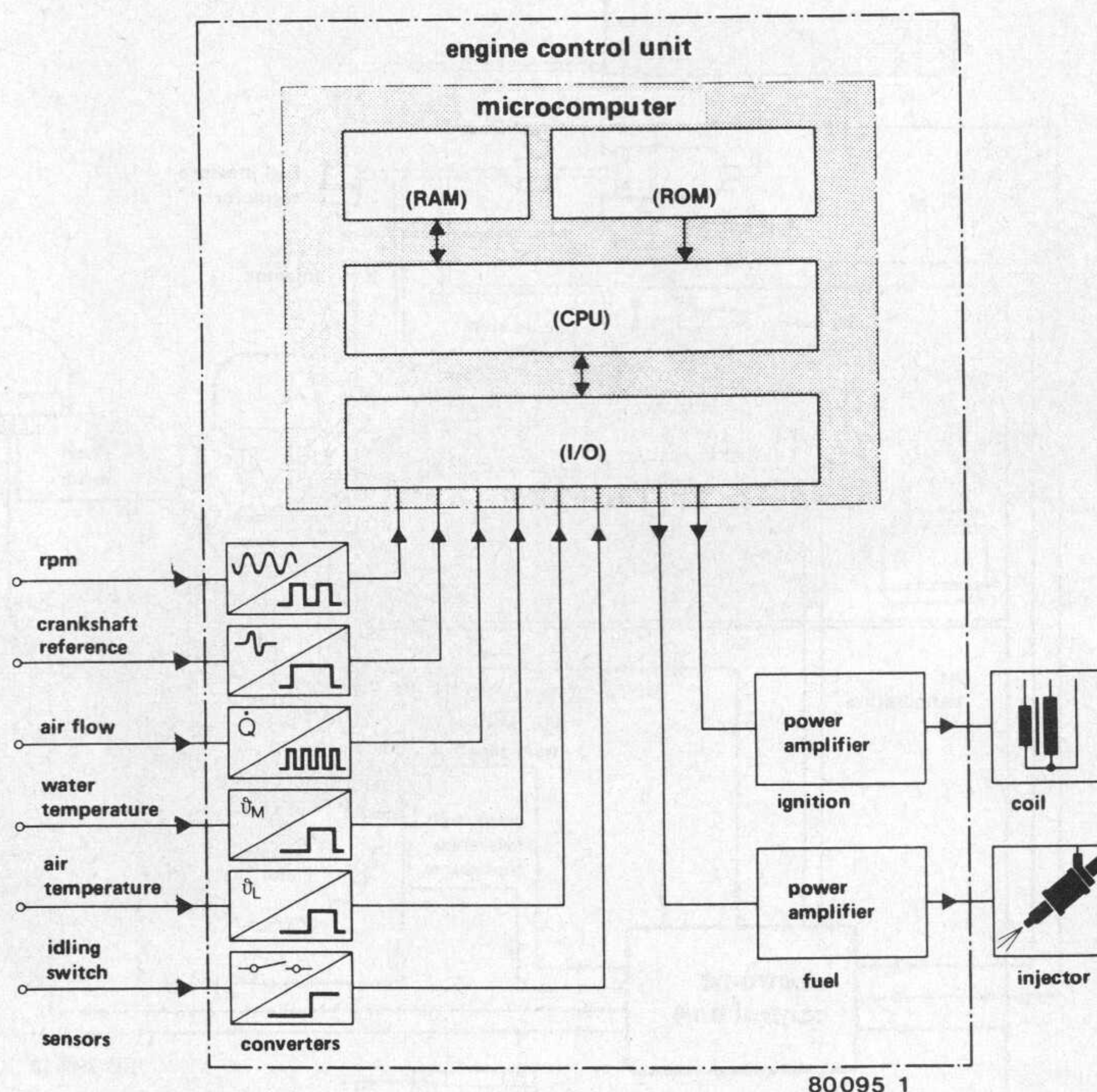
Figure 3 gives an overall picture of the

1

Figure 1. Block diagram of the engine control unit. The microcomputer assembles data from the various sensors to calculate the exact requirements of the fuel injection and ignition systems.

entire system. The highly compact control unit shown in photo 1 has been in production since the summer of 1979. The components and mechanics involved have to comply with tough environmental requirements, before they can be considered to be reliable. They must be able to withstand an impact of 100 G and have a temperature range from $-40°C$ to $+140°C$.

Microcomputer motronics could also be introduced into a 'drive control' system. This would involve the introduction of a central electronic unit to monitor the entire driving system and would eventually lead to further improvements in fuel consumption and driving standards. What will be important to further development depends not so much on electronics, which has already made sufficient progress, as on sensors and control units which will have to drop in price and rise in efficiency.

Electronics for driving safety

Electronic aids to brake systems were an important development during the last decade. Work started on an Antilock Brake System (ABS) during the sixties as part of a co-operation between Daimler-Benz and AEG-Telefunken. The system, which originally consisted of analogue electronics, was converted to digital processing at Bosch.
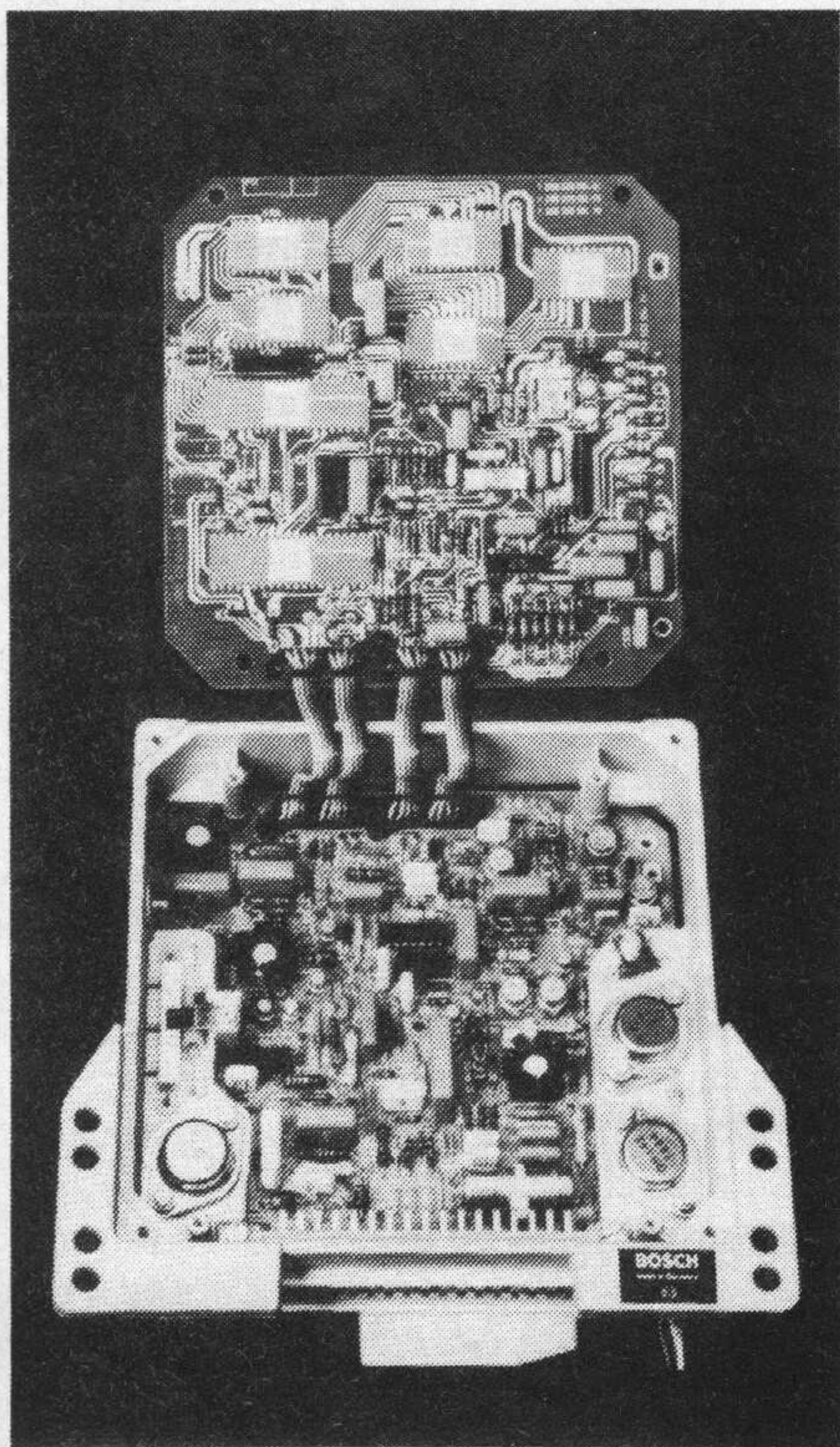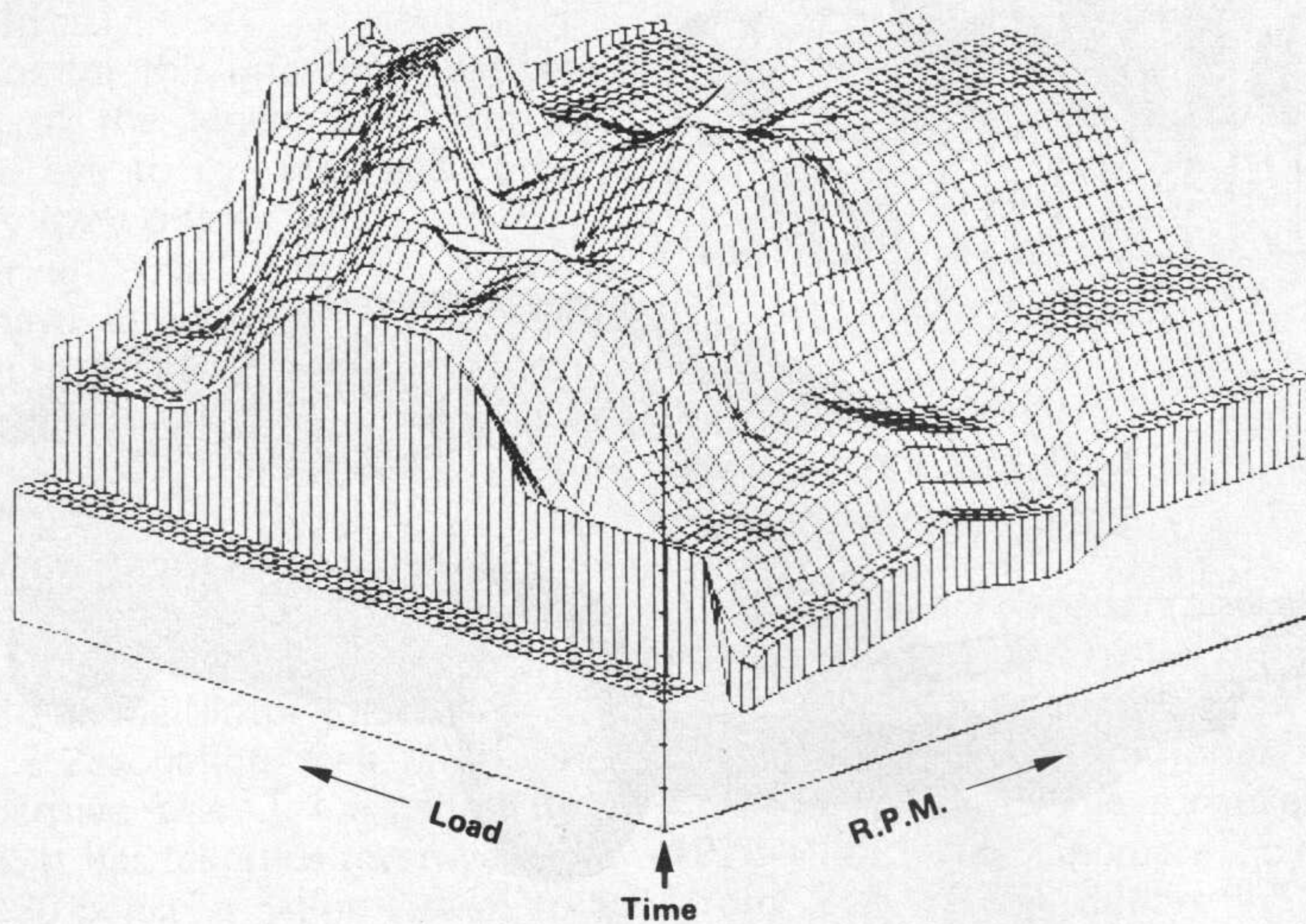
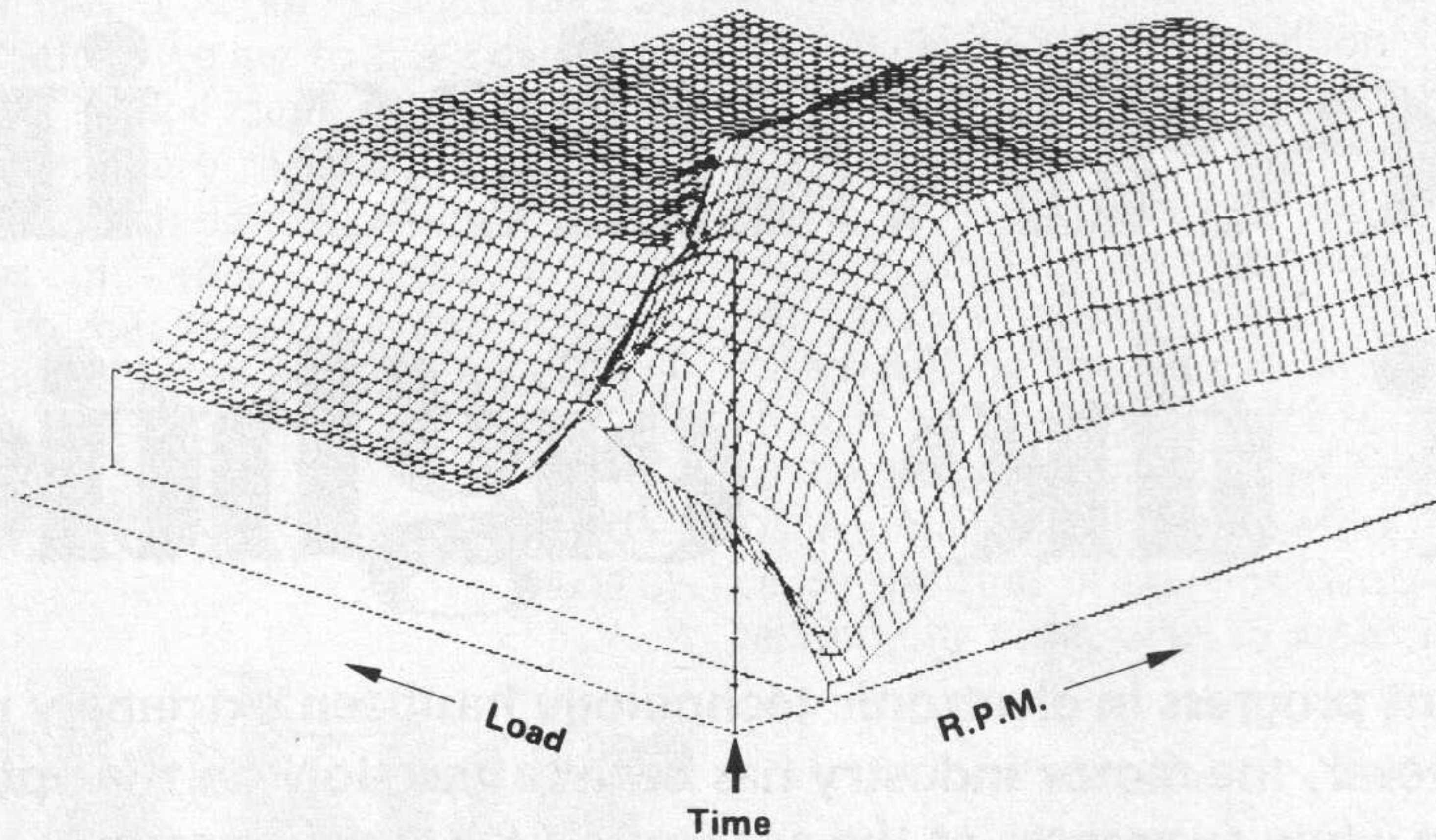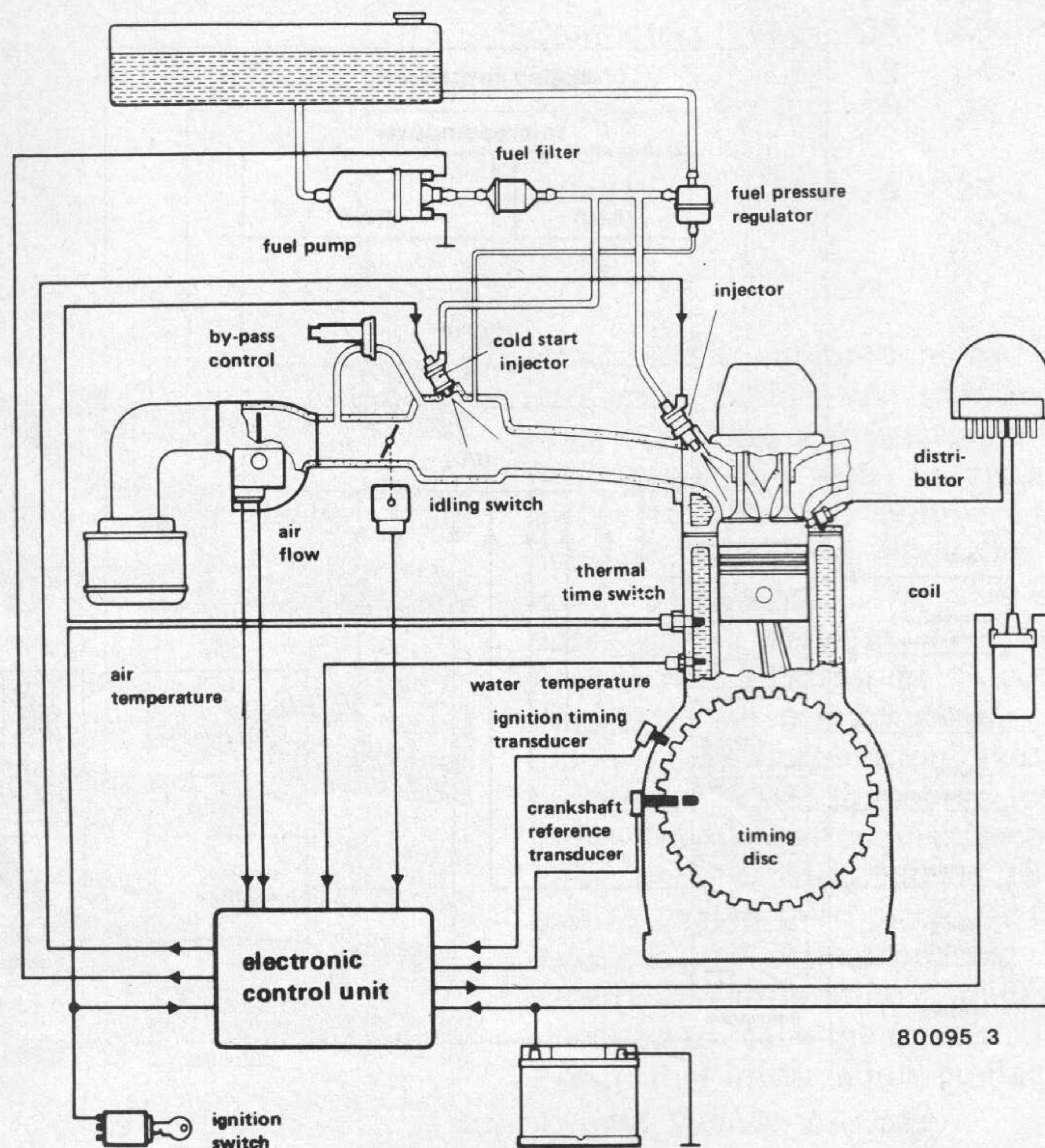Photo 1. The heart of the Bosch Motronic engine control system.

2a

80095 2a

b

80095 2b

Figure 2. Comparison of the ignition characteristics stored in the Bosch engine unit (2a) and those of a conventional transistor system (2b).

3

80095 3

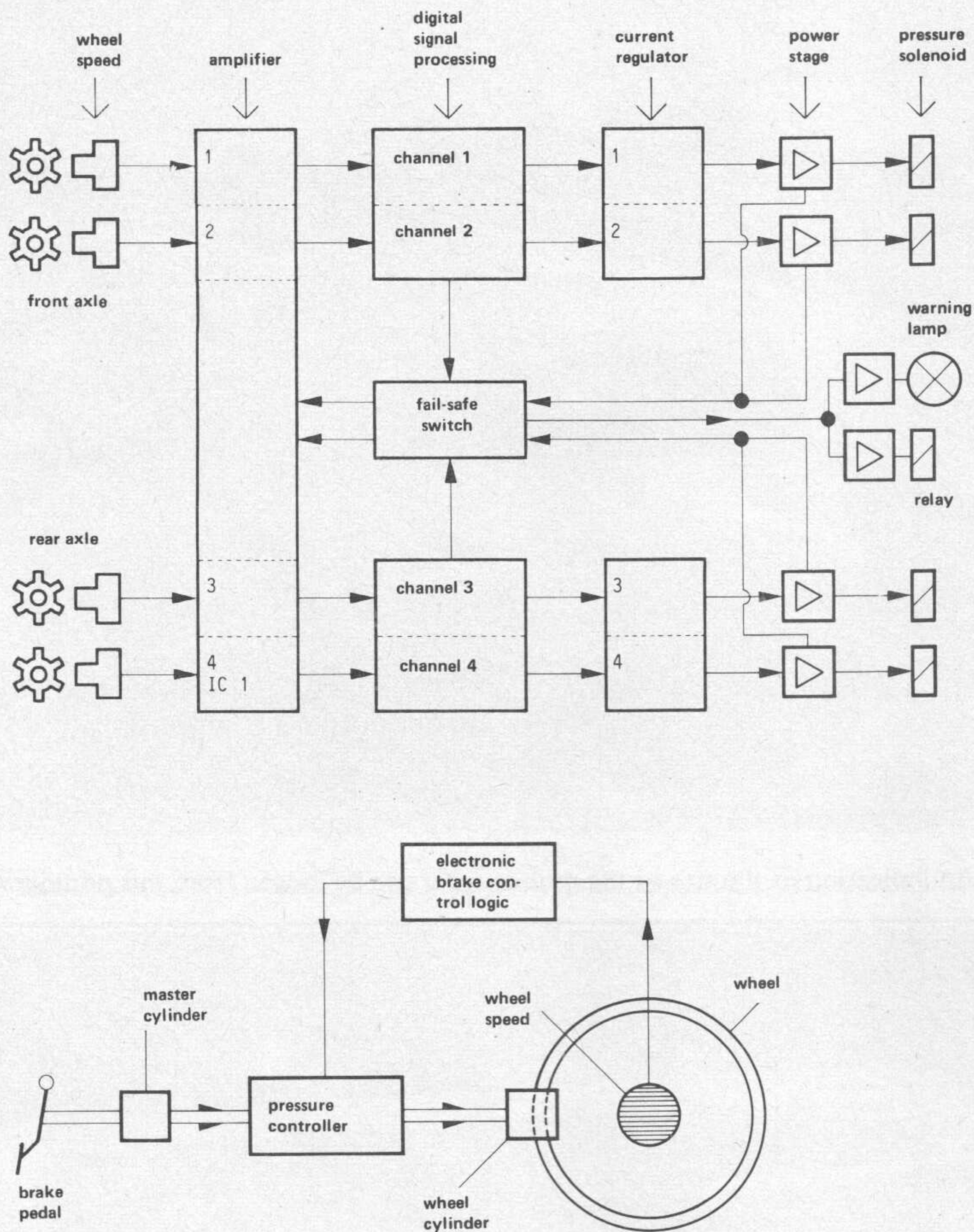Figure 3. Overall view of the entire engine control unit system.

4

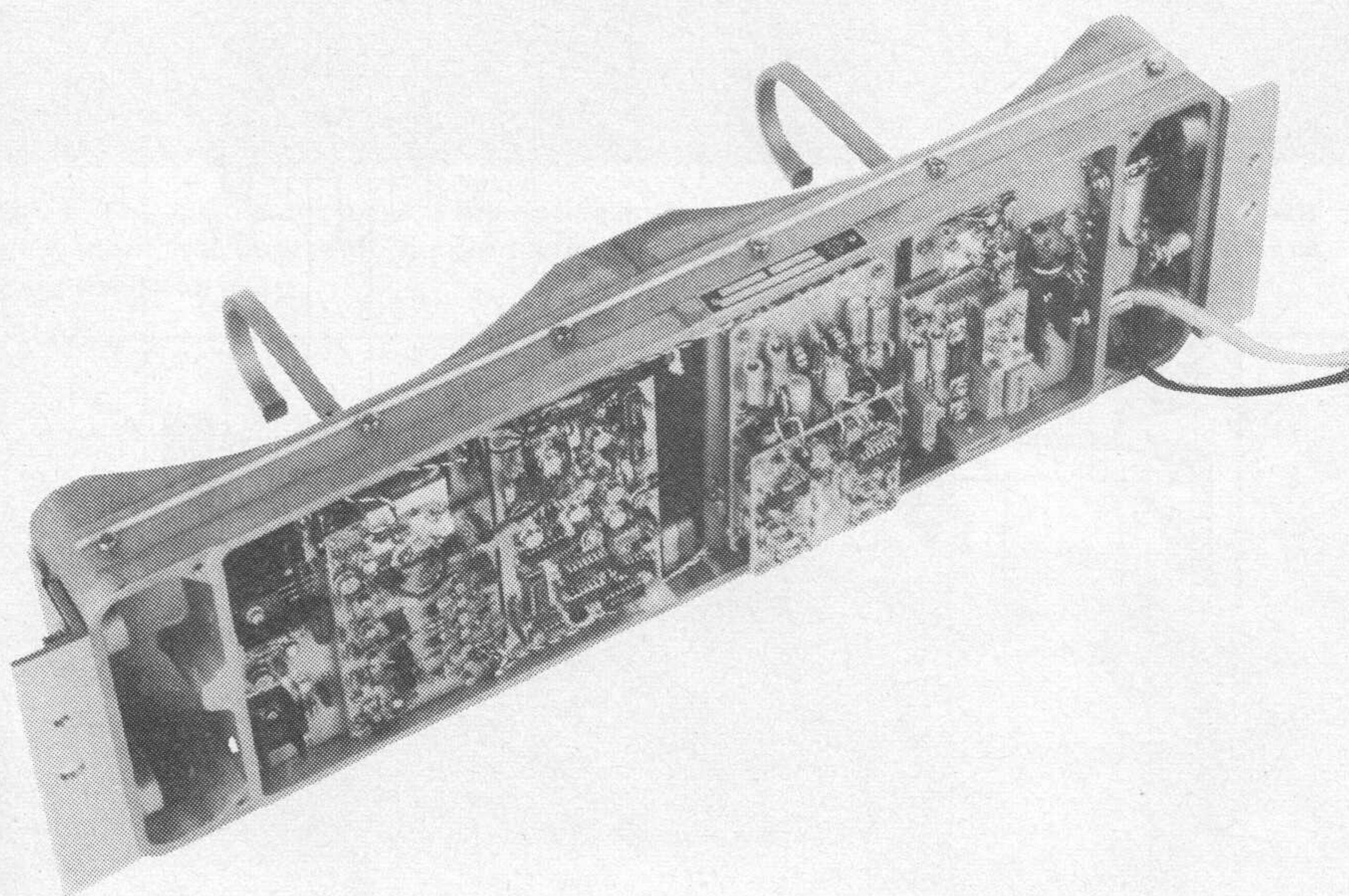Figure 4. Block diagram of an anti-lock braking system.

5

Photo 2. The transmitter and receiver aerials of this radar controlled proximity detector can be clearly seen at the top of this picture.

Figure 4 illustrates the principle behind the operation and gives the layout of the controls. Sensors attached to every hub detect the number of wheel revolutions. When the vehicle is braked violently and the wheels risk being locked, strobing electronics recognise this and operate a hydraulic brake pressure modulator, thereby reducing the brake pressure to a safe level. This works independently for each wheel, so that the best possible brake effect may be obtained. This system gives excellent results as test reports have shown that braking time is improved and the danger of skidding is significantly reduced. The security of the system itself has also been taken care of. When the engine is started, a test circuit checks the system and all its components are constantly monitored while driving. If an error is detected, the ABS switches over to the normal braking system and an indication is given to the driver.

Mobile radar

Another important safety aspect being developed is the remote control warning system using radar for distance calculation (see photos 2 and 3). In several countries wide scale tests are being carried out on a number of vehicles at the very high frequency of 35 GHz. Pulses of 300 mW are radiated and a reflection from a vehicle in front is then detected by the instrument with the aid of a separate receiving aerial. The interval between the transmitted and reflected pulses will determine the distance between the car and the obstacle ahead. This information enables the correct driving speed to be calculated and this will be indicated on a screen. It is a proximity detector incorporating a radar system which fulfils this task with the aid of a microcomputer.

From a technical point of view, there are still a few problems to be solved with regard to frequencies at which the system will not work — especially in narrow bends for instance. There are also psychological problems. Either the driver may become too familiar with the alarm (and not let it 'sink in'!) or he may find it so disturbing that he will switch it off.

Tyre pressure warning

This early warning system (see figure 5) informs the driver if a loss of pressure in any tyre is detected. While the wheel is turning, the tyre pressure data is conveyed to the chassis via transmit and receive coils. The system operates at a resonant frequency when the tyre pressure is normal. The receiver func-

tions as a grid dip meter and therefore any change in tyre pressure results in a change at the output of the receiver.

Systems monitor

Of great importance to safe driving, is the automatic systems monitor (see photos 4 . . . 7). Firstly, the on-board computer relieves the driver of this task and secondly, it can give fair warning of errors in the system and of any dangerous situations which may occur. Furthermore, long-term requirements can be indicated, for instance, the need to renew the brake linings or the spark plugs. The warning or other data may be given either via a visual display or in an accoustic manner, that is, a different sound for each specific warning. Visual indications may now be provided in 'bright' alphanumerics.

The future of the on-baord computer is still open to speculation. Some believe that having such a mathematician in the car will provide more amusement than safety. However, we !eave that aspect open to debate.

Power-ring

The development of digital electronics has led to something new in car electronics: a ring circuit which will replace the many individual cables. This incorporates a control system for the binary coded addresses and commands. At the same time, the load functions may be checked and reported back to the control multiplex centre and to the computer.

The dashboard switches will no longer be connected directly to the electrical components (lights etc.), but to the multiplex centre. Every accessory will have its own multiplex slave station which receives addresses and commands from the centre, acknowledges them and then converts them into actions, for example, lights are switched 'on' with a relay. The advantage of such a system is that the same hardware and multiplex centre may be employed in all vehicles. Adaptations may be made by means of individual programming (software). In the long run, fibre-optic cables will also be applied.

Electronics for easy driving

Electronics also serve to make driving more comfortable. A recent example of this is the newly developed seat positioning memory system now in production in America. Pre-programmed seat positions can be selected at the push of a button for a number of different drivers.

Heating and ventilation may of course be electronically controlled. Even elec-

Photo 3. An indication of the size of the mobile radar can be judged from this photograph.
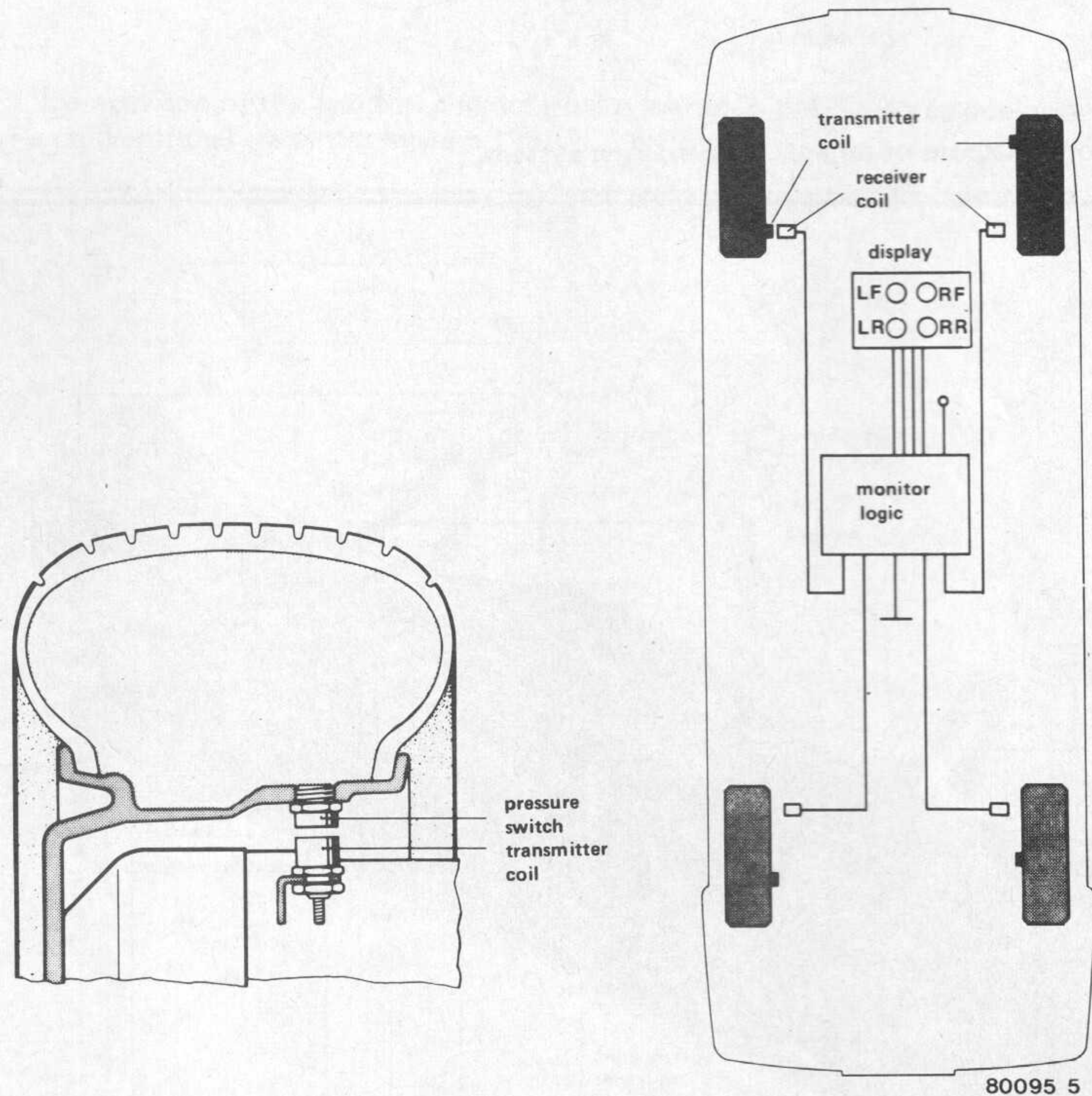

Figure 5. Tyre pressure early warning system. Pressure loss in any tyre is detected via the transmit and receive coils.

cars.80

Photo 4a and 4b. The results of a design study by Ford into the extensive use of electronics in motor vehicles. The car, Probe 1, does actually exist and apparently Ford even have a driver for it.

tronic anti-theft systems may be introduced. Bosch has come up with a very simple design consisting of a gradient detector and a small computer with a memory. When the driver leaves the vehicle, the state it is in at that moment is stored as data. When something occurs to alter it, for instance when someone tries to remove the wheels, the alarm goes off. Hard luck for the would-be car thief!

In the light of all the examples given above, it is highly unlikely that the car will become any cheaper to run, considering the expensive sensors and the mechanical and hydraulic components involved in electronically controlled systems. On the contrary, the high requirements with regard to quality will make driving more expensive, if anything. Electronics is therefore only worthwhile in the car where it saves energy and thereby counteracts rising fuel costs.
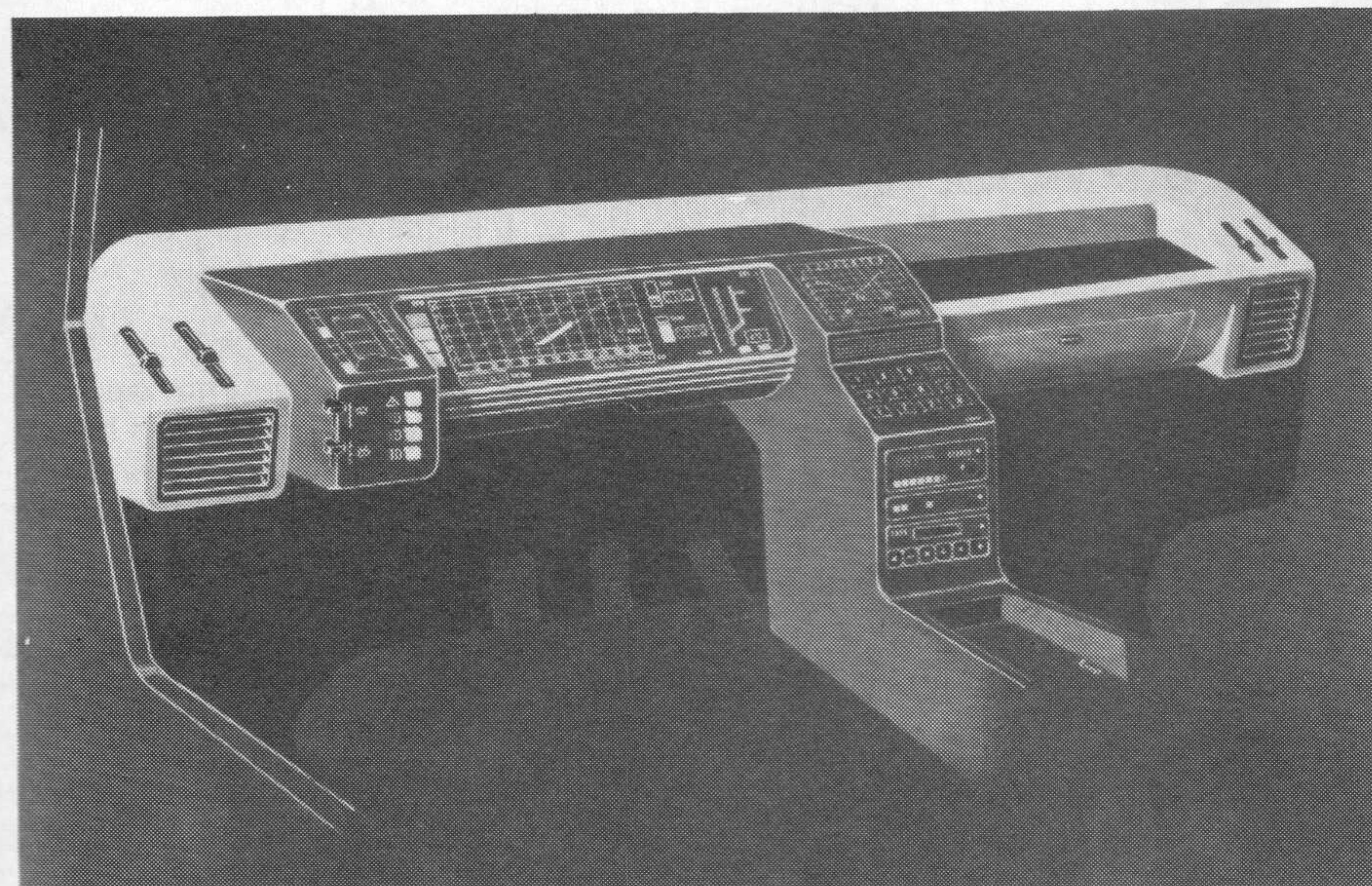

Photo 5. This instrument panel is interesting in that it is a complete liquid crystal display, and what is more, is almost ready for production. The top right hand information is a reminder to change the brake pads.

Photo 6 and 7. Two illustrations of current design thinking where electronics play a significant role in instrument panels.

The dashboard of an up-to-date car displays such an array of push-buttons and switches that the driver sometimes feels he is controlling an earthbound rocket instead of a workaday automobile. Small wonder that is difficult to remember to switch them all off! Unfortunately, many of them regulate battery-run equipment and, especially as far as the headlights are concerned, a moment's forgetfulness could mean a long walk home on a cold night. (For people living in Yorkshire this might be quite a problem!) However, a solution has now been found in the form of an 'intelligent' battery protection circuit. This particular circuit monitors the battery voltage level, and when this drops below a certain safety limit it

battery protection

Don't let your battery leave you in the dark

Forgetting to turn off the headlights need no longer be a motorist's nightmare. The circuit described here is designed to monitor the battery voltage and switch off the lights automatically in all kinds of motor vehicles. Since driving has become as essential to everyday life as it is expensive, the introduction of such a circuit into your car will no doubt be an 'intelligent' solution.

causes the headlights to be turned off automatically. Thus, where the human brain fails, a simple mechanism takes over.

So far it has been considered for use in the car, but it could also apply to other vehicles, including motor bikes, motor boats and caravans, with endless possibilities. All it needs is a little imagination and wiring. The introduction of a battery control system into a caravan, for instance, would enable the television set to switch off automatically, as soon as, say, an electric kettle is plugged in. This is just one example — nevertheless, it illustrates how much energy could be saved. The system seems likely to become an essential requirement in the near future!

Let us now consider the circuit and its layout in figure 1. At first sight it may give the impression of being highly complicated. In actual fact this isn't the case at all, as it operates quite simply. Once the ignition has been switched off (and the lights are still on), the battery voltage is monitored, so that as soon as it enters the danger zone — after the lights have been on for some time — they are turned off. When the engine is running, however, the circuit is inoperative.

The key at the top of figure 1 marks the ignition switch. As long as it is turned on, relay Re is powered via D5. Depending on whether the headlights are on full or dipped, IC1 is connected to the supply through D1 or D2, respectively. As long as the battery is reasonably charged, the output of IC1 will be at full supply voltage; relay Re is powered via D3, even when the ignition is turned off. If the battery voltage drops below par, however, the output of IC1 will switch from 12 V to earth. This causes the relay to drop out and the lights are then turned off.

IC1 is a standard voltage regulator, containing a reference voltage source and an opamp. In this circuit, it is 'misused' — charmingly. The reference voltage at pin 6 is fed to the inverting input of the opamp. A control voltage is derived from the positive supply (the battery!) by means of a voltage divider: R3, P1 and R4. This voltage is applied to the non-inverting input of IC1. When the control voltage is higher than the reference voltage, the output of the opamp will be 12 V and Re will pull in. However, when the battery voltage drops too far, the voltage at the wiper of P1 will also decrease, with the result that the non-inverting input will now be less than the reference voltage. This causes the output of the opamps to swing down to earth and the relay will drop out — switching off the lights. Obviously, the battery voltage will then rise again, so that the opamp might be expected to switch back, but it doesn't. R5 is included to pull the non-inverting input down even further when the battery voltage drops. Theoreticians call this effect 'hysteresis'. Furthermore, once the relay drops out IC1 is no longer connected to the supply. The only way the relay can pull in again is when power is applied through the ignition switch and D5.

P1 presets the battery voltage at which the lights must be switched off. There will be enough energy left to start the engine a few times (20 . . . 50% of full capacity), when the voltage is somewhere between 11.5 and 12 V. The exact level will of course depend on the quality of the car battery.

The battery voltage (during discharge) is plotted in the graph given in figure 2. This particular plot is valid for a 44 Ah accumulator, but other types are similar. As can be seen, 11.5 V corresponds to a battery charge of around 20%. This will

1

Figure 1. The battery protection circuit. Note that the original connection to the light switch must be cut — it now runs through the relay contacts.

D1....D5 = 1N4001

3

80109

have to rise above 12 V, or 50%, for it to be 'normal'.

A printed circuit board is given in figure 3. At first sight, the position of the mounting holes may seem peculiar — but it so happens that they correspond to a fairly commonly available plastic box.

2

12 V 44 Ah 210 A battery
Temperature: +27°C (80°F)

voltage during discharge
(discharge current: 2.2 A)

fully discharged   charge condition   fully charged

Figure 2. The discharge curve of a standard battery.

Parts list

Resistors:
R1,R6 = 10 k
R2 = 3k3
R3 = 5k6
R4 = 1 k
R5 = 1 M

Capacitors:
C1 = 100 μ/25 V

Semiconductors:
D1 . . . D5 = 1N4001

Miscellaneous:
Re = relay 12 V, maximum 100 mA, heavy-duty contacts.

Photo 1.
Prototype of the Elektor transistor ignition.

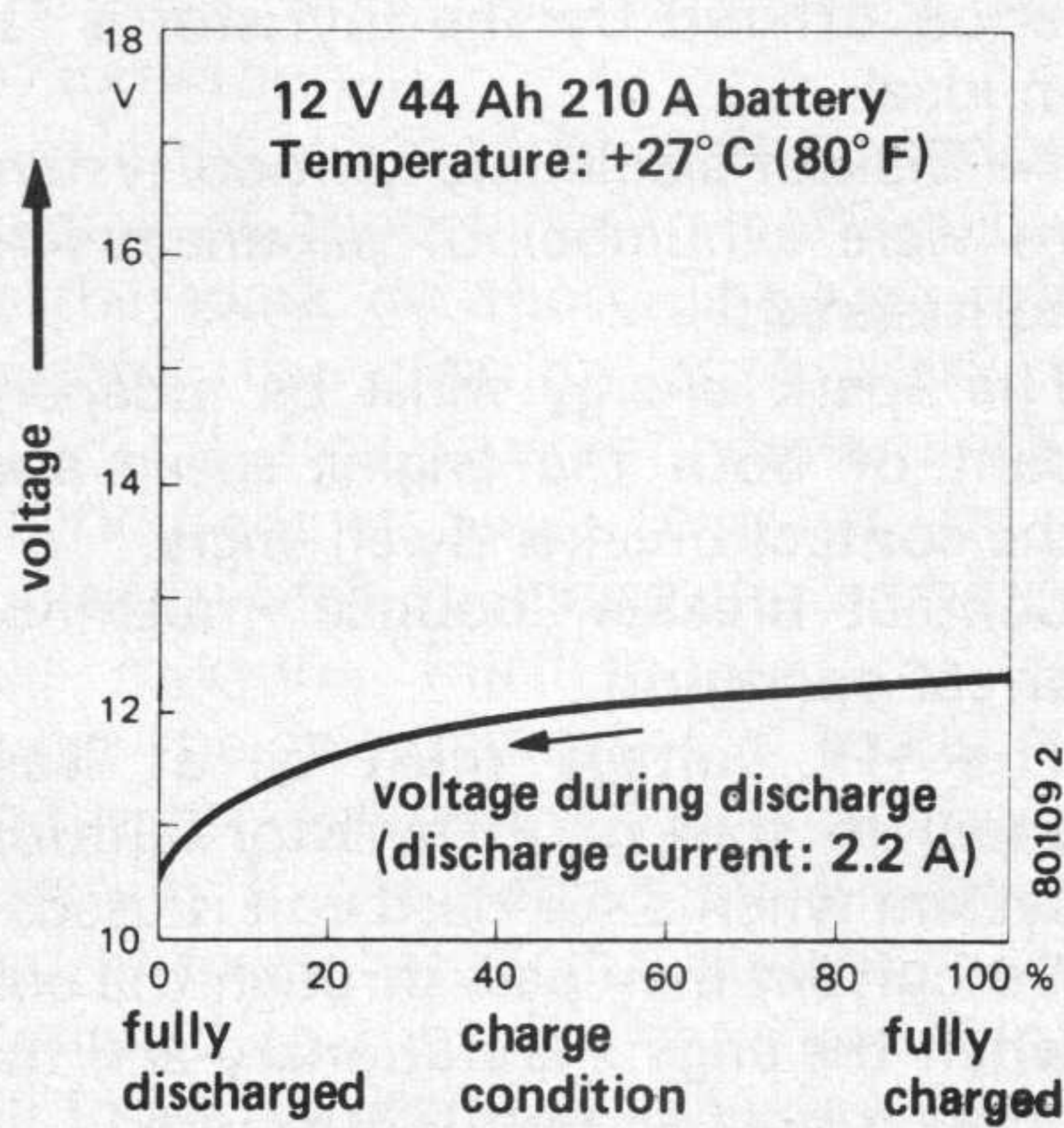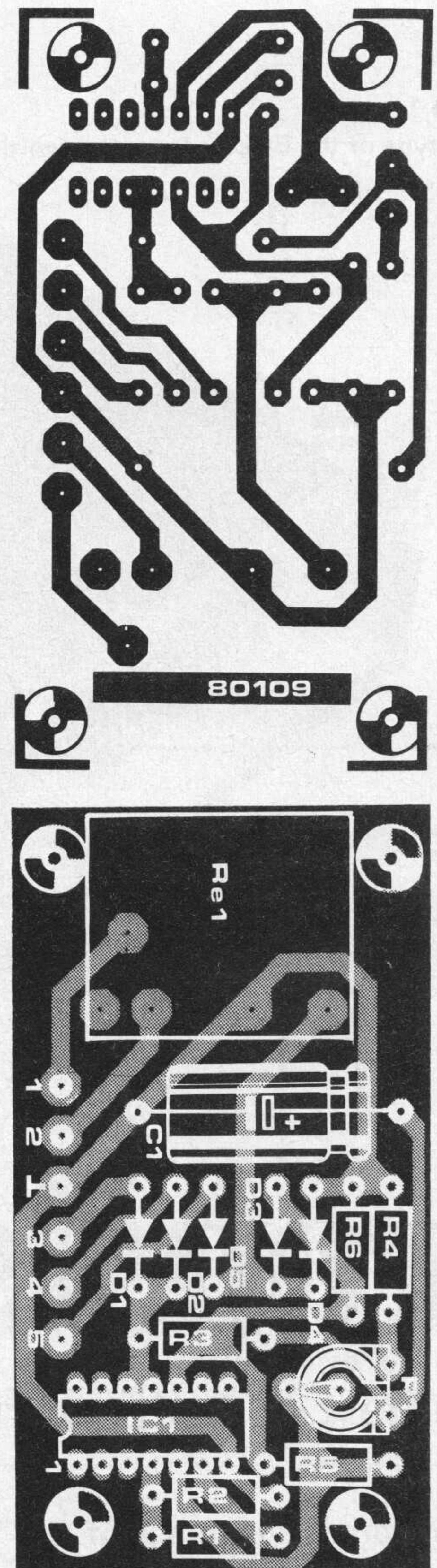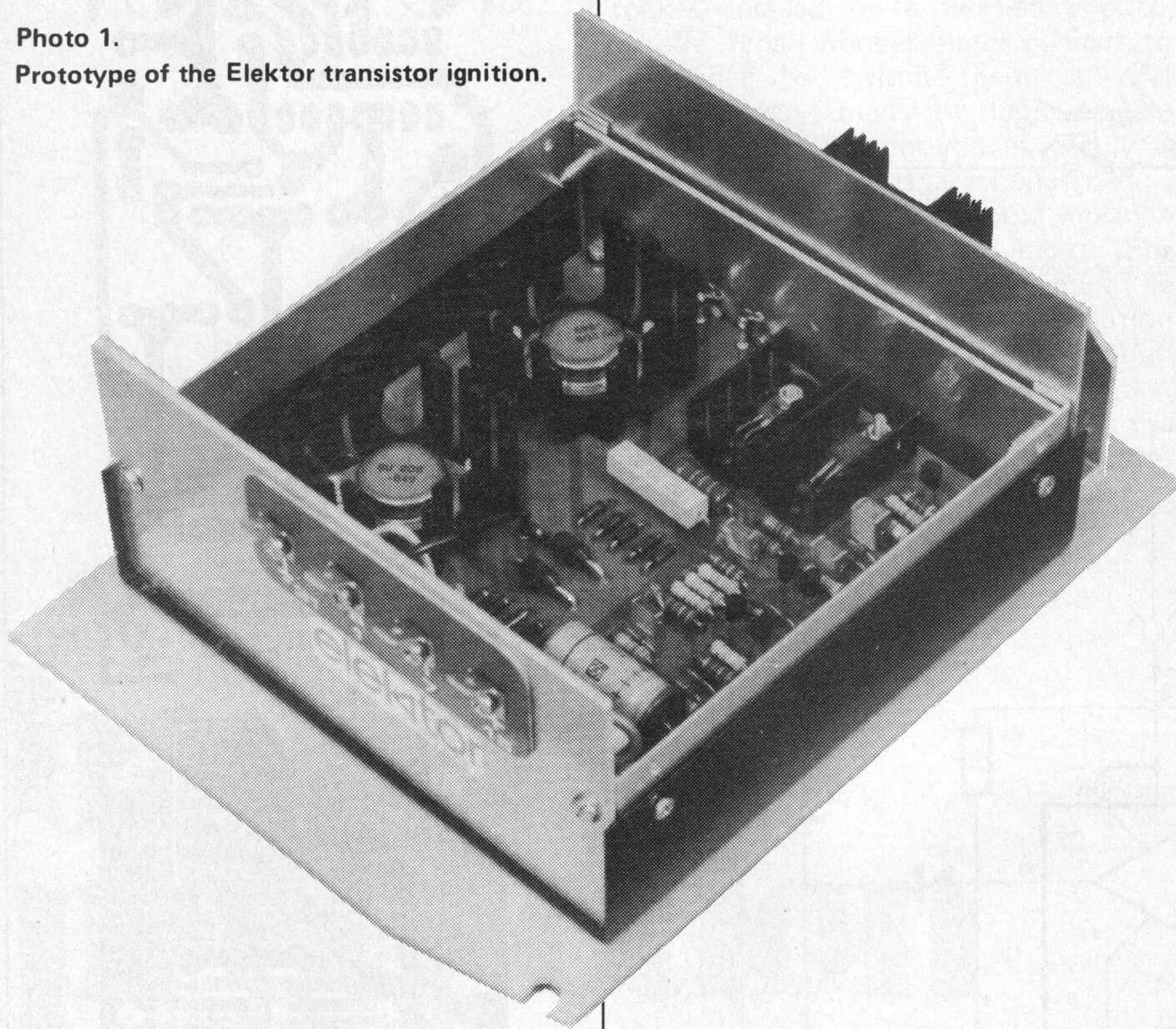breaker points is controlled by the distributor cam. When the points are opened, the current through the primary winding (PW) of the coil is interrupted, thereby causing a large voltage to be induced in the secondary winding (SW).

