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Everyday ELECTRONICS

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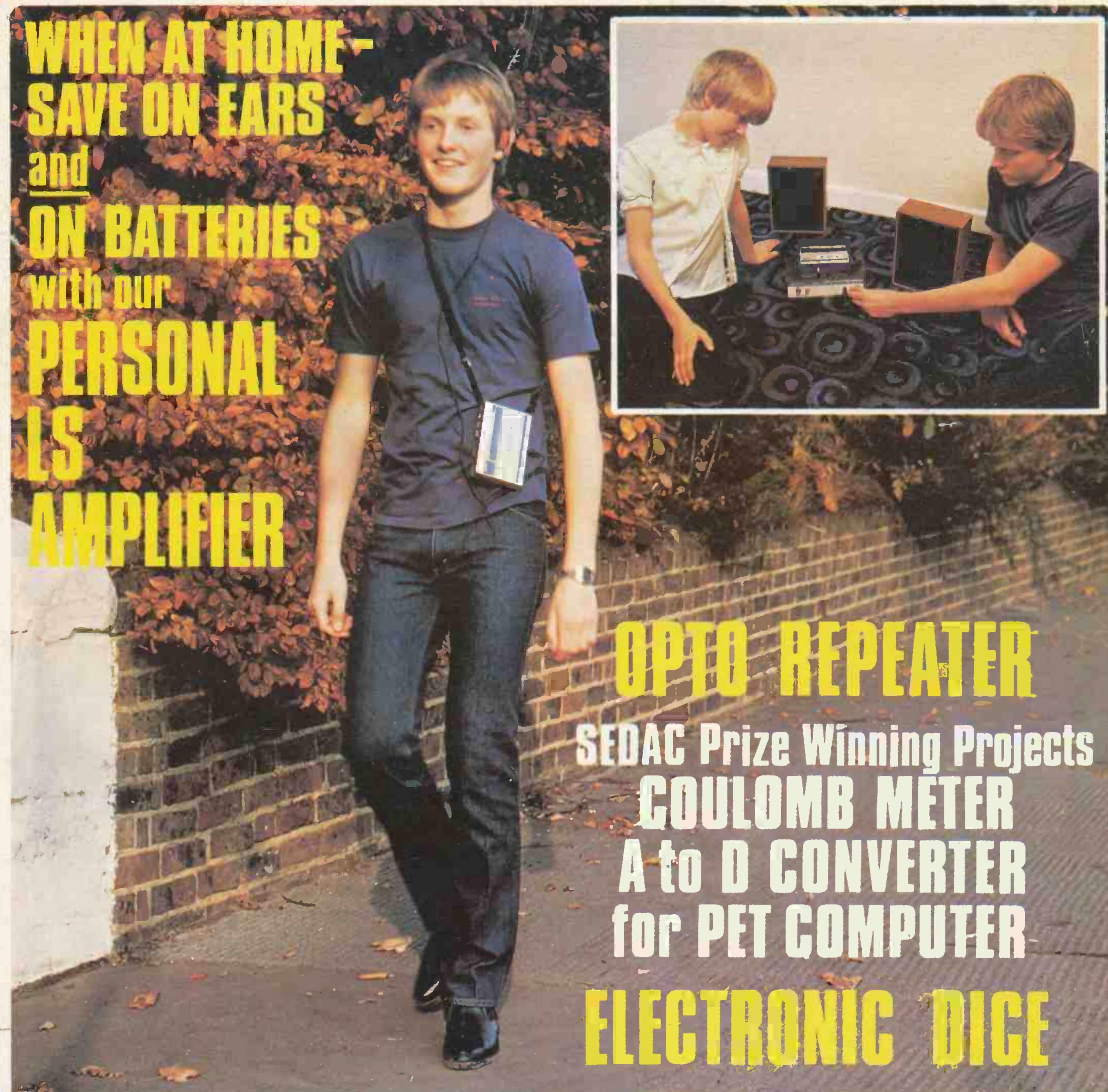

WHEN AT HOME- SAVE ON EARS and ON BATTERIES with our PERSONAL LS AMPLIFIER

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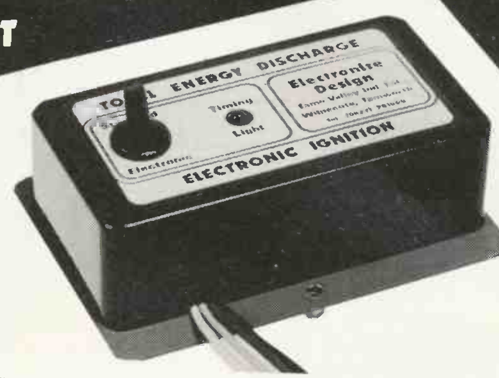

★ Is it **EASY TO START** in the cold and the damp? Total Energy Discharge will give the most powerful spark and maintain full output even with a near flat battery.

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The basic function of a spark ignition system is often lost among claims for longer "burn times" and other marketing fantasies. It is only necessary to consider that, even in a small engine, the burning fuel releases over 5000 times the energy of the spark, to realise that the spark is only a trigger for the combustion. Once the fuel is ignited the spark is insignificant and has no effect on the rate of combustion. The essential function of the spark is to start that combustion as quickly as possible and that requires a high power spark.

The traditional capacitive discharge system has this high power spark but, due to it's very short spark duration and consequential low spark energy, is incompatible with the weak air/fuel mixtures used in modern cars. Because of this most manufacturers have abandoned capacitive discharge in favour of the cheaper inductive system with it's low power but very long duration spark which guarantees that sooner or later the fuel will ignite. However, a spark lasting 2000µS at 2000 rev/min. spans 24 degrees and 'later' could mean the actual fuel ignition point is retarded by this amount.

The solution is a very high power, medium duration, spark generated by the TOTAL ENERGY DISCHARGE system. This gives ignition of the weakest mixtures with the minimum of timing delay and variation for a smooth efficient engine.

★ **SUPER POWER DISCHARGE CIRCUIT** A brand new technique prevents energy being reflected back to the storage capacitor, giving 3½ times the spark energy and 3 times the spark duration of ordinary C.D. systems, generating a spark powerful enough to cause rapid ignition of even the weakest fuel mixtures without the ignition delay associated with lower power 'long burn' inductive systems.

★ **HIGH EFFICIENCY INVERTER** A high power, regulated inverter provides a 370 volt energy source - powerful enough to store twice the energy of other designs and regulated to provide sufficient output even with a battery down to 4 volts.

★ **PRECISION SPARK TIMING CIRCUIT** This circuit removes all unwanted signals caused by contact volt drop, contact shuffle, contact bounce, and external transients which, in many designs, can cause timing errors or damaging un-timed sparks. Only at the correct and precise contact opening is a spark produced. Contact wear is almost eliminated by reducing the contact breaker current to a low level - just sufficient to keep the contacts clean.

TYPICAL SPECIFICATION	Total Energy Discharge	Ordinary Capacitive Discharge
SPARK POWER (Peak)	140W	90W
SPARK ENERGY	36mJ	10mJ
STORED ENERGY	135mJ	65mJ
SPARK DURATION	500µS	160µS
OUTPUT VOLTAGE (Load 50pF, equivalent to clean plugs)	38kV	26kV
OUTPUT VOLTAGE (Load 50pF + 500k, equivalent to dirty plugs)	26kV	17kV
VOLTAGE RISE TIME TO 20kV (Load 50pF)	25µS	30µS

TOTAL ENERGY DISCHARGE should not be confused with low power inductive systems or hybrid so called reactive systems.

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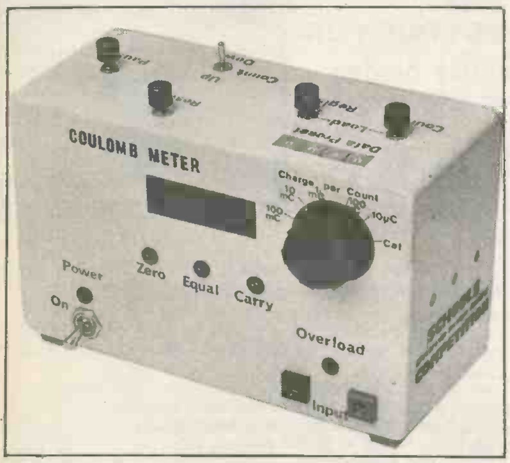
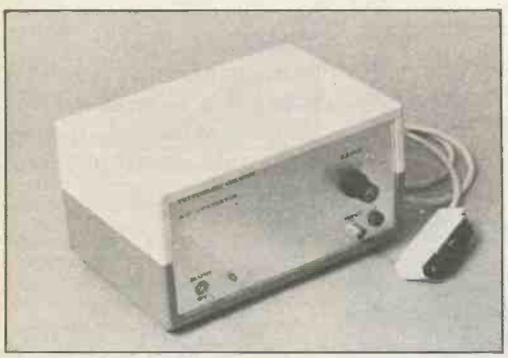
Everyday ELECTRONICS

PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .





SEASONAL GREETINGS TO ALL OUR READERS

Our February 1983 issue will be published on Friday, January 21. See page 35 for details.

Everyday ELECTRONICS

VOL. 12 NO. 1 JANUARY 1983

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EASY ON THE EARS

SHOULD advertisements for personal hi fi systems carry a government health warning? According to the Institute of Environmental Health Officers up to 1,000 people each year risk becoming partially deaf because of the high level of sound from headphones worn by owners of home hi fi or personal hi fi systems.

Similar warnings have been heard at times over the past thirty or so years, ever since the use of headphones became popular for listening to stereo at home. Concentrated acoustical power applied directly to the ears clearly can cause harm and possibly irreversible damage to the human auditory system—if prolonged listening at high volume levels is indulged in. The answer, as in many other things, is moderation: both in level of operation and in length of listening sessions.

This problem has now reached more serious proportions thanks to the phenomenal popularity of the personal cassette player or personal hi fi system, first introduced by Sony with their Walkman two years ago and subsequently imitated by many other hi fi equipment makers. Today, curiosity no longer is aroused by the sight of individuals wearing headphones out of doors or on public transport. The slung cassette looks set to become a favourite personal accoutrement. Those of young to middling age are the most ardent of "personal listeners" and there perhaps lies reason for concern by the health authorities; the consequences of many years of ear battering cannot be lightly dismissed.

We have a partial answer to this problem. When at home, a very sensible and obvious way to alleviate possible harm and at the same time share the pleasure obtained from personal hi fi, is to "de-personalise" it. We publish details this month of a personal loudspeaker amplifier that will enable the cassette player to drive a pair of good quality speakers. Apart from being easy on the ears there is a bonus in that the cassette player is automatically powered from the mains whenever the personal loudspeaker amplifier is used. The internal batteries are thus saved for walkabouts.

FACE TO FACE

It was a great pleasure to meet so many of our readers who visited the Electronics Hobbies Fair last month. The entire staff of EE shared duty on our stand and a useful two-way exchange took place throughout the four days. Your comments and suggestions were invaluable and we shall take them into account as we strive to enlarge and improve the service offered to electronic enthusiasts in our pages. The Fair itself was an undoubted success and we look forward to seeing you again next autumn.

Readers' Enquiries

We cannot undertake to answer readers' letters requesting modifications, designs or information on commercial equipment or subjects not published by us. All letters requiring a personal reply should be accompanied by a stamped self-addressed envelope.

We cannot undertake to engage in discussions on the telephone.

Component Supplies

Readers should note that we do not supply electronic components for building the projects featured in EVERYDAY ELECTRONICS, but these requirements can be met by our advertisers.

All reasonable precautions are taken to ensure that the advice and data given to readers are reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it. Prices quoted are those current as we go to press.

Back Issues

Certain back issues of EVERYDAY ELECTRONICS are available worldwise price £1·00 inclusive of postage and packing per copy. Enquiries with remittance should be sent to Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF. In the event of non-availability remittances will be returned.