When the contact breaker points close, the current through the primary of the coil will increase exponentially to a value I_p in the time t_1, as shown in the graph of figure 2. The value I_p is determined by the resistance of the primary winding and the battery voltage. The spark energy released by the points opening after time t_1 will be at a maximum.

The coil has been designed so that the dwell angle (which dictates the time that the points are closed) can be adjusted allowing the maximum permitted engine revolutions to be reached and the coil fully loaded (just!). We are now faced with a problem. If the dwell angle drops, the primary voltage will no longer be able to reach its maximum value at high engine speeds, which will mean a decrease in high voltage and, therefore, spark energy. This alone is reason enough to design an electronic ignition system which is independent of dwell angle and engine speed.

transistor ignition

the best of both worlds

An apparent advantage of the energy crisis is that it has caused a great deal of energy to be channelled into improving old systems (to save energy of course). We believe that we have done just that with the outdated car ignition system. Yes, there are many transistor/thyristor systems being produced commercially but they all seem to suffer from one disadvantage or another. In this article we describe an ignition system which combines the most significant advantages of all the others, including the conventional system. This recipe, mixed with a few of our own ideas, results in the Elektor transistor ignition system — a spark for all seasons?

It would appear, at first sight, that of the most common types of electronic ignition a thyristor based version would present the best possible solution. This may be true when only the simpler circuits are considered but not when major disadvantages in general are taken into account, for instance, the spark duration offered by the thyristor is far from ideal.

In the Elektor electronic ignition system there were a number of parameters to be considered:

1. The spark energy must be independent of both the engine speed and the contact breaker dwell angle.
2. Contact breaker 'bounce' must not affect operation.
3. The HT voltage must be at least equal to that of a thyristor ignition system when a standard coil is used.
4. No current may pass through the coil when the engine is stationary and the contact breaker points are closed.

The importance of these requirements will be obvious to most of our readers, although the finer points may not be so well known.

Figure 1 shows the conventional system which has been with us since the year 'dot'. The opening of the contact

Although far from ideal, it still makes a lot of sense to retain the conventional contact breaker points. Their major disadvantage is the erosion of the correct gap due to the high current passing through them. This problem is drastically reduced with the use of electronic systems.

This does not render them entirely satisfactory, since mechanical wear and degradation of spring tension (causing contact bounce) will remain the same. (A point to note here — yes, the Elektor circuit does take care of bounce problems). However, these are minor problems when the finding/constructing/fitting of optical or inductive alternatives are considered. In spite of the above drawbacks, the main advantage of retaining the conventional points is that the system can be reverted back to normal at any desired time — at the 'flick of a switch' even!

There is another problem to consider. Any increase in the resistance of the primary circuit of the coil has a detrimental effect on the HT and therefore spark energy. This means any electronic switch in the primary circuit must have a low resistance. Theoretically speaking, this should be no problem. In practice,
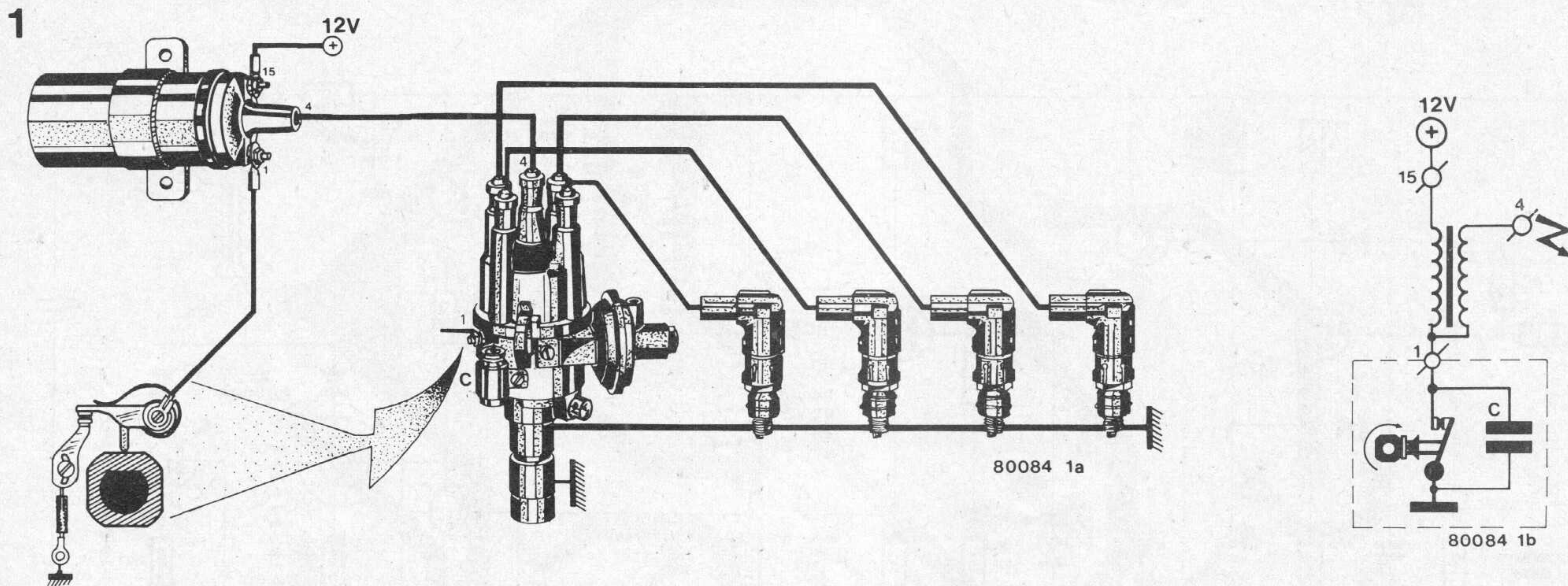
1

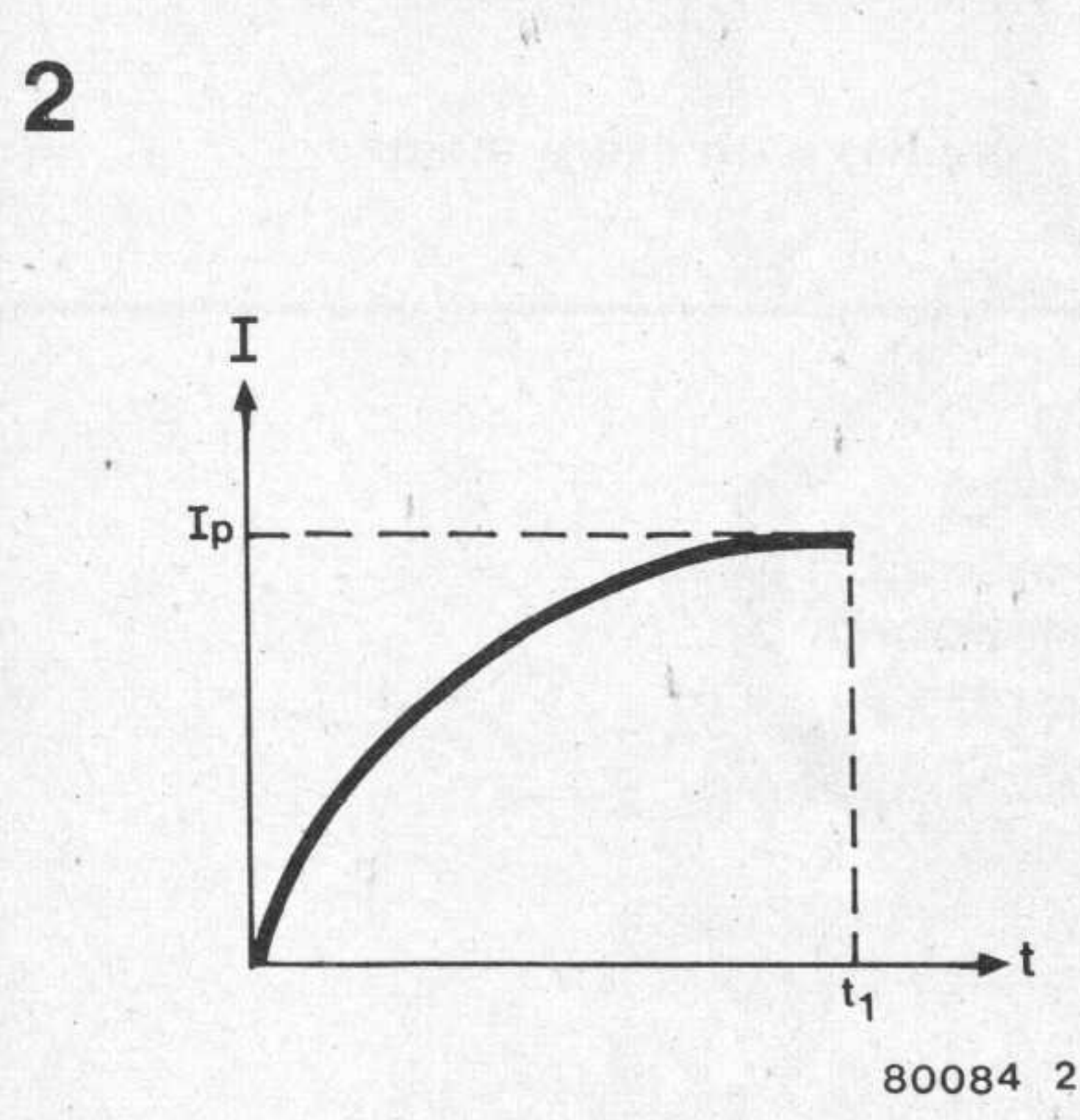Figure 1. The conventional ignition system used in every petrol engine.

2

Figure 2. The curve in the graph shows that time is needed for current in the primary coil winding to rise to a maximum.
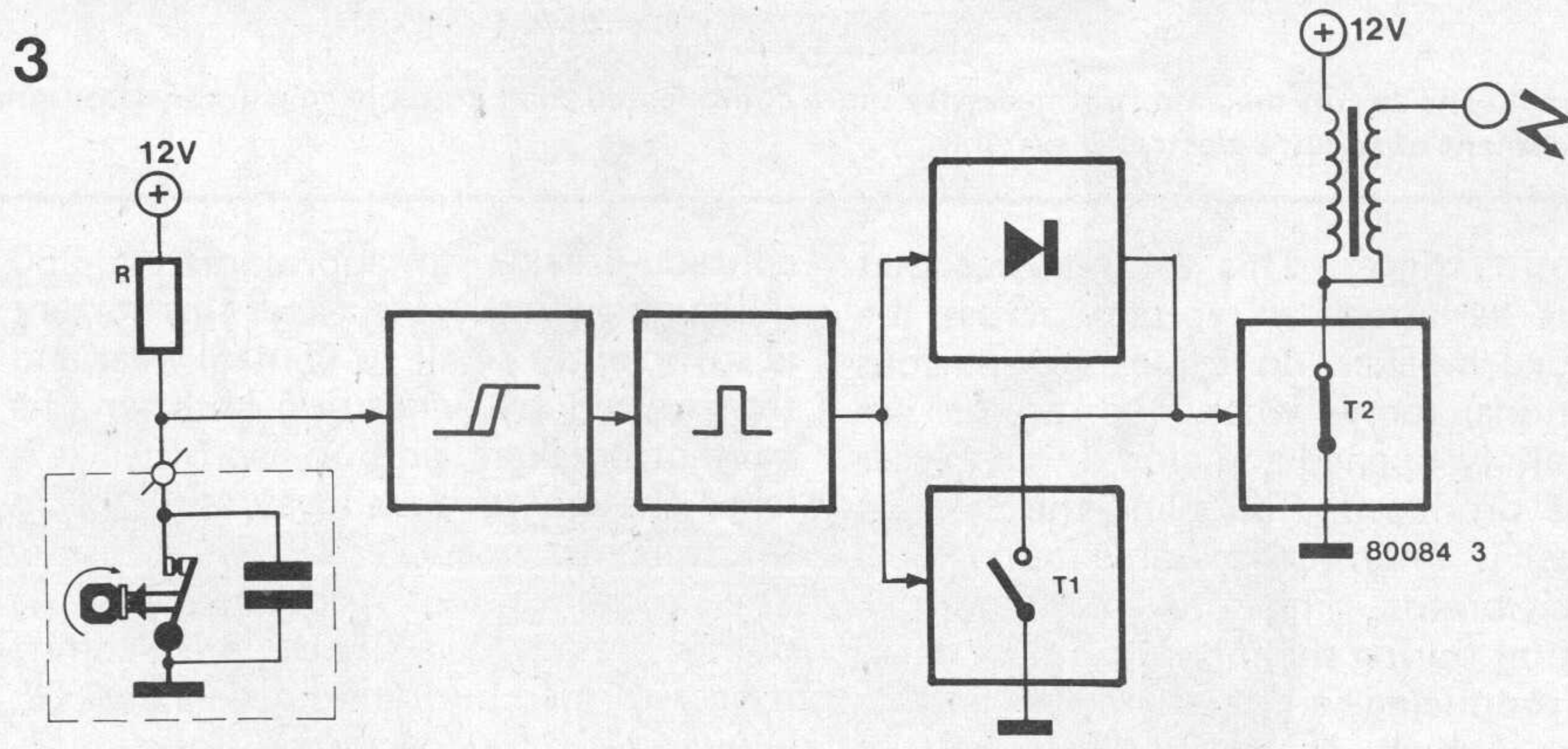
3

Figure 3. The Elektor transistor ignition consists of a Schmitt trigger, a monoflop, an oscillator (T1) and an output stage (T2). The control current for the output stage is obtained by rectifying the monoflop output pulses. This ensures that a current can only pass through the coil if the engine is running.

however, technological limits have to be taken into account; the switching transistor will have to be protected from excessively high voltage. Protection measures, unfortunately, also lead to undesirable attenuation. In the Elektor transistor ignition care has been taken to ensure that attenuation occurs only whenever the voltage limit of the switching transistor is approached.

High voltages are not only dependent on the primary resistance of the coil, but also on the amount of primary current and the speed at which this is interrupted. If higher voltages than normal are to be achieved with the use of a transistor ignition, this could be realised by increasing the voltage to the primary winding. This would certainly require a re-designed coil with a lower primary resistance (R_p) and consequent reduction in primary self-inductance (L_p). The latter takes place because the charge time, which is determined by the L_p/R_p ratio, has to remain the same. This unnecessary expense can be spared, if the current is switched by an electronic means which is faster than the mechanical method. This not only calls for a fast switching transistor, but also for a clever master oscillator. More details

about this later on.

The ability to switch rapidly has the added advantage that the HT rises so quickly that the chances of a flash-over in the distributor are diminished. This is because a flash-over can only occur in the event of air ionisation and that needs quite a bit of time. The sooner the peak HT is reached, the less chance of ionisation.

Not only are the high voltage and spark energy of importance to ignition, but so is the spark duration. The high voltage ensures the creation of a spark. The spark energy (current) determines the spark temperature. It must be sufficiently high to ignite the compressed gas mixture. Furthermore, the spark must be maintained for some time, ensuring ignition. This is because ignition is not helped by the unequal petrol to air ratio (the modern engine is designed to run efficiently on a lot of air to a little petrol, for obvious reasons), and by fluctuations in the gas mixture. In order to ensure a regular ignition, the spark will have to last at least one millisecond. Any longer would be an unnecessary waste of energy.

In the conventional ignition system, a stationary engine with closed contact

breaker points will cause a considerable amount of current to flow through the coil if the ignition is not turned off. This chance situation will allow the temperature of the coil to rise beyond a permissible level. The electronic ignition must therefore be designed in such a way that current can only flow through the coil if the engine is running. How all these requirements have been included in the Elektor design will be seen at a later stage.

Block diagram

From the block diagram (figure 3) it will be seen that the capacitor, C, across the contact breaker points in the conventional ignition is also used in an electronic system. In spite of the reduction in current which flows through the closed contact breaker by way of resistor R, some ionisation would take place between the contact points when these are opened. The capacitor prevents this and so allows the ignition timing to be more exact.

The capacitor and resistor combination will result in a slower rise time on the leading edge of the trigger pulse, but this problem is overcome by using a

4

D1 . . . D6 = 1N4148
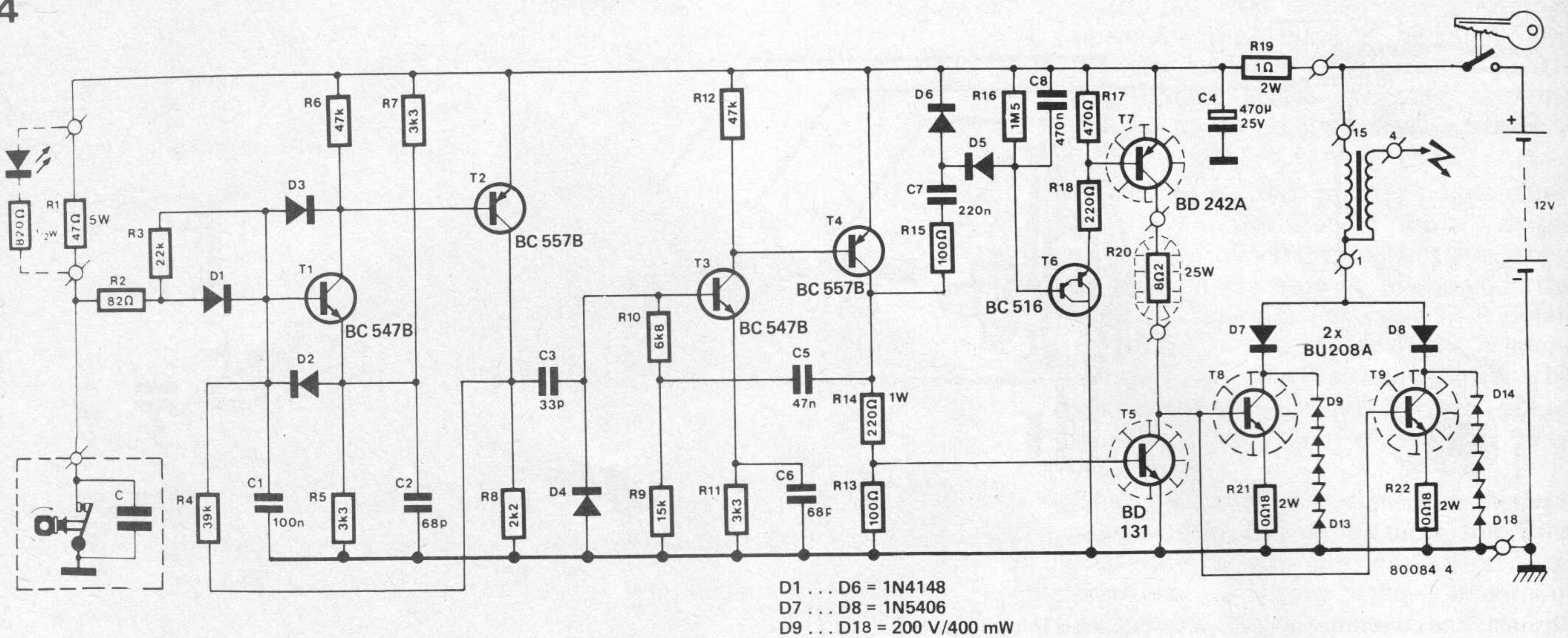D7 . . . D8 = 1N5406
D9 . . . D18 = 200 V/400 mW

Figure 4. The circuit diagram is of necessity more complicated than a simple single transistor ignition as it complies with every major requirement of today's electronic system.

Schmitt trigger. This also ensures that slight variations in voltage across the contact breakers do not lead to spurious ignitions; only when the points are definitely opened and closed, is a trigger pulse produced. Following the Schmitt trigger is a non-retriggerable monostable multivibrator. This prevents repetitive ignition during the monoflop time delay by producing a trigger pulse with a width which is independent of the opening angle (and the dwell angle). The monoflop time delay has been calculated so that a maximum of approximately 6000 revolutions per minute in a four cylinder engine still allows for enough time to load the coil, ensuring a sufficiently high HT voltage.

The output pulses from the monoflop are fed to a master oscillator and a rectifier. The master oscillator causes the coil current to be interrupted at intervals (by switching the current to earth before the output stage). The output of the rectifier supplies the coil primary current via the output stage (T2). This is only possible if trigger pulses are produced (in other words: when the engine is running).

Circuit diagram

A glance at figure 4 will show that there is a great deal more to this type of electronic ignition than the conventional system. How does it work and what sort of technical aspects have been incorporated to meet the set parameters? It seems reasonable to start at the very beginning, which is in this case, at the far left of the circuit diagram.

The purpose of the contact breaker (dotted area) now becomes a simple pulse shaper, as opposed to a power switch. Resistor R1 has been added in order to limit the current through the

contact breaker to approximately 250 milliamps. On the one hand, this current is sufficiently small to control wear and tear caused by ionisation between the contact breakers, and on the other, it is large enough to burn away any dirt on the contacts.

The trigger pulses produced by the points are cleaned up by the Schmitt trigger formed by transistors T1 and T2, allowing a more precise ignition timing. The Schmitt trigger is designed so that the switching levels will be approximately 2.2 and 7.4 volts with a battery voltage of 12 V. The trigger pulses therefore start when the voltage across the contact breaker rises to at least 7.4 V and end when the level drops below 2.2 V. The difference between these switching levels is called hysteresis. It prevents any residual hum voltage across the points from influencing the system.

The trigger is designed to react quickly to positive going transitions (the contact breaker opening), but to have a delayed reaction to negative slopes (the contact breaker closing). This is achieved by the combination of R2, R3, C1 and D1, where D1 provides the shorter and longer time constants, respectively. The shorter time constant is required to trigger the ignition 'on' time and the longer time constant to suppress contact 'bounce'.

The Schmitt trigger is followed by a non-retriggerable monoflop (T3 and T4). This produces a pulse with a fixed period, independent of the dwell angle. When inoperative, these transistors are turned off until the moment the Schmitt trigger produces a positive pulse when they will both start to conduct. The positive going voltage at the collector of T4 is fed back to the base of T3 via C5 and R10. The monoflop now remains in this state until C5 is charged through R9.

Parts list

Resistors:
R1 = 47 Ω/5 W
R2 = 82 Ω
R3 = 22 k
R4 = 39 k
R5,R7,R11 = 3k3
R6,R12 = 47 k
R8 = 2k2
R9 = 15 k
R10 = 6k8
R13,R15 = 100 Ω
R14,R18 = 220 Ω
R16 = 1M5
R17 = 470 Ω
R19 = 1 Ω/2 W
R20 = 8Ω2/25 W
R21,R22 = 0Ω18/2 W

Capacitors:
C1 = 100 n
C2,C6 = 68 p
C3 = 33 p
C4 = 470 μ/25 V
C5 = 47 n
C7 = 220 n
C8 = 470 n

Semi-conductors:
D1 . . . D6 = 1N4148
D7,D8 = 1N5406
D9 . . . D18 = zener 200 V/400 mW
T1,T3 = BC 547B
T2,T4 = BC 557B
T5 = BD 131
T6 = BC 516
T7 = BD 242A
T8,T9 = BU 208A

Miscellaneous:
heatsink for T8 and T9 (TO-3 size)
heatsink for T5 and T7 (TO-66 size)
flexible oil resistant wire 2.5 mm²
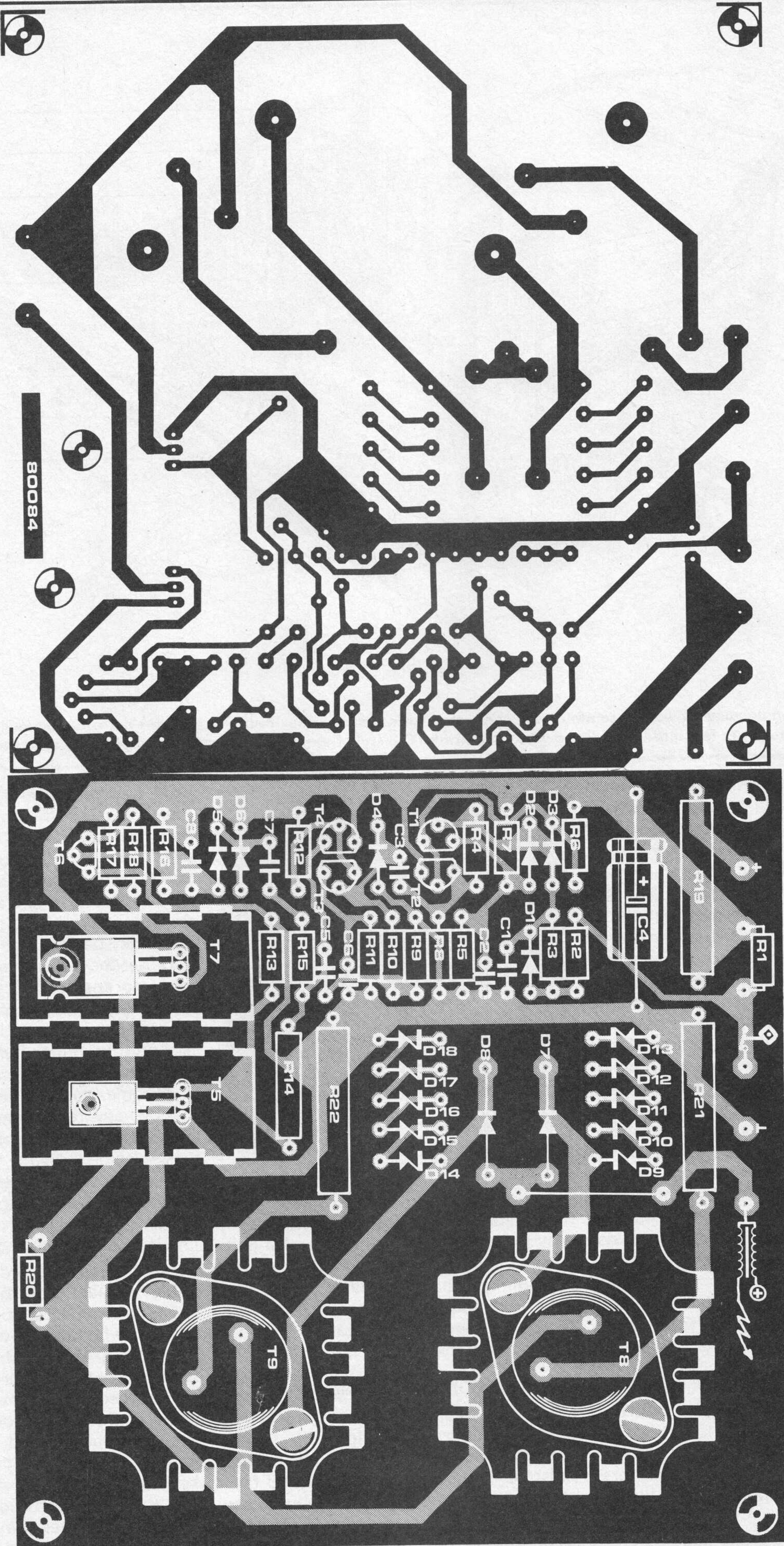suitable die-cast box

5

Figure 5. Printed circuit board and component overlay for the transistor ignition. The eight connection points have been clearly marked using symbols.

6

terminal and connector

insulating plate

plastic TO3 isolator

solder tag

4 BA nut and bolt

locking washer

pin and connector

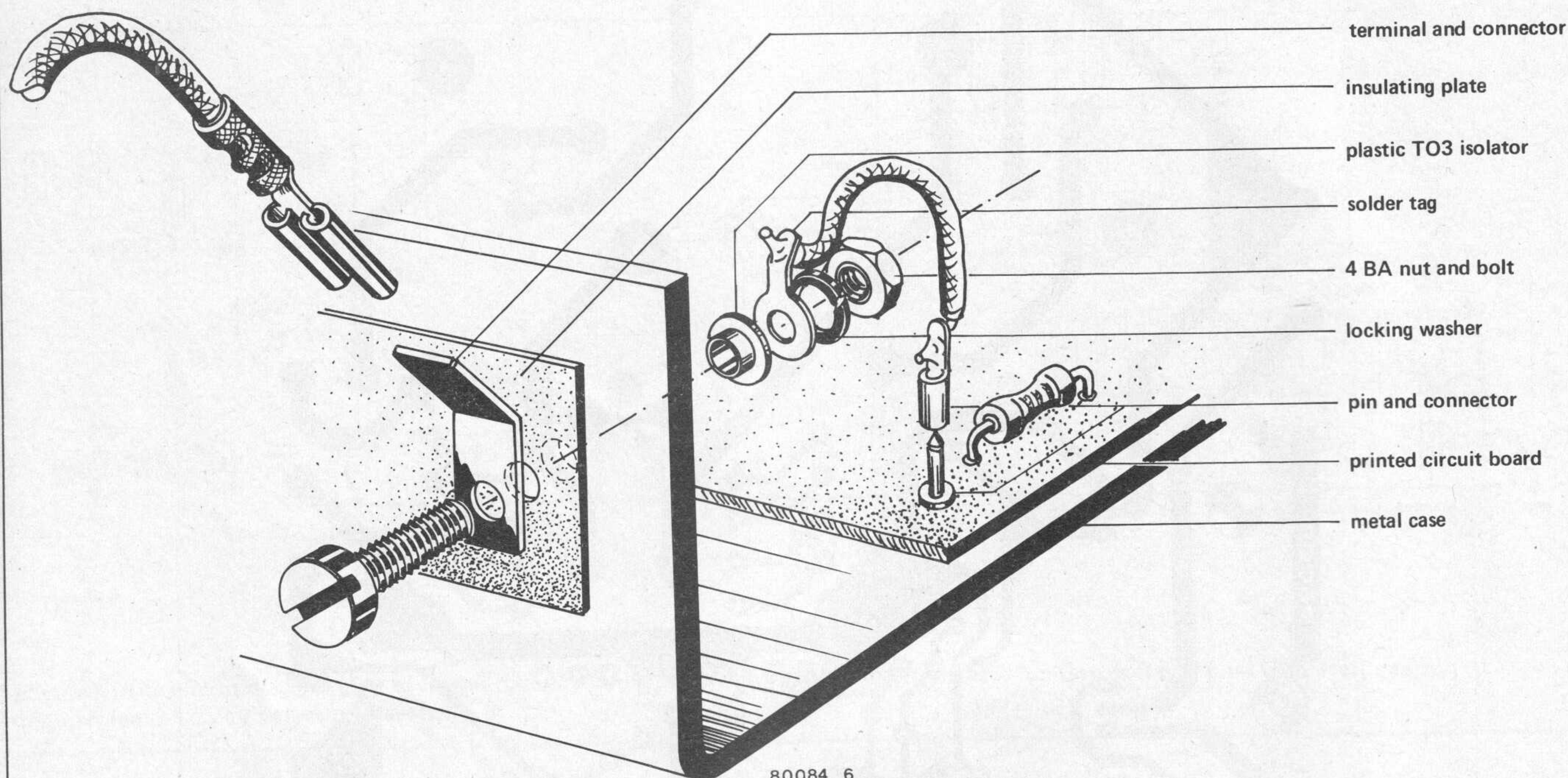printed circuit board

metal case

80084 6

Figure 6. This detailed drawing shows how to mount the connectors onto the case. The insulating plate prevents the terminals from touching the case. The plastic isolator is in fact meant to be used when mounting TO-3 style transistors but it may equally well be used here.

With the given values for C5 and R9, the monoflop period will be approximately two milliseconds. After that time, any further energy pumped into the coil would be completely converted into heat. The monoflop output pulses are rectified by diodes D5 and D6, which (via T6 and T7) only provide transistors T8 and T9 with base drive current when the engine is running. These transistors switch off more rapidly if the charge carriers are removed as fast as possible from the base. This happens more effectively when the base drive current is short circuited to earth rather than interrupted. All the charge carriers that are still moving due to base/collector capacitance during the blockage do not then arrive at the emitter, and this results in a very fast switch off. Switching the base drive current to earth is carried out by T5. The coil current must be switched off quickly to achieve high ignition voltages, and for this reason, T8 and T9 are high speed switching types. With a view to safety and reliability, transistors T8 and T9 are protected from extreme voltages by means of zener diodes (in case of flash-over between secondary and primary windings, for instance).

It is possible for the primary coil voltage to go negative. The switching transistors T8 and T9 do not respond favourably to this and therefore have to be protected by means of diodes D7 and D8.

Why are two switching transistors used? The BU 208A is relatively cheap and complies with the technical require-
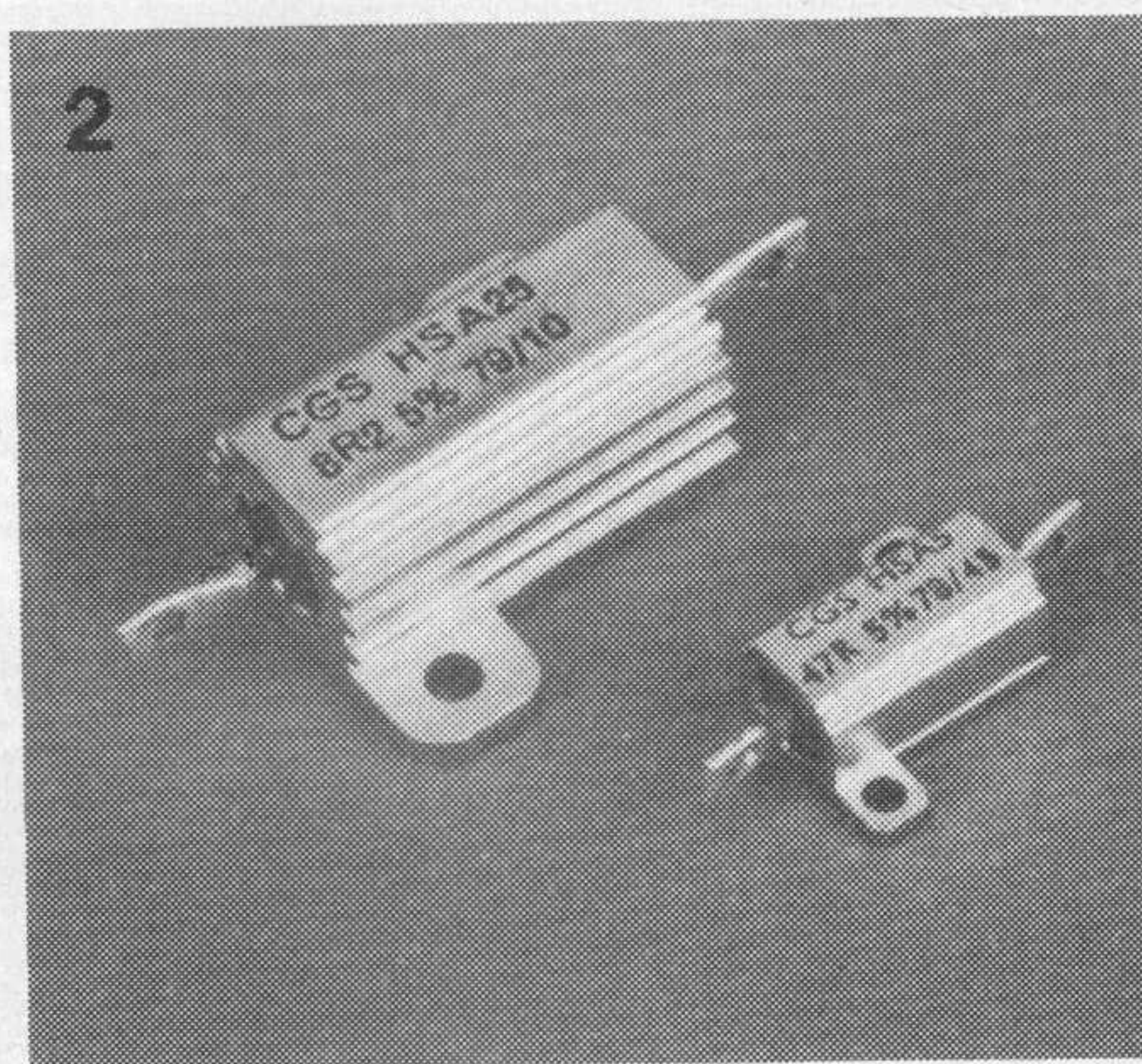

Photo 2. Resistors R1 and R20 are special power types which may be attached to the chassis with aid of nuts and bolts.

ments. Unfortunately, however, it can only just withstand the considerable coil current. Since the ignition forms a vital part of the car, it is better to run no risks and that is why there are two switching transistors in parallel.

Construction and setting up

Mounting the components onto the printed circuit board (figure 5) should not cause any problems. The power resistors R1 and R20 dissipate a fair amount of power and are therefore chassis mounted. Transistors T5, T7, T8 and T9 need to be mounted on separate heatsinks. Do not use mica insulation washers between the cooling surface and the transistor, as this would hinder the

heat transfer. Cooling electronic components under the bonnet is a problem as it is, especially if your car is in a traffic jam on a warm summer's day. Special attention should therefore be paid to cooling the transistors. As a last resort, a special heat conducting silicon paste may be used.

Because they are 'live', care should be taken to ensure that the heat sinks are not electronically connected to any other components or the metal case.

It should be remembered, that if one of the switching transistors T8 or T9 were to become loose and move, it is possible for the emitter to touch the heatsink and therefore the collector. This will most decidedly stop the engine. It is advisable to sleeve both the emitter and base pins and ensure that the transistors are fitted securely.

The ignition system should be housed in a sealed metal case, a die cast metal box would probably be the most suitable. The six connections to the outside world can be made as shown in figure 6, although a minor difference to the illustration may be preferred. The pin and connector on the printed circuit board could be left out and the connecting wire soldered directly to the board. The tag could then be placed on the other side of the 4BA nut (to the right of the illustration) and held in place by a further nut, which will also double as a locking nut for the whole assembly. The tag could still be removed if required without loosening the terminal connector.
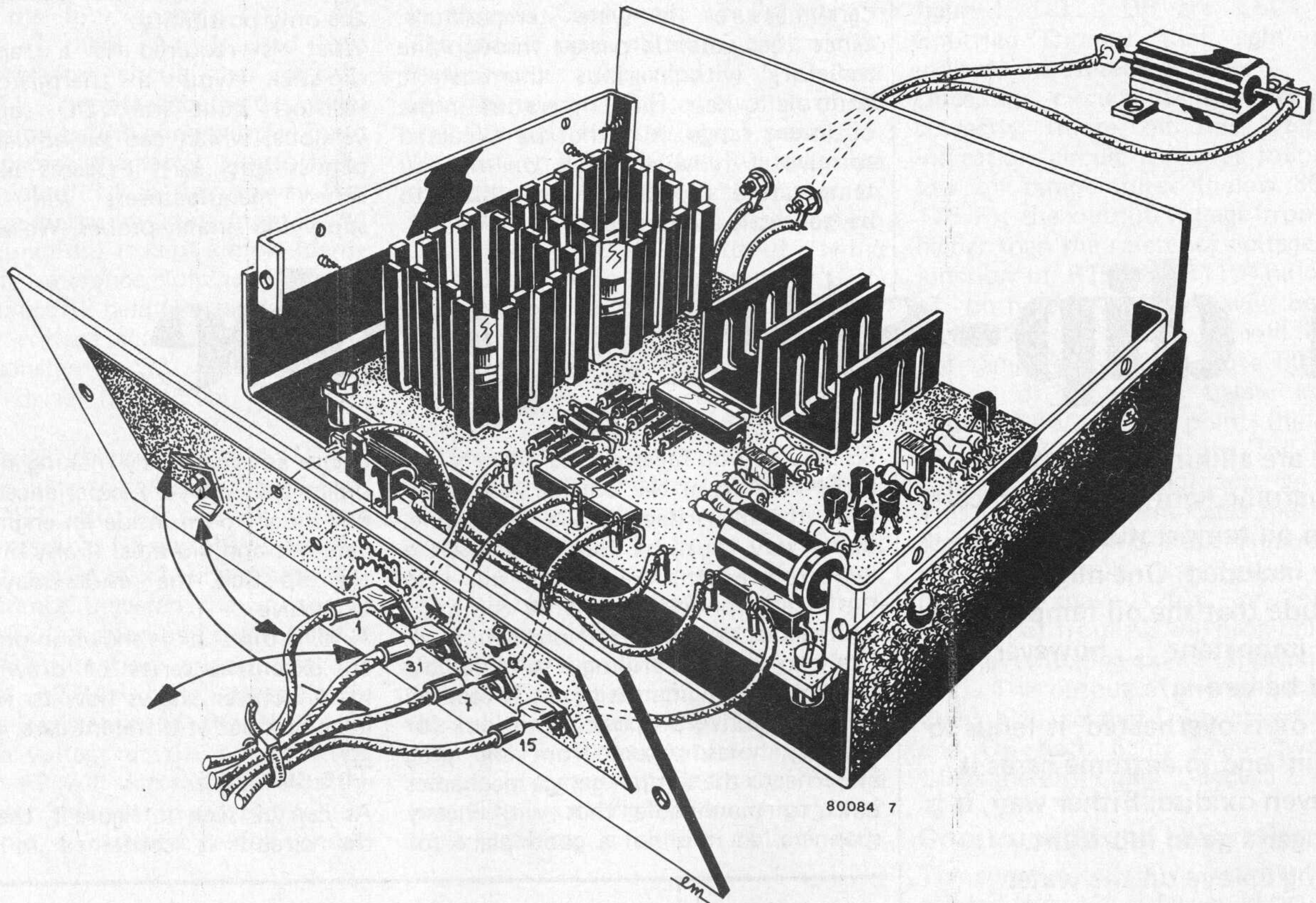
7

Figure 7. This drawing should help avoid any problems while constructing the electronic ignition. The arrows indicate how to convert it back to the mechanical system, should anything go wrong.

The connecting wire used should be 2.5 mm² (at least), flexible and oil proof cable (obtainable at any car accessory dealers). Mounting the two power resistors requires a little more attention. In order to prevent the solder connections from loosening because of heat development, connecting wire needs to be passed through the solder eyes of these resistors and then wrapped firmly before being soldered. The power resistors are a special type (see photo 2) and can easily be mounted onto the chassis using nuts and bolts.

The drawing in figure 7 clearly shows the external connections. Should anything go wrong as far as the electronics is concerned, it would of course be advantageous if the system could revert to the conventional ignition without any difficulty. For this purpose a 'loose' double connection clamp is attached to the case. By connecting the leads from the contact breaker and the coil to this point, the ignition operates once more in the conventional manner. It would, however, be advisable to disconnect the supply to the electronic section also. Arrows in the drawing show which modifications to carry out in order to 'switch off' the electronic system. An alternative, of course, is to include two switches. One (double pole) switch to break the connections from the contact breaker and coil to the unit and join the two together, and one (single pole) to break the positive (or negative) supply connection. This has the added advantage that the second switch can be used as an

anti-theft device. If the system is switched to the transistor ignition and the power to the unit disconnected, the engine will not run.

As mentioned before, the capacitor across the contact breaker is still used. However, its value must be 0.1 µF. Once the unit has been assembled, it can be tested. The ignition timing will remain unchanged. The points gap is now no longer critical, but it is advisable to set it as recommended by the manufacturer. Otherwise, mechanical problems could arise.

To make it easier to set the ignition timing, an LED in series with an 820 Ω/0.5 Watt resistor (shown dotted in figure 4) may be placed across R1. Note that the LED must be connected the right way round. When the contact breaker points close, the LED lights (in contrast to a control bulb placed across the points). It would be far better, however, to have the ignition timing set dynamically with the aid of a strobo-scope. External connections to the coil and distributor are as numbered in figures 1a and 7.

Having completed the construction, fitted the unit into the vehicle and tested the system, it is then highly advisable to take one somewhat strange step further. Remove the unit from the vehicle and take it back to the workshop — for a very good reason. As previously mentioned, the under bonnet environment is extremely hostile and for the sake of reliability a protective measure is called for. The printed circuit

board should be removed and given two or three coats of clear polyeurathane laquer. This will prevent damp from affecting the circuit. When this is dry, the whole unit should then be reassembled paying particular attention to all fixing points, nuts and bolts etc. When satisfied, the unit can then be refitted into the vehicle. It should of course operate perfectly.

This last step may seem a lot of extra effort but take note of the following. Murphy's Law states that if the ignition of any vehicle should fail, it will do so late on a Sunday evening, miles from anywhere, during the worst rainstorm in ten years.

Some cars are equipped with a resistor in series with the coil primary winding which is bypassed during operation of the starter motor. This must not be removed, as overheating of the coil would result. Apart from the number 1 connection to the coil (which, in this case, should be fitted to the other side of the resistor) all connections remain the same. This ensures that the by-pass resistor system is maintained.

If a rev counter is fitted to the vehicle, it should be connected to the coil (connection number 1) when this electronic ignition system is used. ◄

The existing temperature meter in most cars measures the water temperature. Since the water is passed through the radiator, with various thermostatic controls to keep the temperature in the optimum range, it cannot be expected to give a reliable check on the oil temperature. Any indication is likely to be 'too little and too late'.

electrical wiring! — the dip-stick seems the only possibility.

What is required is a replacement dip-stick with a thermistor (NTC resistor) built in. VDO supply two versions, which can be adjusted to fit almost any car; it seems likely that other manufacturers will soon be supplying similar probes. We would not

a dip-stick probe

There are all kinds of indicators and warning lights in modern cars, but an oil temperature indicator is rarely included. One might conclude that the oil temperature is not important . . . however, one would be wrong.

When oil is overheated, it tends to go 'thin' and in extreme cases it may even oxidise. Either way, it is no longer a good lubricant. Keeping an eye on the water temperature may give some warning, of course, but it doesn't tell the whole story — to play it safe, the oil temperature itself should be measured.

The easiest way to add this type of indicator to an existing car is to mount a temperature sensor in the dip-stick.

So how do you measure the oil temperature? Not from the outside, that's for sure: the oil is deep inside the engine. Some way must be found to insert a temperature sensor into the oil — in the sump, for instance. Only the most courageous do-it-yourself mechanics are likely to attempt drilling a suitable hole through the engine casing, so it seems a more attractive proposition to look for existing holes. Apart from the plug underneath the sump — garage mechanics tend to manhandle that with heavy spanners, so it is not a good place for

advise anyone to try making their own, unless they are very experienced: there's not much room inside an engine, and it gets hot and vibrates. If any bits fall off the dip-stick, the results may be very expensive.

A VDO dip-stick is shown in photo 1. In an extensive series of drawings, the manufacturer shows how to fit it in a large number of different cars.

The circuit

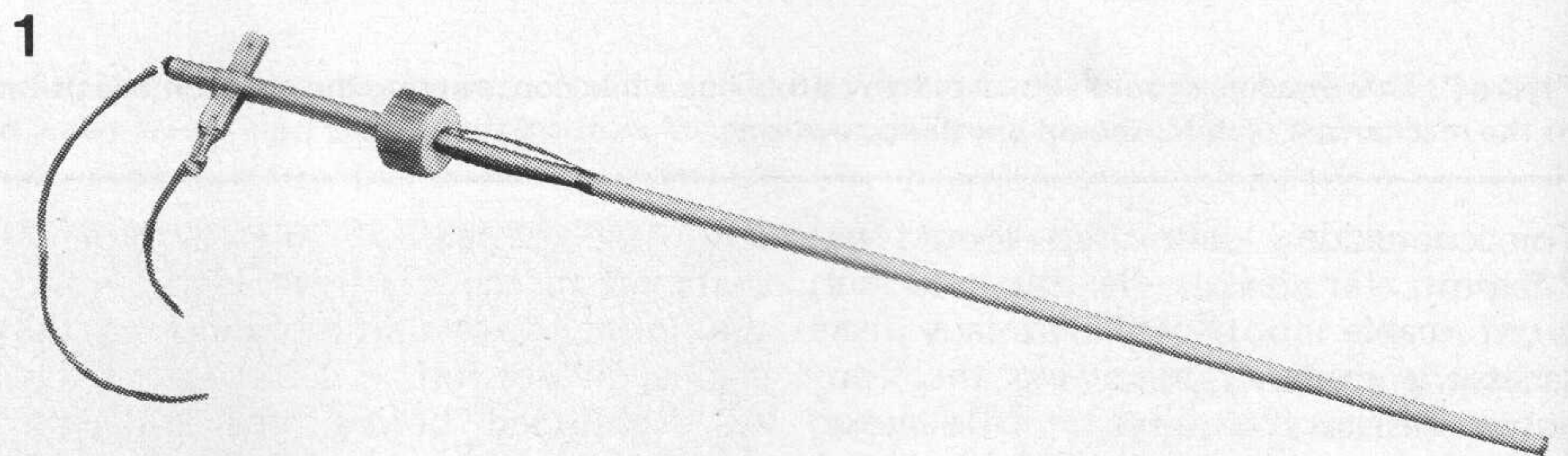As can be seen in figure 1, the bulk of the circuit is contained in a single

Photo 1. A dip-stick with built-in temperature sensor (made by VDO).

A1 . . . A4 = LM 324 = IC1

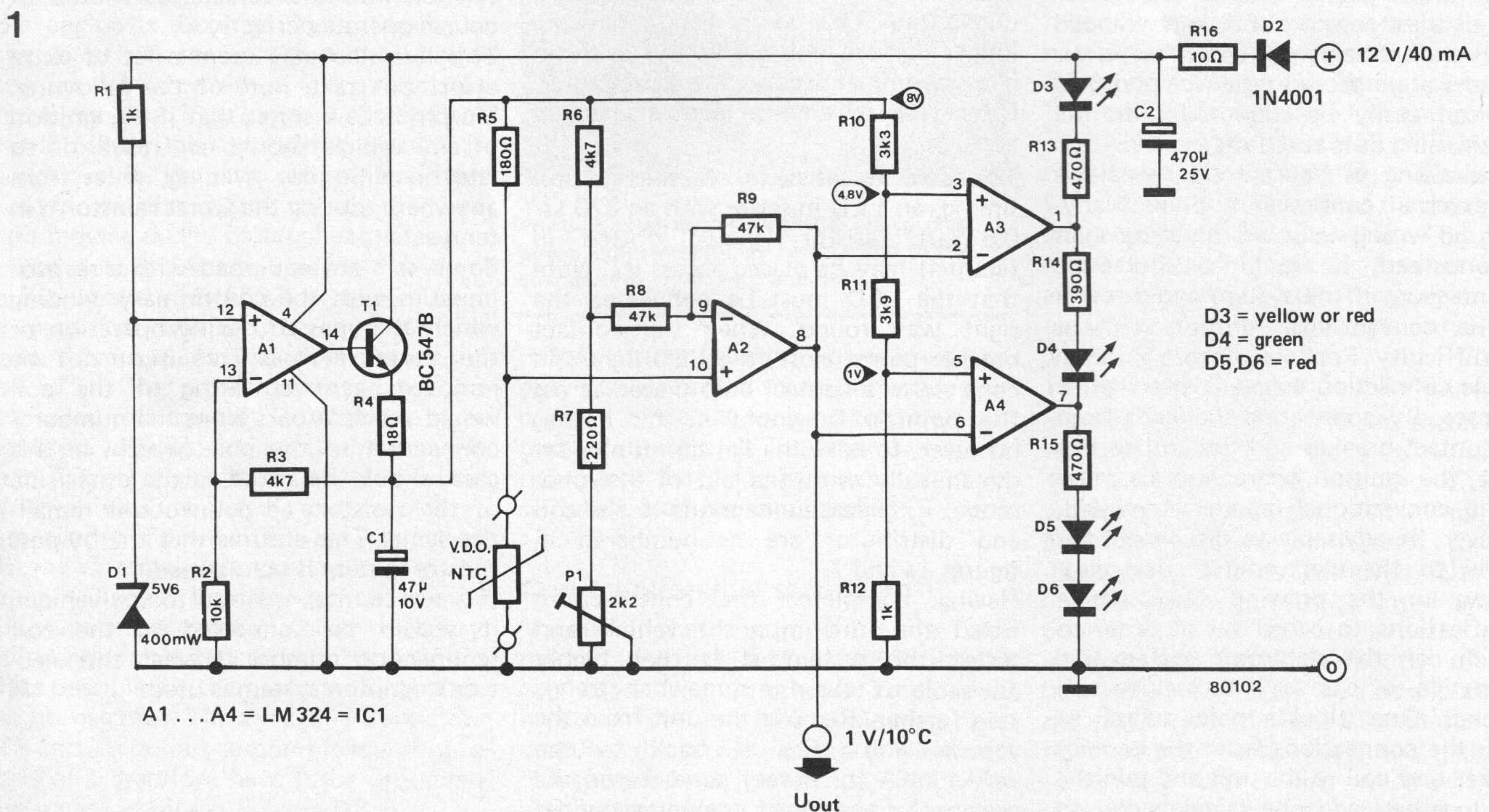D3 = yellow or red
D4 = green
D5,D6 = red

1 V/10°C

U_out

Figure 1. The complete circuit of the oil temperatures indicator. The bulk of the circuit — the four opamps — are contained in a single IC.

integrated circuit: the LM 324; this IC contains the four opamps A1 ... A4. The first of these, A1, is used in a voltage regulator circuit that includes D1 and T1. The reference voltage from D1 is applied to the non-inverting input of the opamp; the latter controls the base current of T1 in such a way that the voltage at the inverting input of A1 (R2/R3 junction) is kept almost identical to the reference voltage. With the voltage across R2 held constant at 5.6 V, the total voltage across R3 and R2 is equally constant at 8 V. This voltage is used to drive the actual measuring circuit.

The dip-stick thermistor (or 'NTC') is connected in a so-called bridge circuit: R5, the NTC, R6, R7 and P1. Opamp A2, with resistors R8 and R9, is a buffer stage with a gain of x1. This means that the difference between the voltage at the R5/NTC junction and the voltage at the R6/R7 junction appears at the output of A2. As the oil temperature rises, the resistance of the NTC will drop; the voltage at the non-inverting input of A2 will decrease, so that the output from this opamp will also fall.

In principle, a voltmeter can be connec-ted to the output of A2 and calibrated in degrees Centigrade or Fahrenheit. The actual scale obtained depends on three factors: the type of NTC used (and the value of R5); the values of R8 and R9; and the setting of preset P1. With a given NTC, R8 and R9 determine the temperature range that can be measured: with the values given (R8 = R9 = 47k) 1 V output swing corresponds to approximately 10°C temperature change ($\approx$ 18°F), so that a total range of some 120°C (216°F) can be measured. The actual scale limits are set by means of P1 — in the example given, 0 ... 120°C (32 ... 248°F) might be chosen.

A different scale can be obtained by modifying the values of R8 and/or R9, and readjusting P1. For a Fahrenheit scale, for instance, R8 = 56 k and R9 = 100 k; this gives an output from A2 of approximately 1 V per 10°F. However, a thermometer using an NTC is unlikely to be highly accurate over the full temperature range; furthermore, the only oil-temperature indication needed in a car is on the lines of 'on the low side — just right — too high'. For these reasons, a simple optical indi-cation was chosen for this circuit. In figure 1, D3 ... D6 are LEDs (Light Emitting Diodes) that light up to indicate the oil temperature.

Once the circuit has been calibrated correctly (more on this later), the indication circuit works as follows. At low oil temperatures (below 80°C or 176°F), the output voltage from A2 is higher than the reference voltage at the junction of R10 and R11. The outputs of both A3 and A4 will be 'low' (virtually 0 V), so only D3 will light. As the temperature rises above 80°C, the output of A2 drops below approxi-mately 4.8 V. At this point, the output of A3 swings 'high' (to full supply voltage); D3 goes out and D4 lights. This (green) LED indicates that the oil temperature is in the optimum range. If the temperature rises even higher, however — above 120°C, or 250°F — the output from A2 will drop below the second switching point (approximately 1 V). The output of A4 will then also swing high, so that D4 goes out and D5 and D6 both light. These two (red) LEDs therefore spell 'Danger'!

Construction and calibration

The complete circuit is mounted on the printed circuit board given in figure 2. It shouldn't be too difficult to find a small plastic box to fit it. According to taste, the whole lot can be mounted 'in sight' or, alternatively, the box can be mounted behind the dashboard and the connec-tions to the LEDs brought out to some suitable point.

Calibration is not too difficult. With the component values given, the changeover points from one LED to the next should be at 80°C and 120°C (176°F and 250°F, respectively). The simplest way to calibrate the unit, therefore, is to dip the sensor into a pan of water at 80°C and adjust P1 until the indication just switches over from D3 to D4. The upper indication will then correspond to 120°C (it is difficult to heat water that far . . .). As a further check, the output of A2 can be measured when the sensor is dipped in boiling water — it should then be approximately 3 V. Absolute accuracy is not essential for this type of indicator, of course.

By way of conclusion, a word about the sensor itself. If the VDO unit is used, the value given for R5 (180 Ω) is correct. For other sensors, however, it may have to be modified. As a rule of thumb, R5 should be between one-half and two-thirds of the resistance of the NTC when the latter is immersed in boiling water. As an example, say that the thermistor value is measured as 100 Ω in boiling water; a good value for R5 is 56 Ω in this case. This, by the way, should also be taken as the minimum permissible: only NTCs with a value between 100 Ω and 10 k at boiling temperature can be used in this circuit (note that this will normally have to be measured: the resistance of an NTC is usually specified at room temperature). ◀
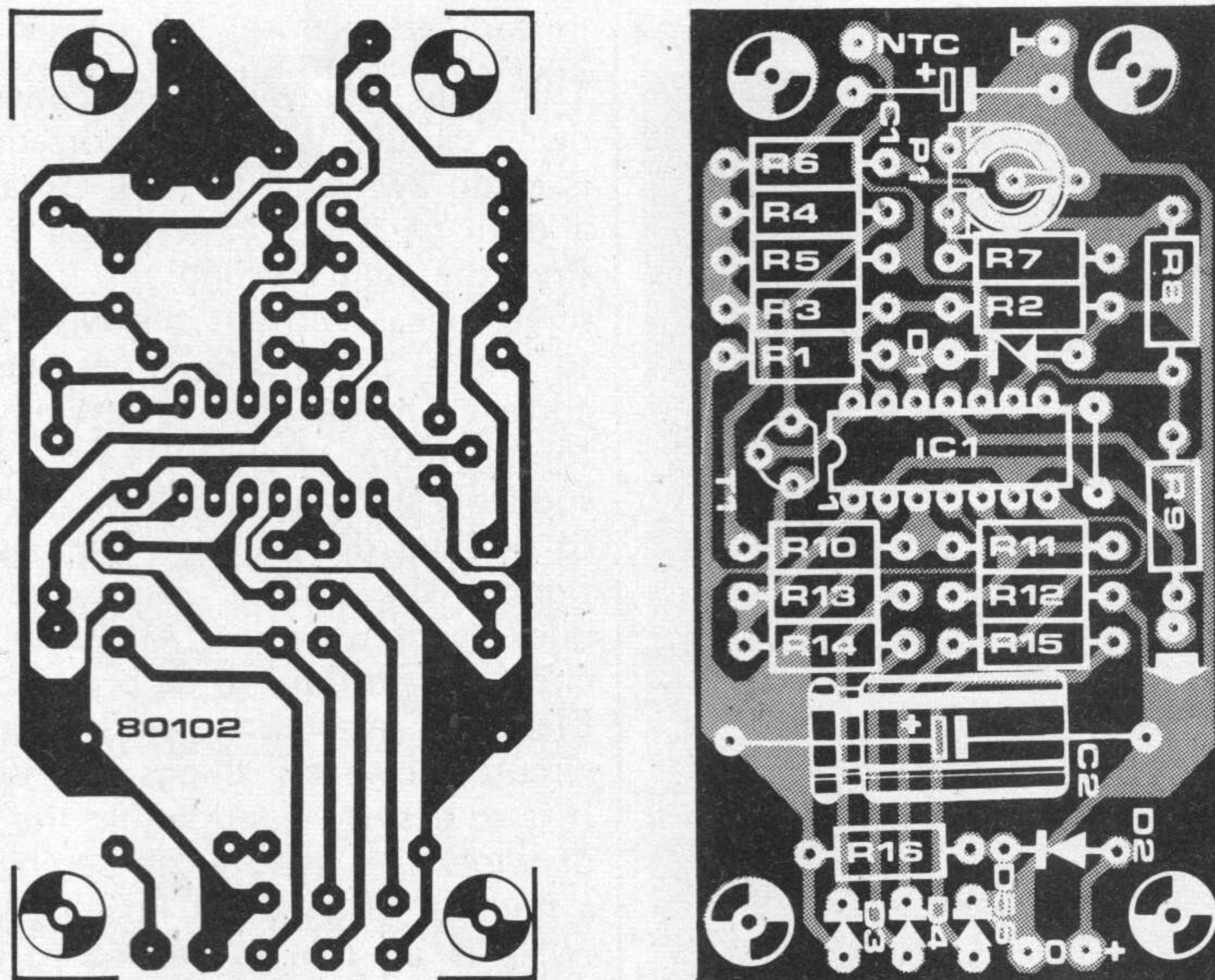

2

Figure 2. Printed circuit board and component layout.

Parts list:

Resistors:
R1,R12 = 1 k
R2 = 10 k
R3 = 4k7
R4 = 18 Ω
R5 = 180 Ω (see text)
R6 = 4k7
R7 = 220 Ω
R8,R9 = 47 k
R10 = 3k3
R11 = 3k9
R13,R15 = 470 Ω
R14 = 390 Ω
R16 = 10 Ω
P1 = 2k2 preset potentiometer

Capacitors:
C1 = 47 µ/10 V
C2 = 470 µ/25 V

Semiconductors:
A1,A2,A3,A4 = IC1 = LM 324
D1 = 5V6, 400 mW zener diode
D2 = 1N4001
D3 = LED (yellow or red)
D4 = LED (green)
D5,D6 = LED (red)
T1 = BC 107B, BC 547B or equ.

Miscellaneous:
Dip-stick with built-in thermistor;
   for example, VDO type 5310024.

An extremely annoying aspect of poor windscreen wipers is that they are fine — until you have to use them. We unfortunately are unable to do anything about that but we can help them cope with varying weather conditions.
There have been many circuits published relating to wiper delays but never one quite like this.
It is intelligent, it only needs to be told once what is required of it.
It will then carry out your orders until you change them, which you can at any time, instantly. It's so good that we (being male chauvinist pigs) are currently converting one into a secretary.

intelligent wiper delay

single push-button control and continuously variable
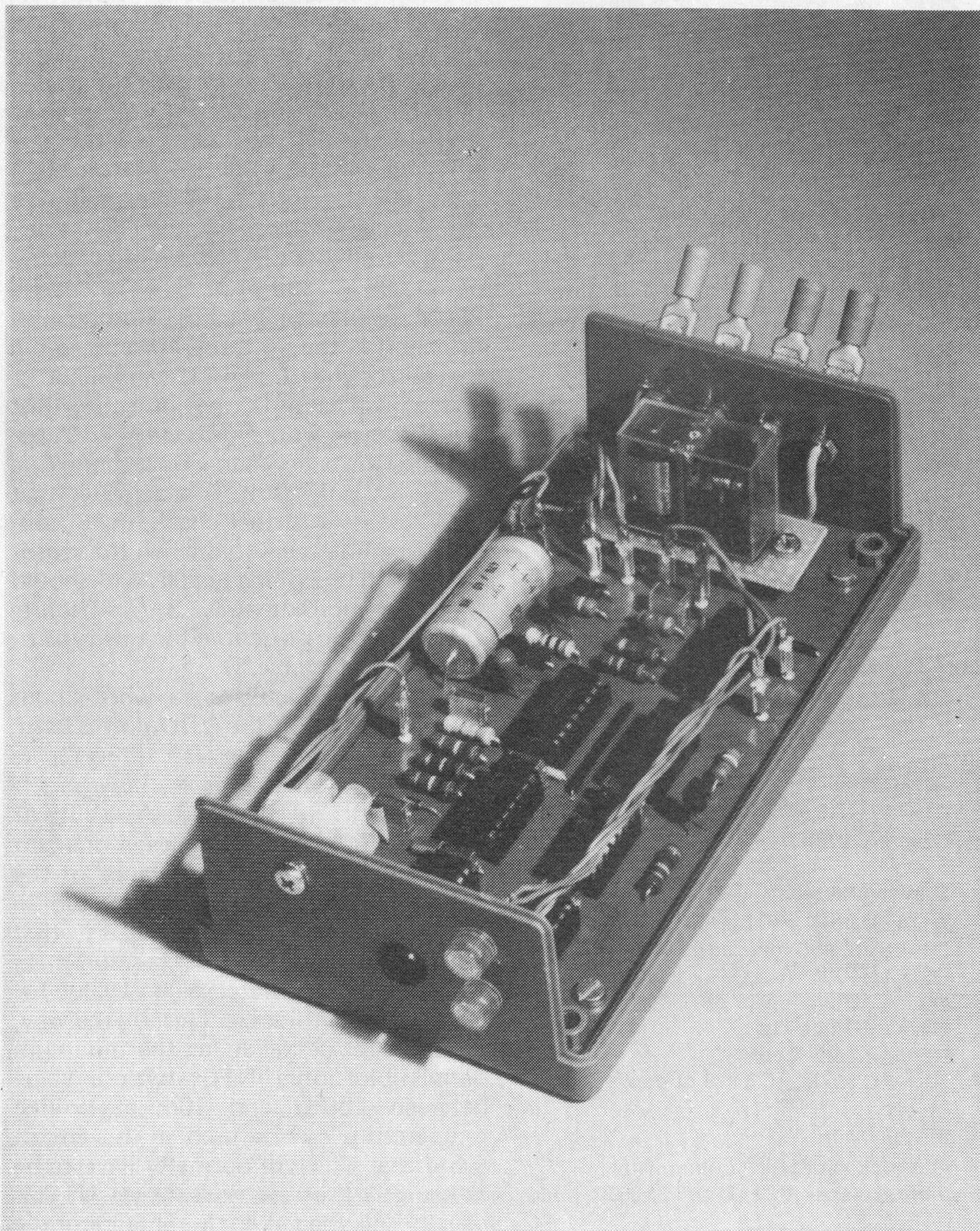
The main disadvantage of conventional delay circuits is that the correct setting is often awkward to find. Usually, it is a devil of a job, when using a pot, to find the right setting for keeping the screen clear without the wipers having to make too many wipes. Once the correct mode has eventually been found, more often than not, the rain suddenly starts pelting down or dwindles to a quiet drizzle, or a car passes and floods the entire windscreen with buckets of water . . . All in all, such a circuit is nothing to be proud of! With Elektor's intelligent windscreen wiper circuit, however, things are different. It is so easy to operate that the number of wipes per minute can be changed in a fraction of a second. Pushing a button twice is all that is needed to effect a change. It will 'remember' how much time passed between the two button presses and will maintain this interval for as long as is required.
Such a simple operation is due to the fact that neither components nor efforts were spared during its design. The circuit itself is fairly complicated, but has been simplified to a reasonable level. Only four leads have to be connected to the existing windscreen wiper wiring. Under the heading 'construction' some reference will be made to the standardisation of the terminal coding in cars. Since this is not generally accepted as yet, a method will also be described of how to find the right terminals easily by using a test lamp. In short, the construction and setting up should not pose any problems. The exact working of the circuit will be a little more difficult to understand. It therefore seems appropri-

ate to start by explaining this, before we go any further.

The block diagram

At the heart of any delay circuit there must always be a memory. This may be of the simple analogue type, an RC network, for instance, where the RC-time determines the delay duration. If the delay is to be regulated as required, the memory will have to be slightly more complicated. Then a pot or a step switch will have to be included, so that the RC time constant may be adjusted.

More up-to-date technology was used in designing the delay circuit in this project. There are of course memory IC's which can store digital information and quite a large amount of memory is available in an IC of this nature. Information may be stored in the form of a '0' or a '1'. The information to be stored is fed into the data input. Furthermore, there are ten lines through which information may be fed to the IC to determine the selected memory location. In the IC used here there are 1024 memory locations, or addresses. If these are numbered from 1 to 1024, they may then be selected by setting the number on the ten address lines in a digital (binary) code. The code will be given by a counter which can count to 1024. If we allow the counter to count pulses from a clock-generator, a time factor is introduced into the memory. Should the clock-generator, for example, produce five pulses per second, five memory addresses per second will be selected in succession. The memory also has a read/write control input, thereby allowing information to be written into or read out of memory. Previously stored information appears at the data output during the read cycle. By utilising this method of operation, a useful delay circuit can be realised.

The block diagram of the circuit is shown in a simplified form in figure 1. Any contact bounce in the wiper control switch is eliminated by the pulse shaper. The output of the pulse shaper controls an electronic switch which determines the read/write mode of the memory section. Also included is a clock-generator which produces a fixed number of pulses per unit of time. Apart from this, there is a reset-section and a small block to control the windscreen wiper motor. The most important part of the system is the block marked counter and memory.

When the wiper switch is operated, the wipers wipe (once), the counter is reset, and a number of memory addresses are filled with 'noughts'. When the wiper switch is operated a second time, a 'one' is entered into memory and the counter again reset. The memory is now placed into the read mode and scanned until the '1' is found. This causes the wipers to operate and the counter to be reset. As the memory is read at the same
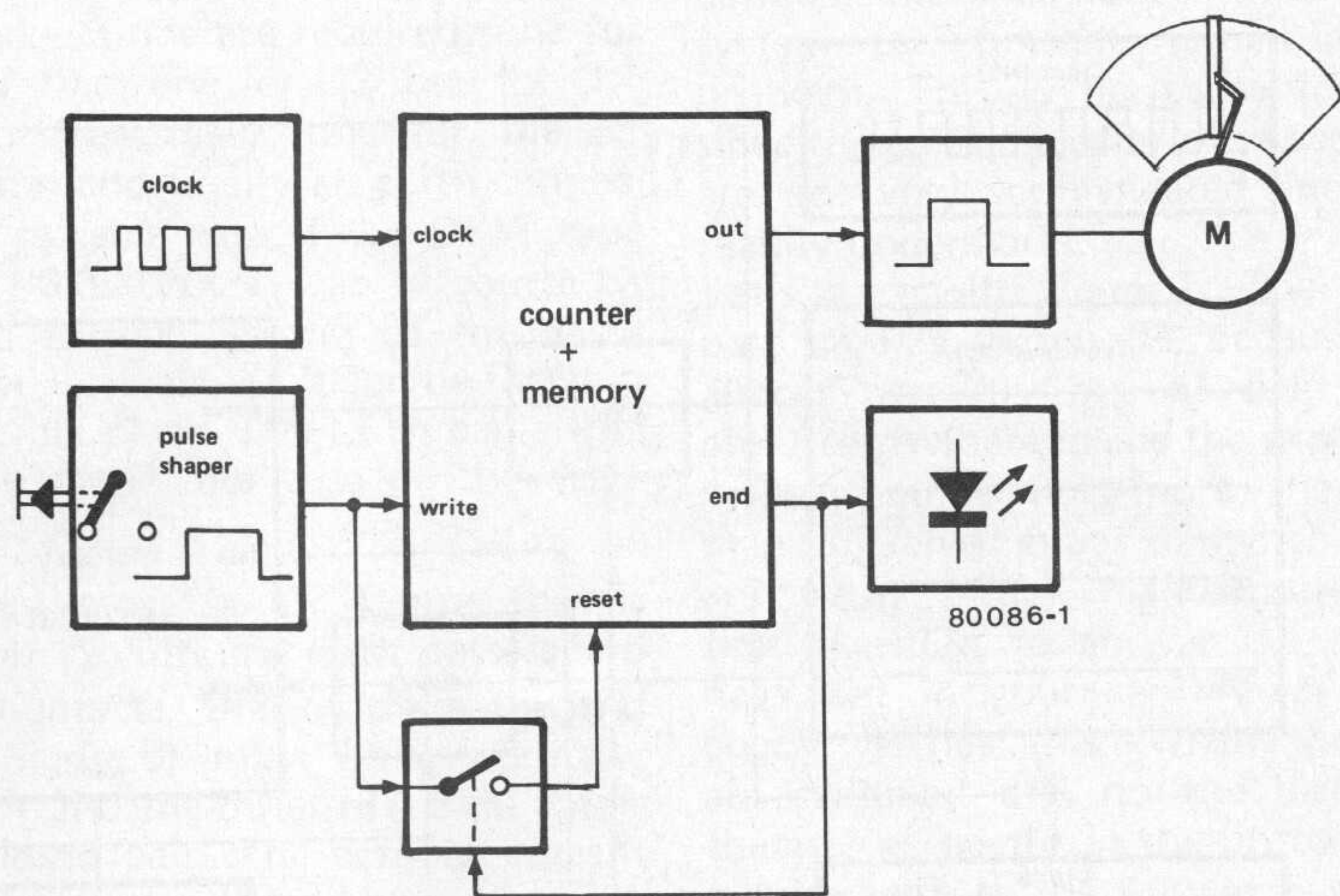

figure 1. The simplified block diagram of the windscreen wiper delay circuit that includes a digital memory.

speed that information was entered the time delay between successive wipes will be the same as that between the two initial operations of the wiper switch.

All this sounds simple enough, but in practice quite a few obstacles will have to be overcome. For instance, it is highly important that everything happens at the right time and in the right order. Usually all important events start the moment the clock-signal changes in level. However, when the memory is controlled, the events have to occur in a fixed order. Thus, of course, the address first has to be chosen before the information is written into it. Trying to do this simultaneously would probably cause the information to end up in the wrong memory location. Instead of a single clock-signal, therefore, several will be needed. These will change in level at different moments, but will have the same frequency. That is why only one clock-generator is used, but its output is fed to a sequencer before it controls various IC's. Each of the outputs from the sequencer go high in turn for the duration of one clock pulse.

Only four of the ten available output signals are used in the delay circuit. In figure 2 an attempt has been made to illustrate how the various important parts of the circuit function.

The circuit

The complete circuit diagram of the 'intelligent' wiper is shown in figure 3. The actual switching of the windscreen wiper motor is carried out by a relay. When the relay is activated, it will operate the wipers. But first it is better to discuss the relay control. The clock-generator is formed by the circuit

around N1. As soon as the supply voltage is applied, the frequency of oscillation, determined by the values of C2/R3, will be fairly high (a few kilo Hertz). When C1 is sufficiently charged, D1 will conduct, holding the voltage at the junction of C2/R3 high. This makes the oscillator run at a much lower frequency (approximately 25 Hz) because of the greater time constant of R4/C3.

The output of the clock-generator is fed to IC1, a 4017, which serves as the sequencer mentioned previously. The output at Q1 is high during the second clock period, Q5 during the sixth, etc. The memory is contained in a single 2102, IC2, which is connected directly to the binary counter, IC3, via its address lines (A0 ... A9). Two flip-flops are contained in IC4. They operate as follows. When switch S1 is operated the output of N3 will go low. This '0' is fed to the D input (pin 5) of the first flip-flop. During the positive transition of the next clock pulse (Q5 of IC1) this '0' will appear at the Q output (pin 1) and will be inverted at the $\overline{Q}$ output (pin 2). The flip-flop in the second half of IC4 reads the 'old' condition of the first flip-flop during the first clock-pulse and remains unchanged. It is not until the second clock pulse that the second flip-flop passes on the new data from the D input to the $\overline{Q}$ output (inverted of course).

During the second clock pulse however, the first flip-flop does not react (at least not unless S1 is operated again). The signal change at the D input of the first flip-flop does not arrive at the $\overline{Q}$ output of the second flip-flop until after two clock pulses. The remaining IC, IC5, is a monostable multivibrator which is triggered by a negative going edge. When
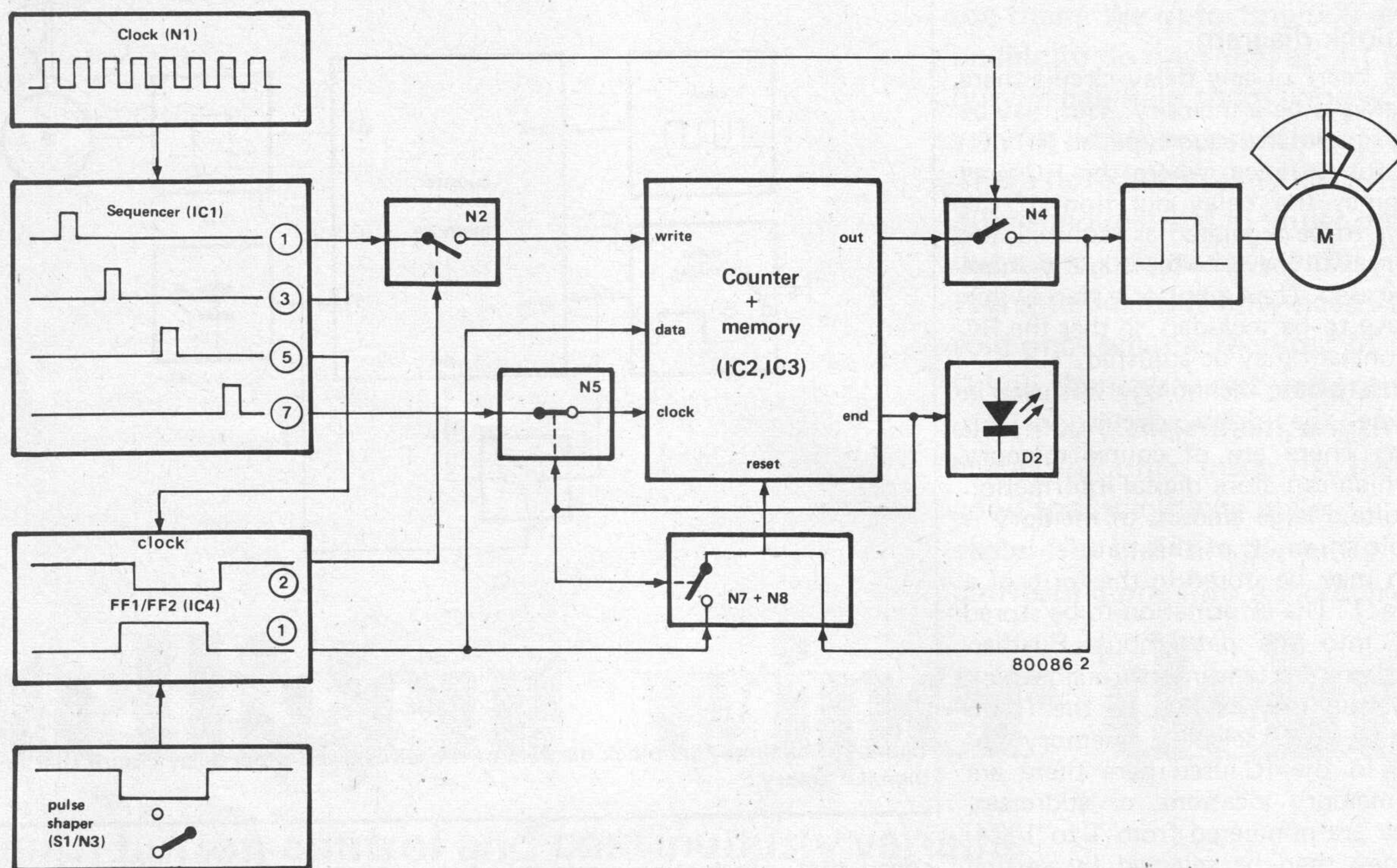
figure 2. An extensive block diagram of the wiper circuit.

the level at its input (pin 5) goes low, its output (pin 6) will go high for a period of time determined by the values of R10 and C5. When this output is high, transistor T2 is turned on and the relay is energised.

That just about covers the main components of the circuit, but now we go into greater detail.

Normally, when the windscreen wipers are inoperative, the wiper of S1 will be connected to ground. The input of N3 will therefore be low and its output will be high, when the supply voltage is applied. As soon as the supply is 'on' the clock-generator starts to oscillate. The information at the D input of the first flip-flop then arrives at its output as soon as Q5 of IC1 goes high. The data input of IC2 will be low. At the next pulse from the Q5 output of IC1 the $\bar{Q}$ output of the second flip-flop will go high. The output of N2 is only low when both inputs are high, therefore, IC2 will be put in the 'write' mode and a 'nought' written into the memory when the Q1 output of IC1 goes high. Let us suppose that the output of N6 is high immediately after switch-on. The output condition of N5 is then determined exclusively by the signal from Q7 of IC1. This clock signal is applied to the counter (IC3) via N5 and so successively incrementing the address lines of IC2. This causes a 'nought' to be written

into each memory location. After a maximum of 1024 clock pulses the Q11 output of IC3 goes high. The output of N6 will then be low thereby inhibiting the clock pulses to IC3. The circuit is now ready for use and the LED (D2) will go out. All this happens in about one second flat, because the clock frequency is high immediately after power-up. If the wiper switch is operated and held closed, the D input of the first flip-flop will be taken low. At the following positive transition from Q5 of IC1 the data input of IC2 will go high. The memory will still be in the 'write' mode as the $\bar{Q}$ output of the second flip-flop is still high. The counter receives a reset pulse, via N7 and N8, when the $\bar{Q}$ output of the first flip-flop goes high as Q11 of IC3 is also high at that moment. This means that a '1' is written into the first memory location as soon as the Q1 output of IC1 goes high. A little later, Q3 of IC1 will go high and as the memory is now in the read mode, both inputs of N4 will go high providing a trigger pulse for IC5. The output of IC5 goes high turning on T2 and activating the relay. At the following pulse from Q5 of IC1 the memory is put in the 'read' mode via the second half of IC4 and N2. The '1' in the first address location is read once more and the wipers move again. At the same sime, however, IC3 is once

again reset. In this way the circuit continues to read the first address. The interval timing is started as soon as the driver releases S1. This is because the information at the D input of IC2 then changes to '0'. A little later, the memory IC is switched to 'write' by means of the second half of IC4 and 'noughts' are written into memory. The '1' in the first memory location is over-written with a '0'. When the memory is read only 'noughts' appear at the output of IC2 and the windscreen wiper stops. IC3 is no longer reset,

After the required interval has passed, S1 is again operated. Now the information at the D input changes to '1', while IC2 is still in the 'write' mode. After this '1' has been written (while Q1 of IC1 is high), the same '1' is read (while Q3 is high). This causes the windscreen wipers to operate but soon after, IC3 is reset by way of N7. With the aid of Q5 the R/W input is switched to 'read' via the second flip-flop. All the 'noughts' written in the memory are now read in succession until the '1' is read again. Then IC3 is reset, so that the cycle starts at the beginning.

The monoflop time of IC5 can be selected in such a way that every time IC5 is triggered the wipers make a single stroke. By enlarging the value of capacitor C5, two strokes can be made instead of one.

The LED D2 lights whenever the Q11 output of IC3 is low. This is the case if the supply voltage has been available for long enough and S1 is not closed. D2 will therefore indicate when the circuit is ready for use. If the windscreen is to be continually wiped while D2 is still lit, this can be done quite simply by presetting a very short interval. S1 must then be switched very briefly.

Finally D3 lights when the relay is under power. Now it will be clear, even without the LED, when the relay is activated, but the LED will indicate a defect or, at least, show whether the circuit is working properly.

Construction

The printed circuit board and component layout for the intelligent delay is shown in figure 4. Mounting the components onto the printed circuit board should not cause any problems, as long as IC sockets are used. A good idea is to insert the entire circuit into a plastic case. Secure terminals for outside connections will also be necessary. At least eight connections are required: one for the 12 V line, one for D3, one for D2, three for the relay, one for the S1 connection and finally an earth connection. A suitable case is the OKW type number 90-30-087. It can of course be mounted at the bottom of the dashboard for instance, or it can be fitted in a less visible place. The LEDs can either be mounted on the case or the dashboard.

The relay must be of a type that is reliable at 12 volts and must possess two sets of contacts. One of these (88 and 88a in figure 5) must be a normally open pair and the other (87, 87a) a normally closed pair. The contact current rating of the relay should be at least 5 A (preferably 10 A). It is also important that the coil current must be no more than 400 mA as this is the safe limit for transistor T2 (BC 517).

Installation

Without any prior knowledge of wiper circuits, the installation of the delay system can present something of a problem. This is no cause for alarm, since the great majority of wiper circuits are not very sophisticated and can be readily understood.

Let's start with figure 5. The problem part here is switch 'H' because this is almost certainly out of sight, tucked away somewhere inside the wiper motor mechanism. What is more, there are as many different types of switch as there are wiper motor manufacturers. The first question to answer is — do you have one in your car? A very simple check verifies this. When the wipers are switched off, do the blades park themselves neatly at the bottom of the windscreen? If the answer is yes, you can sit back with a sigh of relief. If the answer is no, then changing the wiper motor for a later model might be a solution for you as the fitting of this
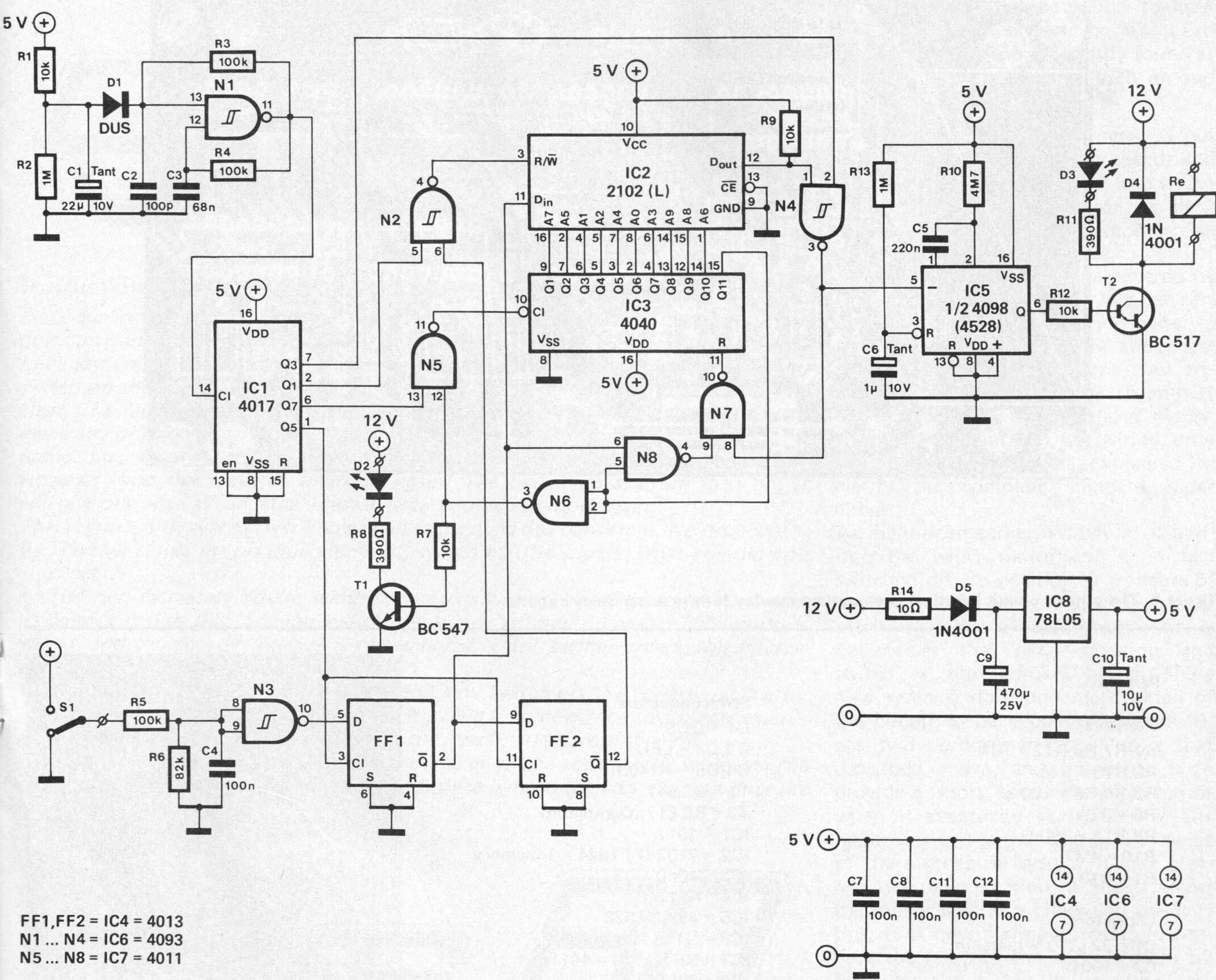
FF1, FF2 = IC4 = 4013
N1 ... N4 = IC6 = 4093
N5 ... N8 = IC7 = 4011

80086 - 3

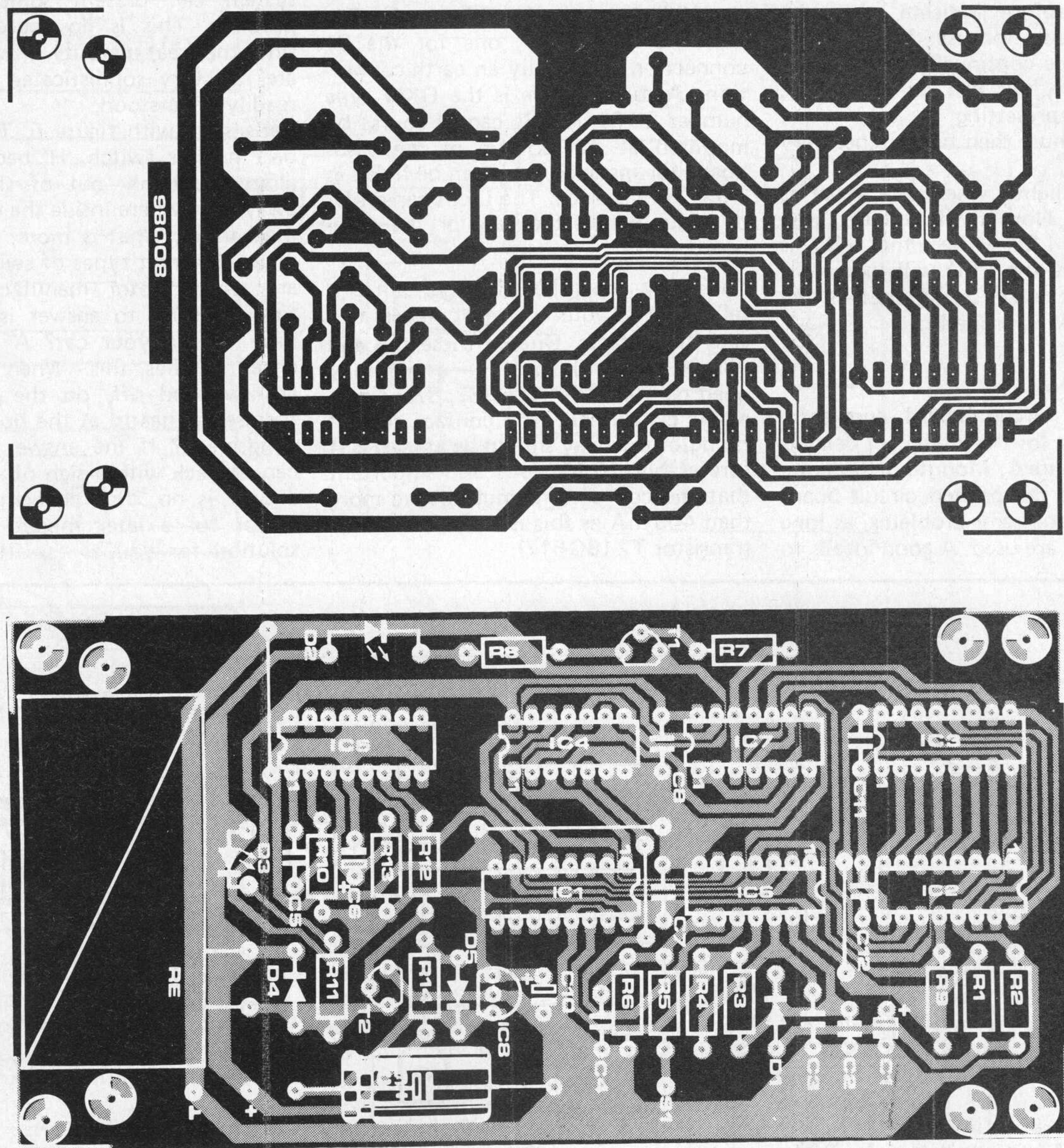figure 3. The circuit diagram of the 'intelligent' windscreen wiper delay. The relay must be able to switch at least 5 amps.

figure 4. The printed circuit board and component overlay for the wiper delay circuit.

Parts list

Resistors:
R1,R7,R9,R12 = 10 k
R2,R13 = 1 M
R3,R4,R5 = 100 k
R6 = 82 k
R8,R11 = 390 Ω
R10 = 4M7
R14 = 10 Ω

Capacitors:
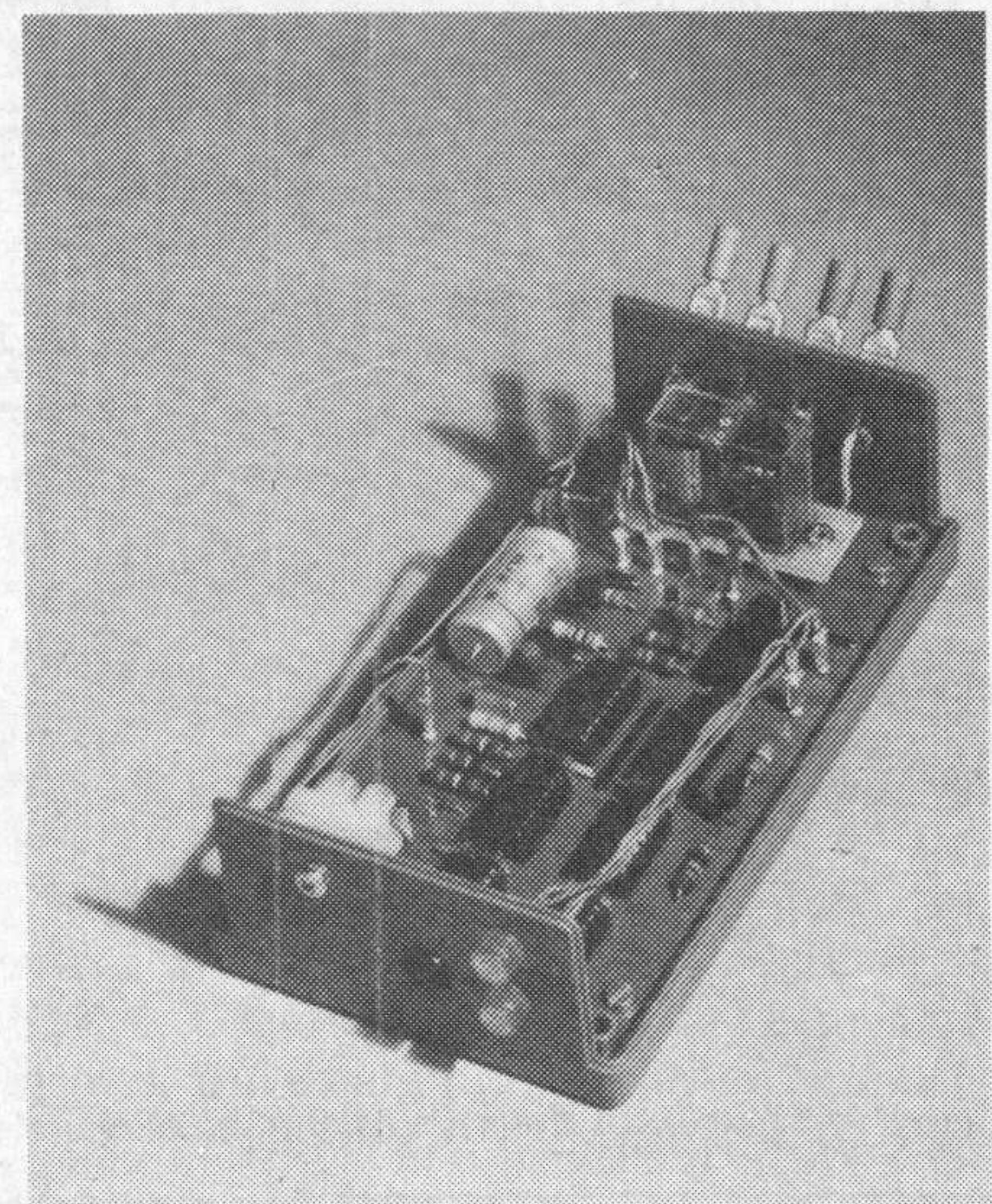C1 = 22 μ/10 V tantalum
C2 = 100 p
C3 = 68 n
C4,C7,C8,C11,C12 = 100 n
C5 = 220 n
C6 = 1 μ/10 V tantalum
C9 = 470 μ/25 V
C10 = 10 μ/10 V tantalum

Semiconductors:
D1 = DUS
D2,D3 = LED
D4,D5 = 1N4001
T1 = BC 547
T2 = BC 517 (Darlington)
IC1 = 4017
IC2 = 2102 (L) 1024 x 1 memory
IC3 = 4040
IC4 = 4013
IC5 = 4098, 4528
IC6 = N1 . . . N4 = 4093
IC7 = N5 . . . N8 = 4011
IC8 = 78L05

Miscellaneous:
S1 = double pole switch
Re = relay 12 V (e.g. Bosch)
case OKW type 90-30-087
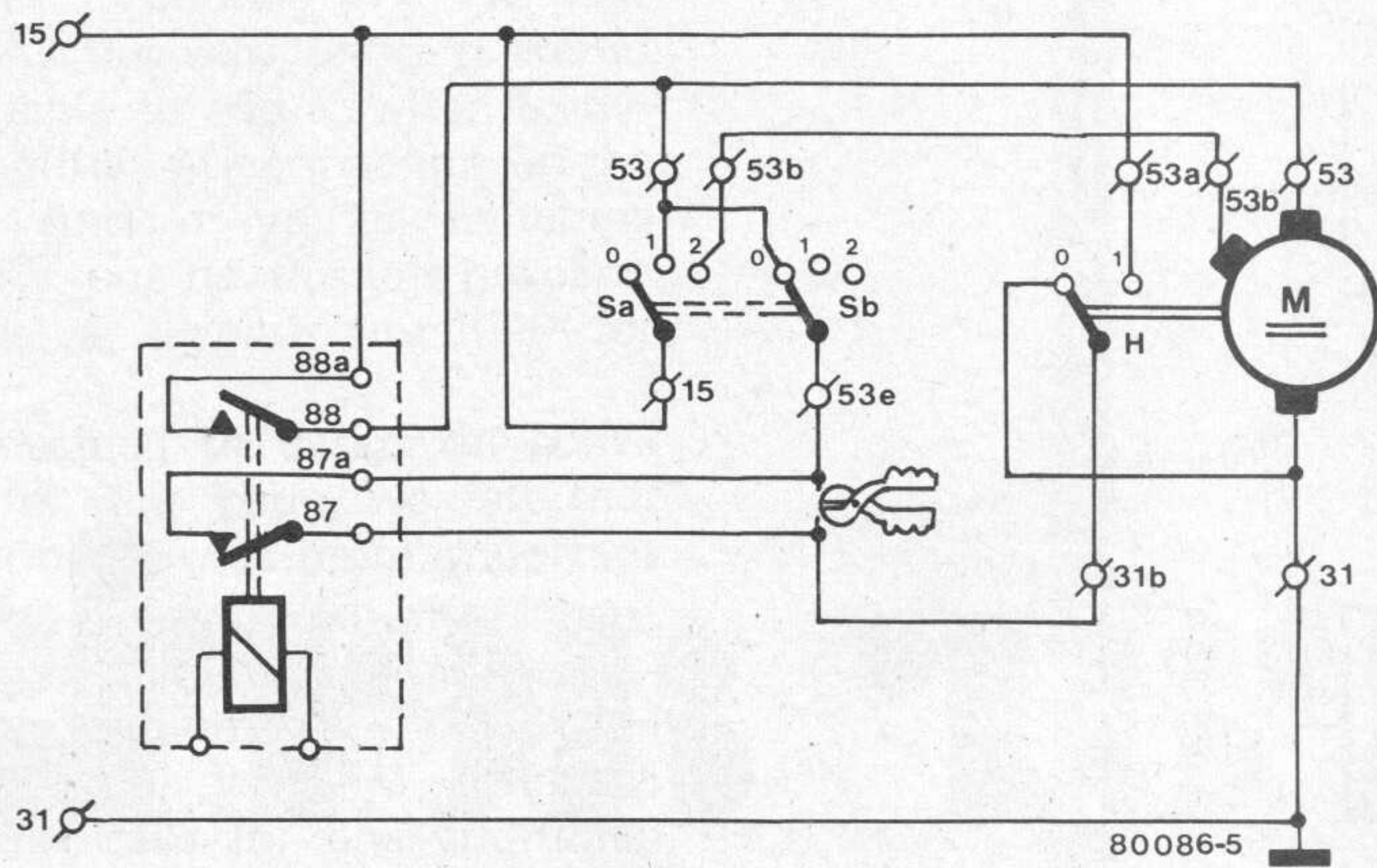
figure 5. What the windscreen wiper wiring will look like in your car. The dotted area contains the relay contacts of the delay circuit.