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Binders to hold one volume (12 issues) are available from the above address for £4·60 inclusive of postage and packing worldwide.
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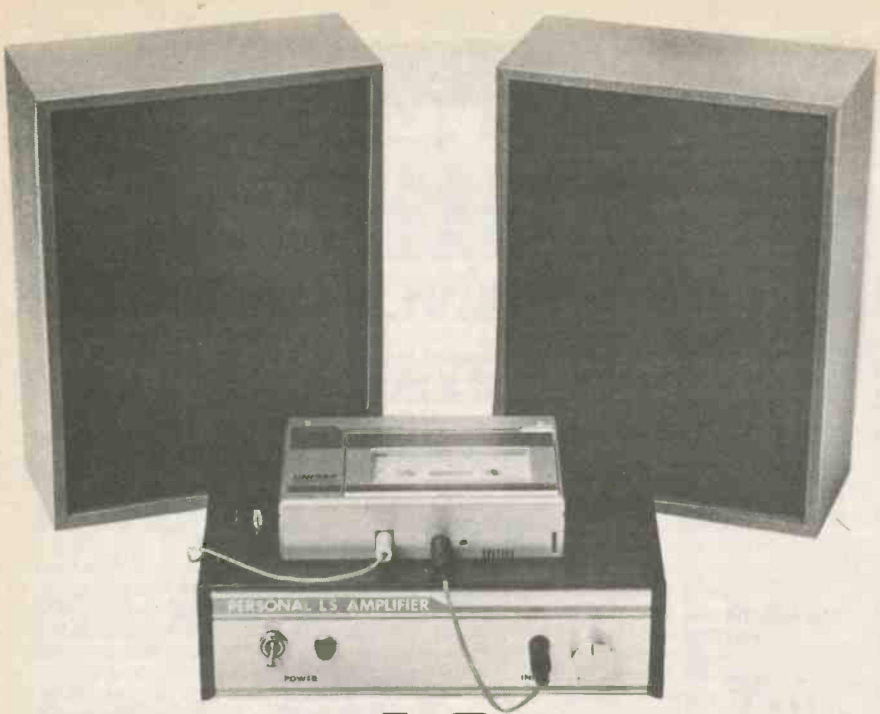


PERSONAL LS AMPLIFIER

BY L. COHEN

It's not unusual these days to come across people on trains, buses, in the street and other public places, wearing headphones. They are most probably listening to their Personal Hi Fi.

For those unfamiliar with this term, it describes a piece of equipment (usually a cassette player) small and lightweight capable in most instances of high quality sound reproduction into headphones. It is worn about the person of the user. Hence its name.

Such a system has limited use. It can only be enjoyed by one person at a time. At home with other family members, the user may be accused of being anti-social.

Also, there is concern about the damage (permanent) that could result to the users "ears" when they are regularly subjected to high volume headphone listening. With these factors in mind, the Personal LS Amplifier was developed. It is a stereo amplifier, mains powered, and produces up to 2 watts per channel into 8 ohm speakers when driven by the headphone outlet on the Personal Hi Fi.