Instructions for use

Even an 'intelligent wiper delay' unit must be told what to do. Fortunately, it is quick on the uptake. More specifically, it is designed to work 'as you would expect'. Let's say you're driving along, and it starts to rain slightly. At a certain point, you switch on the wipers to clear the windscreen — than you switch off again when it's clear. The fact that the wiper switch actually controls an 'intelligent' wiper doesn't make any difference.

Some time later, it becomes time for another wipe. So you switch on the wipers. However, you don't switch them off again! The circuit does. From then on, It will give one wipe at the same interval, until you switch it off again.

This is great, but, every driver knows rain is anything but consistent. No problem!

- *The rain stops. In this unlikely event, switch off the wipers. What else did you expect?!*
- *The rain increases. You're windscreen needs wiping, but the automatic system doesn't realise this. So you switch the wipers off and on again. The 'screen is wiped, and the shorter interval is remembered. Until further orders, this interval will be maintained between wipes.*
- *The rain decreases. So what do you do? You switch off the wipers — just after they've cleared the windscreen. When it's time for a new wipe, switch on again — and leave them on! They'll do the job, at the new interval, from then on.*

Intelligent? Yessir! You operate the wiper switch in the normal way, whenever the amount of rain changes. But you only do it once — from then on, the unit does the job automatically.

switch is not a practical proposition. The other switch in figure 5, Sa/Sb, is in fact the car wiper switch (standard fitting on most cars!). The circuit shown is of a typical two-speed wiper system. The numbers indicated on the motor and switch wiring (15, 31, 53 etc.) are the European DIN standard designations, this means you may or may not find tem on your car. However, for the sake of simplification it is convenient to use them here.

The question now of course is, how do you identify these wires on your wiper motor? For this a small 12 volt bulb with two connecting leads is required. One lead is connected to the chassis (or the battery's negative terminal) and the other is used to scan the terminals of the motor. There is no need to disconnect any of the wiring for these tests. With the wipers switched off, the bulb will light on only one of the leads to the wiper motor. This will be 53a on the drawing. If, both the ignition and wiper switch are now turned 'on' (to low speed if there are two positions) a further lead will be found to light the bulb and this will be 53. Lead number 31b can now be easily found as on this one the bulb will flash on and off.

The dashboard switch can now be put in the second position (fast speed) and 53b will 'light the light'. The lead which never produces any reaction at all is number 31, or the negative connection of the system.

At least 90% of cars will be covered by this simple testing method. In some cars however, the negative supply is switched (positive earth systems). The above test procedure remains the same, but the positive and negative (leads 15 and 31 in figure 5) will have changed places. Having now identified the wiring, only two points need to be explained to clarify the complete standard wiper circuit.

As mentioned earlier, switch 'H' is built into the wiper motor and is in fact switched off (to position '0' in figure 5) by the motor when the wiper blades reach the edge of the screen. This is known as the 'park' position and switch 'H', the 'self-park' switch. There now remains only one more detail of the circuit to be explained. Switch 'H' has two purposes in life. One is that described above, and the other is to provide a 'short' across the wiper motor when it eventually switches off. The reason for this is that due to the inertia of the mechanical system, it may overrun the park position, a 'short' across the motor acts as a brake and prevents this. It is now a simple matter to connect the relay to the wiper system by following the circuit in figure 5. Only one lead needs to be cut, and this is labelled 31 and 53e as shown. Please do not ask us why DIN standards require two numbers for one cable, we have quite enough illogical answers to this already.

active car aerial
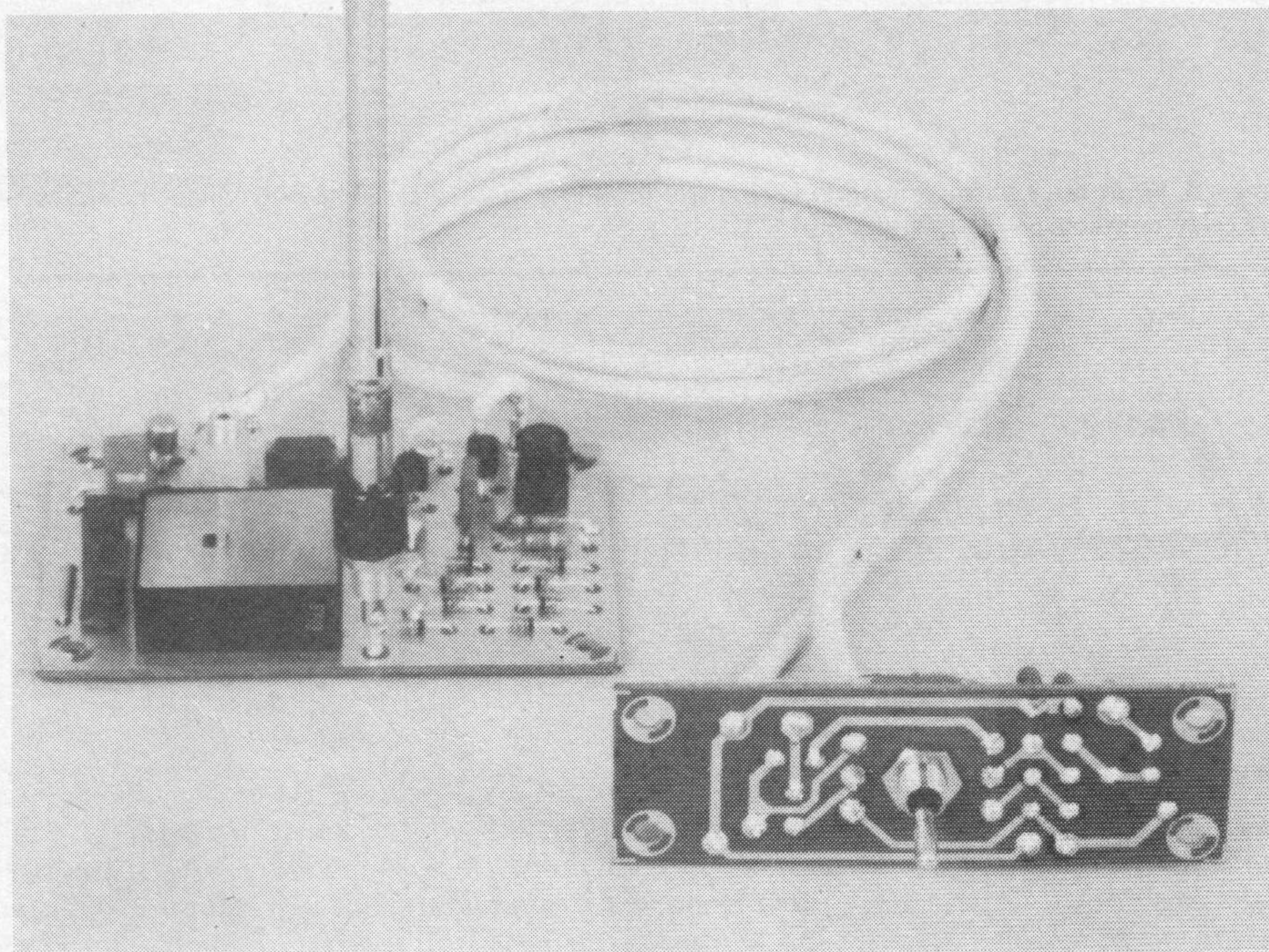
Better reception
with less noise

Aerial amplifiers are often used for domestic receivers — in some cases, even, where they do more harm than good. In cars they are not nearly as common, surprisingly, since that is one place where they can often be extremely useful! The few aerial amplifiers installed in cars are usually the standard commercial type: 'wide-band', they say, but not much good for VHF-FM. This 'car issue' seems the ideal place to present our ideas on the subject. With a proven circuit, of course: an aerial amplifier that can be switched for AM or FM reception. Improved performance on all wavelengths — that's what an aerial amplifier should provide!

Whether or not to install an aerial amplifier is always a difficult choice. It is often doubtful whether the reception quality will improve sufficiently to justify the expense. A poor receiver in a fringe reception area is virtually a lost cause — aerial amplifiers don't work miracles! On the other hand, if reception is already good enough there is no point in investing in further improvement.

Aerial amplifiers are intended for the 'normal' case between these extremes, where reception is quite good normally, but fades out in fringe areas. Signals that are on the border-line of being acceptable can be boosted satisfactorily. All this is valid for both VHF-FM and AM reception. But there is a difference. VHF-FM transmitters have a fairly small 'service area', and trying to receive them in a moving vehicle with a normal car aerial doesn't help matters. Depending on the transmitter power, height, amount of housing around and the sensitivity of the receiver, the

'fringe area' can be anywhere between 20 and 50 miles from the transmitter. This means that most people are faced with poor reception more often than not! AM on the other hand (long and medium waves, in particular) has a much wider range. You don't need an aerial amplifier for Droitwich! However, if you like to listen to Continental transmitters, or if you intend to drive to the Continent, an aerial amplifier may be a useful investment.

Having made the decision to install an aerial amplifier, there is still a difficult choice to make: what type? To be honest, most commercial amplifiers supplied for cars are not really worth writing home about. They often contain a FET, used as a source follower, and a wide-band amplifier. The idea is to cover the whole tuning range of the receiver in one go. A very laudable endeavour — it simplifies operation in that you don't have to switch amplifiers each time you change to another waveband — but it also entails some

heavy penalties. Reception on medium and long waves may be improved at the expense of poorer VHF-FM performance. At the very least, it would seem reasonable to add a switch to by-pass the amplifier when listening on the FM band. And if you're switching anyway, why not do the job properly and include a second amplifier for VHF-FM?

When we decided to design an active car aerial for this issue, we felt that good performance was more important than avoiding a switch. All effort went into designing two good amplifiers — one for long, medium and short waves and the other for VHF-FM — and the fact that this calls for one additional switch beside the radio was considered acceptable.

Block diagram

Do you really have to switch between the two amplifiers? Surely it must be possible to include filters that separate the low frequencies (AM) from the high (VHF-FM), feed each to its own amplifier, and then mix them again before

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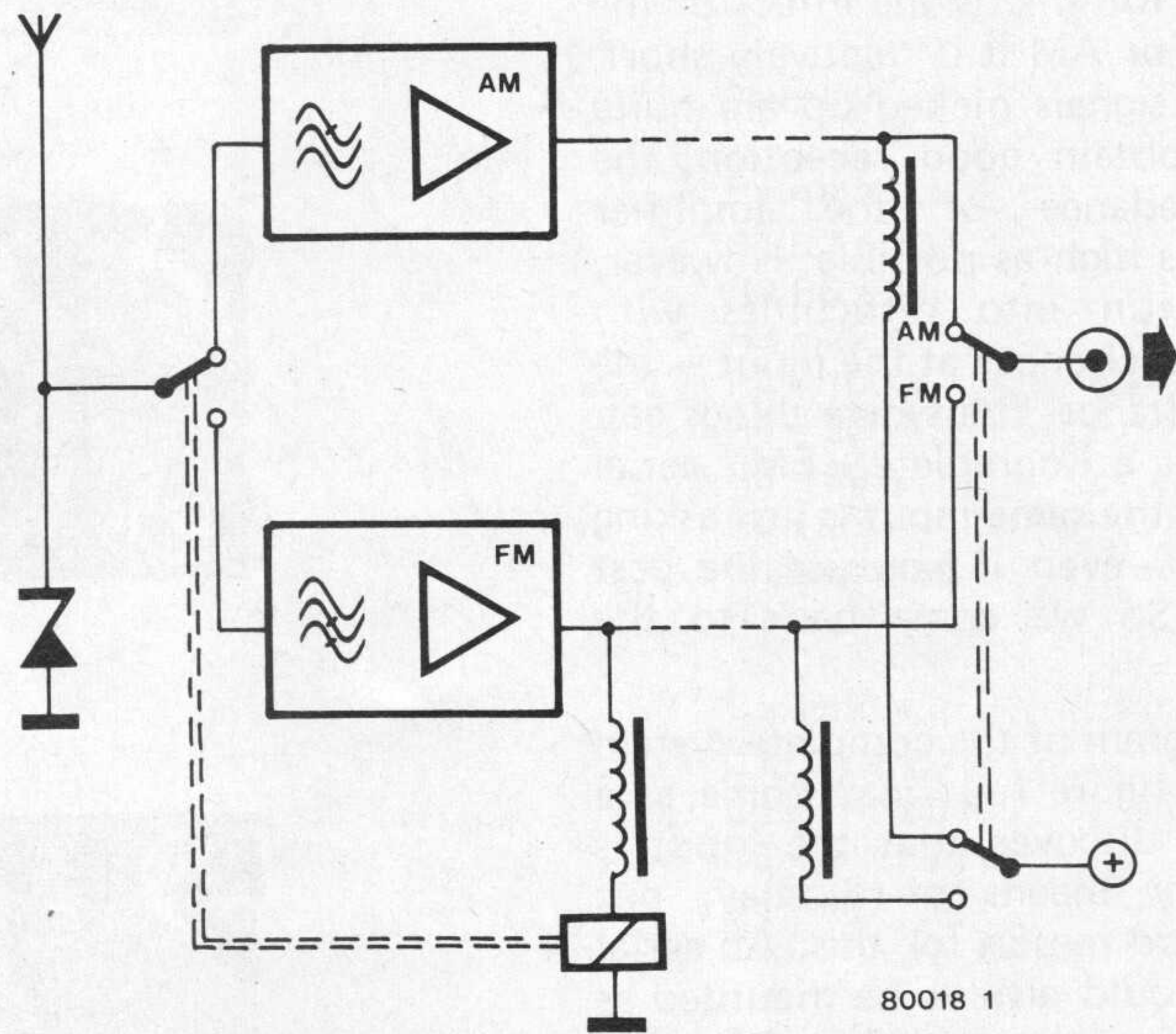
Figure 1. Block diagram of the active car aerial. The amplifier consists of two sections: one for AM (long, medium and short waves) and the other for VHF-FM.

2
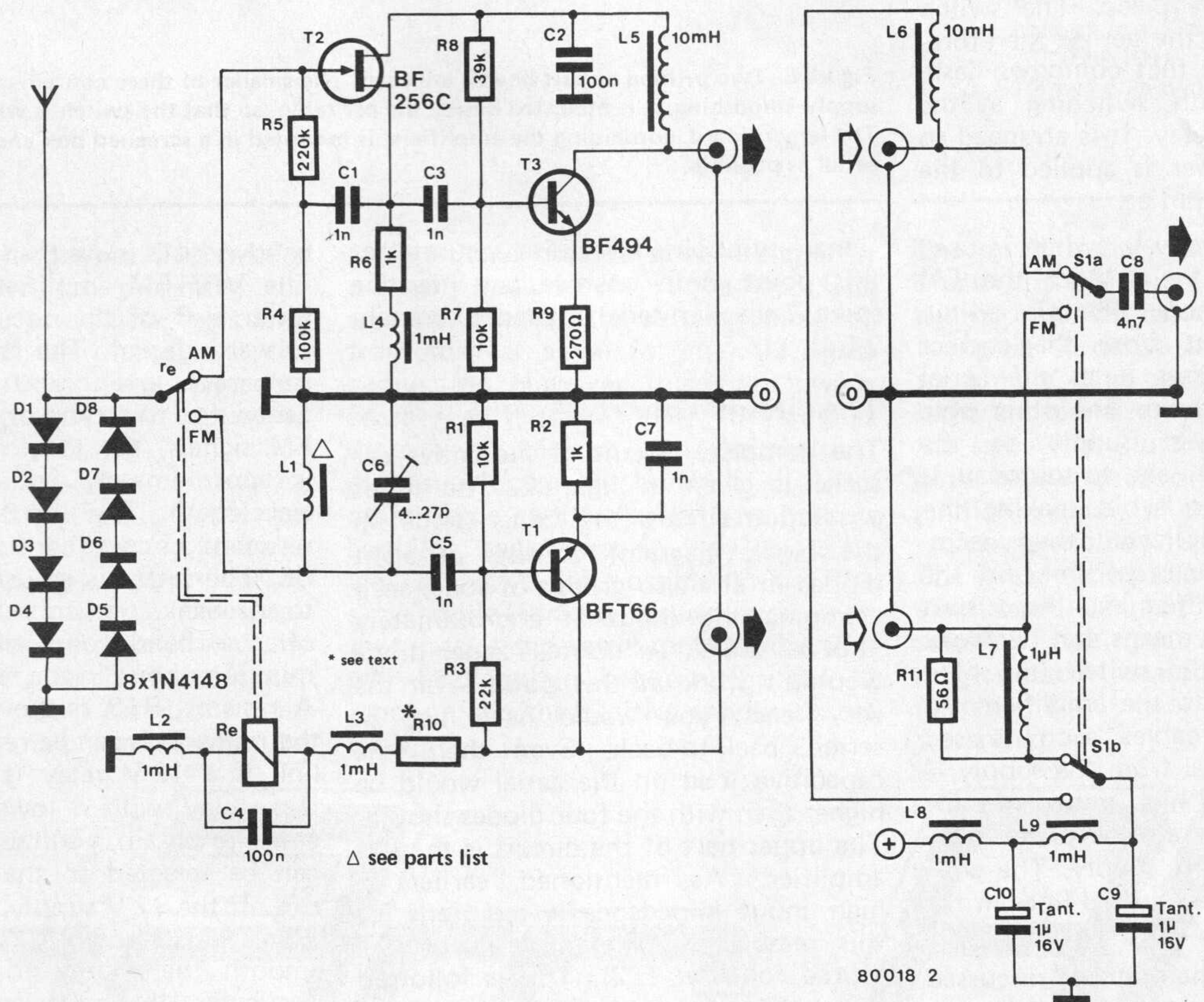
Figure 2. The complete circuit. The two amplifiers are at the left (AM at the top and FM at the bottom); the right-hand section is the supply smoothing and switching circuit.

passing them to the radio? Agreed: that is a possibility. But it is not the best!

The reason for this is the effect of the car aerial. For AM it is relatively short, and so the signals picked up are quite weak. To obtain good reception, the input impedance of the amplifier should be as high as possible. However, you then run into difficulties with parasitic capacitances at the input — the more capacitance, the worse things get. Connecting a complete FM aerial amplifier to the same input is just asking for trouble — even if you use the best of filters! So we come back to the switch.

A block diagram of the complete system is given in figure 1. It may come as a surprise to discover that the input is switched by means of a relay, but there's a good reason for this. An aerial amplifier should always be mounted as close to the aerial as possible. After all, the idea is to boost weak signals, and there is no point in making matters worse by first passing them down a cable that makes them even weaker.

That sort of thing doesn't improve the final signal-to-noise ratio. However, if the amplifier is mounted near the aerial, what do you do with the input switch? Obviously, you can't run long cables to the dashboard — that's even worse than mounting the amplifier there in the first place. The switch must be close to the aerial, therefore. The only solution that combines dash-board control with switching at the aerial is to use a relay. It is arranged to pull in when power is applied to the VHF-FM aerial amplifier.

A double-pole two-way switch is used to select either the AM or the FM amplifier. One pole of this switch selects the output from the correct amplifier, and passes it to the aerial input of the car radio. The other pole switches the power supply to the selected amplifier — and to the relay, if FM is chosen. To avoid making the wiring more complicated than neces-sary, the same cable is used for both the power to an amplifier and the output signal from it. This means that two coax cables run from the switch (mounted beside the radio) to the amplifiers. At each end of both cables, a coil is used to isolate the signal from the supply — its inductance is a high impedance for the aerial signals, and virtually non-existent for the DC supply. The coax cables are shown as dotted lines in the block diagram.

One last detail remains to be discussed in the diagram: the zener diode between the aerial and supply common.This is obviously not intended for DC voltage regulation . . . The reason for including it is to protect the input stages of the amplifiers from high voltages. These could be picked up by the aerial as a result of static charge or even lightning flashes. Actually, as we will see, the
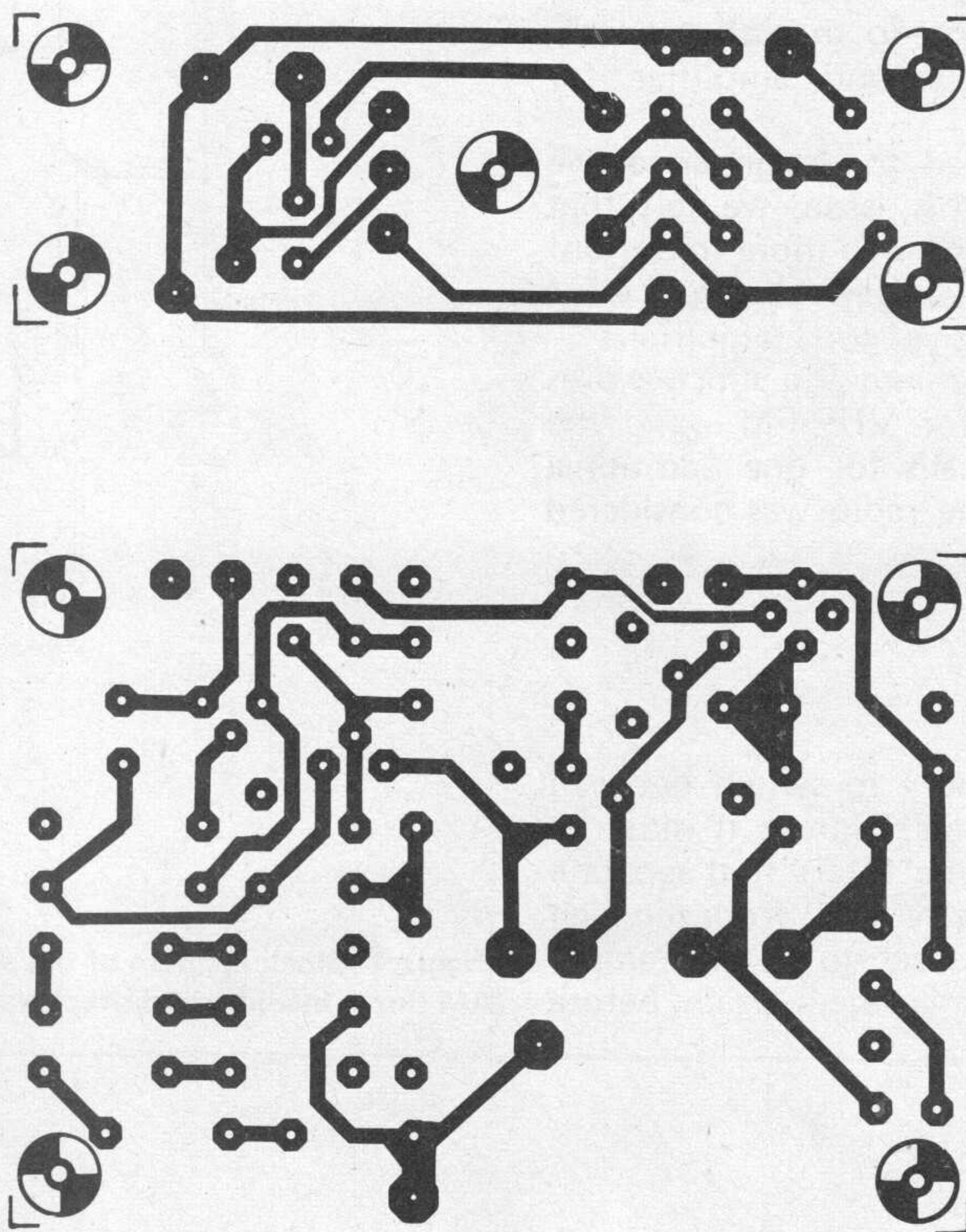
3

Figure 3. Two printed circuit boards are used. The smaller of these contains the switch and supply smoothing; it is mounted beside the car radio, so that the switch is within easy reach. The larger board, containing the amplifiers, is mounted in a screened box and as close to the aerial as possible.

'zener' symbol is not quite accurate: at this point, both positive and negative spikes are limited to approximately 2.5 V.

The circuit

The complete circuit of the active car aerial is given in figure 2. The input protection circuit (the 'zener diode' in the block diagram) consists of eight diodes in all: two groups of four, each clamping the input at approximately + or − 2.5 V. A 'normal' zener diode wouldn't work at this point — at the very least, you would need two in series, back-to-back. Even then, the capacitive load on the aerial would be higher than with the four diodes shown. The upper part of the circuit is the AM amplifier. As mentioned earlier, a high input impedance is required; for this reason, the first stage is a FET source follower (T2). This is followed by a single-transistor amplifier stage (T3); the gain is determined by the value of R9. The total bandwidth of the amplifier is such that a significant im-provement in signal-to-noise ratio can be expected at frequencies up to 18 MHz. Since most receivers don't go above about 6 MHz, even on the short-wave band (6 MHz corresponds to 50 m), this

bandwidth is more than adequate.

The VHF-FM amplifier, shown in the lower half of the circuit, is a straight-forward design. The BFT66 used here is a very low-noise transistor, ideally suited for this type of application. For FM signals, the length of a car aerial is approximately equal to a quarter wavelength. The input is tuned by a resonant circuit, consisting of L1 and C6. The latter is adjusted by tuning in to a weak transmitter in the centre of the band, and trimming C6 for minimum noise in the received signal.

A resistor, R10, is shown in series with the relay. This can be replaced by a wire link if a 12 V relay is used; however, if a relay with a lower coil rating is easier to obtain, a suitable value for R10 can be selected so that the relay can run off the 12 V supply.

L8, L9, C9 and C10 are included to smooth the supply to the circuit. In particular, the nasty spikes caused by the ignition system!

Construction

A printed circuit board and component layout for the active car aerial are given in figure 3. To be more precise: two boards. The first is mounted as close as possible to the aerial: it contains the
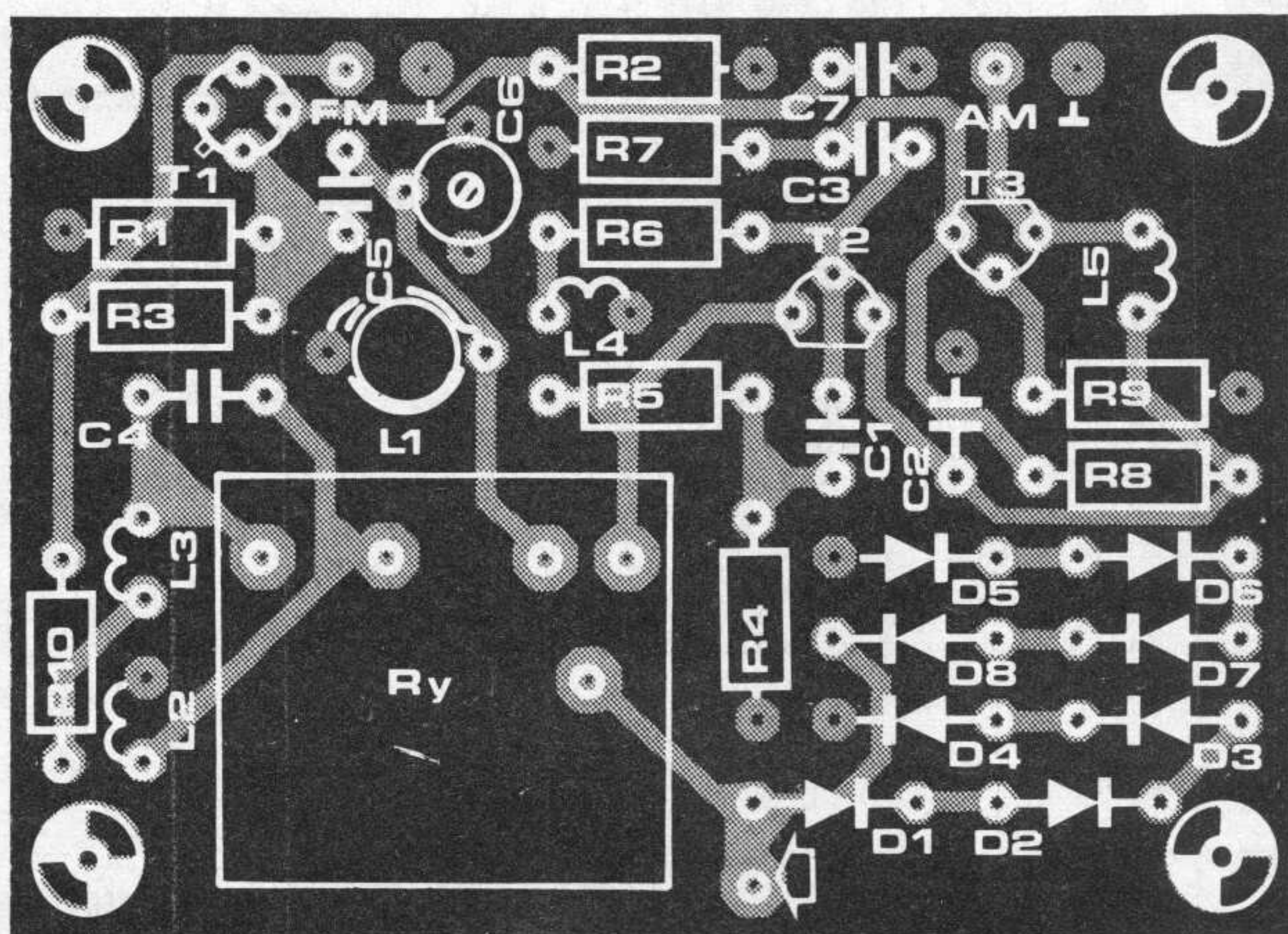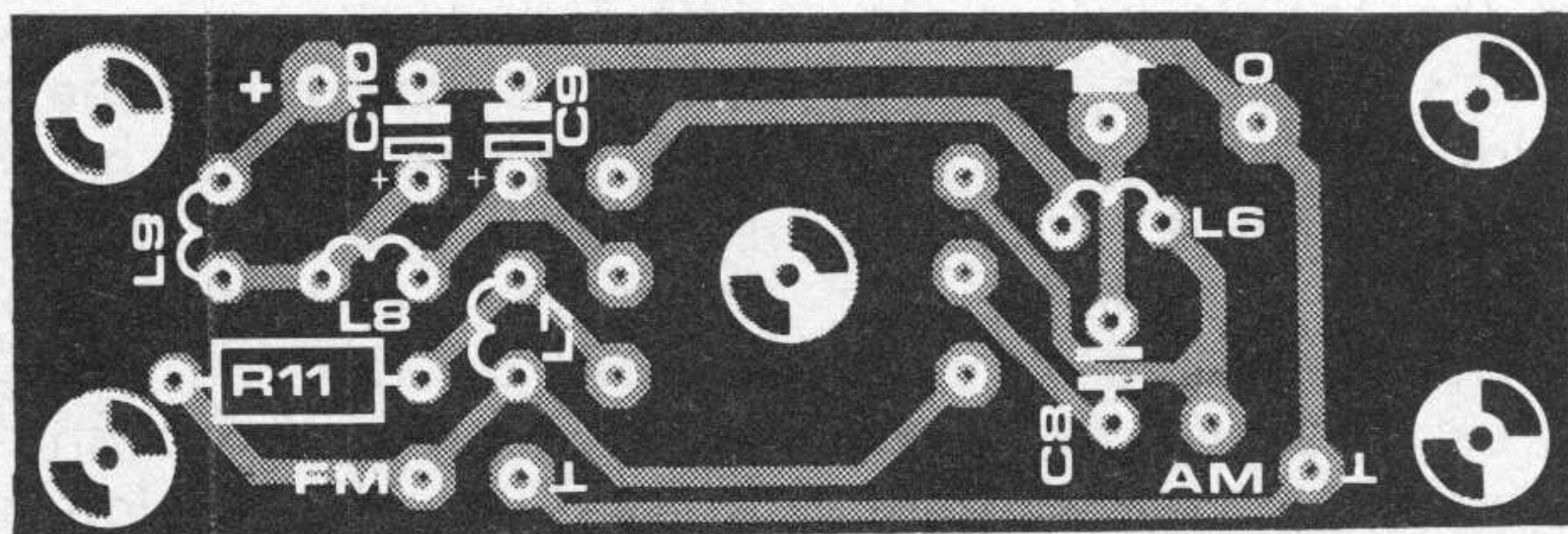
Parts list

Resistors:

R1,R7 = 10 k
R2,R6 = 1 k
R3 = 22 k
R4 = 100 k
R5 = 220 k
R8 = 39 k
R9 = 270 Ω
R10 = see text
R11 = 56 Ω

Capacitors:

C1,C3,C5,C7 = 1 n
C2,C4 = 100 n
C6 = 4 . . . 27 p
C8 = 4n7
C9,C10 = 1 μ (tantalum)

Semiconductors:

D1 . . . D8 = 1N4148
T1 = BFT66
T2 = BF256C

Inductors:

L1 = 3.5 turns on VHF coil
    former, Toko type S18.
L2,L3,L4,L8,L9 = 1 mH
L5,L6 = 10 mH
L7 = 1 μH

Sundries:

Re = 12 V relay, changeover
    contact (e.g. Siemens V23027-
    A0002-A101)
S1 = two-pole two-way switch

two amplifiers and the relay. The smaller board is intended for mounting the switch and the associated coils and capacitors; it can be placed near the radio. The two boards are connected by means of two coax cables, as mentioned earlier.

For the VHF-FM signal connection, normal 'aerial coax' (50 . . . 75 Ω) can be used. However, it is not a good idea to use this type of low-impedance cable for the AM connection. Its capacitance would appear in parallel with the input circuit of the receiver, and it may well be so high that it cannot be compensated for by the trimmer on the radio. (Some kind of 'aerial trimmer' is normally included in car radios.) One solution is to use the existing coax feed from the car aerial for the AM signal connection. However, this is not always as easy as it may appear: the core is often very thin, so that the slightest pull is sufficient to break it. Furthermore, some of these cables have built-in coupling capacitors. If they can't be 'got at', it is not possible to use the same cable for the power supply; in that case, a separate supply connection will be required between the R8/C2 junction and the positive supply (across C10).

The power supply is connected to the smaller of the two boards. Since this will be mounted beside the car radio, it is logical to derive the positive supply from there. This has the advantage that radio and aerial amplifier both run off the same fuse; furthermore, they may both be switched off together by the ignition switch, if that's the way the radio was originally wired.

The larger of the two boards — with the amplifiers — should be mounted in a screened box. We always use 'raw' printed circuit boards, since the copper makes for good high-frequency screening. ◄

stop thief!

Who wants to steal a car with engine trouble?

Protecting one's property is a popular hobby -- particularly when that property is attractive to others. There are all sorts of systems for protecting cars, but the one described here is unusual: it is deception, rather than protection. It doesn't make it impossible to steal the car (for that matter, no system does), but it makes it very unattractive: who wants to steal a car with an engine that stalls every few yards?

Even the most effective of theft prevention systems normally suffer from the drawback that it is immediately apparent to a thief that some kind of protective device is built in. If he is sufficiently courageous, persistent and experienced, he can put the device out of action and make off with the car. If he's a professional thief, it's 'Goodbye, car!'; if he's joy-riding, you *may* just be lucky . . . but normally the vehicle ends up severely crumpled or burned-out. An alarm system that sounds the car horn even seems to be attractive to certain types of 'joy-rider'. Amazing, but true. All in all, no theft prevention system can be guaranteed to keep thieves out of your car. Once in, the chances that they can get it moving are quite high. The system described here should give

— no spark — no go. One dead engine! It can be started again — no problem — and it will run as smoothly as before. Until the relay pulls in again, that is. The circuit is given in figure 1. It is put into operation by operating switch S1. A 'secret' switch, of course. Bear in mind that the best place to hide a switch is very often the most obvious: right in the middle of the dashboard, say. As long as you don't lable it 'theft protection'. Anyway, to get to the circuit: the timer IC (a 555) is used as a multivibrator. As soon as power is applied, via the ignition switch and S1, it starts to produce a squarewave output at about 0.2 Hz. A period time of 5 seconds, in other words. After bridging the ignition switch (that's how they do it), the thief can start the engine
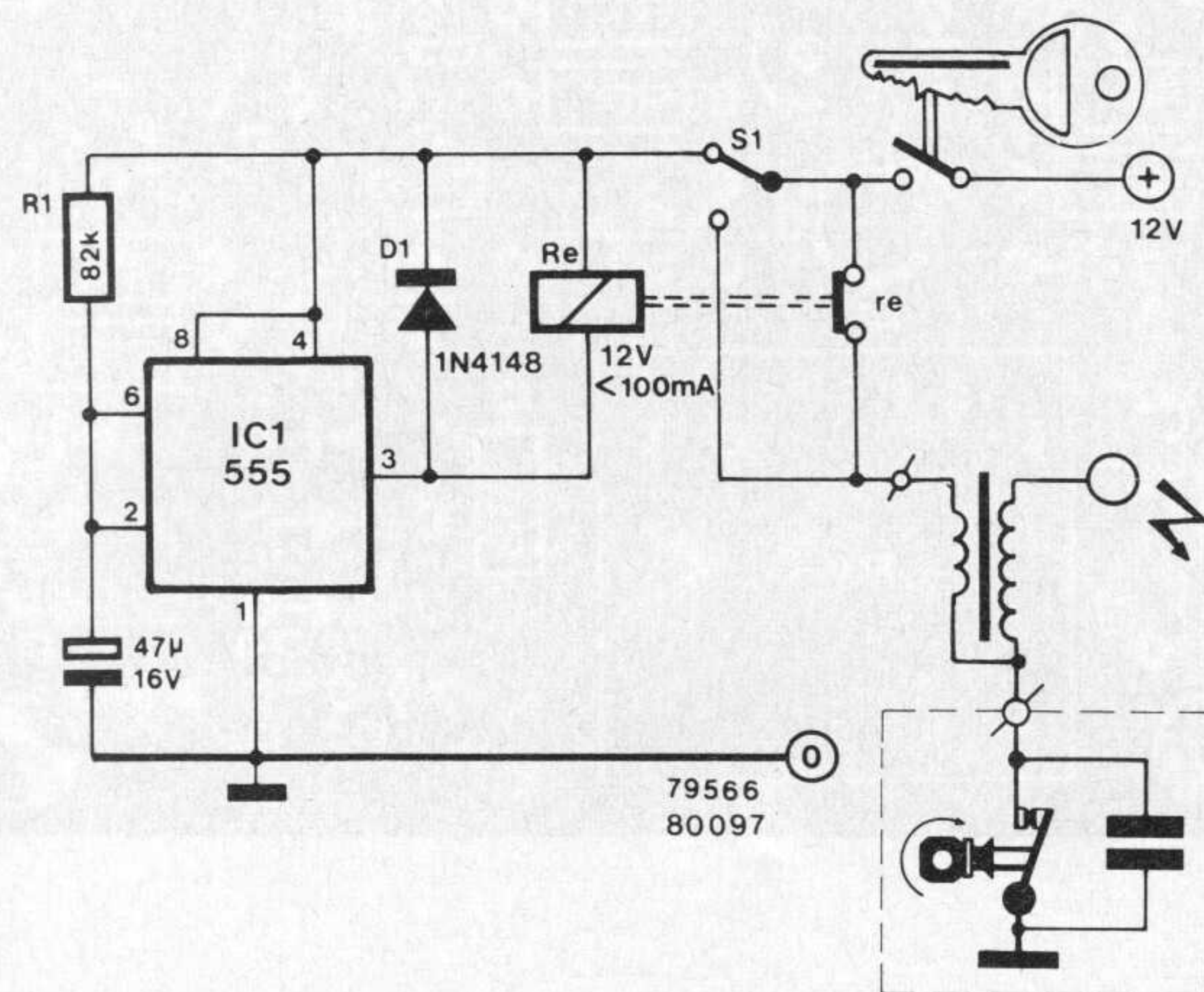
Figure 1. Only six components — cheap ones, at that! — are needed for a quite effective anti-theft device.

adequate protection against joy-riders. It should even discourage most 'professional' thieves — all except the type who is prepared to steal a furniture removal van first and then run your car into it! At the same time, this system has the advantage that it does the job on its own, without giving silent or raucous alarm signals to the owner or other passers-by. There's no need to chase after your property in the middle of the night, wearing only pyjamas and a dressing gown: you can rest assured that it will never end up far away. It is highly unlikely that the would-be thief will drive more than a few hundred yards. What is the basic principle behind such an effective system? Simple! The engine is about as reliable as that of a twenty-year old car with water in the petrol tank!

In practice

The wire from the positive side of the ignition coil to the 12 V supply from the ignition switch is cut, and passed through the break contact of a relay. As long as the relay is not energised, power is supplied to the ignition coil and the engine runs smoothly. However, when the relay pulls in it breaks the connection. No power to the ignition coil

without any problems. However, after five seconds the relay pulls in. The ignition coil is cut off, and the engine stalls. After a few seconds of frustated fiddling, the engine will fire again (the relay has dropped out!), but the feeling of achievement is doomed. Five seconds later, the engine will again stall. To sum it up: the engine *will* run, so apparently there is no theft prevention circuit in the car, but it conks out at short notice. Very frustrating for any thief. His best bet is to leave the car where it is and try someone else's. Always hoping *that* owner doesn't read Elektor as well. The circuit can be modified, according to personal taste. The period time of the 555 (corresponding to the time that the engine will run) is determined by R1 and C1. Too short is suspicious, too long corresponds to a longer walk to your car next morning. A printed circuit board and component layout for this unique anti-theft device are given in figure 2. There is room on the board for a miniature relay; a larger type can obviously be mounted 'off-board'. It is a good idea to look for a relatively 'silent' type, or else mount it in a sound-proof box. A loud Click as the engine cuts out would give the game away!

B.H.J. Bennink

Parts list:

Resistors:
R1 = 82 k

Capacitors:
C1 = 47 µ/16 V

Semiconductors:
IC1 = NE555 or equ.
D1 = 1N4148

Miscellaneous:
S1 = single-pole changeover switch
Re = 12 V/100 mA relay with
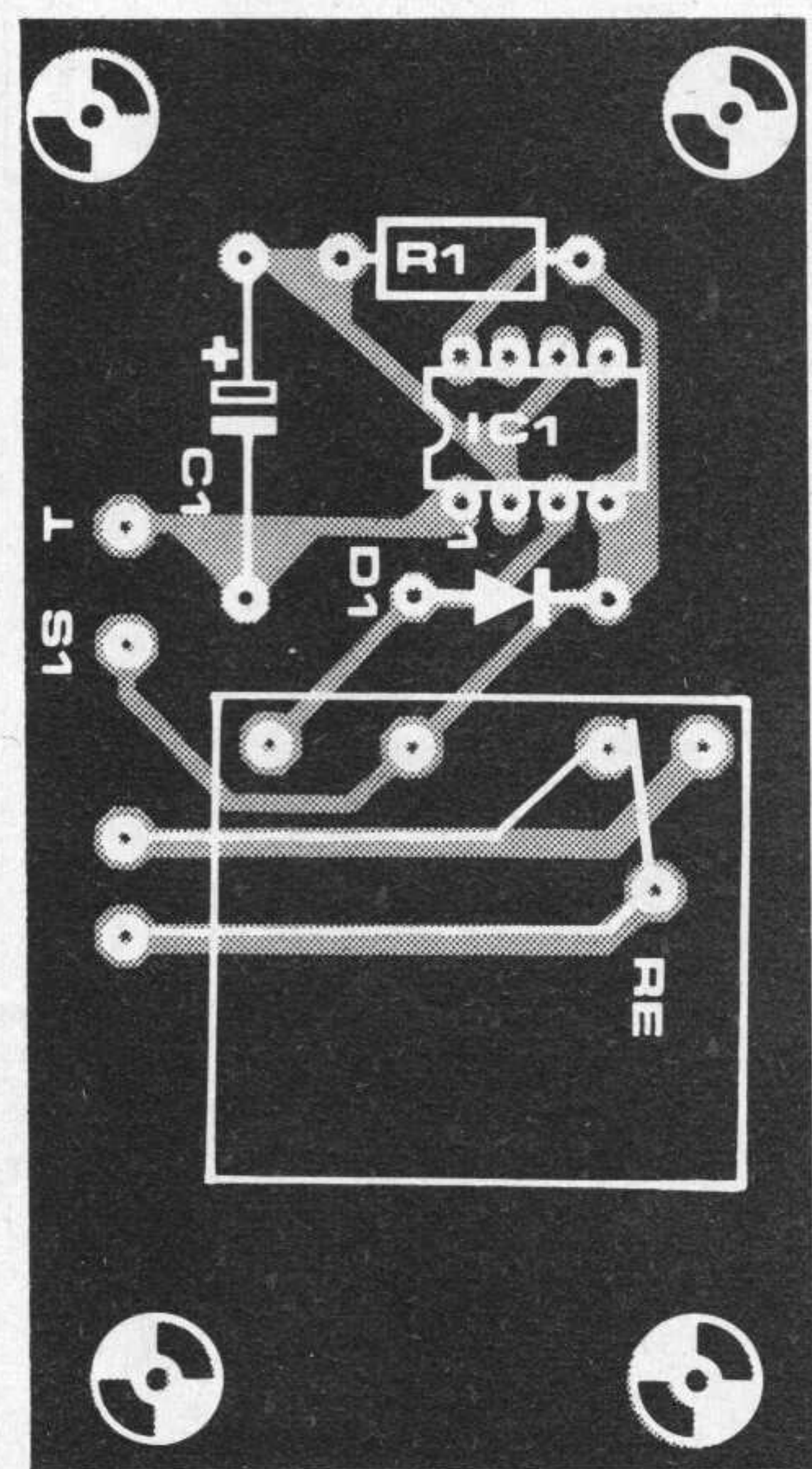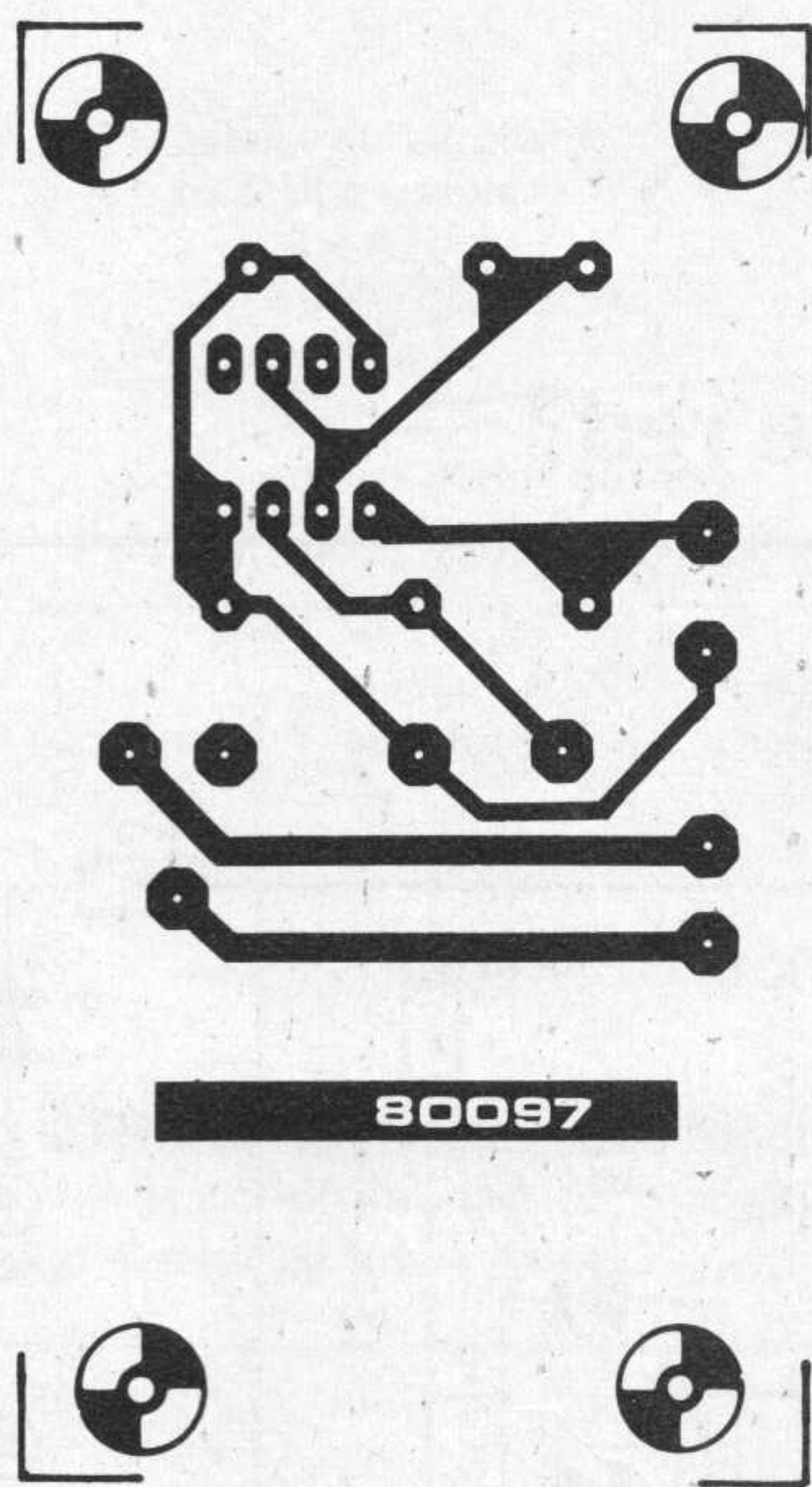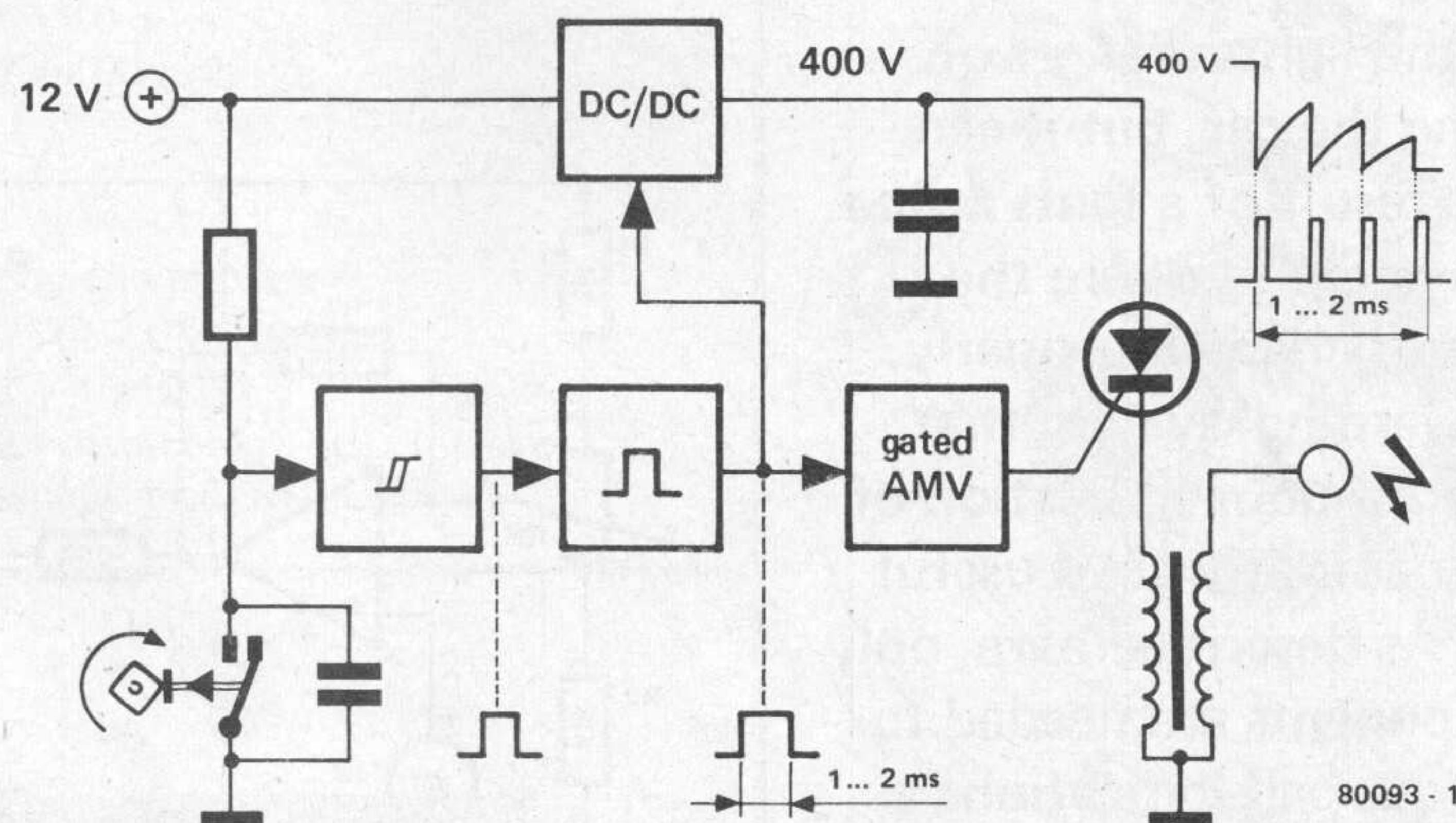   heavy-duty break contact.

2

Figure 2. Printed circuit board and component layout. There is room for a miniature relay, but a larger type can be mounted off-board. 'Sound-proofing' is important!

ejektor

an invitation to investigate, improve and implement imperfect but interesting ideas

thyristor burst ignition

Electronic ignition systems fall into two categories: inductive and capacitive. The inductive type is relatively simple. However, it cannot produce a spark voltage as high as that of a capacitive system unless certain steps are taken, such as in the case of the transistor ignition system described elsewhere in this issue. An inductive ignition system has the advantage that the spark can easily achieve a burning period of one to two milliseconds. This must be reached, as otherwise combustion would only be partial and this would reduce engine power and at the same time pollute both the engine and the environment.

A capacitive ignition system can produce a highly powerful spark, which, unfortunately, does not usually last long enough (unless the steps mentioned above are taken).

A 'proper' thyristor system is comprised of a transistor circuit, usually quite simple, and a high voltage section with a thyristor to control the coil voltage. A capacitor having a voltage of approximately 400 V across it is discharged through the primary of the induction coil by the thyristor. The simple transistor circuit then maintains the spark. Alternatively, a burst of pulses can be applied to the thyristor. The interval between two successive pulse groups can be calculated to keep the spark 'on'. Since a relatively low voltage is required to maintain the spark, once the gas mixture between the spark plug's electrodes has been ionised, the DC/DC converter can be controlled to reduce the voltage during the burst.

The principle of operation is illustrated in the block diagram of figure 1. The signal produced by the (mechanical or electronic) contact breaker is 'shaped' and 'debounced' by a Schmitt trigger. The output of the Schmitt trigger is fed to a monostable multivibrator which produces a pulse with a duration of 1 to 2 milliseconds. This pulse controls the output amplitude of the DC/DC converter and also triggers a gated astable multivibrator (AMV). The AMV is an oscillator which starts up the moment the level of the control input changes and it continues to oscillate until the input level returns to normal. The end result of all this is that for 1 to 2 ms the gate of the thyristor is fed with a series of 'ignition' pulses thereby maintaining the flow of current through the coil and so prolonging the spark.

An ignition system based on this principle would reap the benefits of both inductive and capacitive types without having any of their drawbacks.

battery voltage indicator

It can be rather a nuisance when a car battery goes 'dead'. This can happen if the lights are left on after leaving the car, but it can also be the result of a fault in the electrical system — where the battery is not charged properly. An 'early warning' system that gives an continuous indication of the battery condition is a useful accessory. As described here, only a few components are needed to obtain an 'optical' indication: a single lamp that changes colour from green to red as the battery goes into the danger area.

The circuit in figure 1 uses a two-colour LED as an indicator. Below a certain threshold (12 V, for instance) the LED lights up red to indicate that the battery is low. When the battery is fully charged, the LED will be green. The colour changes gradually from red to green as the voltage increases.

The heart of the circuit is an LM 10 (C) (National). This IC contains a reference voltage source of 200 mV connected internally to the non-inverting input of A1. The circuit round A1 is a differential amplifier; the gain depends on the value of resistor R3. The upper threshold

of the battery voltage is set by P1 — at 14 V, for instance (voltage across C2). At voltages at or above this threshold, the output of A1 is 0 V. As the battery voltage drops, the output of A1 will increase until it reaches the positive supply voltage. The value selected for resistor R3 determines the range of battery voltages over which the output of A1 switches from 0 V to completely positive. With the value of R3 given here, it will be equal to the supply voltage when the battery voltage has dropped by approximately 2 volts (in other words at 12 V). With the voltage

in the green or in the red?

Figure 1. The car battery voltage indicator circuit. The opamps A1 and A2 and the 200 mV reference voltage source are contained in one IC: the LM 10(C).

between 12 and 14 V, the output of A1 will assume corresponding values. A1 controls an oscillator circuit around A2. As A1's output alters, the duty-cycle of the squarewave output from the oscillator circuit will also change. This causes the two-colour LED (D2) to change colour. At both thresholds (12 and 14 V) the output voltage produced by A1 will be at a fixed level (12 or 0 V, respectively). In that case, the oscillator will stop and the LED will light up red or green according to the battery condition.

In figure 2, the battery voltage is plotted as a function of the charge condition. When the engine is running, the battery will be recharged according to the upper curve; the LED will light up green, when it is 70% charged. What will happen during discharge is also evident from the graph.

The printed circuit (figure 3) for the car battery voltage indicator can be fitted quite simply behind the dashboard. It is also possible to use two separate LEDs instead of one two-colour type — considerably reducing the construction cost.

◄

free protection

Elsewhere in this issue, theft protection circuits are included. They're good. But no protection can possibly be complete. Fortunately, most would-be car thieves are amateurs. Even the simplest protection scares them off! For instance: a clearly visible warning: 'This car is electronically protected against theft'. Whether or not some device is actually built in, a warning like this is liable to give them second thoughts.

2

Figure 2. The battery voltage as a function of the charge condition, during charge (upper plot) and discharge (lower plot).

Parts list

Resistors:
R1 = 1 M
R2 = 10 k
R3 = 3M9
R4,R5,R6 = 100 k
R7 = 100 Ω
R8,R9 = 390 Ω
R10 = 10 Ω
P1 = 10 k preset

Capacitors:
C1 = 10 n
C2 = 100 μ/25 V

Semiconductors:
A1,A2 = LM 10(C)
D1 = 1N4001
D2 = two-colour LED (or two separate LEDs)

3
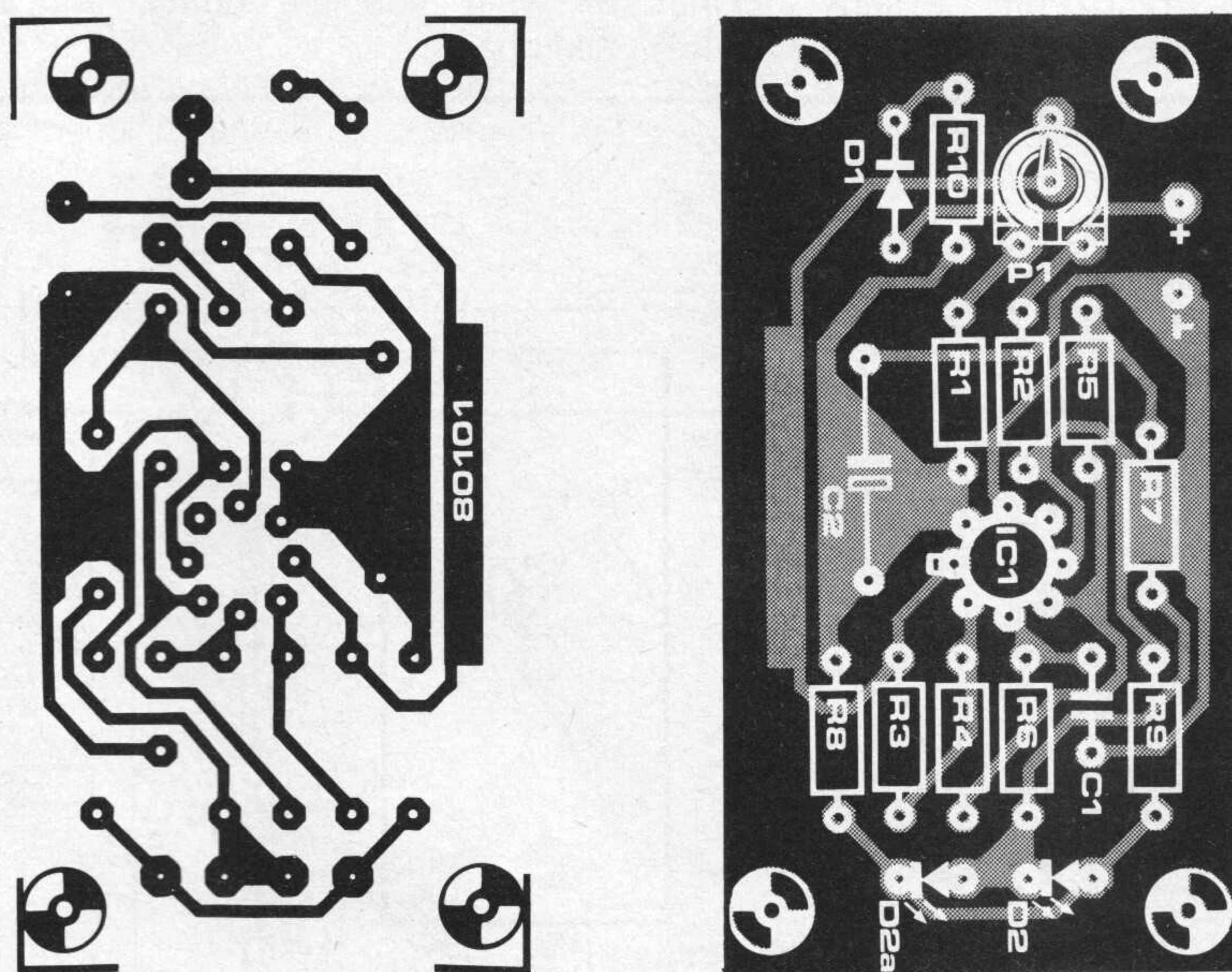
Figure 3. The printed circuit board and component layout.

With this in mind, Elektor readers can take advantage of our FREE protection sticker. Mount it in a clearly visible position, and the chances of your car being stolen are reduced to less than one-tenth!

Subscribers should find the sticker in this issue — provided it didn't drop out in the post . . . Those who buy their copies at a news stand may have also received a sticker — we certainly supplied plenty of them!

If you didn't get yours, you can send up for one. While stocks last, we are supplying them free of charge. Simply send a stamped, addressed envelope to Elektor, Canterbury, with request 'Anti-theft sticker'.

Please, readers, don't ask for more than you need! Stocks are limited, and we operate on a first-come-first-served basis. Remember, other readers also have cars!

It is probably true to say that every touring caravan uses a 12 volt power supply for something, even if only for lighting. This is often taken from the towing vehicle's battery via the van's

Most caravanners are aware that they can connect a mains power supply to their van and many assume that equipping it with 240 volt light fittings, power points etc. is a difficult and costly business. This is of course true and, fortunately, unnecessary. For a very reasonable cost, about £5, it is possible to build a mains to 12 volt converter with a current capability of 2 Amps, sufficient to cater for all the lighting needs of most touring caravans.

Shower power

For normal lighting purposes a 2 Amp power supply will be adequate. However, more and more electrical appliances are becoming available for use in caravans. High on the popularity list is the electric water pump and this may require a power supply capable of delivering up to 5 Amps (especially if a shower is fitted). Figure 4 shows the circuit for a very simple design using a

aide - de - camp
mains power supply for caravans

lighting connector. This can be less than ideal if extra electrical facilities are fitted into the caravan and starting the vehicle in the mornings could be a problem. With this in mind, many caravan holiday sites are fitting mains power point facilities. This article describes a converter which allows the caravan's existing 12 volt system to be supplied from the mains connection point.

2 Amps to see with

As can be seen in figure 1, the circuit is very simple. The IC used is the 723 precision voltage regulator with current limiting set (by R3) to 2 Amps. The preset P1 should be adjusted to give 12 volts at the output. It is important that the power transistor (T1) is mounted on an adequate heatsink of the type shown in photo 1.

It would be convenient to use a 'potted' bridge rectifier with a hole through the centre allowing for a more secure fitting. The completed converter can be assembled in any suitable metal case (not forgetting the fuse) and this can be placed near the mains input connection cable. It may be more convenient to mount the switches remotely on a separate panel.

It should be remembered that a caravan on the move is subject to severe vibration and therefore considerable efforts must be made to ensure that components are securely fitted, particularly the transformer, where locking nuts would be desirable.

high power regulator, IC1. This device, in common with the other 78 series regulators, features thermal overload and short circuit protection. A substantial heatsink will be required for this regulator together with a potted 7.5 – 10 Amp bridge rectifier B1. Good quality components should be used throughout. All components should be secured as mentioned previously.

Regulations

It should be noted at this point that the regulations regarding the connection of mains to caravans are fairly extensive, not to say confusing. There are of course two sets, the I.E.C. regulations and the U.K. regulations. The reader is advised to obtain a copy of these from his local caravan dealer.

One thing should be made absolutely clear, the incidence of fire in caravan accidents is very high with a large percentage citing electrical faults as a reason. Be warned — if you are not sure of what you are doing, ask a professional.
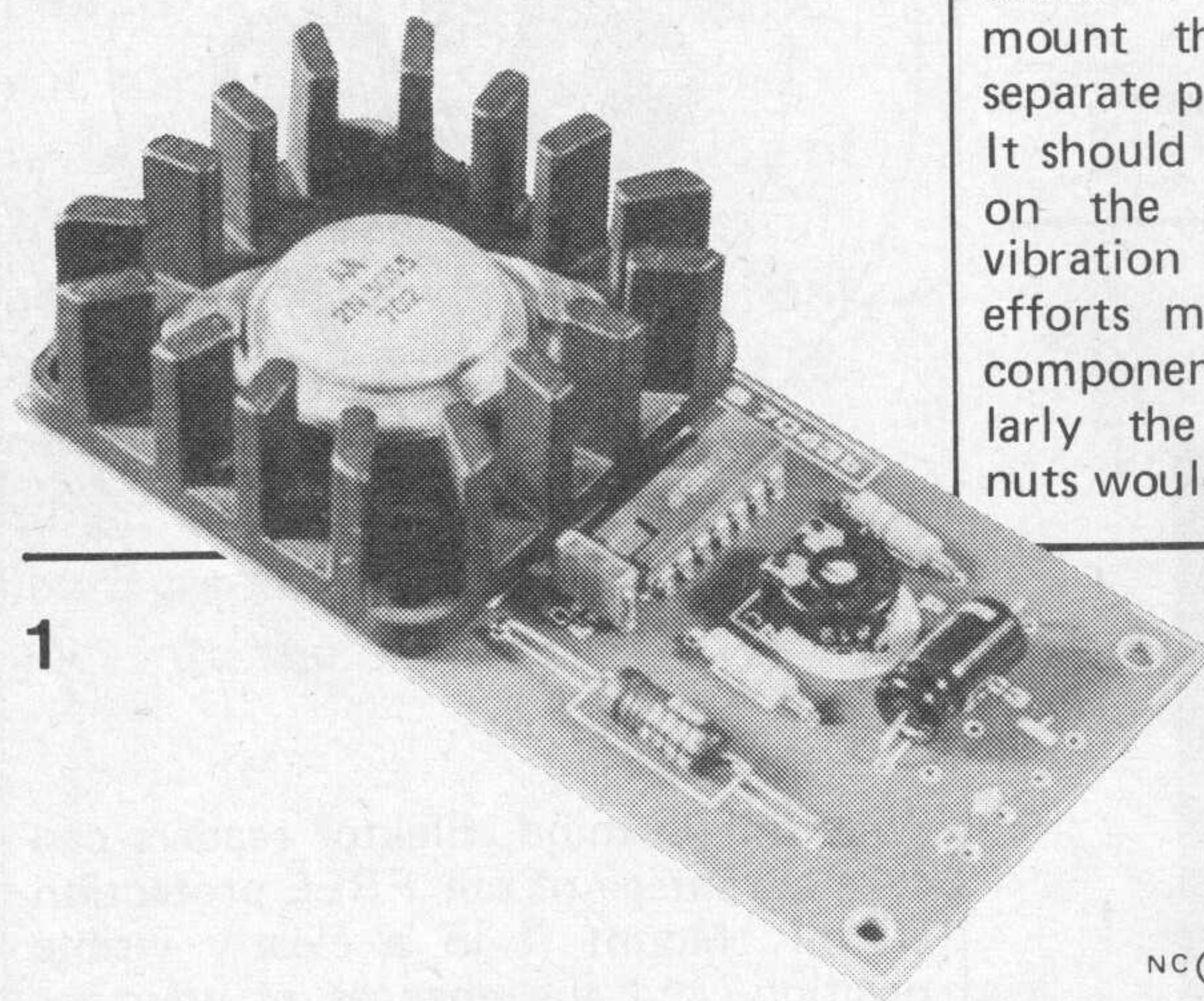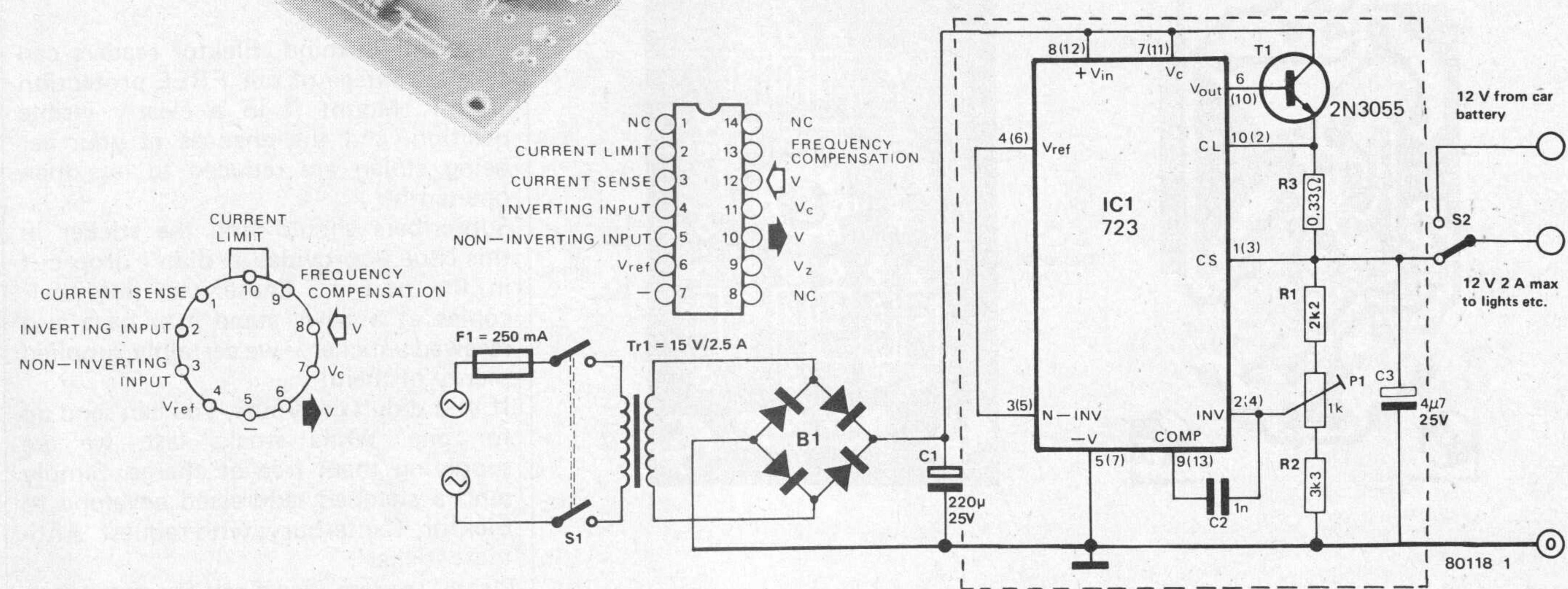

1

Figure 1. Complete circuit diagram of the 12 volt converter. All the components inside the dotted line are mounted on the printed circuit board.
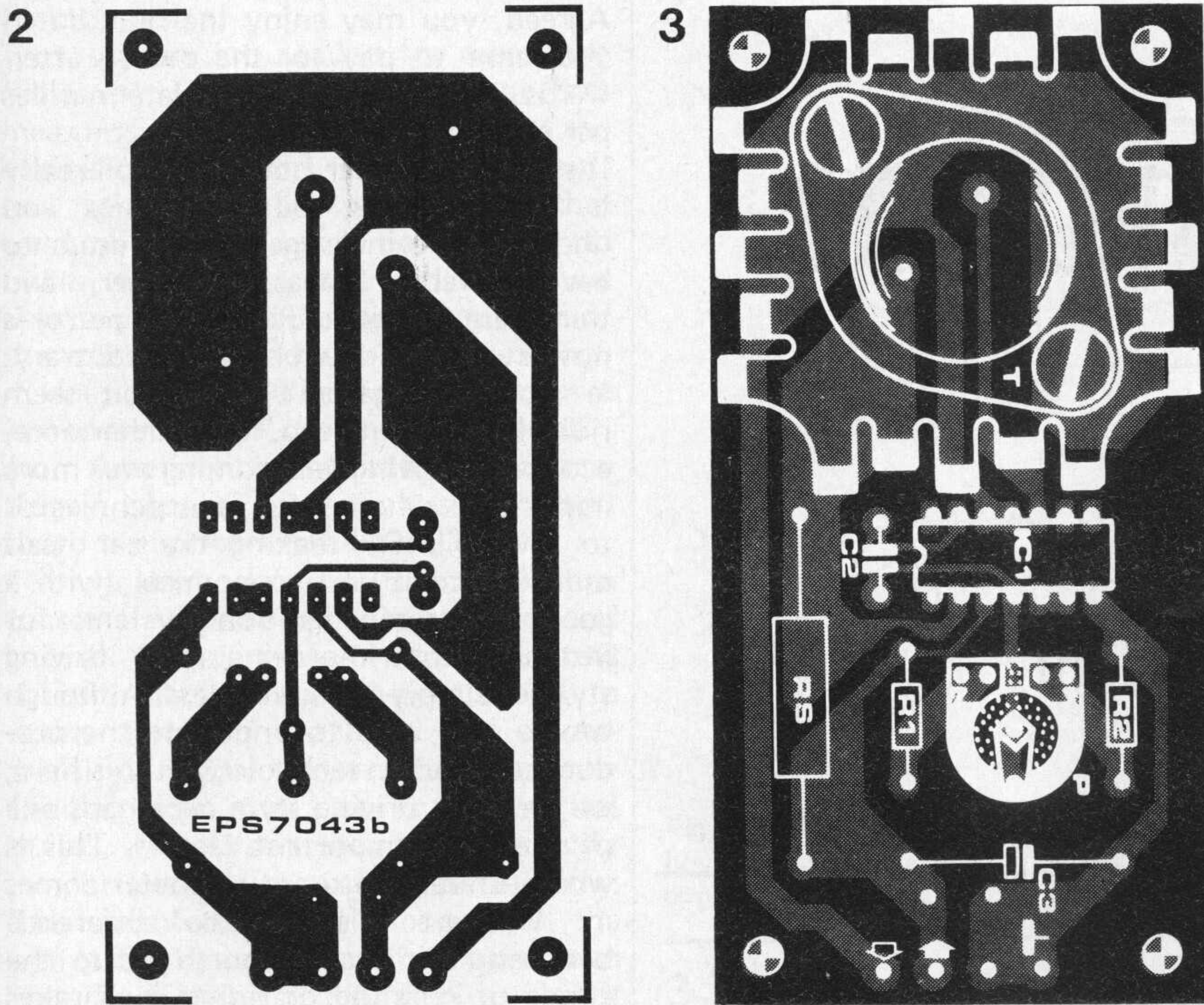
2

3

Figure 2. Printed circuit board for the 12 volt/2 amp converter (EPS number 7043b).

Figure 3. Component overlay for the printed circuit board.

a means of overcoming these problems. As can be seen, the circuit is connected between the neutral and earth leads at some convenient point inside the caravan. Ingenious constructors may find a method of fitting it inside the circuit breaker housing: however, that is a matter of personal preference.

If the mains inlet cable is connected correctly the LED (D1) will remain unlit. If, on the other hand, the cable is connected wrongly, the neutral lead will become 'live' and the LED will glow, thereby indicating an 'unsafe' condition. The current through the LED is limited by the reactance of capacitor C1. The working voltage of this capacitor should be at least twice that of the mains voltage. Diode D2 is included to protect the LED from excessive reverse voltages. If polarised connectors are used, but the LED indicates a fault, something will have to be rewired. This can be dealt with however, by incorporating the changeover switch S2 to cross over the live and neutral input leads to the caravan, as illustrated in figure 5. Regardless of whether the mains inlet cable is wrongly connected at some point, the LED will always indicate whether or not the changeover switch is in the correct position. If the
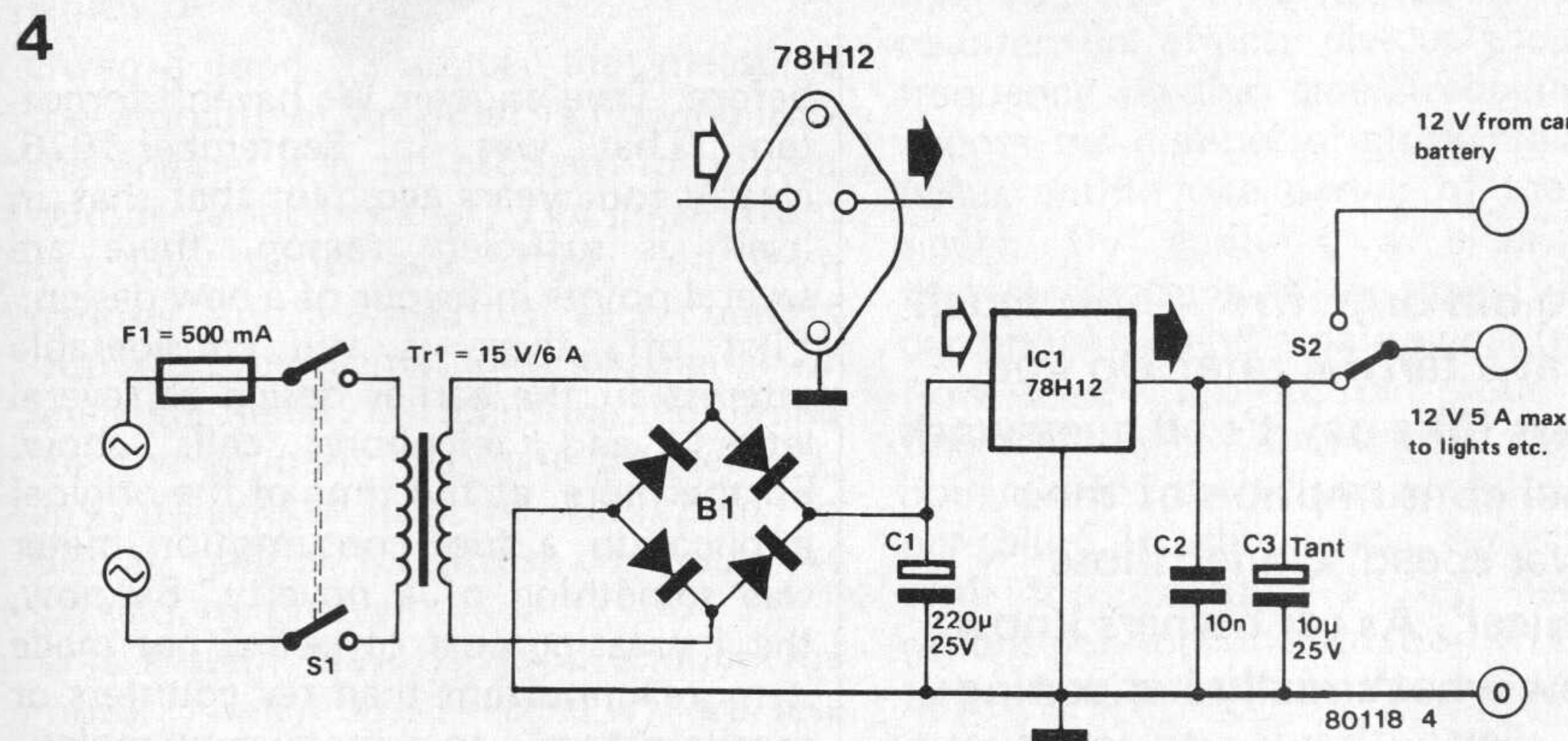
Parts list for figure 1.

Resistors:
R1 = 2k2
R2 = 3k3
R3 = 0.33 Ω
P1 = 1 k preset

Capacitors:
C1 = 220 μ/25 V
C2 = 1 n
C3 = 4μ7/25 V

Semiconductors:
IC1 = 723
T1 = 2N3055
B1 = 5 Amp 500 V potted bridge rectifier

Miscellaneous:
Tr1 = 15 V/2.5 A transformer
F1 = 250 mA fuse
S1 = double pole two-way switch
S2 = single pole two-way switch

Parts list for figure 4

Capacitors:
C1 = 220 μ/25 V
C2 = 10 n
C3 = 10 μ/25 V

Semiconductors:
IC1 = 78H12
B1 = 7.5–10 Amp 500 V potted bridge rectifier

Miscellaneous:
Tr1 = 15 V/6A transformer
Fr1 = 500 mA fuse
S1 = double pole two-way switch
S2 = single pole two-way switch

A safety checker

Care must always be taken when connecting mains to anything — especially caravans. It is essential that the mains be connected correctly, LIVE to LIVE, NEUTRAL to NEUTRAL, EARTH to EARTH — to avoid ASHES to ASHES and DUST to DUST! If polarised plugs and sockets are used there would appear to be no problem. However, it may arise that the actual site connection point is wrongly wired. Where reversible mains inlet connectors are used (such as the Continental types) a 'safe' connection cannot always be ensured.

The simple circuit shown in figure 5 is

LED is on, switch over S2. Since mains connections are uncertain it is essential that the isolating switch S1 is a double pole type.

4

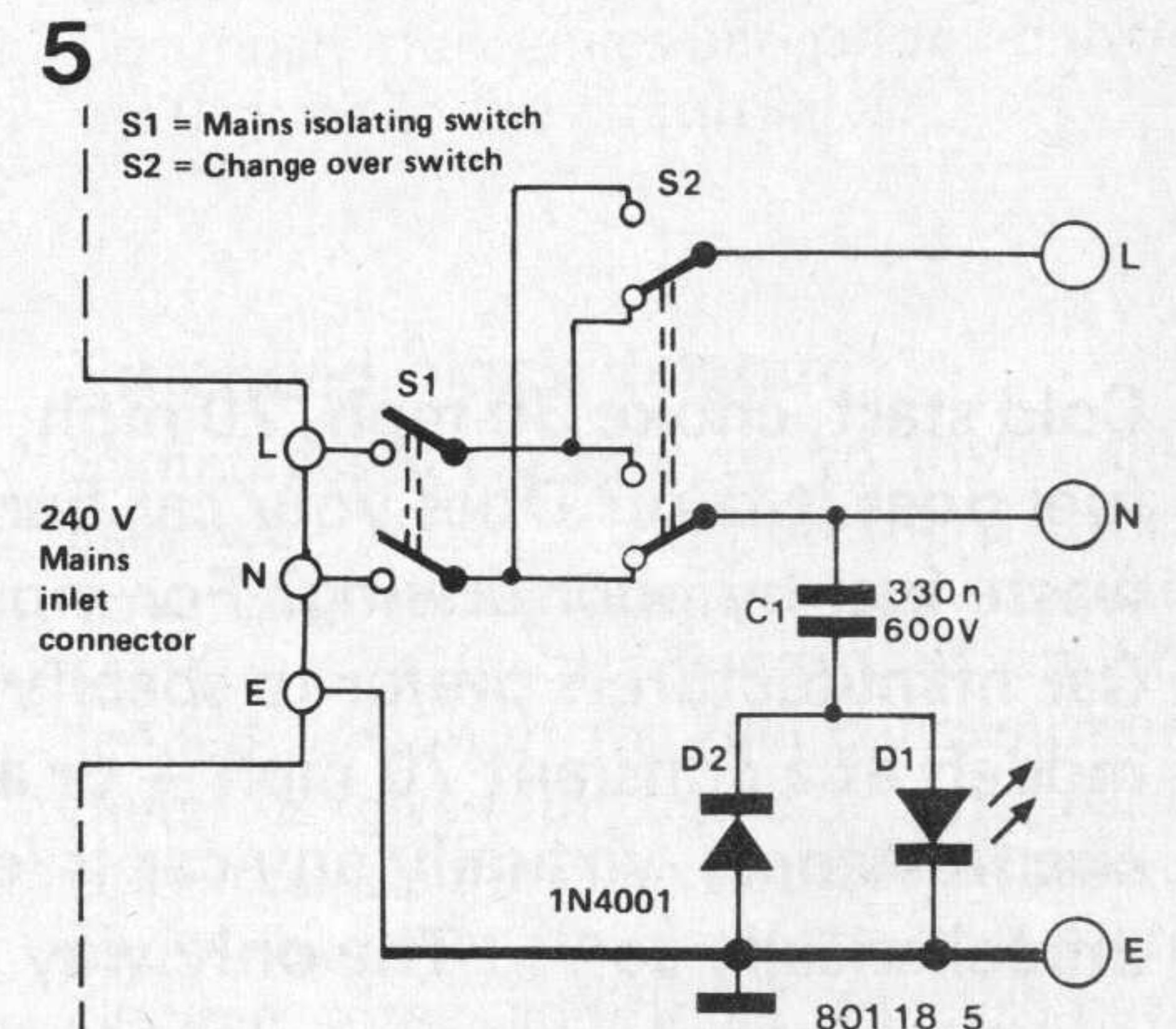Figure 4. Circuit diagram of a 5 A converter.

5

Figure 5. Simple circuit to ensure correct connection of the mains inlet cable — especially useful on the Continent.

fuel consumption meter

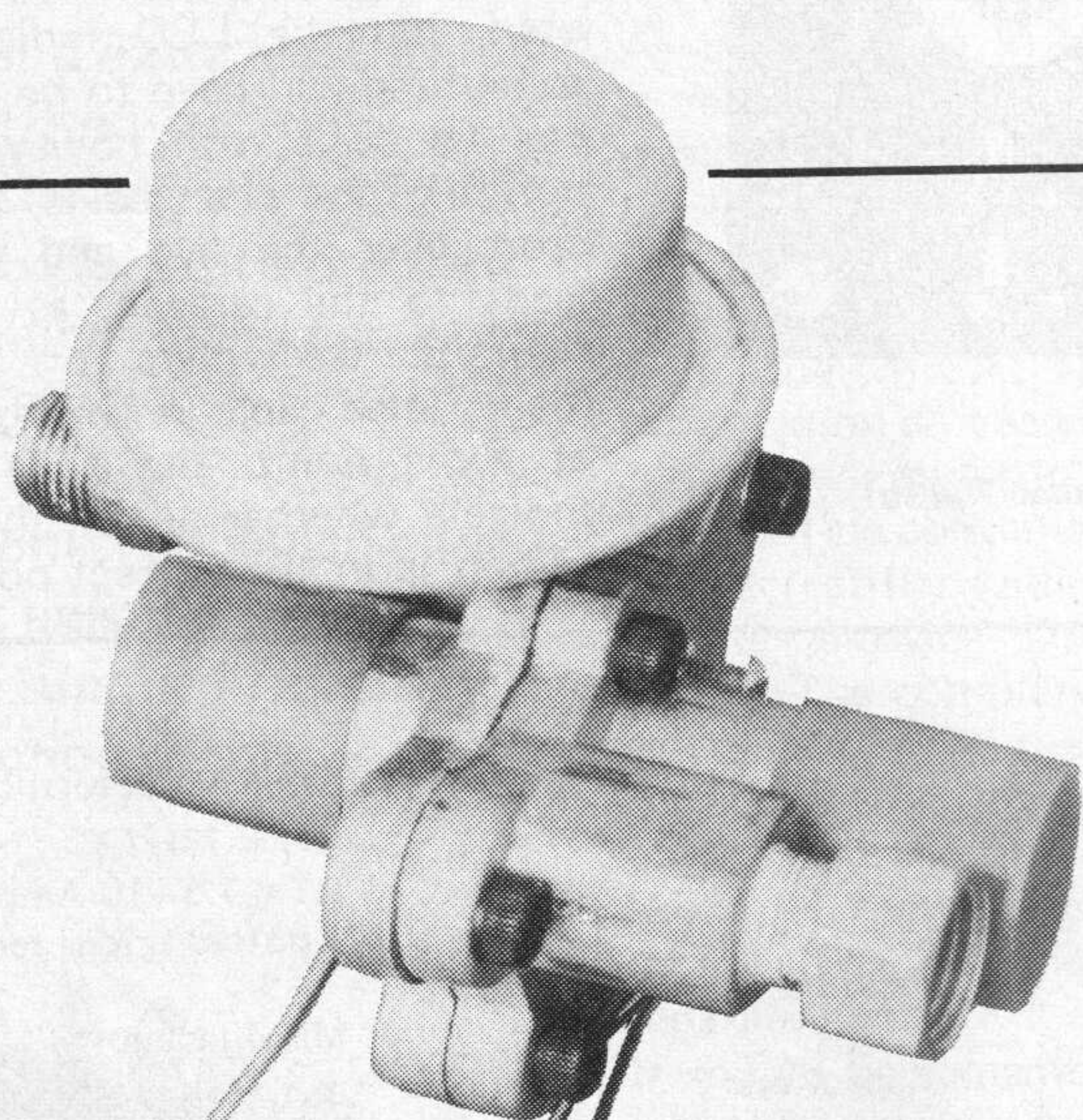## how to get more miles per gallon!

Figure 1. The two main transducers for the fuel consumption meter. The speed transducer is mounted in the drive cable to the speedometer; the flow sensor in the petrol pipe between the pump and the carburettor.
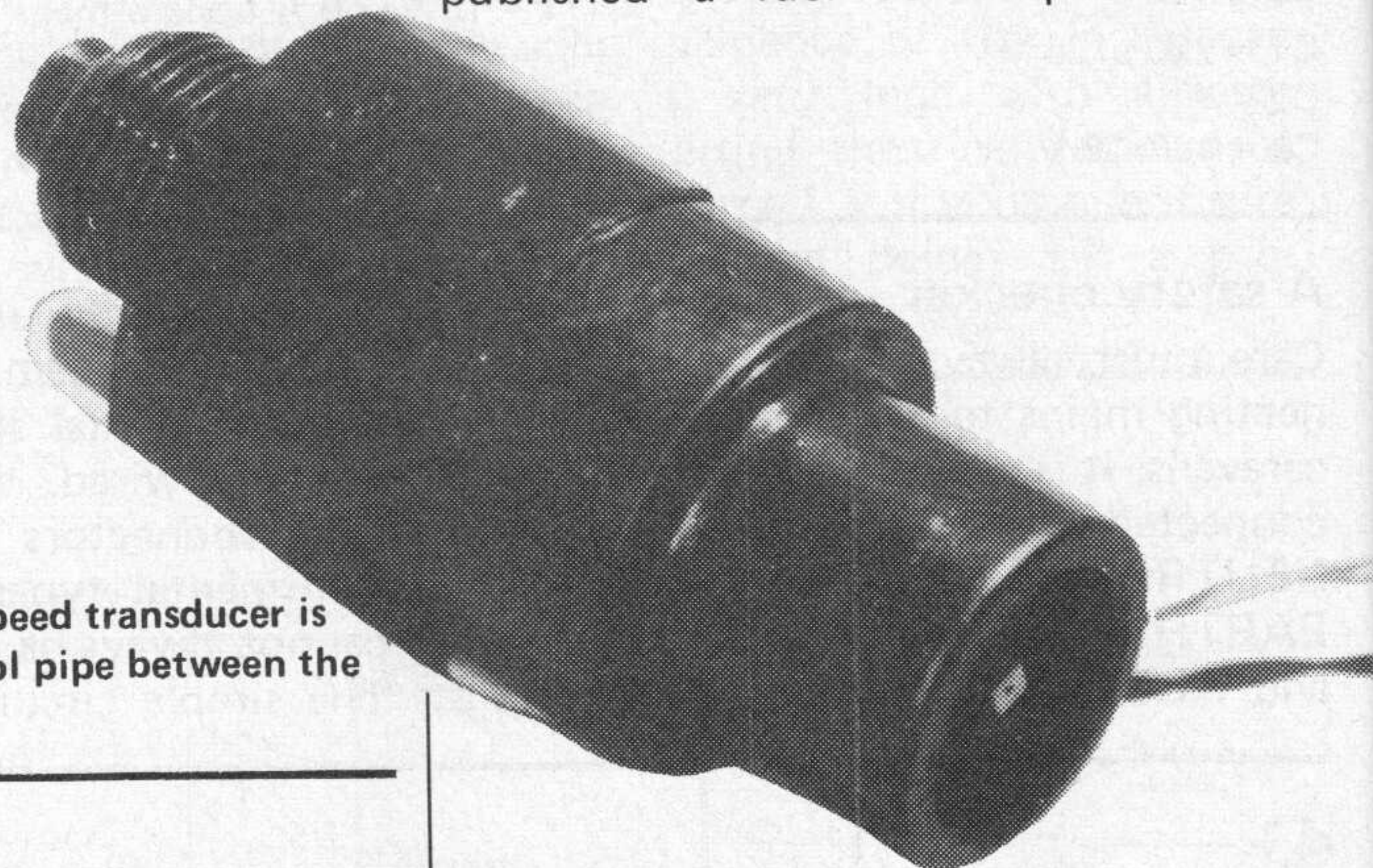
Cold start, choke 30 mph, 70 mph, zoo-o-o-om or purrrr — how much fuel does it take? Does your car burn fuel at a terrific rate? Do you waste fuel by poor driving? For most drivers (like us) it's all guesswork. Car manufacturers prefer to specify the fuel consumption of their models at a constant 70 mph — or at a lower speed. Under those circumstances, virtually any car is 'economical'. As car owners know: unrealistically so . . . The only way to know what's really happening as you drive is to use an instant fuel consumption meter. A unit, in other words, that gives instant indication of your present fuel consumption in miles per gallon. An instrument like the one described here!

'Enjoy the ride'? Forget it, nowadays. Agreed, you may enjoy the ride; but if you have to pay for the petrol, afterwards . . . you start to calculate in miles per pound.

It's not at all clear how scarce oil really is. Governments, oil companies and 'independent investigators' all seem to have different ideas. However, two things are obvious: the price of petrol is not likely to go down — on the contrary, 'a pound a gallon' may soon seem ridiculously cheap. Furthermore, economic driving is becoming ever more important, whether to save pennies or to save oil. By making the car itself more efficient and economical (with a good electronic ignition system, for instance), by improving your driving style or simply by driving less. Although we do not wish to underrate the products of modern technology in this field, we feel that driving style is perhaps one of the most important factors. This is where a fuel consumption meter comes in. Without this aid the difference between third and fourth gear, the effect of coasting or riding the brakes and the fuel required to pick up speed sedately or more rapidly remains purely guesswork. If you want to cut the petrol bill, there's nothing like a meter that drops from 35 mpg down to 10 mpg as you tread on the accelerator!

Two transducers.

By now, a large number of regular Elektor readers will be reaching for their pens to remind us that we have published a fuel consumption meter before. True enough. We haven't forgotten. That was in September 1976. Nearly four years ago. Not that that, in itself, is sufficient reason: there are several points in favour of a new design. First off, there is still considerable interest in the earlier design as several letters and telephone calls show. Furthermore, at the time of the original publication a fuel consumption meter was something of a novelty. By now, the increasing cost of petrol has made it more important than rev counters or speedometers — to name two examples. Another reason is that, in our opinion, the original design has lost some of its 'charm'. The pointer instrument is rather old-fashioned in this 'digital' era,

and it wasn't a completely home-grown Elektor design.

Two sensors are needed for measuring 'miles per gallon': a flow sensor that measures the flow of petrol to the engine (in 'gallons per hour', say); and some kind of speed sensor that gives an output which corresponds to 'miles per hour'. In the 'old' design we used a pick-up coil, glued to the back of the existing speedometer. Even though it does work it is not as elegant as a 'speed transducer' designed for the job.

An American manufacturer, Space-Kom*, supplies both flow sensors and speed transducers (see figure 1).

The 'active' components in the flow sensor are a lamp, a phototransistor and a small 'paddle wheel'. As petrol flows through the unit the wheel starts to rotate between the lamp and photo-transistor. The latter converts the flashing light into a series of electrical pulses, with a frequency that is directly proportional to the rate of petrol flow. The complete unit is mounted in the petrol feed between the fuel pump and the carburettor, so that it gives almost instant indication of the petrol used at any given moment. It is factory-calibrated at 13.3 gallons per hour (16.0 *American* gallons per hour); at that flow rate it produces an output of 14.22 Hz. Not that 13.3 gallons per hour is realistic for many European cars — even half that is really burning it up — and in practice output frequencies between approximately 0.5 Hz and 5 Hz may occur.

The speed transducer (or 'tachogenerator') is similar to a dynamo. It is mounted in the cable to the existing speedometer, and produces a DC output voltage that is directly proportional to the speed of the car, 5.6 V corresponding to 70 mph. Obviously, since all cars are different, there are several types of speed transducer and an even more extensive range of connectors and adapters (see Table 1). In some cases the unit is mounted at the back of the speedometer; in others, it is fitted on the gearbox.

Miles per gallon

Given a good transducer that measures the amount of fuel that is flowing into the engine, it is no problem to build a gallons-per-hour meter. The pulses from the flow sensor are simply fed to a counter, and the result of each count is displayed on some kind of digital or analogue meter. By adjusting the timing for the counter (the 'gate frequency'), any transducer can be calibrated to display gallons (or litres) per hour. As we said, no problem.