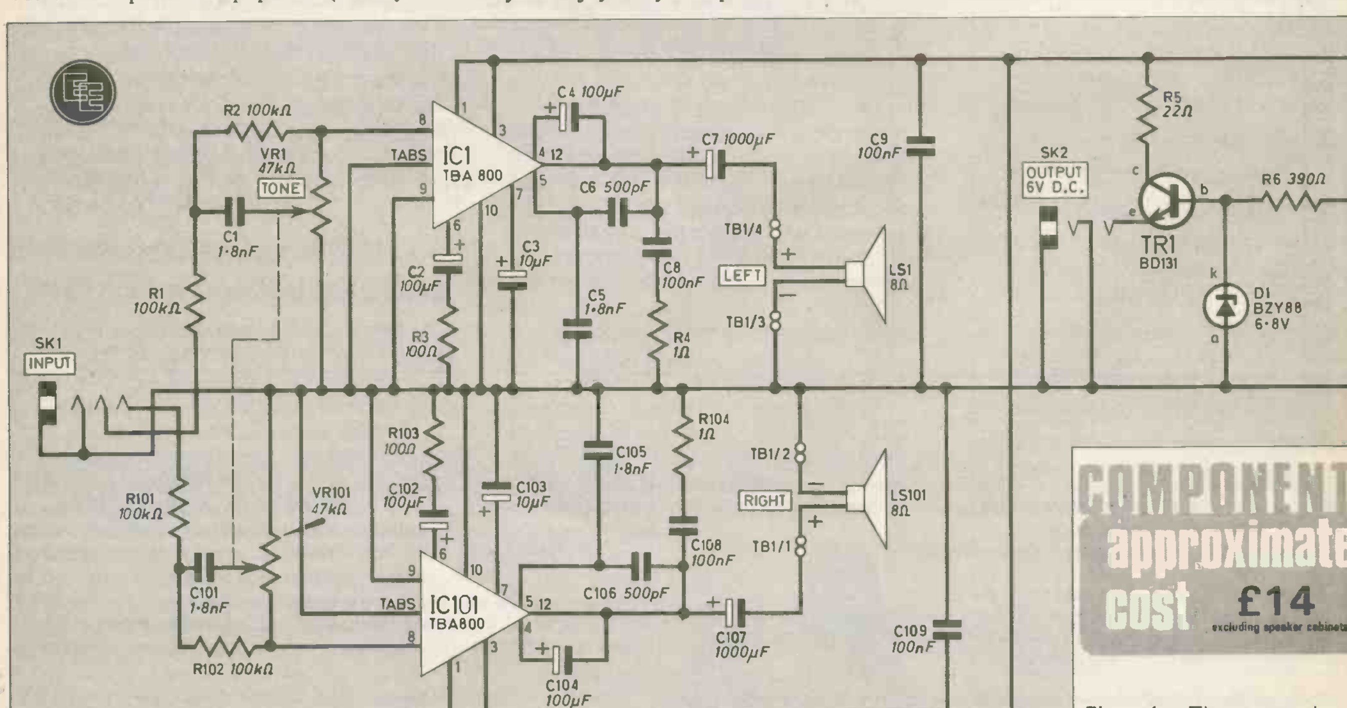
It is expected that this unit will be welcomed by teenagers with Personal Hi Fi systems and provide them with an inexpensive and good quality stereo hi fi system to be shared by friends and family.

The amplifier is based upon a stereo amplifier kit (complete with p.c.b.) available from RTVC. Circuitry is included to provide a mains derived d.c. supply, to plug into the external supply socket on the Personal Hi Fi. This preserves battery power for portable (headphone) operation.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Personal LS Amplifier is shown in Fig. 1. The component references in the right-hand channel are those in the left-hand channel preceeded by "100".

The stereo signal from the "Personal" enters the amplifier at SK1. In the prototype a 3·5mm jack socket was used here, the same as that fitted on the prototype Personal. Any three-pin socket may be used here: a 3-pin DIN socket for example is suitable and cables fitted with 3-pin DIN at one end and 3·5mm jack plug at the other may be obtained ready assembled.



COMPONENTS approximate cost £14 excluding speaker cabinets

Fig. 1. The complete circuit diagram for the Personal LS Amplifier.

Consider only the left-hand channel. The right-hand channel operates identically. R1, R2, VR1 and C1 form a filter designed to provide varying degrees of treble and bass cut according to the setting of VR1. This control provides the user with a means of setting the tonal quality of the output from harsh treble to solid bass. This signal reaches the input of IC1, pin 8.

AUDIO AMP I.C.

The gain of IC1 is set by the values of feedback components R3 and C2, the latter fixing the lower frequency roll-off point. Capacitors C5, C6 with R3 control the bandwidth of the amplifier.

Capacitor C4 is the bootstrap capacitor while C3 forms part of the supply ripple rejection circuitry.

The amplified signal appears at IC1 pin 12. Here the amplified output signal swings about half the positive supply rail and is coupled to the loudspeaker via C7. The series connected components R4 and C8 across the output of IC1 are included to help stabilise the load impedance at the output. C9 functions as a decoupling capacitor which helps prevent oscillations on the power supply lines.

POWER SUPPLIES

Mains voltage enters the unit and is switched to T1 primary by S1, the on-off switch. T1 is a step-down transformer which provides a 12V r.m.s. across the secondary. This alternating voltage undergoes full-wave rectification by the bridge arrangement of rectifiers D2 and D5 to produce a 16V d.c. smooth level across C10. This is the positive supply to both left and right amplifiers.

Resistor R6 and Zener diode D1 places 6·8V on the base of TR1 to turn it on (TR1 conducts). There is a 0·7 volt (approx) voltage drop across TR1 base/emitter junction, to give about 6V d.c. at SK2. Resistor R5 functions as an output power limiter. When the current passing through R5 and TR1 reaches a particular value, the voltage drop across R5 increases to cut-off TR1. 300mA may safely be drawn from this supply, which is on average, what Personals require.