This system may be good enough for motor boats, but in cars we are less interested in the number of gallons

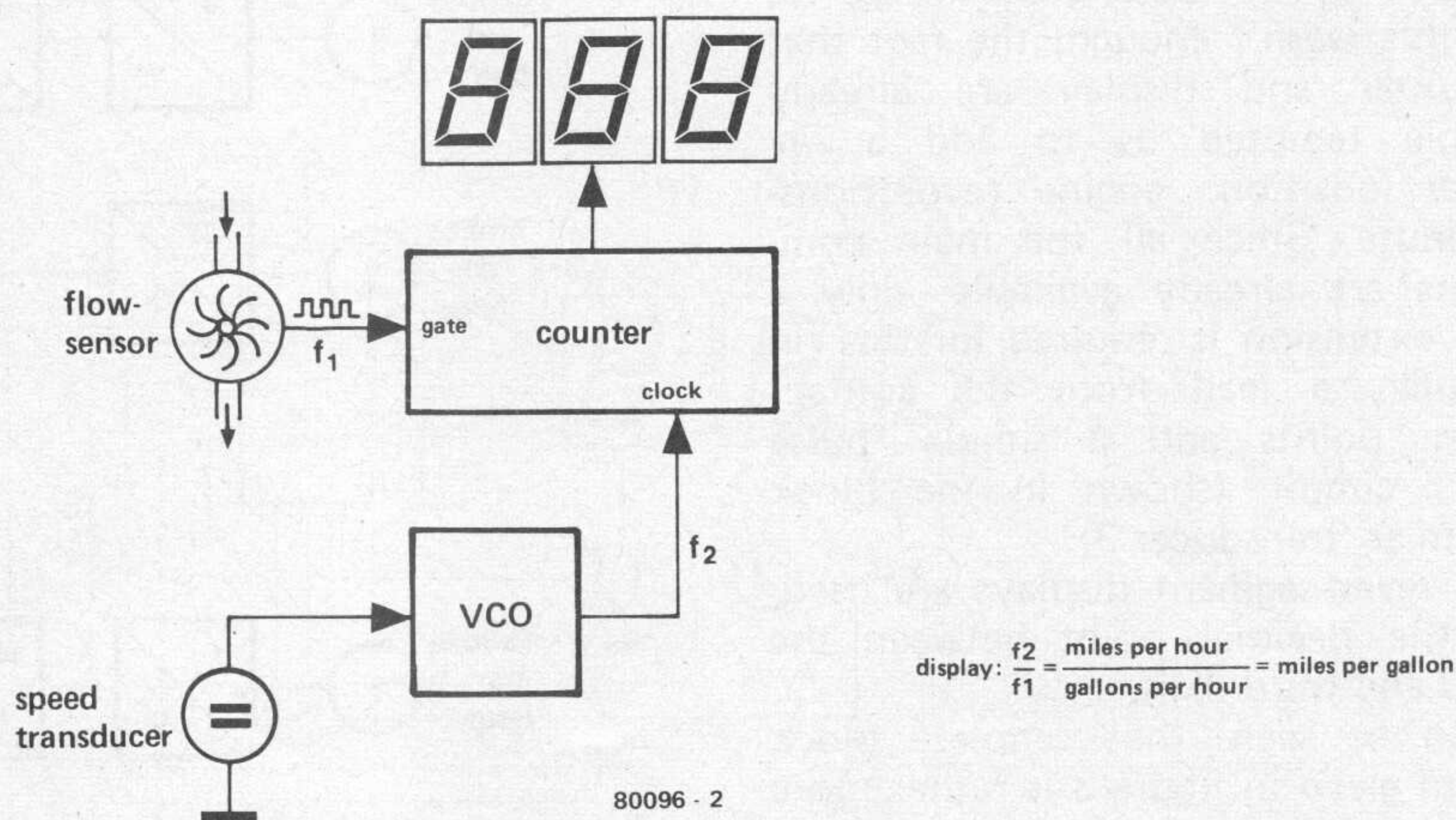*Imported into Europe by Medel B.V., Roden, The Netherlands.*

Figure 2. The basic principle of the fuel consumption meter. The 'speed' information (miles per hour) is divided, in the counter, by the fuel flow information (gallons per hour). The result appears in the display: miles per gallon.

$$\text{display: } \frac{f2}{f1} = \frac{\text{miles per hour}}{\text{gallons per hour}} = \text{miles per gallon}$$
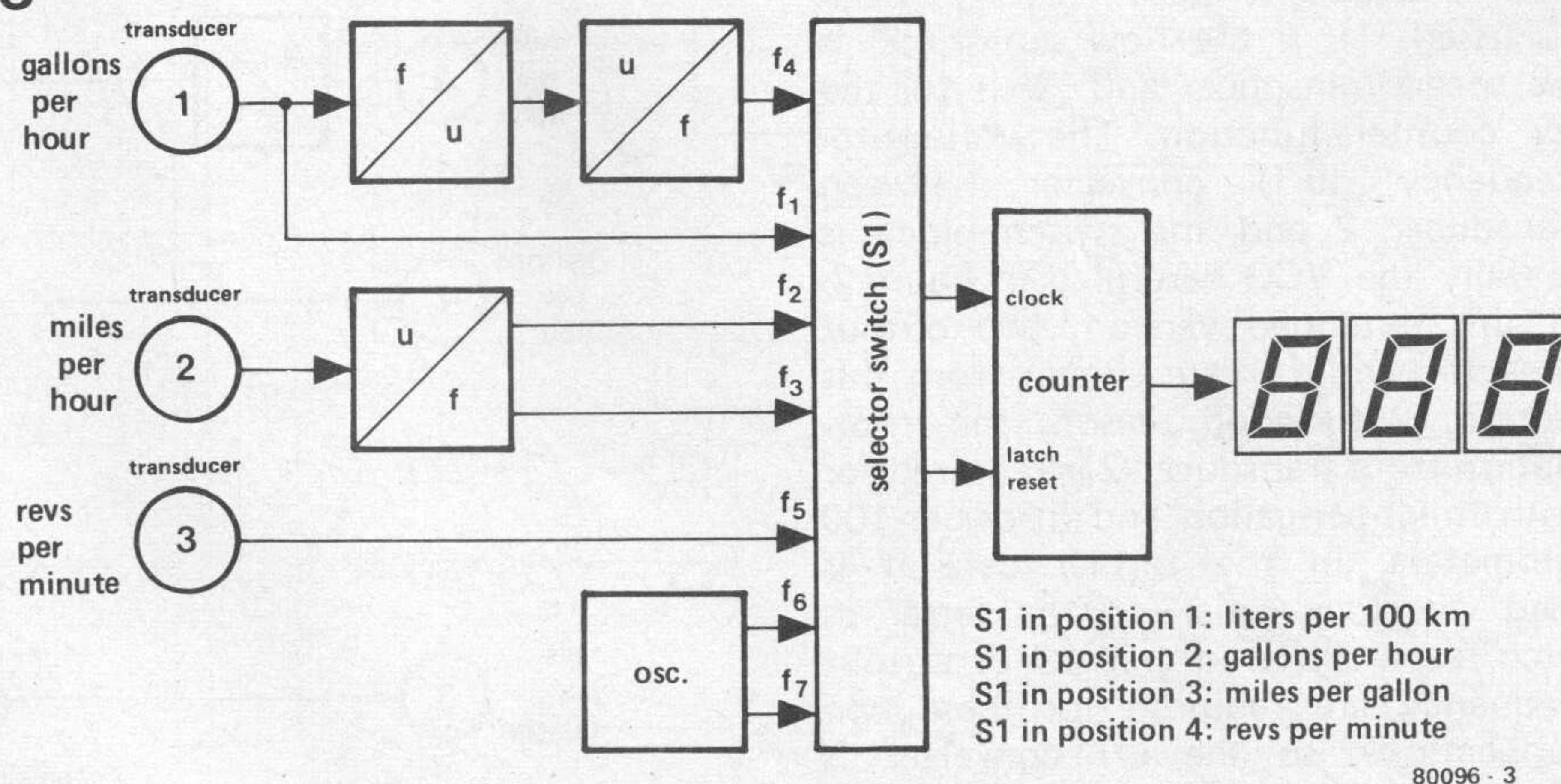

Figure 3. By extending the principle, the number of ranges can be increased: not only miles per gallon, but also gallons per hour, litres per 100 kilometers and revs per minute.

S1 in position 1: liters per 100 km
S1 in position 2: gallons per hour
S1 in position 3: miles per gallon
S1 in position 4: revs per minute

that we are using per hour. The true clue to economic driving is an indication in miles per gallon. The basic principle of this type of measurement is given in figure 2. The thing to realise is that a counter, in effect, divides the 'clock' frequency by the 'gate' frequency — it counts the number of clock pulses that occur within one period of the gating signal. By applying a clock signal that corresponds to the speed in miles per hour (f_2) and a gate signal from the flow sensor (gallons per hour, f_1), a final display is obtained in miles-per-hour divided by gallons-per-hour: miles-per-gallon, in other words. Perfect!

With the transducers used here, the gallons-per-hour information (f_1) can be taken direct from the flow sensor. The same is not true, unfortunately, for the miles-per-hour information (f_2): the speed transducer produces a DC voltage — not a frequency — that varies with speed. However, if this voltage is used to

control a VCO (Voltage Controlled Oscillator) the desired signal is obtained: a frequency that is directly proportional to speed. This signal is fed to the clock input of the counter.

So much for miles-per-gallon only — we'll come to the circuit later.

Extended block diagram

Sometimes it's a pity to do things the easy way, when with a bit more effort you can make them more complicated . . . A block diagram of an extended version of the fuel consumption meter is given in figure 3. The basic principles are the same as those discussed above; however, to make the unit more flexible some additional 'blocks' have been added.

The complete unit can not only measure *miles-per-gallon* (or *kilometers-per-litre*, if required). It can also be switched to

read *gallons-per-hour*, or even *litres-per-100 kilometers* — the 'upside down' German way of looking at things. As if all this wasn't enough, the fact that a counter and display are already available tempted us to add a *rev counter* position: engine revolutions-per-minute. Since all the main components are already available, only a minor extension is required for this: in particular, a lead from the contact breaker points and a simple 'pulse shaper' circuit (shown in the block diagram as 'transducer 3').

Three seven-segment displays are used, with the decimal point between the second and third digit.

As can be seen, the complete block diagram given in figure 3 is rather more extensive than the basic version (figure 2). There are quite a few additional sections... First off, the 'switch block'. This is simply a multi-way switch, that selects two of the available frequencies ($f_1 \ldots f_7$) for use as clock and gate ('latch/reset') signals for the counter.

The transducers have already been discussed: '1' is the flow sensor, '2' is the speed transducer and '3' is for the rev counter function. The voltage-to-frequency (u/f) converter between transducer 2 and the switch block is actually the VCO described in figure 2. In this extended version, two output lines (f_2 and f_3) are shown from this section. With good reason: the information from transducer 2 is required for both miles-per-gallon and litres-per-100 kilometers; in the former case it is used as clock-signal, in the latter as latch/reset. Different ranges of output frequency are required for these two applications, so the u/f converter is switched (by means of S1) between two frequencies, f_2 and f_3.

The same applies for the oscillator: as required, it provides one of two frequencies: f_6 or f_7. This oscillator was not included in figure 2: it is added for measuring gallons-per-hour and revolutions-per-minute. On these two ranges, only one transducer is used: either the flow sensor or the contact breaker with its pulse shaper. The signal from the transducer is used as clock input for the counter; a fixed frequency from the oscillator serves as latch/reset signal. By adjusting the oscillator frequency as required for each application, the display can be calibrated to read gallons-per-hour or revs-per-minute.

Two further sections are added: f/u and u/f between transducer 1 and the switch block. In figure 2, the signal from this transducer went straight to the counter. In one position of the switch in figure 3, it still does: signal f_1.

However, when measuring gallons-per-hour or litres-per-100 kilometers the signal from transducer 1 must be used as clock signal, instead of as latch/reset. For this application, the frequency f_1 (0.5 . . . 10 Hz) is too low — each count cycle would have to take anything from
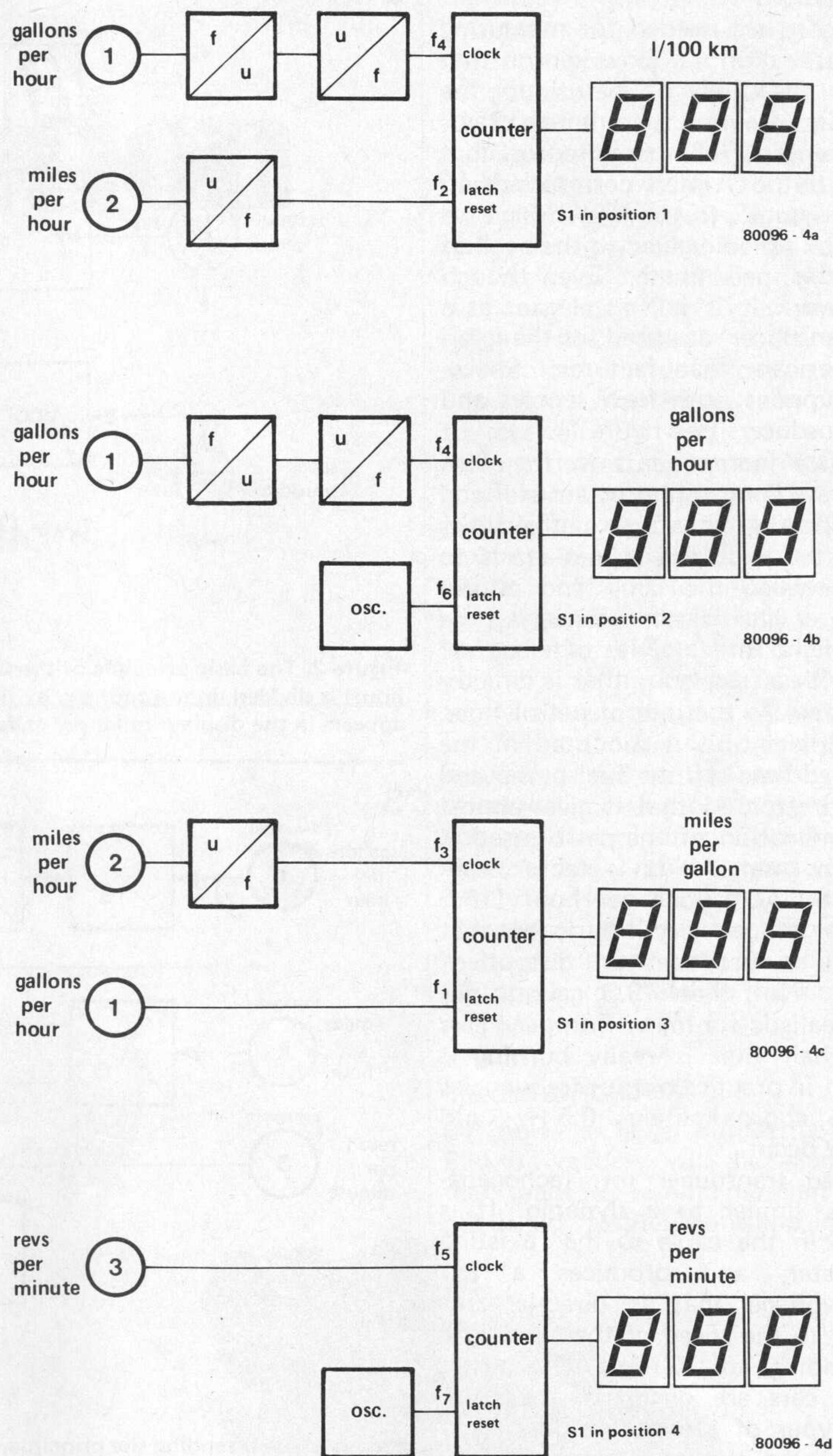
Figure 4. These four block diagrams show the measuring principle in the four positions of the selector switch.

10 seconds up to almost a minute, depending on the desired scale. This problem can be avoided by converting the varying frequency f_1 into a varying DC voltage, and then using this voltage to control a VCO (u/f). The output from this VCO (f_4) can be set to any desired range by selecting the necessary conversion factors for the f/u and u/f sections. In effect, the original frequency f_1 is multiplied to produce a suitable clock signal (f_4) for the counter.

So much for the various sections in the block diagram. Now it's time to see how they are used in practice.

Four in one

It will be clear by now that several

of the sections in the block diagram are only required for one or two of the possible measuring ranges. This, by the way, provides a clue to the possibilities of cutting the component cost when constructing the unit. If certain ranges are not required, the corresponding components can be omitted! As an extreme (but eminently practical) example, for measuring miles-per-gallon only one u/f converter and the counter are required. (More on this later.)

This is illustrated in figure 4. The four block diagrams give the measuring circuits in the four positions of S1. The switch unit itself is not shown: the various signals are taken direct to the counter. That helps to make things a lot clearer.

Let's start with figure 4c. This is the situation when the switch is set to
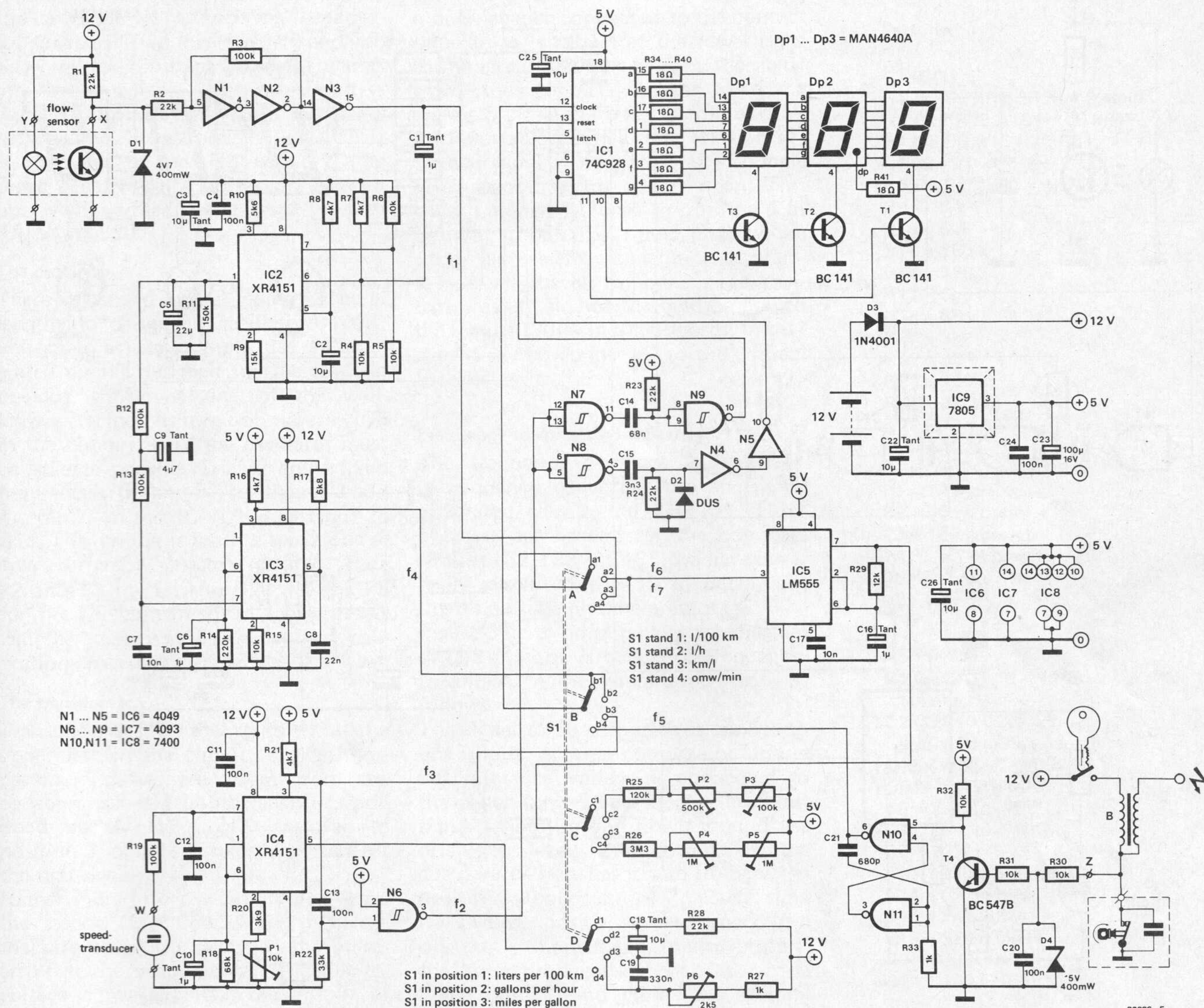
5

Figure 5. The complete circuit for the extended version, capable of measuring on all four ranges. As explained, it can be simplified if only 'miles per gallon' is required; see figure 7!

position 3, for miles-per-gallon. Comparing this diagram with the one given in figure 2, we discover that it is basically identical. The DC voltage that corresponds to 'speed' is fed to a u/f converter; the output signal (f_3) goes to the clock input of the counter. The gate (latch/reset) signal is the output from the flow sensor (f_1). In this third position of the switch, therefore, clock frequency divided by latch/reset frequency corresponds to miles-per-hour divided by gallons-per-hour. The result, miles-per-gallon, appears on the display. Now for figure 4b: position 2 of the main selector switch. In this case, the output from the flow sensor must be used as the clock signal for the counter. As explained earlier, this involves multiplying the output frequency from the sensor by means of an f/u and a

6
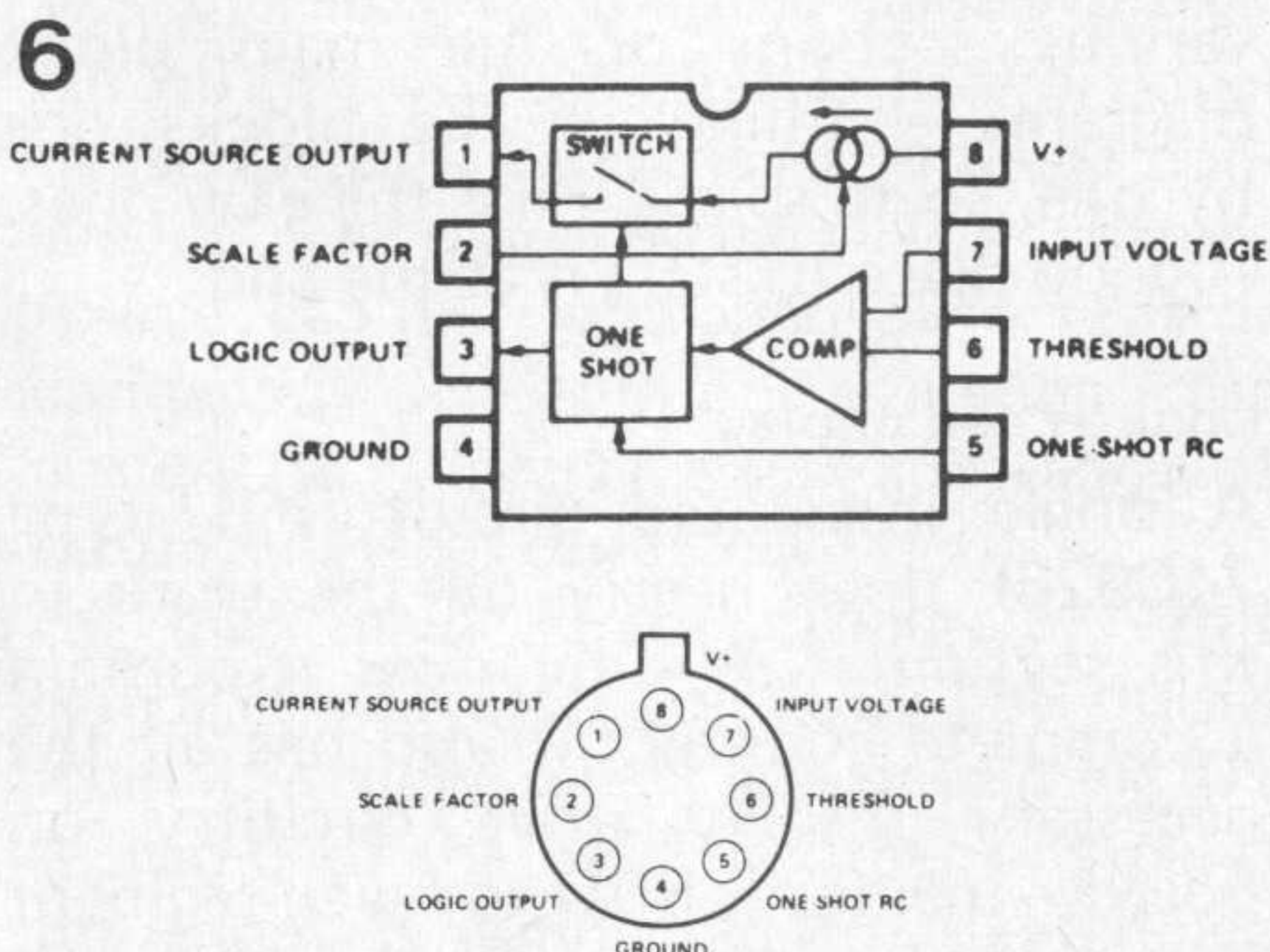
Figure 6. The Exar integrated circuit type XR 4151 that is used for the voltage-to-frequency and frequency-to-voltage conversions.

u/f converter, connected in series. The result, f_4, goes to the counter. The latch/reset signal for this measurement is derived from a fixed-frequency oscillator. This frequency (f_6) is adjusted to give a display that is calibrated in gallons-per-hour.

Figure 4a — position 1 of the selector switch — is added for the Germans... If they want litres-per-100 kilometers, they can have them! As in the previous case, the output from the flow sensor is frequency multiplied to provide the clock signal for the counter (f_4). The output from the speed transducer goes through its voltage-to-frequency converter to provide the latch/reset signal for the counter. In this case, the u/f converter is set to give a much lower range of output frequencies (f_2) than in figure 4c.

7
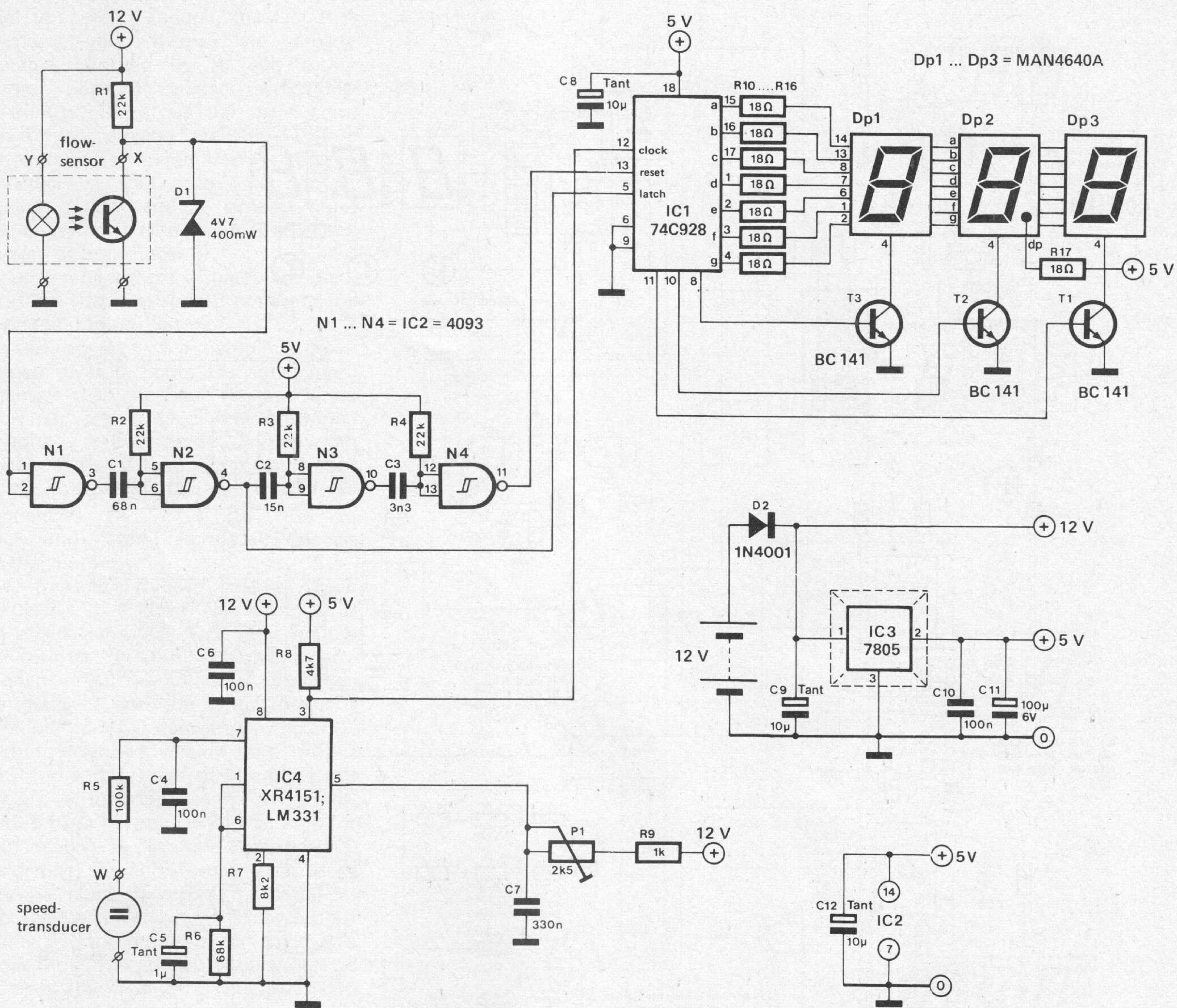
Figure 7. Simplified circuit for measuring miles-per-gallon only.

Finally, position 4 of the selector switch: the 'rev counter'. The corresponding block diagram is given in figure 4d. The pulses from the contact breaker are fed to the clock input of the counter. We don't intend to count 'sparks-per-second', of course: we are interested in revolutions per minute. The two are related, obviously: for a four cylinder four-stroke engine, there are two pulses from the contact breaker for every revolution of the engine. The display is calibrated in rpm by adjusting the output frequency from the oscillator (f_7) accordingly. As is common with this type of indicator, the display is actually calibrated in 'rpm x 100': when it reads '42.5', say, this corresponds to 4250 revolutions per minute.

The circuit

Figure 5 is the complete circuit of the most extensive version of the fuel consumption meter/rev counter. Quite a jungle, at first sight! The best approach seems to be to locate the various sections of the main block diagram — filling in the blocks one by one, so to speak. First the easy ones. A good place to start is at the end:

Counter and display

A single integrated circuit (IC1, type 74C928) does nearly all the work in this section. Not only does it contain a complete counter: it also has all the necessary display drive circuitry on board — memory, BCD-to-seven-segment decoder/driver and display multiplexer. Three BC141s select the three display digits. As is common practice nowadays, so-called multiplex technique is used: one digit is selected at a time (by T1, T2 or T3) and, simultaneously, the corresponding drive to its seven segments is applied via resistors R34 ... R40. The three displays light up in sequence, so

rapidly that it appears to the eye as if they are all on all the time. The decimal point after the centre digit is permanently on, via R41.

Latch/reset signals

To obtain a correct count and display, the counter must first be reset. Then it is allowed to count for a specified period, after which the final count must be transferred into a memory by means of a 'latch' pulse. This is immediately followed by a further reset pulse, in readiness for the next count cycle. Another way of looking at this is to say that each count is preceded (and followed) by a latch pulse and a reset pulse in quick succession. In the block diagrams, 'latch/reset' was considered as a single signal; it will now be apparent that this is not strictly true. The 'latch/reset' signal must be split into separate latch and reset signals that occur in quick succession.

This is done by gates N4 ... N9. The combined latch/reset signal selected by S1 is fed to N7 and N8. The latter is followed by an RC network (C15/R24) and a diode to clamp the negative-going spikes. Two inverters, N4 and N5, clean up the resultant pulse for use as the 'latch' signal. A similar circuit is used to produce the reset pulse. As before, the Schmitt-trigger gate (N7) is followed by an RC network; the short, negative-going pulses are 'cleaned up' by N9 and fed to the 'reset' input of the counter.

The oscillator

There is no future in going to great lengths to design an oscillator circuit: you may as well simply use an integrated circuit designed for the job. An obvious choice is one of the well-known 'recipes' using a 555 timer — IC5 in the circuit. Since the oscillator must be able to provide two different fixed frequencies (f_6 and f_7, see figures 3 and 4), pin 7 of the IC is brought out to S1c. This switch is used to select one of two different resistor chains: R25, P2 and P3 for f_6, and R26, P4 and P5 for f_7. The adjustment of these presets will be discussed later, under 'calibration procedure'.

The transducers

Transducer 1, the flow sensor, is at the upper left in the circuit. The 'gallons-per-hour' pulses are taken from the collector of the phototransistor, polished up by N1 ... N3, and fed to position 3 of S1a. That takes care of the first signal, f_1.

Rather more effort is required to derive the second 'fuel flow' signal, f_4, from the output of N3. Via C1, the pulses arrive at the output of a frequency-to-voltage converter, IC2; the output of this IC (pin 1) goes to a voltage-to-frequency converter, IC3. Its output, at pin 3, is the desired frequency-multiplied signal (f_4); it goes to positions 1 and 2 of S1b. Obviously, this description of the circuit around IC2 and IC3 is very brief — but we will give a much more extensive explanation further on.

The speed transducer ('2' in the block diagrams) is shown at the lower left in figure 5. As explained, this is a DC generator that produces a voltage that is proportional to speed. This voltage is passed — via an RC network for interference suppression — to pin 7 of IC4. The IC takes care of the voltage-to-frequency conversion (u/f). Its output, from pin 3, can be used in two different ways. In position 3 of S1 the signal is passed directly through S1b to the clock input of the counter (f_3); in position 1 short negative pulses, derived from the original signal by means of an RC network and N6, are fed through S1a to the latch/reset circuit. This signal, f_2, must be at a much lower frequency than f_3. For this reason, the timing network of the u/f converter is switched by means of S1d. In position 1, C18 and

R28 are connected to pin 5 of IC4; in position 3, C19, R27 and P6 are used.

The third 'transducer', for the rev counter, is actually nothing more than a pulse shaper connected to the contact breaker. It is shown at the lower right in the circuit. As can be seen, the signal from the contact breaker drives a transistor, T4; the latter is followed by a monostable multivibrator (N10, N11) that provides a short pulse at TTL logic level each time the points open. This output signal, f_5, goes to position 4 of S1b. It should be noted that, when using an electronic ignition system, it is usually better to connect the 'contact breaker' side of the ignition coil to the input (R30) — in other words, in that case it is *not* connected to the contact breaker itself.

Frequency-to-voltage converter (IC2)

The frequency-to-voltage and voltage-to-frequency converters use an EXAR integrated circuit, the XR4151. Three of these are needed for the complete circuit: IC2, IC3 and IC4. We have never really discussed this IC in detail, but there's no time like the present.

Figure 6 is a simplified block diagram of the interior circuit. For frequency-to-voltage conversion, it is used as follows:

The signal to be converted is applied to one input of the comparator and a DC reference voltage is connected to the other (pins 6 and 7). As the input signal swings up and down around the reference level, the output of the comparator switches to and fro between positive supply and 0 V. Each time it swings positive, it triggers the one-shot (monostable multivibrator); the latter produces a short pulse at the 'logic output' and closes the 'switch' for a brief, constant period. When the switch is closed, a constant current from the current source is passed to output pin 1, where it can be used to charge an external capacitor. It will be obvious that when the input frequency is higher the switch will close more often; the external capacitor will therefore charge to a higher voltage. An output voltage that is proportional to frequency: frequency-to-voltage conversion, in other words! The current source can be controlled by a resistor connected to pin 2; adjusting the current in this way alters the range of output voltages obtained.

In the main circuit (figure 5), this principle is used for IC2. The pulses from the flow sensor are passed via C1 to pin 6 of the IC. The other comparator input is connected to a reference voltage, determined by R6 and R5. The RC network C2/R8 determines the period time of the one-shot; this, in turn, corresponds to the time that the switch in the IC is closed. In effect, therefore, the RC network determines the output voltage range. C5 is the 'external capacitor'; it is charged via pin 1 when the 'switch' is closed, and
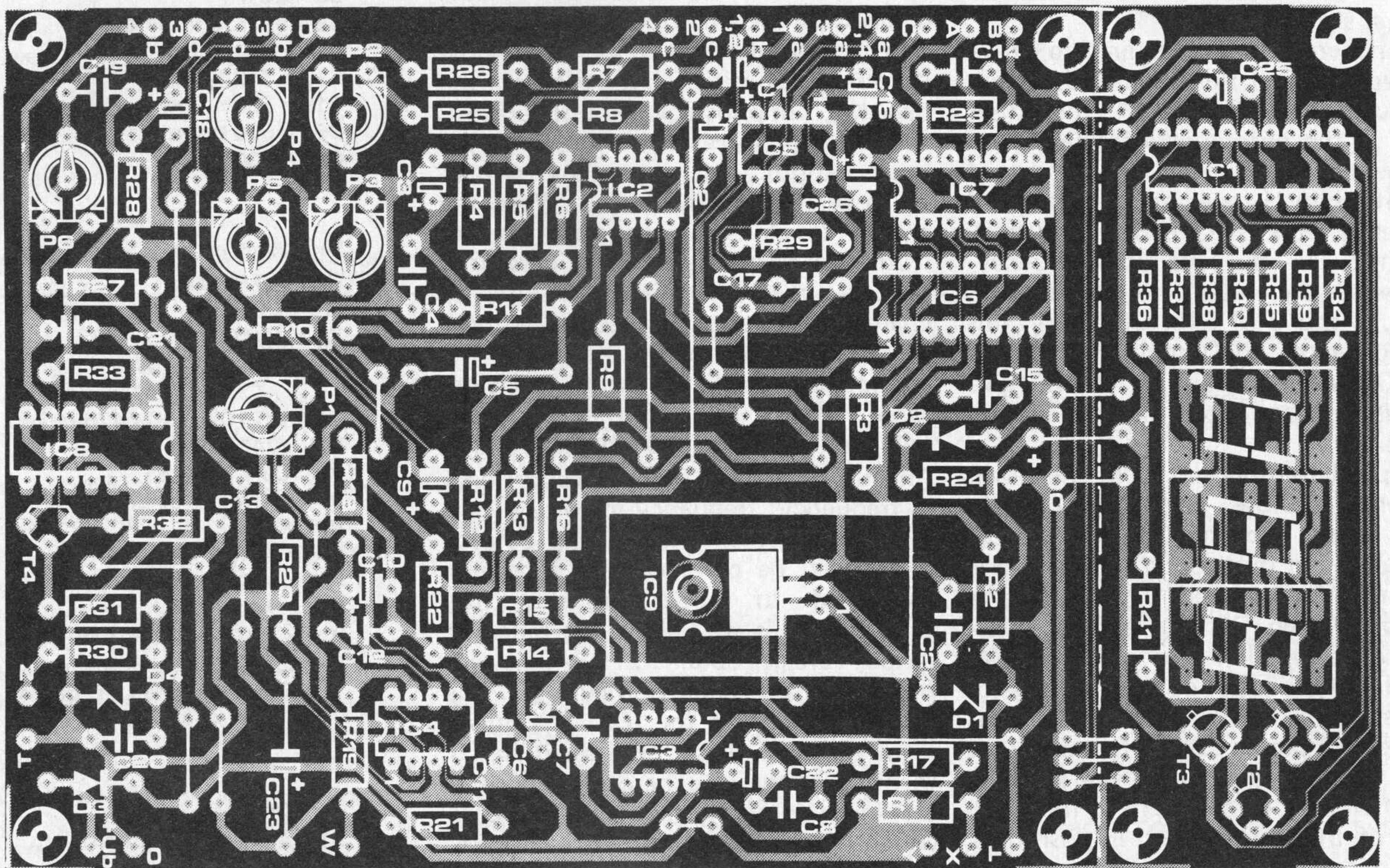
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Figure 8. Printed circuit board layout for the extended version.

Figure 9. Component layout for the p.c. board.

discharges through R11 between pulses. Resistor R9 sets the current supplied by the current source. The various component values (for C2/R8, C5 and R9 in particular) are chosen so that the output voltage varies between 0 and 8 volts over the full range of input frequencies.

Voltage-to-frequency converters (IC3, IC4)

Two of these are required in the fuel consumption meter. The first as part of the frequency conversion circuit for the signal from the flow sensor (IC3), the second is used to convert the signal from the speed transducer (IC4). The same IC is used as in the frequency-to-voltage converter, so we can again refer to figure 6. In this case, it is used as follows:

The input voltage is applied to pin 7. When this voltage is higher than that at pin 6, the comparator triggers the one-shot. During the one-shot period, the current source supplies current through the switch to pin 1; at the same time, the 'logic output' is at 0 V. After the one-shot period, the switch opens and the logic output swings up to positive supply. As before, the current pulses from pin 1 are used to charge an external capacitor (C6 or C10 in figure 5). This capacitor is also connected to pin 6, so that each time the switch closes the voltage at pin 6 increases by a constant amount. In practice, the circuit is arranged so that the voltage across the capacitor can rise above the input voltage within one step; the switch then opens, and the capacitor starts to discharge through R14 or R18.
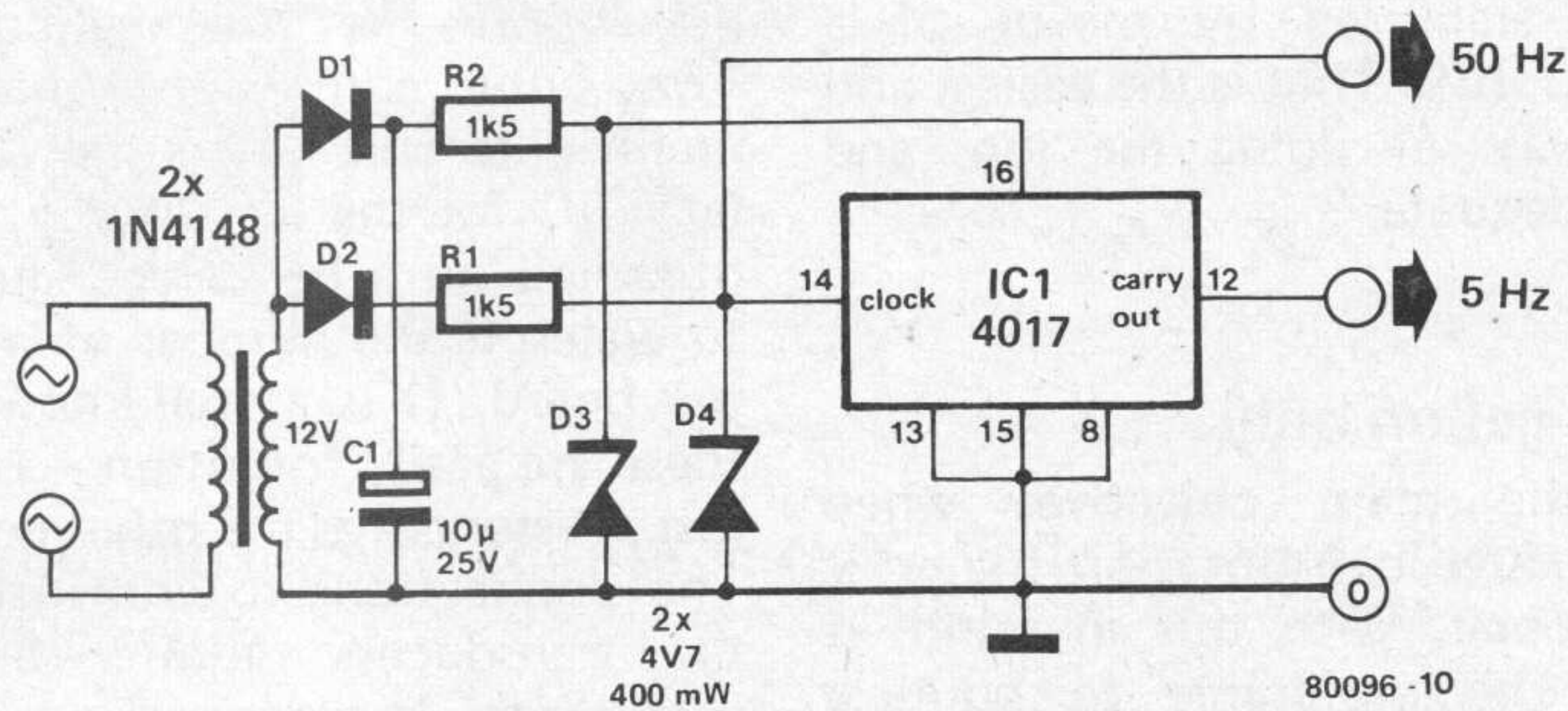
Figure 10. This little circuit can be used for calibrating the meter.

When the voltage at pin 6 falls below the input voltage at pin 7, the one-shot is again triggered: the capacitor is charged, and then starts to discharge again.

It will be obvious that if the input voltage is relatively high, the capacitor will discharge quite rapidly to this level and so the one-shot will be triggered quite often. A low input voltage, on the other hand, will result in a relatively infrequent charge cycle. Effectively, therefore, the control pulses to the switch must occur increasingly often as the input voltage rises. As the switch opens and closes, pulses are also appearing at the 'logic output'. The frequency of this output signal is also proportional to the input voltage, of course. In other words, an input voltage at pin 7 is converted into a frequency at pin 3. Just what we want.

The output frequency range can be modified by changing the values in the network connected to pin 5. After all, this RC network determines the one-shot period. As we have seen, this is actually done for IC4: one of two different networks is selected by means of S1d, two produce either of the two desired output frequency ranges (f_2 or f_3). P6 is included in one of these networks for calibration purposes.

The output frequency can also be modified by altering the control resistor at pin 2: this determines the current output from the current source. A fixed resistor is used for IC3, but IC4 requires calibration. This is why P1 is included.

The main function switch (S1)

S1 is simply a switch with four wafers and four positions. By now it should be clear which measuring ranges can be selected. Which signals are switched through what wafer has also been mentioned at various points. However, a brief summary may prove useful — especially when 'pruning' the circuit to give only the ranges that are required for a particular application.

S1a selects the latch/reset signal for the counter. As required, one of the four signals is used: f_2, f_6, f_1 or f_7.

S1b passes the clock signal to the counter: f_4 for positions 1 and 2, f_3 for position 3 and f_5 for position 4.

The oscillator is switched by S1c: frequency f_6 in position 2 and f_7 in position 4. It is not used in positions 1 and 3.

Finally, S1d is used to switch the RC networks for the voltage-to-frequency converter (IC4): frequency range f_2 in position 1 and f_3 in position 3. This converter is not used in positions 2 and 4.

And then, of course . . .

. . . the power supply. This is the last section in the circuit diagram that has not been discussed. For that matter, there is very little to say. It is quite obvious from the circuit that we didn't see any point in trying to be 'different'. Why bother?

Two supply voltages are required: 12 V

Table 1.

Recommended For Use On	Speedtransducers		
	Speedometer Cable Fitting	Speedtransducer Mounting	Speedtransducer Model No.
Volkswagen Beetle Porsche (some models only)	18 x 1,5 MM Metric	Speedometer	G-18
Volkswagen Dasher, Gulf	18 x 1,5 MM	Transmission	G-18
Audi-BMW-Fiat-Mercedes-Opel-Volvo	18 x 1,5 MM Metric	Transmission	G-18
Fiat-Volvo	16 x 1,5 MM	Speedometer	G-16
Mazda-Toyota-Datsun-Colt Luv and Courier pickups	22 x 1,5 MM Metric	Transmission	G-22
Mazda-Toyota 1973 and later Rover (some models only)	Snap-On	Speedometer	G-9
All American cars except Ford Products & American Motors	7/8-18 SAE	Transmission	G-7
All American cars 1968 and older — cars with cruise control option	5/8-18 SAE 16 x 1,5 MM	Speedometer	G-8
Datsun — Most American made trucks (if in doubt check THD fitting)	Metric		
Ford Products 1969 and newer	Snap-On S-100	Speedometer	G-9
American Motors 1972 and newer	Snap-On S-400	Speedometer	G-10

Table 1. Speedtransducer selection table, based on manufacturer's data.

and 5 V. The 12 V supply is readily available — it is simply derived from the car electrical system. The second voltage is stabilised by means of a regulator IC, IC9. That is the easiest and cheapest way of doing the job, and perfectly adequate.

Miles -per-gallon only

One of the main objectives when building a fuel consumption meter is to save money. With this in mind, it will often be preferable to build a simple unit that measures miles-per-gallon only — doing away with all the other ranges. The result is shown in figure 7. Compare this to figure 5!

The operating principles are the same — with the minor exception of the circuit that produces the latch and reset pulses (N1 . . . N4). If it is to be mounted on the board given in figure 8, it is possible to connect the output of N3 in figure 5 to the inputs of N7 and N8. This will do the same job as N1 . . . N4 in figure 7, but it costs two ICs instead of one.

A board for the simplified version will be given next month.

Construction

The complete extended version — including the displays — can be mounted on the printed circuit board given in figures 8 and 9. The only components not included on the board are the transducers and S1. All connections to these are clearly indicated, so the wiring should not present any problems. As indicated by a dotted line on the component layout, the display section of the board can be cut off and mounted at right-angles to the rest. This makes for a 'flat package' construction. The only component that may be inclined to run hot is the voltage regulator IC for the 5 V supply. It must be mounted on a heatsink. Another point to watch is the number of wire links on the board. It is a well-known fact that these are easily forgotten — but they are just as essential as the other components! The connections to and installation of the transducers require some further comments. The connection from transducer 3 to the ignition coil is no problem. However, it should be noted that some electronic ignition systems provide a special output for rev counters. If available, this should be used; if it is not provided, the best connection will usually be to the ignition coil — not to the contact breaker.

Only one type of flow sensor is available, suitable for most cars. It can not be used in cars that have a fuel overflow feed back from the carburettor to the petrol tank. In practice, this means that cars with high-pressure fuel injection systems are ruled out. It cannot be used on diesels, either. In all other cases, it can be mounted in the petrol line between the pump and the carburettor. The speed transducer is more complicated. This is mounted in the (mechanical) drive cable to the existing speedometer. Since car manufacturers seem reluctant to standardise these cables, several versions of the speed transducer exist with different connections. Table 1 gives a general idea of the possibilities. It would seem a good idea, when ordering, to state exactly in what make and model of car it is to be installed. Obviously, retailers and even importers may be reluctant to stock all possible versions, but we have been assured that they are available: less common types may have a longer delivery time, that's all.

The electrical connection to the speed transducer consists of two wires. Which of these is '+' will depend on where it is mounted (on the speedo or on the gearbox). If the connections are transposed, the unit will not work — but no damage can be done. Swapping the wires will cure the problem.

There are four wires from the flow sensor. Two of these (green and yellow/black) are for the lamp; one is connected to 'Y' (+12 V) and the other to 0 V. A normal lamp is used, so transposing these connections makes no difference. The other two wires (blue and red) are connected to the phototransistor. Blue is the emitter, so it is connected to 0 V; red, the collector, goes to 'X'.

Calibration

The transducers are factory calibrated. (Don't touch the adjustment screw on the flow sensor!) This means that the circuit can be calibrated by applying replacement signals to the transducer inputs, before mounting the whole lot in the car. A replacement signal for the speed transducer is the easiest: all that is required is a low DC voltage. For the flow sensor and rev counter, however, low-frequency squarewaves are required. To avoid the need of buying a function generator for this one job, a simple auxiliary circuit can be built to produce these signals. As can be seen from figure 10, this consists of a simple mains supply and a divide-by-ten counter; it produces 50 Hz and 5 Hz reference signals. Using these, the full calibration procedure (obviously, if a simplified meter is built — with less ranges — the corresponding steps in the procedure can be omitted) is as follows:

1. Disconnect the flow sensor and apply the 5 Hz signal to point 'X'. With S1 in position 2 (gallons per hour), P2 and P3 are adjusted until the display reads 4.7 gallons per hour (or 21.3 litres per hour).

2. Leave the 5 Hz signal connected to 'X'; disconnect the speed transducer and apply +5 V to this input (from the power supply in the circuit). Set S1 to position 1 and adjust P1 until the display reads 21.3 litres per 100 km.

3. Applying the same signals as above, switch to position 3. Adjust P6 for a reading of 13.3 miles per gallon (or 4.7 kilometers per litre).

4. Switch to position 4, and connect the 50 Hz test signal to the rev counter input (R30). Adjust P4 and P5 for the correct display: 15.0 (x100) rpm for four-cylinder four-stroke engines and 10.0 (x100) rpm for six-cylinder types. We assume that those with 8 or 12 cylinders are not interested in fuel consumption . . .
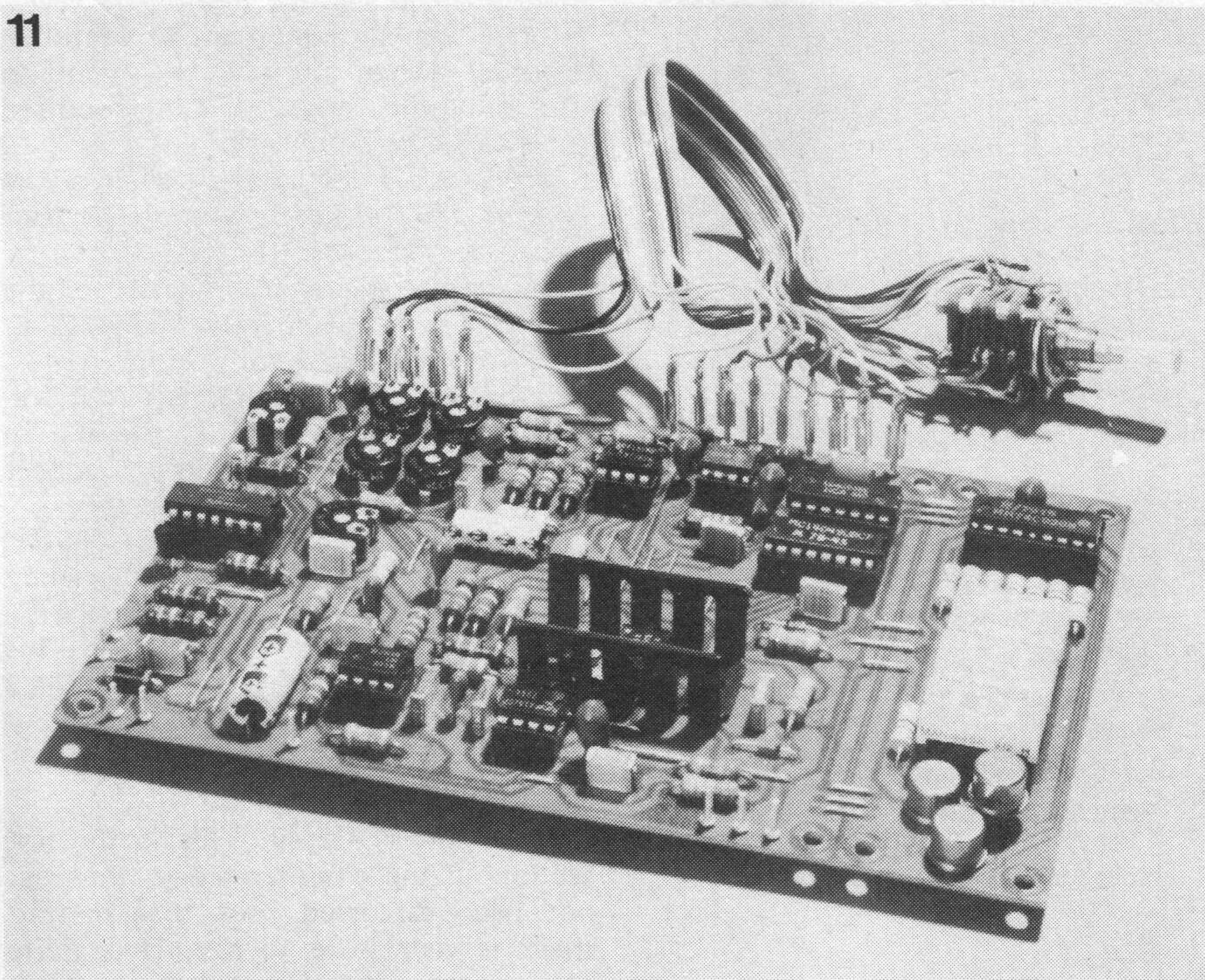

Figure 11. The prototype of the fuel consumption meter.

old hat ?

Obviously, this is not the first time we have published circuits for use in cars. While browsing through some earlier issues, we found several interesting little circuits.
A few of these are repeated here, for the benefit of new readers. In general, limited stocks of the printed circuit boards are still available.

simple wiper delay

For those readers who require a very small and simple wiper delay control, the circuit described here is ideal. This circuit was in fact first published in Elektor E17 but has been so successful that its inclusion here is not out of place.
The circuit is based on the well known 555 timer and can be seen in figure 1. The maximum output current of this

IC is 200 mA, so it can drive a relay direct. This circuit will operate on 6 or 12 volt cars. The only circuit change is the relay (12 V relay for a 12 V car, 6 V car 6 V relay).
Most circuits using the 555 don't give a wipe immediately after being switched on. To cure this, R1 is included. This resistor keeps the timing capacitor (C2) charged, so that the relay is activated as

soon as the delay circuit is turned on.
A further improvement of this circuit is the possibility of having the wipers sweep twice between delays. This multi-wipe function is adjusted with P1. The installation of this circuit is exactly the same as that for the 'intelligent' wiper delay described elsewhere in this issue.

Figure 1. The Simple Wiper Delay uses the well known 555 timer.
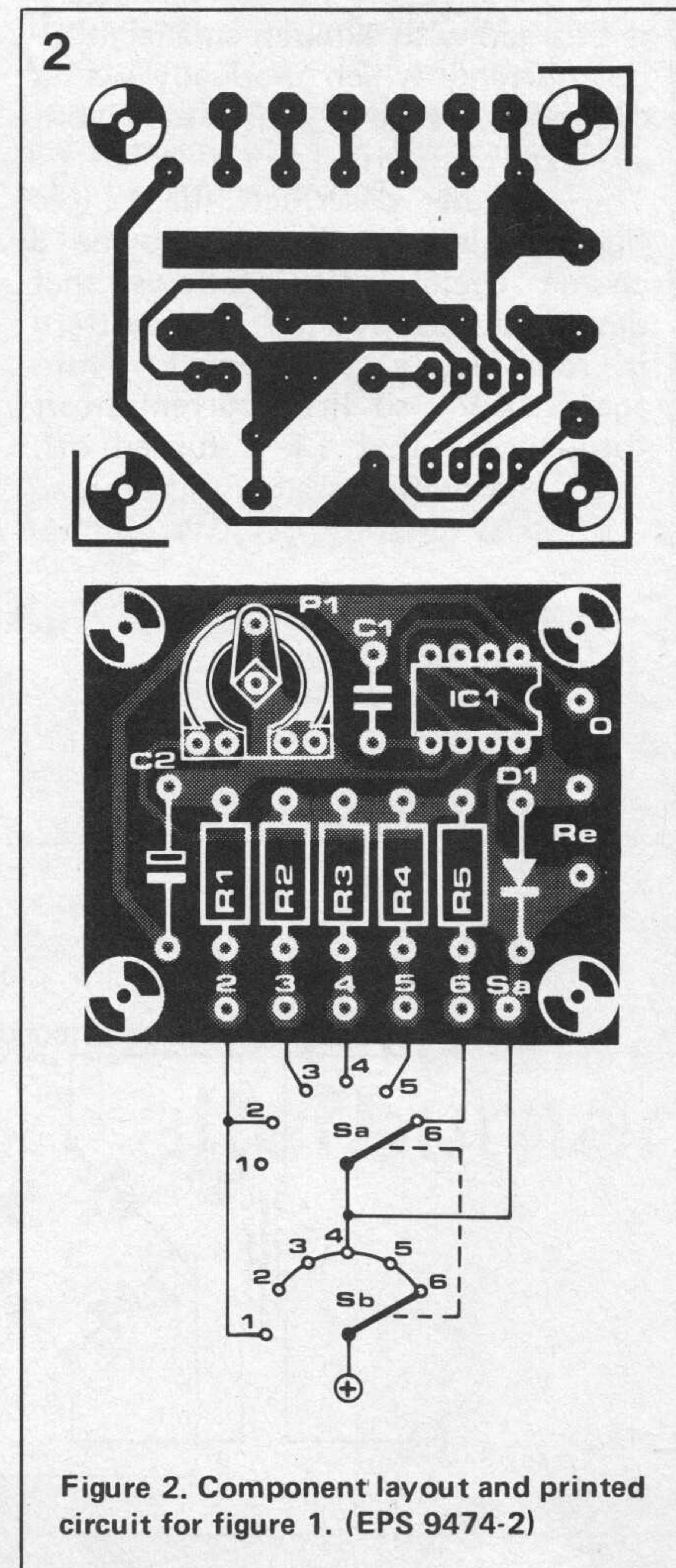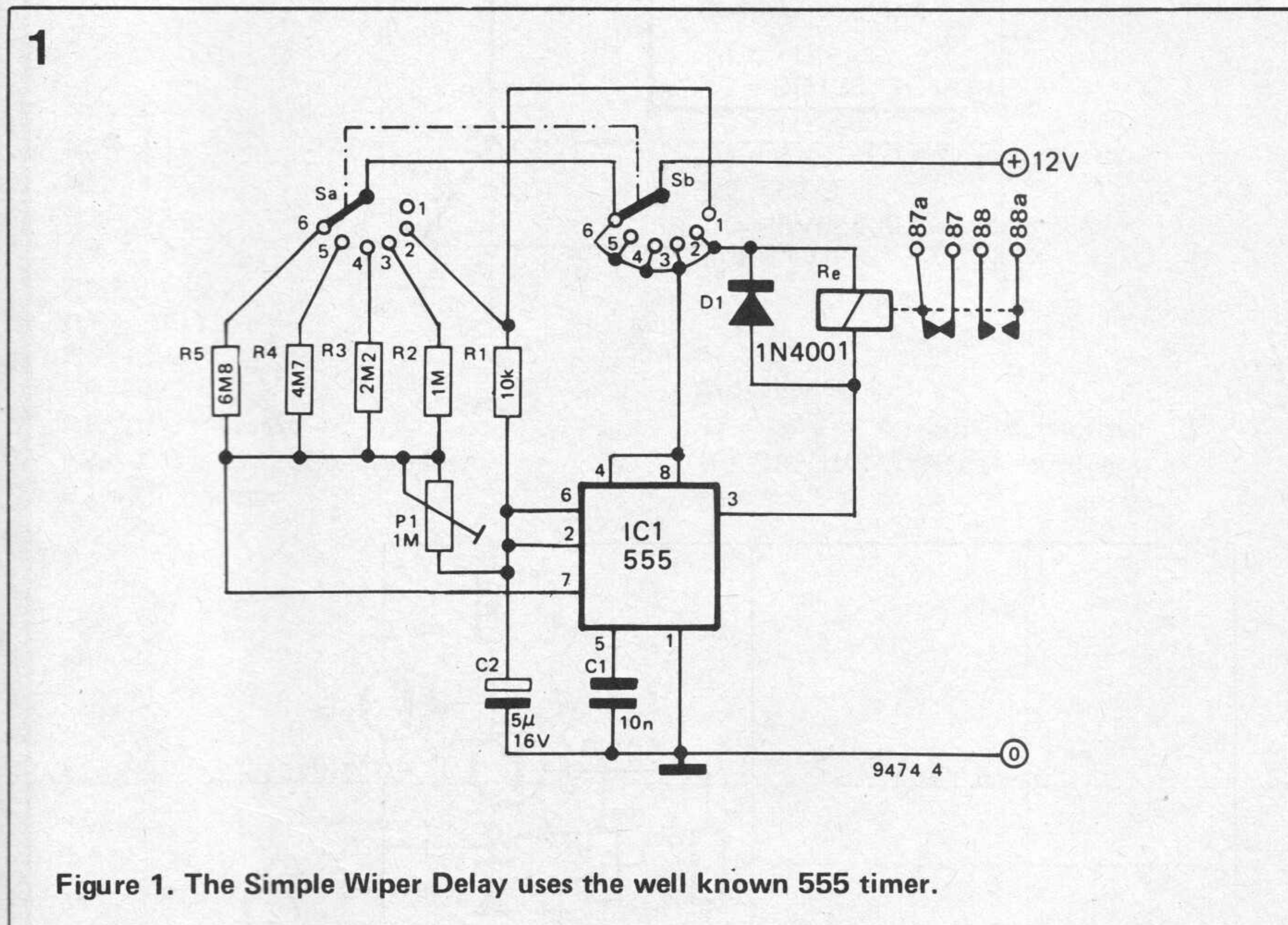
parts list

resistors:
R1 = 10 k
R2 = 1 M
R3 = 2M2
R4 = 4M7
R5 = 6M8
P1 = 1 M preset

capacitors:
C1 = 10 n
C2 = 5/16 V

semiconductors:
D1 = 1N4001
IC1 = 555

miscellaneous:
S1/Sb = double pole 6-way switch
Re = 12 volt relay

Figure 2. Component layout and printed circuit for figure 1. (EPS 9474-2)

automatic battery charger

Recharging lead-acid batteries is often assumed to be an extremely straightforward matter. And that is indeed the case, assuming that no special demands are being made on the life of the battery. On the other hand, if one wishes to ensure that the battery lasts as long as possible, then certain constraints are placed upon the charge cycle.

Figure 1 illustrates the ideal charge current characteristic for a normal 12 V lead-acid battery which is completely discharged. During the first phase (A—B), a limited charging current is used, until the battery voltage reaches approximately 10 V. This restriction on the charging current is necessary to ensure that the charger is not overloaded (excessive dissipation). For the next phase (C—D), the battery is charged with the '5-hour charging current'. The size of this current is determined by dividing the nominal capacity of the battery in ampere-hours (Ah) by 5. At the end of this period the battery should be charged to 14.4 V, whereupon the final phase (E—F) starts. The battery is charged with a much smaller 'top-up' current, which gradually would decrease to zero if the battery voltage were to reach 16.5 V.

The circuit described here (see figure 2) is intended to provide a charge cycle which follows that described above. If the battery is completely discharged (voltage < 10 V), so little current flows through D3 that T1 is turned off.

The output of IC1 will be low, so that the base currents of T2 and T3, and hence the charging current, are determined solely by the position of P1.

If the battery voltage is between 10 and 14 V, D3 is forward biased and T1 is turned on. The output of IC1 still remains low, so that the charging current is now determined by both P1 and P2. If the wiper voltage of P3 exceeds the zener voltage of D1, then due to the positive feedback via R4, the output voltage of IC1 will swing up to a value determined by the zener voltage of D1 and the forward voltage drop of D2. As a result T1 is turned off and the charge current is

once again determined by the position of P1. In contrast to phase A—B, however, the higher output voltage of IC1 means that current through P1, and hence the charging current, is reduced accordingly.

Since D2 is forward biased, the effect of resistors R2 and R3 will be to gradually reduce the charging current still further, as the battery voltage continues to rise.

To calibrate the circuit, P3 is adjusted so that the output of IC1 swings high when the output (i.e. battery) voltage is 14.4 V.

By means of P1 the 'top-up' charge current is set to the 20-hour value (capacity of the battery in Ah divided

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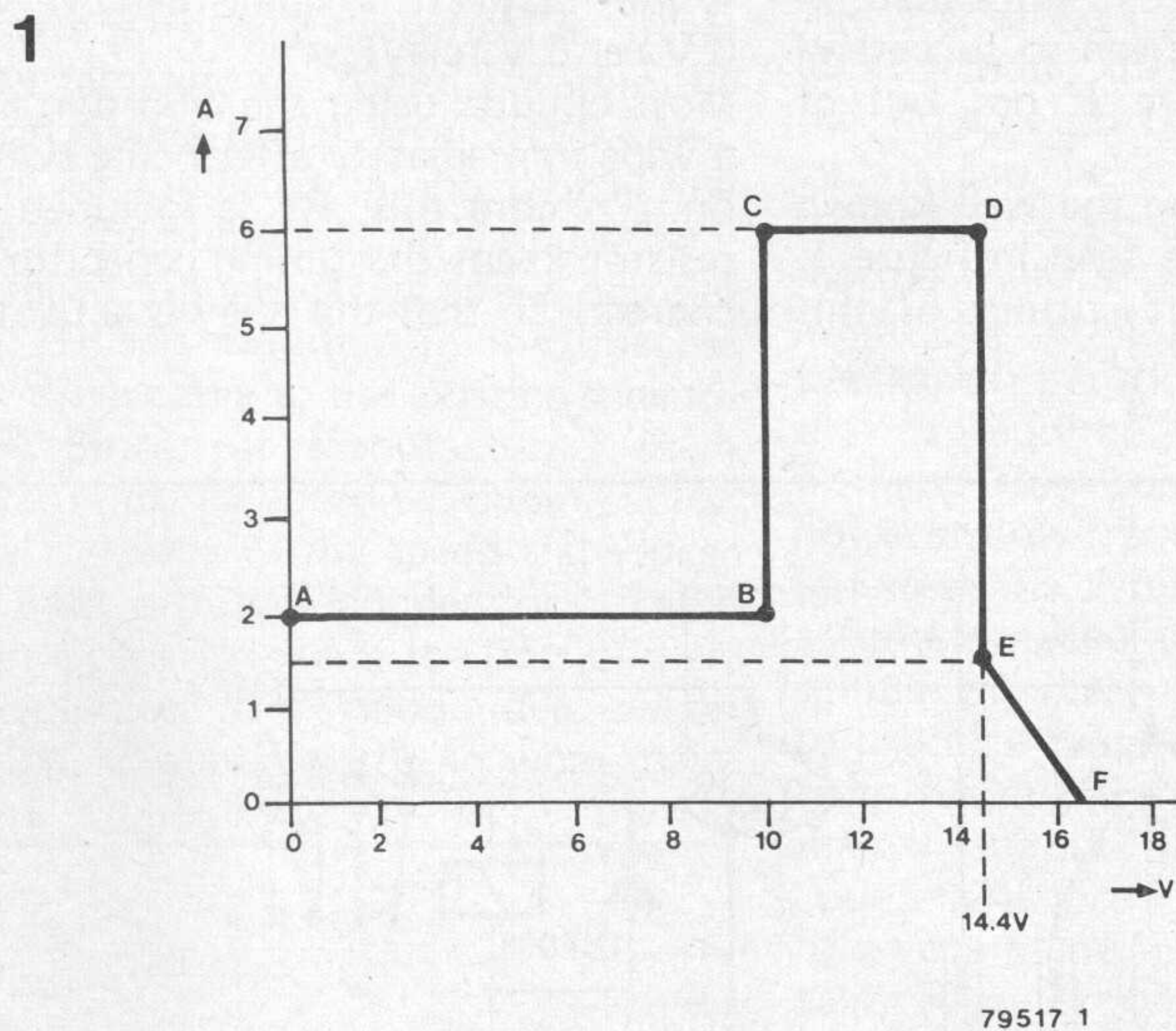
79517 2
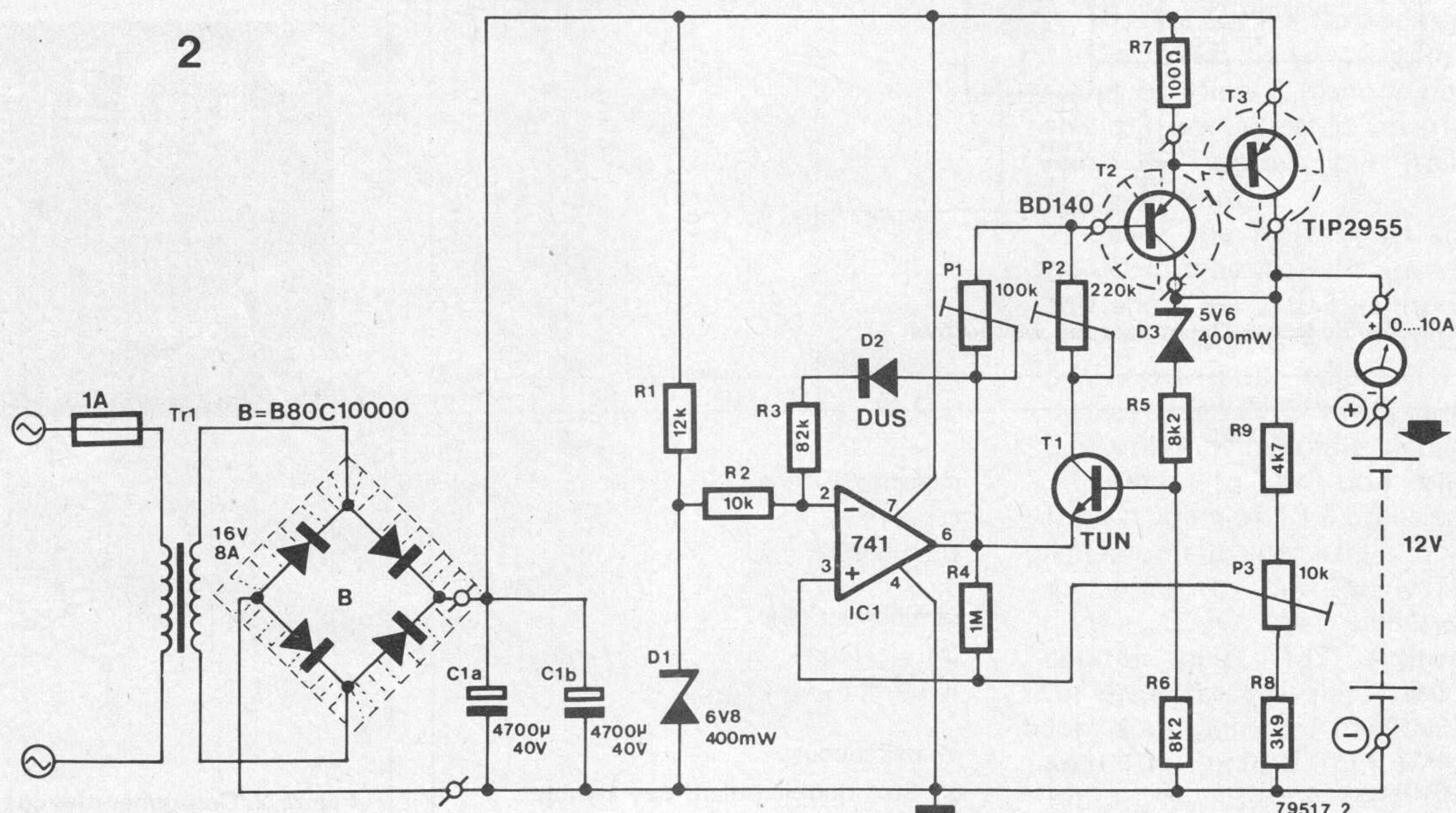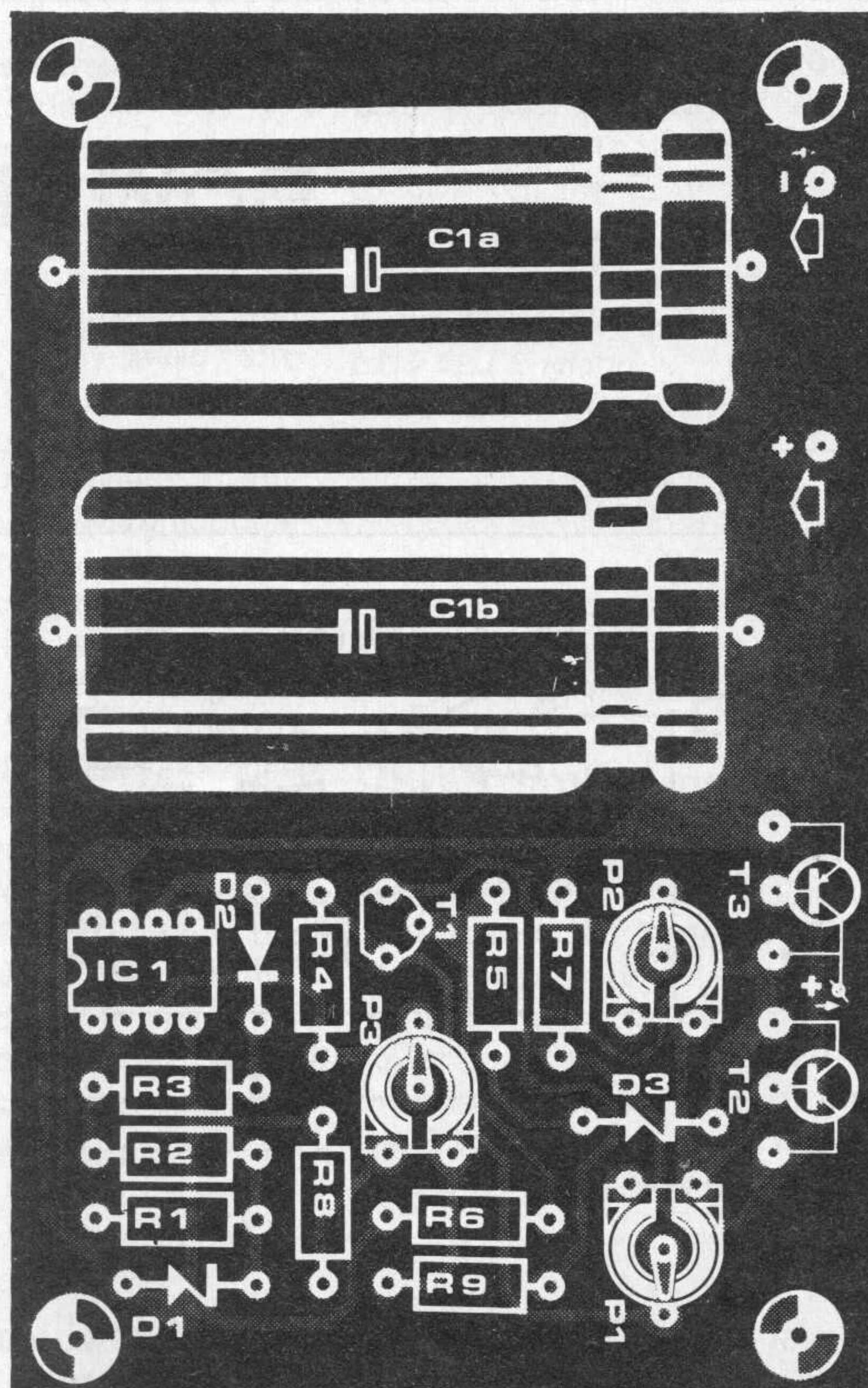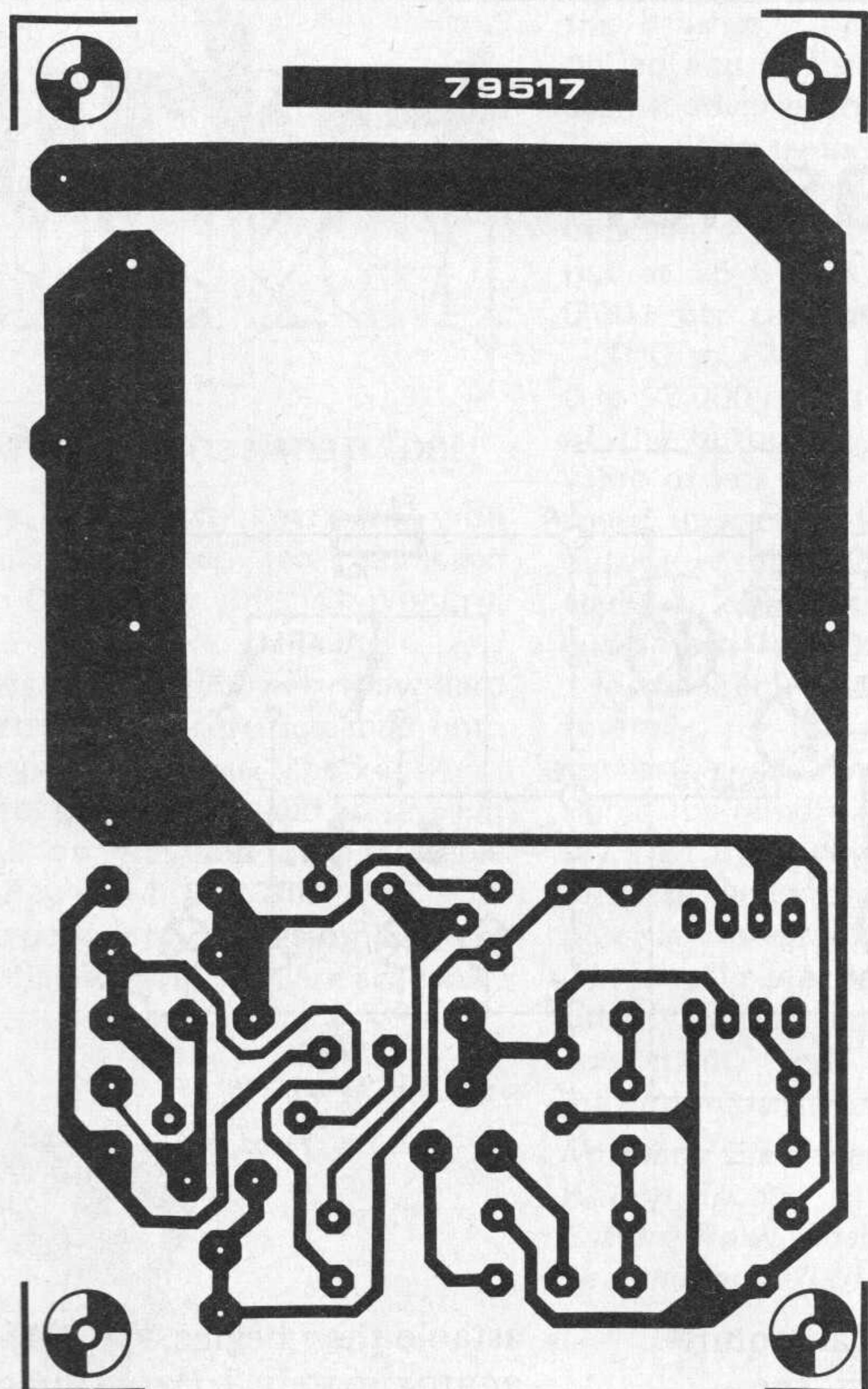
Parts list.

Resistors:
R1 = 12 k
R2 = 10 k
R3 = 82 k
R4 = 1 M
R5,R6 = 8k2
R7 = 100 Ω
R8 = 3k9
R9 = 4k7
P1 = 100 k preset
P2 = 220 k . . . 250 k preset
P3 = 10 k preset

Capacitors:
C1a = C1b = 4700 μ/40 V

Semiconductors:
T1 = TUN
T2 = BD138, BD140
T3 = TIP2955
D1 = 6V8, 400 mW zener diode
D2 = DUS
D3 = 5V6, 400 mW zener diode
IC1 = 741

Miscellaneous:
Tr = 16 V, 8 A mains transformer
B = B80C10000 bridge rectifier
fuse = 0.5 A slo-blo

by 20) for voltages between 14.5 and
15 V. Finally, with a battery voltage
of between 11 and 14 V, P2 is ad-
justed for the nominal (5-hour)
charging current.
The initial charging current (phase
A—B) is set by the value of the
'top-up' current, and depending upon
the characteristics of the transistors,
will be approximately 30 to 100%
greater.

*Siemens Components Report
Volume XIII, No. 1 March 1978.*

W. Ferdinand

When starting a car journey after dark it
is useful to have a device which will
keep the interior lighting on for a while
after the doors have been closed, and so
make it easier for the occupants to
fasten safety belts and insert the
ignition key. This can be done with the
simple time-switch circuit shown.
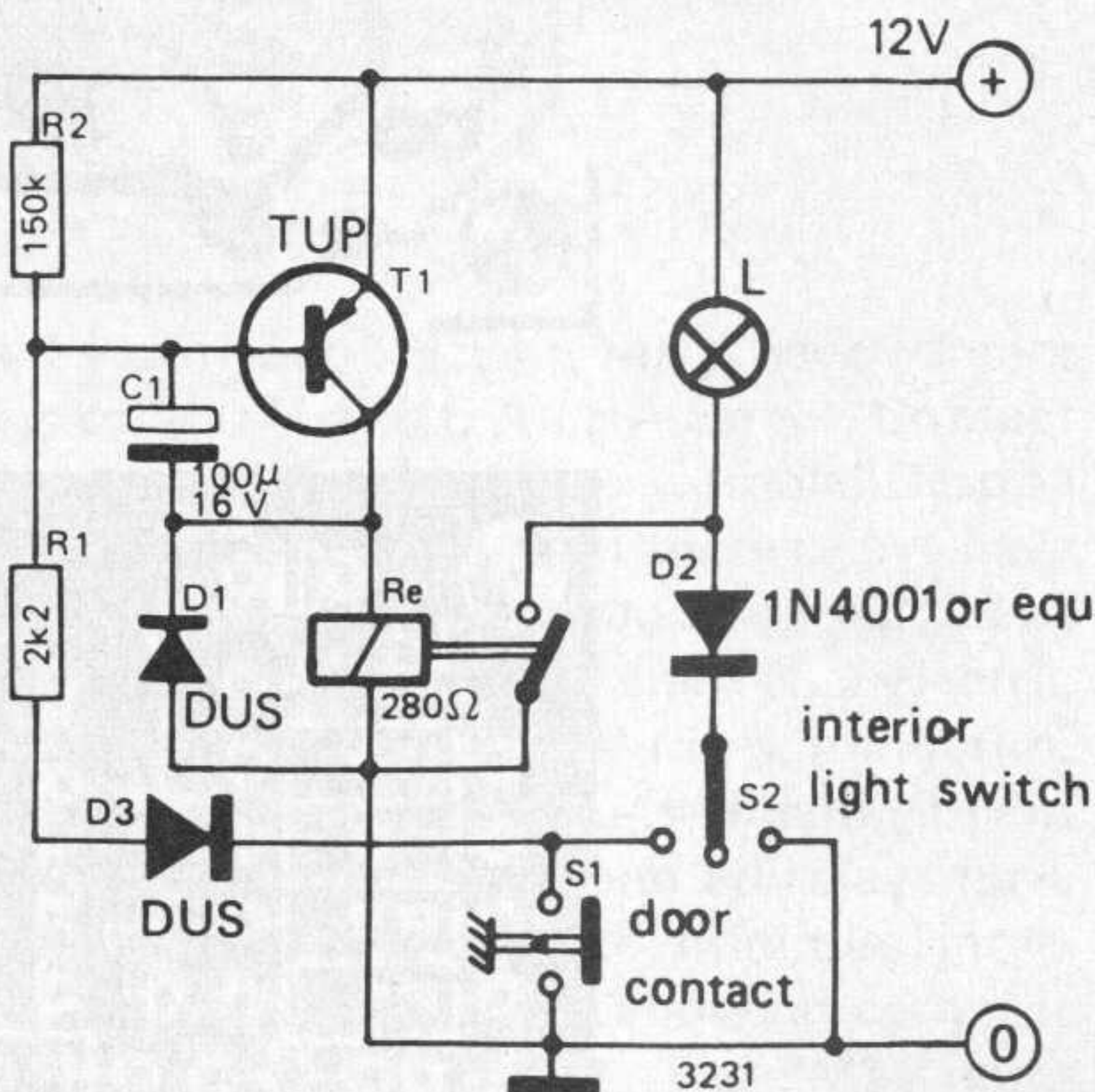
afterburner

power flasher
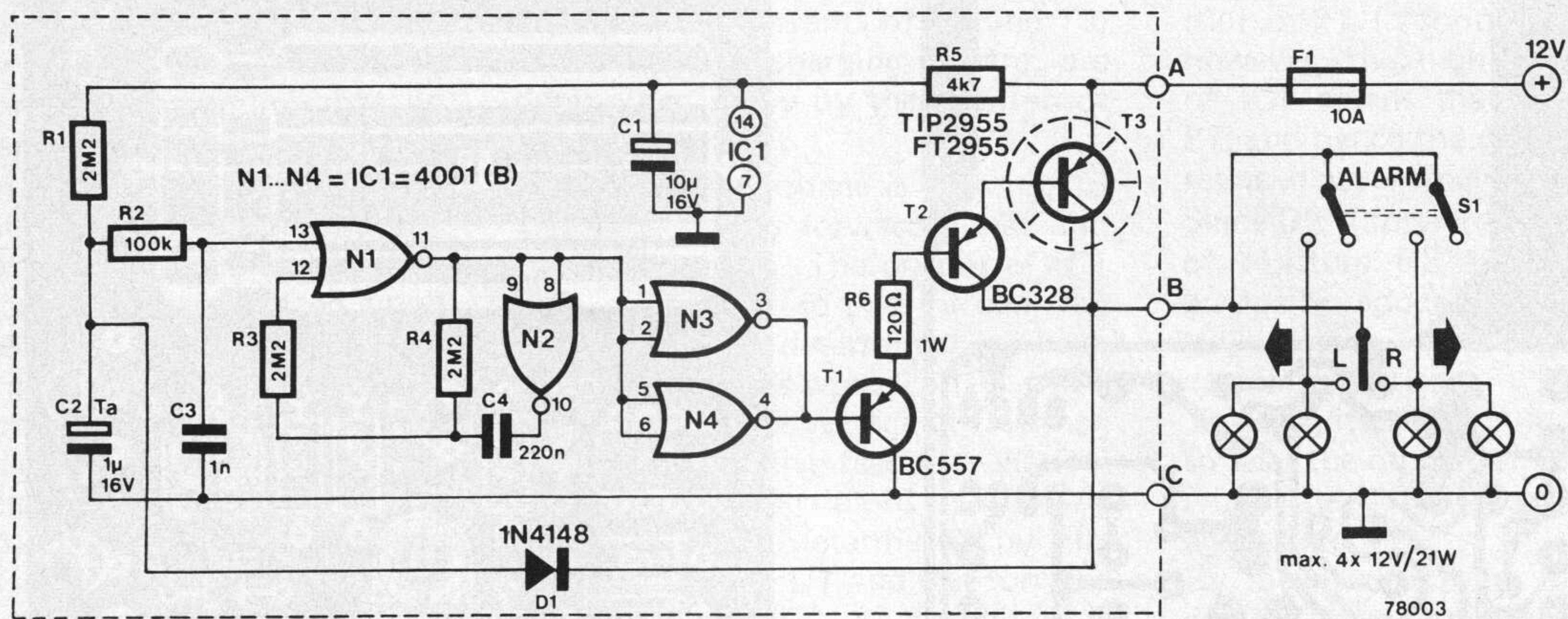
Despite the vast array of solid-state devices now available, the flasher units for car direction indicators are still almost exclusively electro-mechanical. Apart from the obvious objection of unreliability, these units suffer from the problem that the flashing rate is dependent on ambient temperature, battery voltage and load. This latter factor means that if one wishes to wire all four indicators to flash simultaneously as a hazard warning, it is necessary to use a separate flasher unit.

The electronic flasher discussed here suffers from none of these disadvantages. The repetition rate is practically independent of battery voltage, temperature and load, has a built-in hazard warning switch and is extremely reliable. Furthermore it

complies with all the legal requirements for turn indicators, the repetition rate of 40 to 90 flashes per minute being within the specified range and the circuit being arranged so that the indicators light immediately when the turn indicator switch is operated.

The circuit is basically an astable multivibrator constructed around two CMOS NOR gates N1 and N2. N3, N4, T1, T2 and T3 buffer the output of this astable to drive the indicator lamps.

When the indicator switch is operated C2 discharges rapidly through D1 and the indicator lamps. Pin 13 of N1 goes high and its output goes low. The outputs of N3 and N4 thus go high, turning on T1, T2 and T3 and lighting the indicators. The

astable then begins to oscillate at approximately 1 Hz, turning the indicator lamps on and off.

If the hazard warning switch, S1, is closed then the circuit operates in exactly the same fashion except that all four lamps are connected in parallel and flash in synchronism. T3, which switches most of the load current, must be mounted on a heatsink. If a metal box is used to house the unit then T3 can be bolted to the wall of this using an insulating washer and bush. The current in the leads connected to points A and B is quite large (up to 8 A) so heavy-gauge wire must be used for these connections. The positive supply lead must be fitted with a 10 A fuse if not already fused.

Parts list.

Resistors:
R1,R3,R4 = 2M2
R2 = 100 k
R5 = 4k7
R6 = 120 Ω (1 Watt)

Capacitors:
C1 = 10 μ/16 V
C2 = 1 μ/16 V (tantalum)
C3 = 1 n
C4 = 220 n

Semiconductors:
IC1 = 4001 (B)
T1 = BC 557, BC 177
T2 = BC 328, BC 327
T3 = FT 2955 (Fairchild) TIP 2955
D1 = 1N4148

EPS 78003
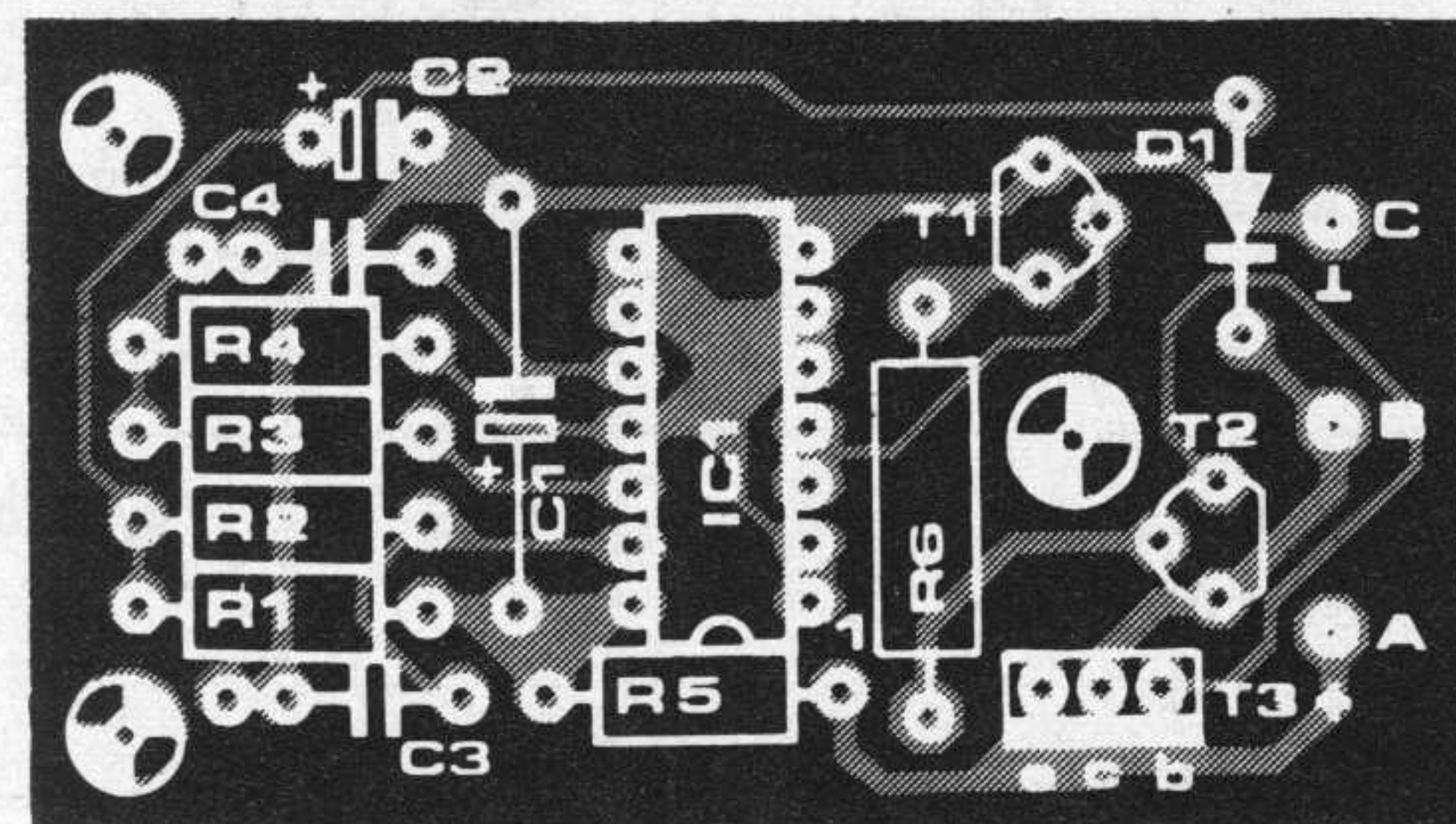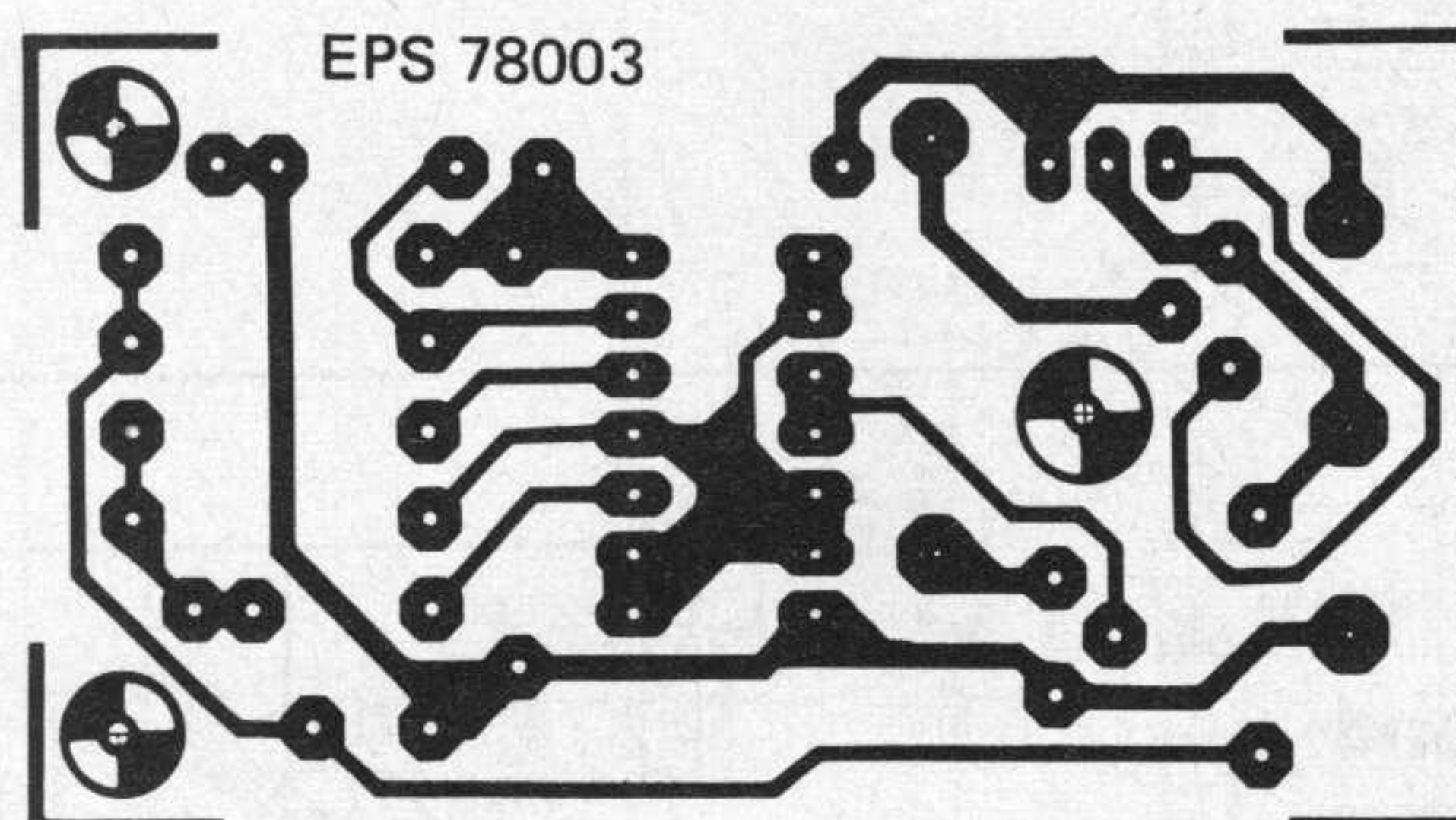
market

Low-cost keyboard has snap feel

A low profile, low cost keyboard with discrete keytops and snap feel has been introduced by Chomerics, Inc. of Woburn, Massachusetts.

The Chomerics Quickey EH keyboard features contacts and circuitry screened onto a single folded piece of hinge. The keys provide a tactile feel and are recessed to prevent accidental actuation. Keyboards are available in 12 or 16 key configurations with X/Y matrix or single pole outputs. Customized key legends and special output codes are available.
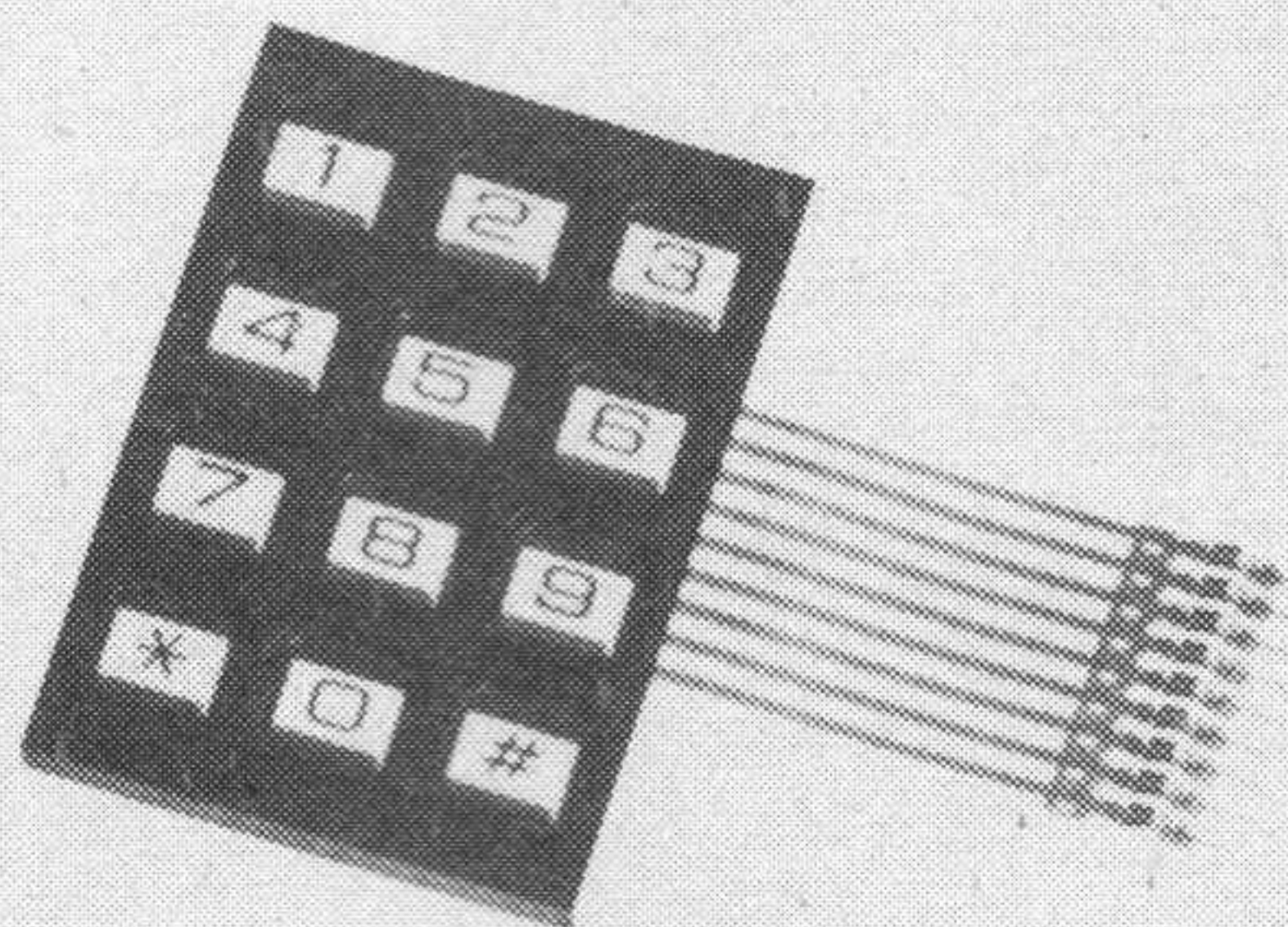
The EH keyboard measures $2^3/_8$" x 1½ x ¼", is equipped with heat staking corner posts and may be flush or panel mounted. Flex tail or pin terminations are available and the contact rating is 20 mA, 30 vdc. The keys are on ½" centers and key life is 10 million actuations. Operating temperature is −40°F to 150°F and bounce is less than 3 ms.