COMPONENTS

See Shop Talk page 23

Resistors

★R1,101	100kΩ (2 off)	★R4,104	1Ω (2 off)
★R1,102	100kΩ (2 off)	R5	22Ω 3W
★R3,103	100Ω (2 off)	R6	390Ω

All $\frac{1}{4}$W carbon ±5% except where stated otherwise.

Capacitors

★C1,101	1·8nF ceramic axial leads (2 off)
★C2,102	47μF to 100μF 16V elect. axial leads (2 off)
★C3,103	5μF to 10μF 16V elect. radial leads (2 off)
★C4,104	47μF to 100μF 16V elect. axial leads (2 off)
★C5,105	1·8nF ceramic axial leads (2 off)
★C6,106	300pF to 500pF polystyrene (2 off)
★C7,107	300μF to 1000μF 16V elect. (2 off)
★C8,108	100nF plastic or ceramic (2 off)
★C9,109	100nF plastic or ceramic (2 off)
★★C10	1500μF to 2200μF 16V elect. radial leads

Semiconductors

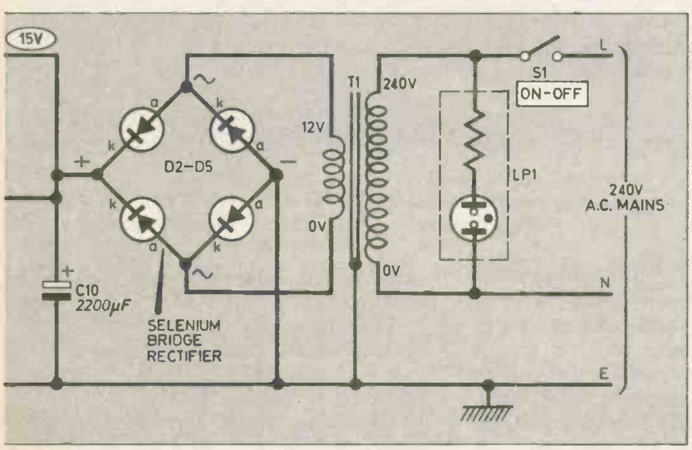
★IC1,101	TBA800 audio power amplifier i.c. (2 off)
TR1	BD131 silicon *npn*
D1	BZY88C6V8 6·8V 400mW Zener diode
★★D2–D5	Selenium 0·5A @ 30V rectifier or silicon bridge

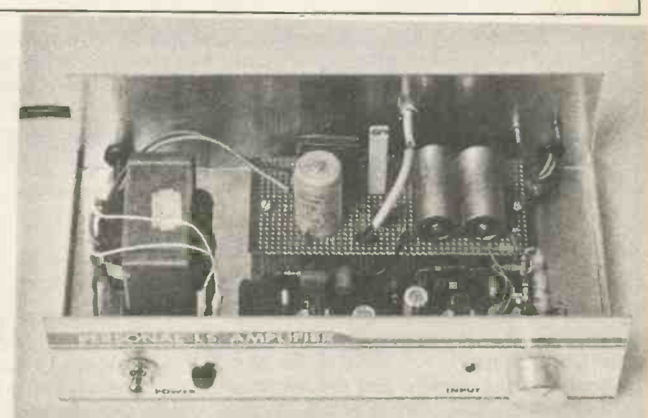
Miscellaneous

SK1	3·5mm panel mounting stereo jack socket or other panel mounting stereo socket to suit
SK2	2·5mm panel mounting jack socket
★★★LS1,101	8Ω elliptical (5in. x 3in.) loudspeaker
TB1	4-way 2 amp screw terminal strip
★★T1	mains primary/12V 1 amp secondary transformer
LP1	panel mounting mains neon
S1	mains on/off switch
★VR1,101	47 kΩ + 47 kΩ linear ganged carbon potentiometer

★ Printed circuit board, size 130 x 50mm; 0·1 inch perforated board, size 130 x 50mm; plastic stand-offs (Verobox type 22-1417G) (6 off); 4BA nuts, bolts, washers (2 off each); rubber grommet; knob to suit VR1 shaft; rubber feet for case; case style WB3 size 230 x 125 x 60mm; 6BA nut, bolt, washer (2 off); stranded p.v.c. covered wire; speaker cable (twin "figure 8") length to suit; mains cable, approx. 1 metre; 4BA solder tag; about 150mm length of twin stereo cable terminated at each end with stereo 3·5mm jack plugs; about 150mm length of insulated wiring fitted with 2·5mm jack plug at one end, cassette power plug at other.