Chomerics Europe
Thomas W. Walsh
Holbeinstr. 62
D-6000 Frankfurt 70
Telephone: (0611) 63 45 35

(1458 M)

DC tachometer generator

A new 'one-piece' design of DC tachometer generator is now available from Neco Electronics (Europe) Ltd. The new 7 volts per 1000 rpm (12,000 rpm maximum) unit (ref ST-7447A-2) is more compact, better sealed and lower in price than equivalent tachometer generators of traditional construction. The generator is in the form of a 'one-piece' housing, with access only from a moulded cover at the non-drive end which also retains
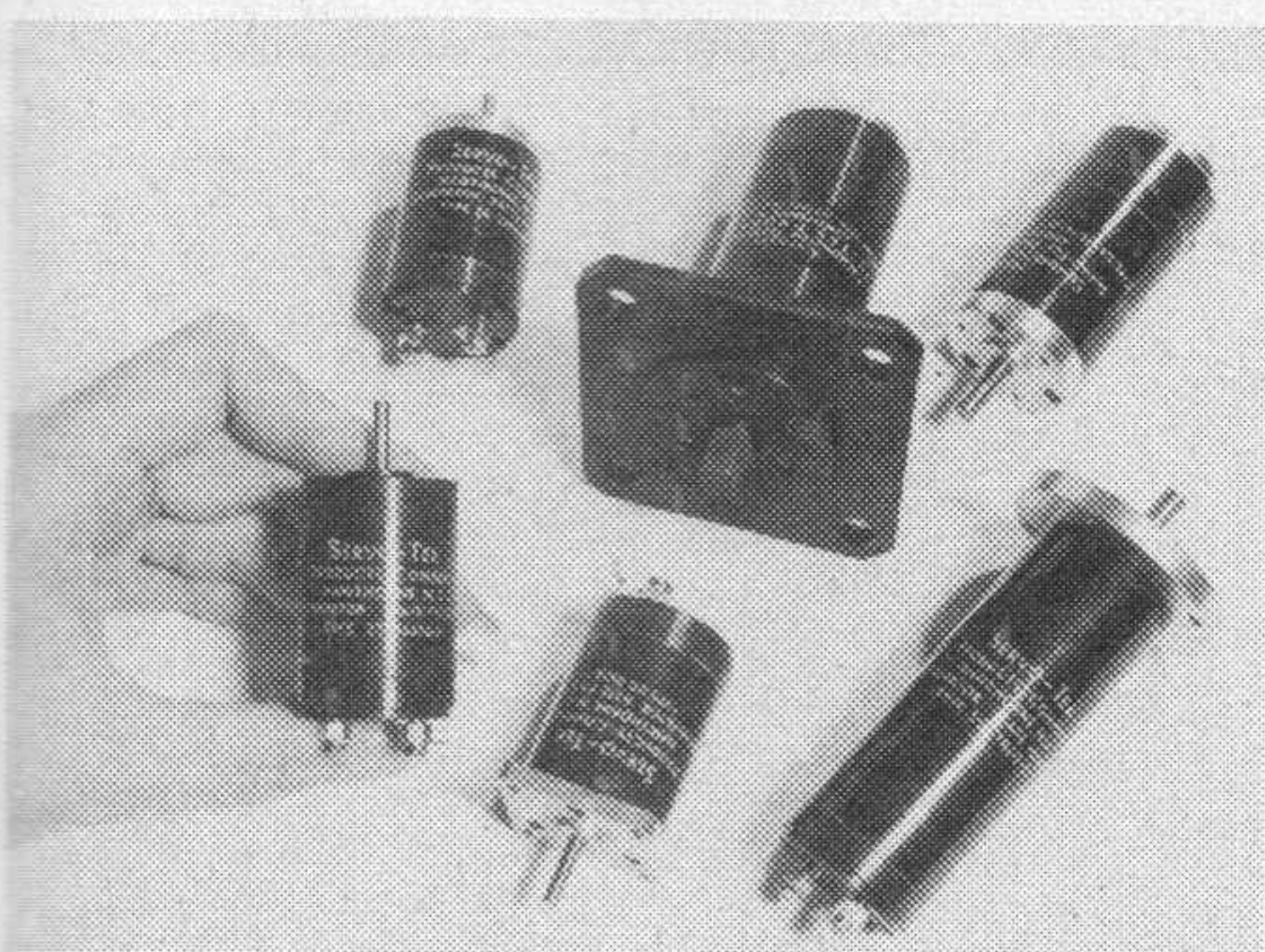
the brushes. Construction is therefore simplified and the enclosure is better protected against adverse working conditions.

The unit is temperature compensated and is suitable for operation in ambient temperatures between −55°C to +100°C. The voltage output at 25°C will not deviate by more than 0,001 per cent per degree of change within −20°C to +75°C. Linearity at any speed from 0 to 12,000 rpm is said to be better than 0.1% of the output at 3,600 rpm. An rms ripple value of less than 3% of the DC value at any speed in excess of 40 rpm, and bi-directional output within 0.25% of nominal output are claimed. Brushes and commutators are guaranteed for 100,000 hours at 3,600 rpm, 1 mA maximum current.

Intended for use wherever there is a need to convert speed into an electrical analogue signal for remote indication or control, Neco say that the accuracy and low driving torque of these generators make them ideal for use in precision integrators and as rate generators for damping in positioning servos. They are also suited for use as transducers for recording equipment and for under-or-over speed indication by direction and magnitude.

Normand Electrical Company Limited,
Walton Road,
Eastern Road, Cosham, Hampshire, PO6 1SZ.
Telephone: (0705) 370988.

(1456 M)

market

Sub-miniature reed relay

Measuring less than an inch long and weighing only 3 gm, the Erg PM21 high reliability reed relay can switch 10 W loads. Switching rate is 500 Hz and coil drive power only 70 mW. Standard versions of this completely encapsu-

lated 1 Form (n.o.) s.p.s.t. relay have contact ratings of 200 V at 0.5 A (1 A carry). Contact resistance is 200 mΩ and very stable. Despite their small size (25 x 8 mm) these relays have a reed/coil insulation resistance of 10^{10} Ω at 500 V r.m.s. minimum, and a dielectric strength (reed/coil) of 500 V r.m.s. minimum. Leadout pins are set on a standard 0.1 in pitch for p.c.b. mounting, and all relays have internal magnetic screens to minimise interaction with adjacent relays allowing compact and economic p.c.b. layout. The PM21 components are available with coil voltages of 5, 12 and 24 V d.c. Consistent reliable operation
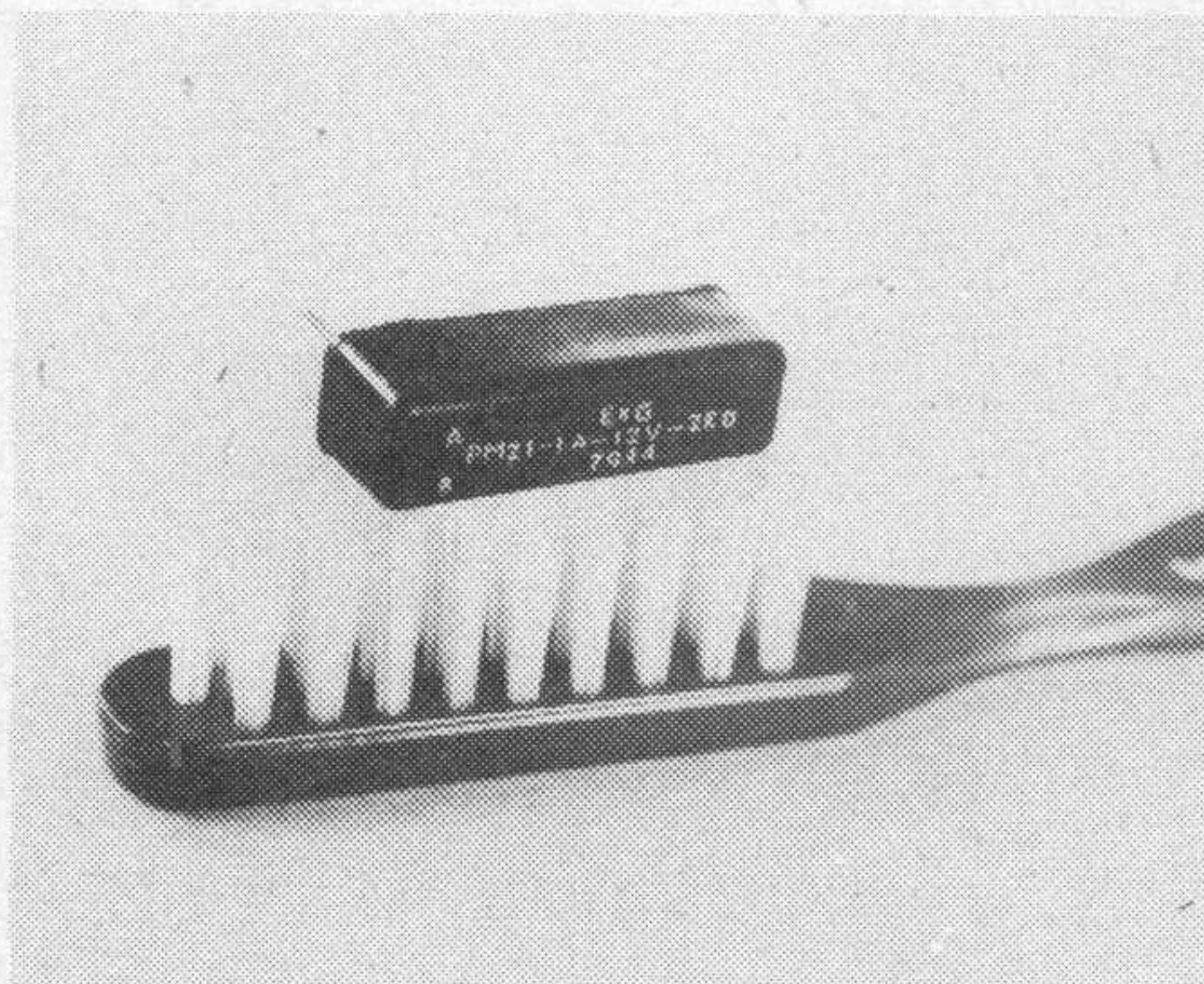
is assured even with voltage variations if −10% +50%. Designed to conform with BS912, each relay is vacuum encapsulated in epoxy resin with glass-loaded shell and header to give reliable protection and performance even under adverse conditions.

Erg Industrial Corporation Limited
Luton Road, Dunstable, Bedfordshire,
LU5 4LJ England.
Telephone: 0582-62241

(1457 M)

VSWR/Power meter

A combined VSWR and power meter offering direct reading of both functions without interpolation is available from Zycomm Electronics Limited.

In operation, the unit is autoranging for power output, covering 20 W to 2 KW in three ranges for 1.8-30 MHz and 50-150 MHz, and 2 W to 200 W for the 430-470 MHz range. VSWR from 1:1 to infinity can be measured.
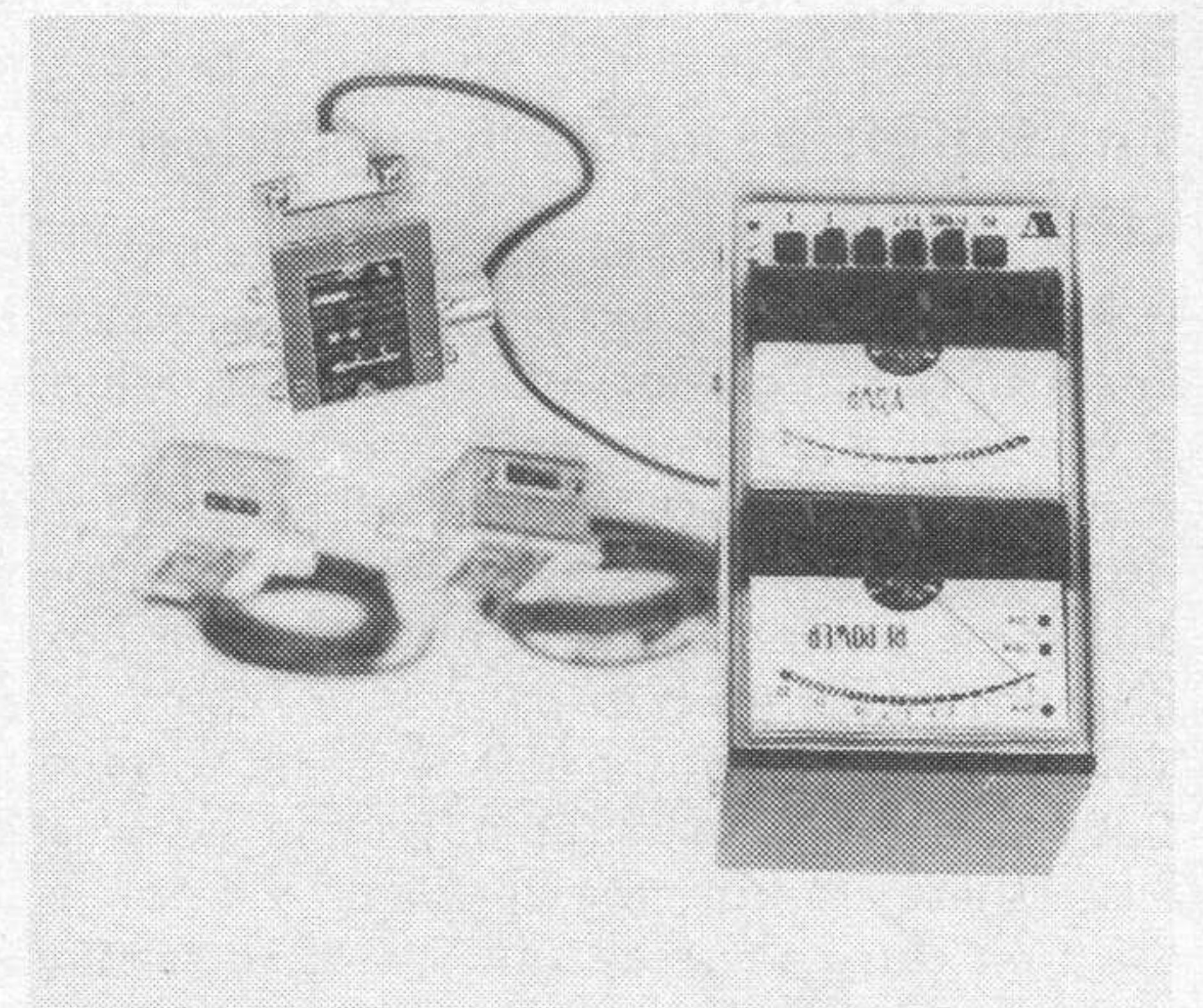
Separate sensing heads are supplied to cover each frequency range, and these can be connected at any position in the feed line — including the mast head for precise radiated power indication. Press switches on the front panel allow the selection of the appropriate head, and the display of forward and reverse power as either peak or RMS readings.

The electronic comparator included in the unit allows constant readout of VSWR irrespective of power variation, i.e. gives true indication during speech on SSB.

A 240 V, 50 Hz supply is required for operation.

Zycomm Electronics Ltd.
47, 49 & 51 Pentrich Rd,
Ripley, Derbys. DE5 3DS
England.
Telephone: Ripley (0773) 44281

(1451 M)

market

market

market in depth

The Elektor special offer kit reviewed

The Surefire Capacitive ignition kit

It is not usual for Elektor to review products in depth but this is a special motoring edition, it is a special offer to readers, and it is a kit, so all things being equal . . .

It can be upsetting to discover that, on some electronic equipment, the inside of the box does not match the outside.

This is certainly not the case with the Surefire C300 and ES200 electronic ignition systems. Since these are kits, the 'inside of the box' is the first thing you see and it will be readily apparent that component quality is high on the list of priorities of Suretron systems. It doesn't stop there either, the case is probably second to none in both finish and appearance. It is an anodised aluminium extrusion and so exceptionally smart that constructors would not doubt find many uses for the case alone.

Assembly of the kit is simple with the very explicit instructions supplied. Only one minor problem requires careful attention. The cable grommet on the end plate is a somewhat tight fit. A word of warning, don't be tempted to open out the hole for an easier fitting. Persevere, it will go in . . . The working environment for an ignition system is far from ideal and the case needs to be totally proofed against icy and boiling water, snow, cold and hot oil, petrol, sand and 'most everything else'. (It's a wonder anything works under there really, let alone electronics).

Vibration proof shouldn't be forgotten either and for this reason the tie wrap supplied for the capacitor must be securely fitted and extra care taken with all solder joints.

When assembly of the board is completed, two or three thorough coats of polyeurathane lacquer over everything will pay dividends (take note of the specific instructions regarding this).

The completed unit should be fitted under the bonnet as close as practical to the ignition coil. Again the instructions for fitting are very complete even for the inexperienced, and no problems should be encountered.

This electronic system is fitted with a three position switch allowing (a) electronic ignition, (b) no ignition, (a theft protection, if the car is to be left for any lengthy period of time) and (c) conventional ignition, which in this case remains totally unchanged.
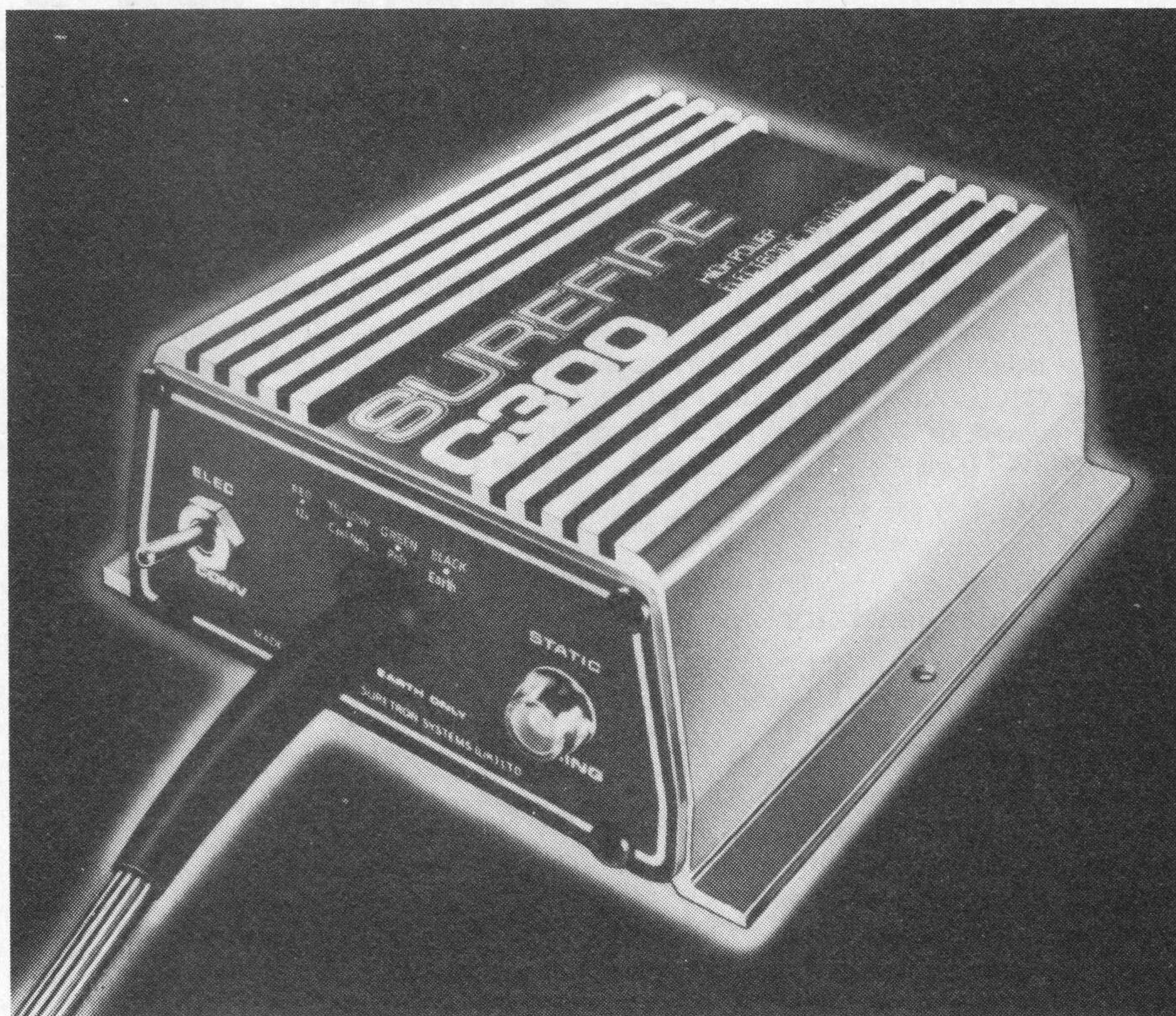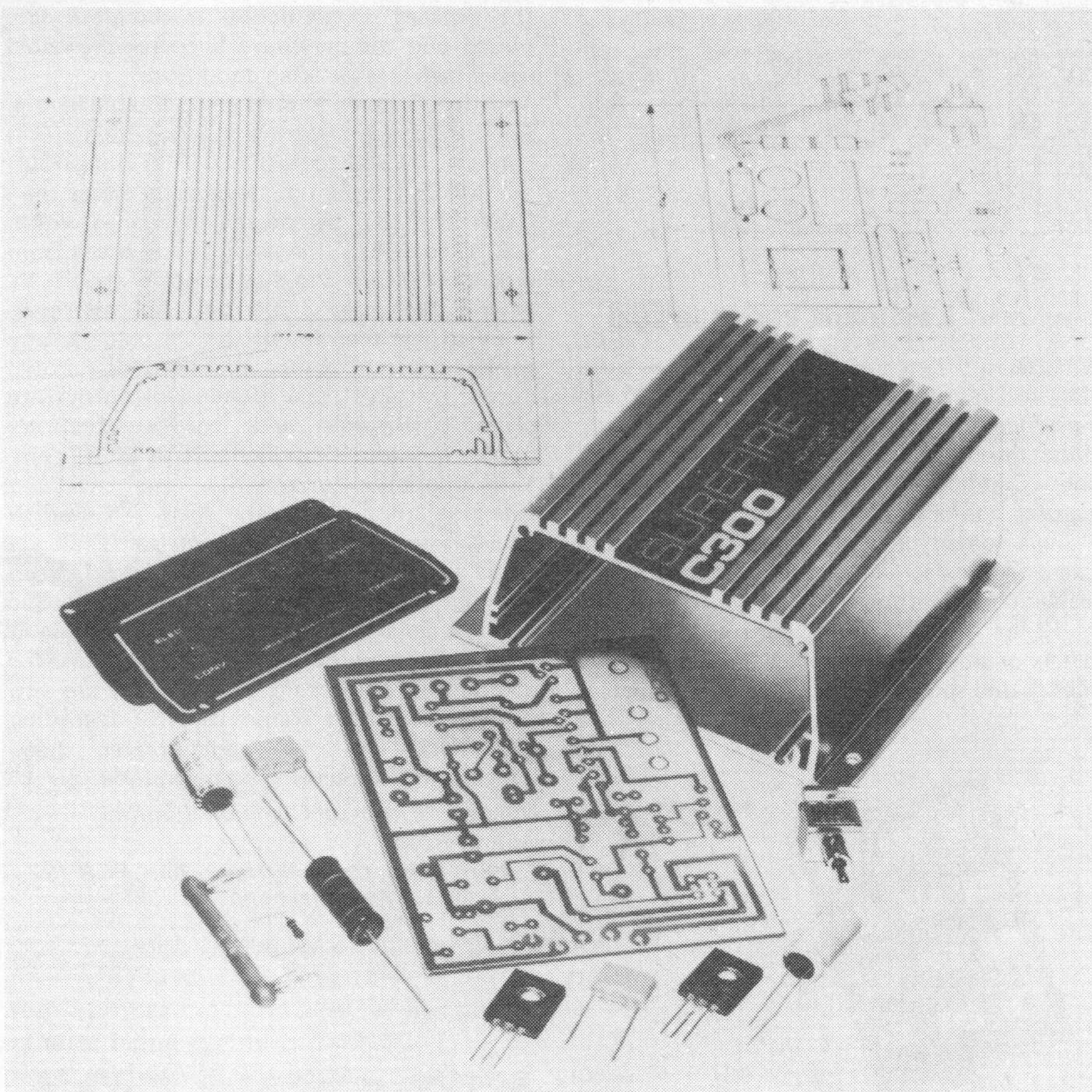
To realise the full benefits of an electronic ignition it is important that the rest of the ignition system is in perfect working order, in other words, fit new plugs and points and have the ignition timed electronically. The review 'kit' has now completed about 15,000 miles, most of them on the Continent, in the rain and at night with only infrequent stops for black coffee. Both starting and running performance have been improved by the fitting of this electronic ignition system and

no adjustments whatever have been needed since.

All in all, an excellent kit and very good value for money especially at the Elektor special offer price of £15-95 for the C300 and 411-95 for the ES200. See the advertisement elsewhere in this issue.
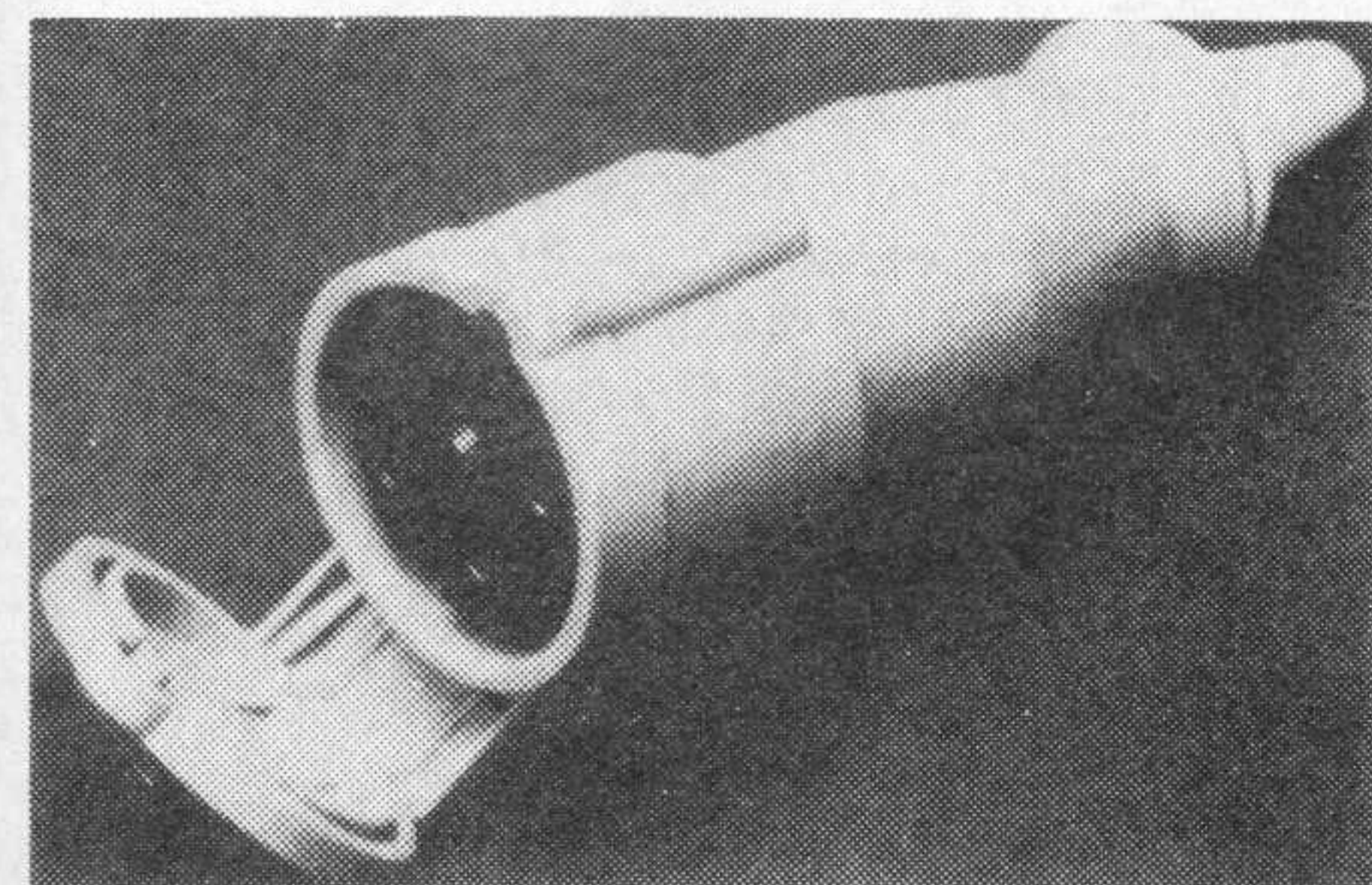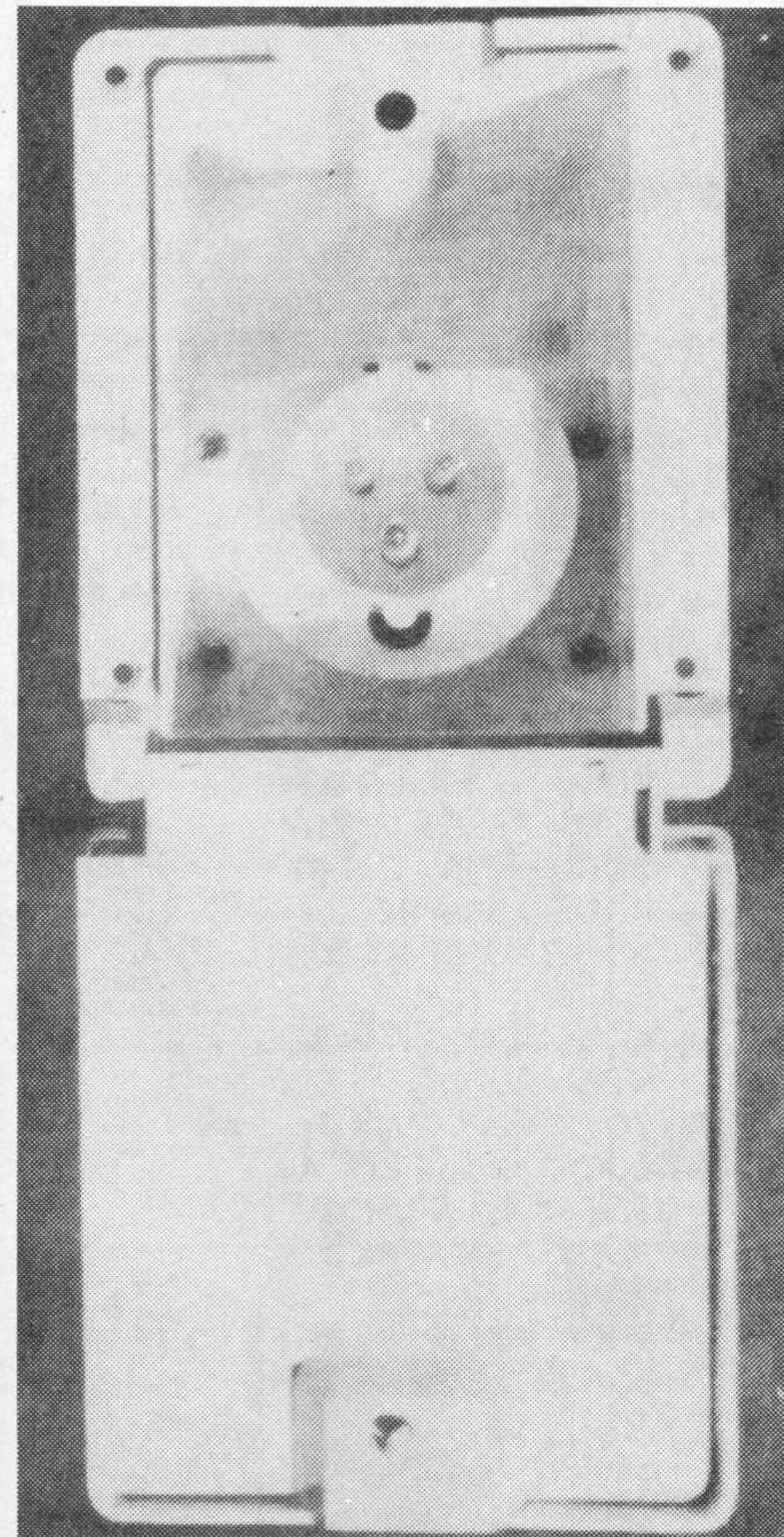
*Suretron Systems (UK) Ltd.,
Piccadilly Place, London Road,
Bath BA1 6PW.
Telephone: (0225) 23194/313846*

(1478 M)

market

Weatherproof mains inlet sockets and couplers

Connecting mains power lines to a caravan or outbuilding is not an easy job at the best of times. However, many difficulties may be overcome by using suitable plug and socket arrangements. A large variety of these types of weatherproof exterior plugs and sockets are available from Continental Electrical Components (UK) Limited. Primarily intended for touring caravans (for which purpose they are extremely useful) they could equally well be used for the outside workshop, electric lawn mower supply and even garden lighting systems etc.

The range includes weatherproof male sockets of both polarised and unpolarised (Continental) types and of course line plugs to fit them. This company can also supply a small mobile trip unit capable of handling up to 25 amps. These units are complete with current operated earth leakage circuit breakers designed to trip within 0.2 seconds if the connected equipment assumes a dangerous electrical condition. Fire protection against possible earth faults is also afforded.

Continental Electrical Components (UK) Ltd.,
Tranby Croft, Tranby Lane, Anlaby,
Hull, HU10 7EE.
Telephone: (0482) 659309/659300

(1479 M)

Caravan electric water pump

Elsewhere in this issue we refer to the growing trend towards the fitting of electric water pumps into caravans. Leisure Accessories have realised this fact and have just released a new addition to their ever increasing range. This new water pump has many advantages over other types and is of superior quality both in design and construction.

The 1021 is the 12 volt version of the 1000 series. It is very small and compact enabling it to be mounted virtually anywhere, and yet it delivers 1.15 imperial gallons per minute (5.25 litres/minute). A built in pressure switch makes it fully automatic — just open a tap, and the pump operates, close it and it shuts off. It self primes quickly and efficiently to 4ft or 5ft (1.2 m to 1.5 m) and is powerful enough to compress and expel entrapped air in the supply lines — no priming tap is required. It requires a current of only 3 amps whilst delivering water at free flow with an initial surge current of approximately 4 A.

Perhaps the most important factor of all is that it can run dry without damage. So you know it won't burn out if someone forgets to fill the water tank. It doesn't relay on complicated switches to achieve this, the capability is designed in from the start. Installation is straightforward and uncomplicated. The company also manufactures an extensive range of fittings for mobile water systems.

Leisure Accessories Limited,
6 Guardian Road, Norwich, NR5 8 PF.
Telephone: (0603) 60925

(1480 M)

New Instant Fuel Consumption Monitor

EnviroSystems Ltd have recently developed an instantaneous digital fuel consumption monitor for motor vehicles. This display unit, using half-inch high LED numerals, can be mounted in or on the dash panel.

Quick and accurate reading of the display is of paramount importance because the system provides an instant and continuous reading of actual fuel consumption in m.p.g. Therefore the driver can adjust his driving habits and monitor systems efficiency to minimise fuel consumption. The display panel is coated with GLARECHEQ to eliminate reflected glare and extraneous light. GLARECHEQ is a unique process whereby acrylics, with a normally glossy surface, are sprayed with a special formulation. This imparts a clear hard matt finish, thus reducing reflected glare to a minimum.

Although available as a consumer product the FuelStretcher is basically a scientific measuring system using the latest silicon semiconductor chip technology. Transducers in both the speedometer cable and fuel line generate signals which are fed to the semiconductor processor; there they are integrated to produce an accurate and continuous measurement of the fuel consumption. The figures are displayed on a dashboard unit in large red numerals. The system can be fitted by the average DIY enthusiast.
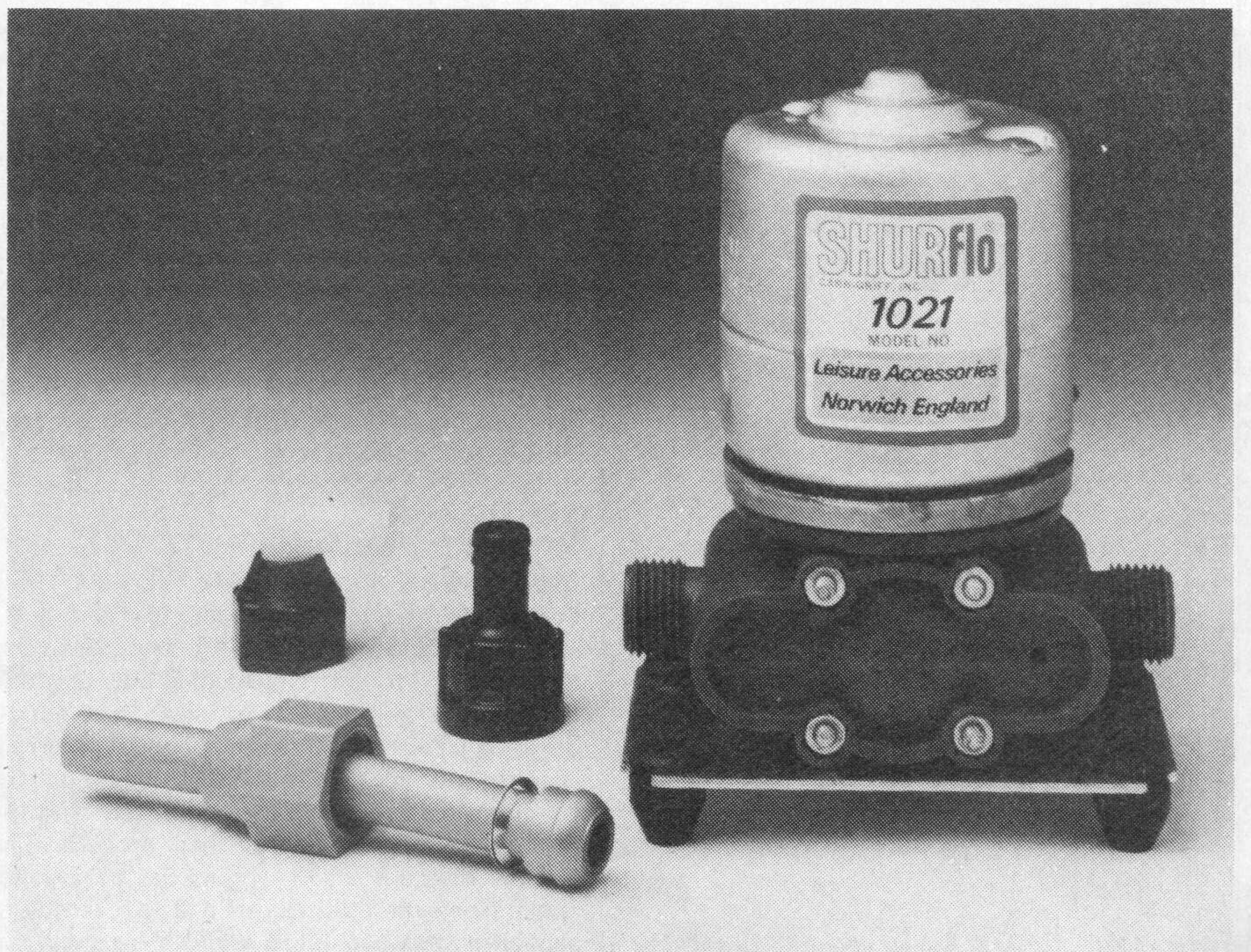
For GLARECHEQ:
Mr. Bob Burnett,
Chequers Engraving Ltd.
Phone: 01-739 6964

For the FuelStretcher:
Dr. D. van den Broek,
EnviroSystems Ltd.
Phone: Grange-over-Sands 04484 4233

market

market

## RF power meters

Precise RF power measurement from 0.01 watts to 100 watts over the frequency range 1 MHz to 1 GHz is provided by a new range of three absorption wattmeters announced recently by Racal-Dana Instruments Limited.

The three models, each with dual range switching and large clear panel meters, cover six overlapping ranges for additional accuracy. Good VSWR performance is a major feature and high reliability is assured by the use of thick-film resistive elements and specially designed, lightweight heat sinks.

In addition to the wattmeter function, each instrument may be used as a highly accurate 50 Ohm load down to DC. An attenuated output is available for connection to other test instrumentation, such as frequency counters or modulation meters, enabling measurements to be made directly from the output of transmitters.
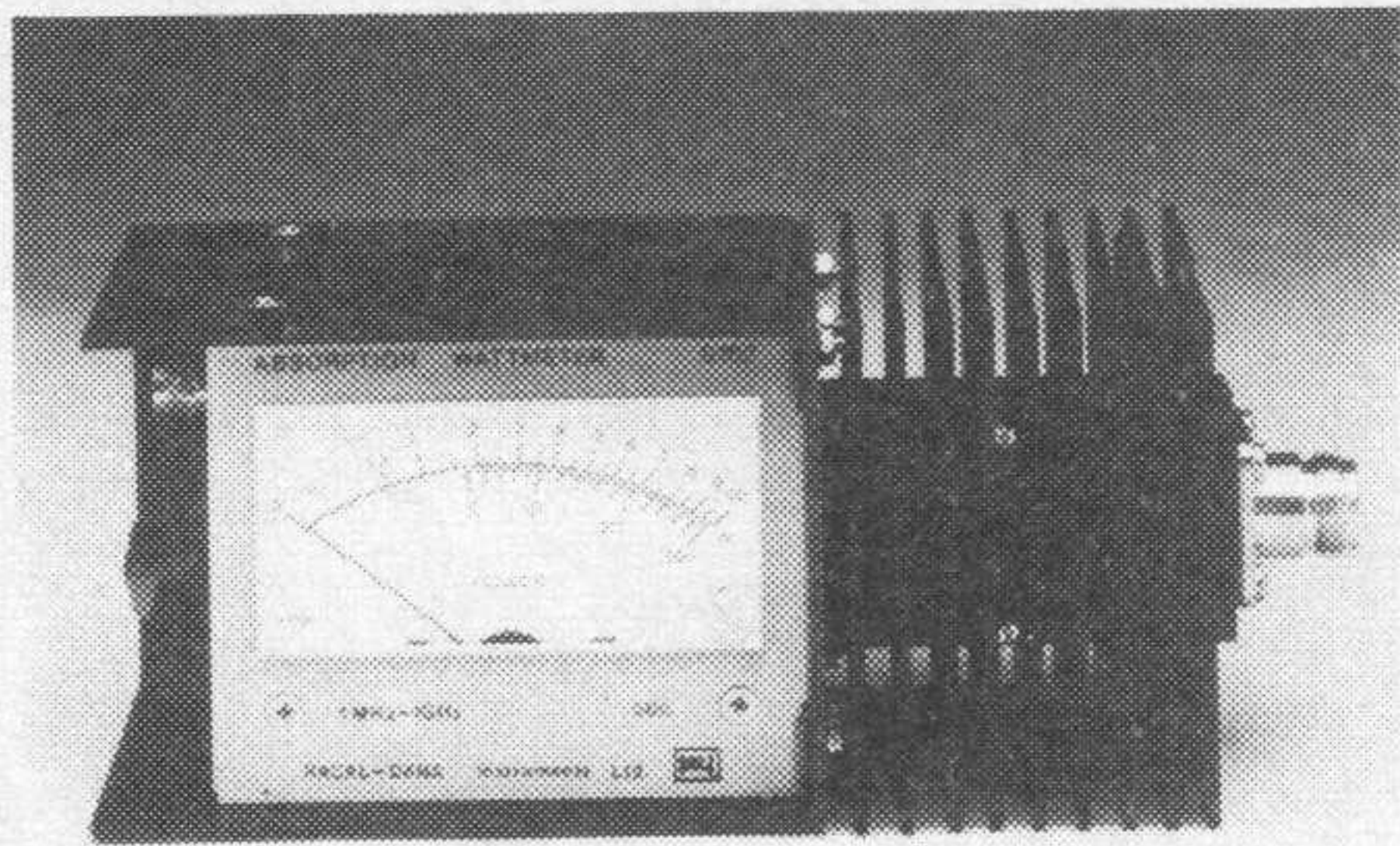
Accuracy of the instruments is within six percent of full scale while a VSWR better than 1.2 to 1 is maintained over the entire frequency range. Frequency response is within ± 0.3 dB referred to 30 MHz and operating temperature range is −10°C to +45°C.

Racal-Dana Instruments Ltd,
Duke Street,
Windsor,
Berkshire, SL4 1 SB.

(1455 M)

missing link

Modifications to
Additions to
Improvements on
Corrections in
Circuits published in Elektor

The ICU — a mini microprocessor

Elektor E57, March 1979 page 3-28. In the circuit shown, switch S3 should be normally closed.

Burglar's battery saver

Elektor 51/52, Summer circuits 1979 page 7-05. The value of C1 is incorrect, it should be 33 nF.

pcb for variable fuzz box

Elektor 54, October 1979 page 10-20. Diode D2 is shown the wrong way round in figure 1. Figures 3 and 4 of the original article (December 1978) are correct. The printed circuit board is also correct.

Charging nicads — fast

Elektor 56, December 1979 page 12-10. In figure 3 the zener diodes D1, D2 and D3 are shown as 8 volt versions, they should be 18 V.

Voice operated control switch

Elektor 56, December 1979 page 12-40. There was no mention of the value of L1. This can be made by winding five turns of enamelled copper wire (0.1 . . . 0.25 mm dia.) around a ferrite bead.

Colour generator

Elektor 57, January 1980 page 1-06. In some instances we have had reports of flickering lamps. This can be remedied by increasing the value of C1 to 470 nF/400 V. Zener diodes D3 and D4 were shown as 5V6 both in the circuit diagram (figure 3) and the parts list. Operation can be improved by reducing this to a value of 4V7. Finally, we should have made it clear that presets P1 and P2 control the initial switch on time of lamps La2 and La3 — after this they have no effect. To adjust the timing of the lamps the unit must be switched off, the presets adjusted, and the circuit switched on again.

Vocoder

Elektors 57 & 58, January & February 1980. Page 1-28: several times in the text, A5 & A7 are transposed for A3 & A4 and vice-versa with respect to the circuit diagram, figure 3. The easiest remedy is to alter the circuit diagram. Page 1-29: again, several errors cropped up in the text. The 'line input' for the circuit of figure 6a is non-existent and the sensitivity control (P13) has moved! The circuit diagram itself (figure 6a) is correct apart from the addition of a 22 µF tantalum capacitor between R115 and 0 V, as shown in

figure 6, page 2-19 (February issue). Page 2-16: capacitors C79 & C80, referred to on this page as being mounted on the bus board are in fact mounted on the input/output board.

While we're on the subject of the bus board, many readers may have noticed that points 'g', 'h', 'i' and 'j' are incorrectly connected (bottom right of figure 9, page 2-23): point 'g' should be connected to point 'h', while 'i' should be connected to 'j'. There is no need to worry, however, as the printed circuit board (EPS 80068-2) supplied by the EPS service is correct.

ESS 005 Luna

It has been pointed out to us that there is an error in the Lunar-lander program. This error causes the program to function correctly during one landing only. After this, all landings (even the successful ones) will be indicated as 'crashed'! The reason for this is that two variables (stored in locations ØD5B and ØD5C) are not brought back to their initial value of ØF. A minor addition to the end of the program (see below) will solve the problem.

```
        $ 36
ØDD8    C1Ø9 LD Ø9 (1)
ØDDA    98Ø5 JZ $ 37
ØDDC    C4Ø7 LDI Ø7
ØDDE    5Ø ANE
ØDDF    C9Ø9 ST Ø9 (1)
        $ 37
ØDE1    9Ø27 JMP $ 39
        $ 38
ØDE3    37 XPAH 3
ØDE4    C4AØ LDI AØ
ØDE6    33 XPAL 3
ØDE7    3F XPPC 3
TAB:
ØDE8    Ø7 6D ØØ 4F 5B ØØ 7F 5B
ØDFØ    7F 3F ØØ
TAB:
ØDF3    AØ 5E 79 74 6D 77 5Ø 39
TAB:
ØDFB    ØØ 5E 79 5E 37 77 38
TAB;
ØEØ2    ØØ ØØ 77 37 3E 38 ØØ ØØ
        $ 39
ØEØA    C4ØD LDI ØD
ØEØC    37 XPAH 3
ØEØD    C45B LDI 5B
ØEØF    33 XPAL 3
ØE1Ø    C4ØF LDI ØF
ØE12    CBØØ ST ØØ (3)
ØE14    CBØ1 ST Ø1 (3)
ØE16    C4ØC LDI ØC
ØE18    9ØC9 JMP $ 38
```

APPOINTMENTS

ASSISTANT FILM RECORDISTS AND TRAINEES

Would you like to specialise in sound with the BBC TV's Film Department? There are vacancies in West London.

ASSISTANT FILM RECORDISTS work initially in sound transfer and dubbing areas operating sound recording and reproduction equipment for a wide range of programmes. There are prospects of progressing to mobile Film Recording work in due course. If you have professional experience in this field, the starting salary would be £4,185 p.a., perhaps higher if exceptionally qualified, rising to £5,605 p.a. An additional allowance is paid for shift work (not nights). Normal hearing essential.

EXCELLENT TRAINING is given if you have ambitions to do this type of work but lack experience. You will need good 'O' level standard of education or equivalent, including Physics and Maths and a basic knowledge of electronics. You should be able to demonstrate a practical interest in sound and recording. Trainees will start at a salary of £3,800 p.a. at the end of August 1980, and should qualify for promotion to Assistant Film Recordists about a year later.

Salary review date April. Conditions of Service excellent. Contact us immediately for application form (quote ref. 2053/EL and enclose s.a.e.): **BBC Appointments, London W1A 1AA. Tel: 01-580 4468 Ext: 4619.**

BBC tv