★ KIT A, ★★ KIT B, ★★★ KIT C. See *Shop Talk* for further details.





The prototype with lid removed.

TWO CIRCUIT BOARDS

Two boards were used in the prototype, one a p.c.b. (part of the amplifier kit) the other a piece of plain matrix board. The latter holds the power supply components including the 6V d.c. supply, and the output capacitors.

The layout of the components on the topside of the p.c.b. is shown in Fig. 2, together with the pattern to be etched on the underside. Assemble the components on the topside paying special attention to the polarity of the electrolytic capacitors. Attach sufficient lengths of flying leads to reach the other case mounted components and board A. Some of the flying leads are attached directly to the tracks on the underside as there were no holes provided for these connections in the supplied p.c.b.

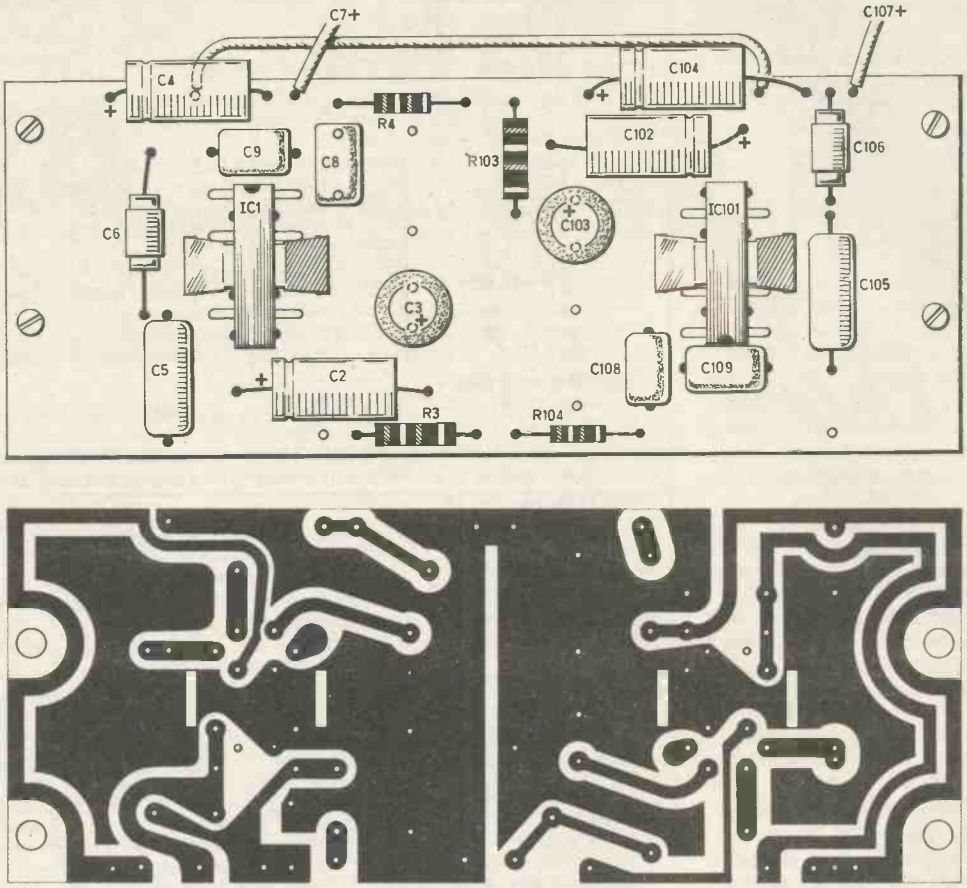


Fig. 2 (above). Shows the layout of the components on the topside of the p.c.b. (board B) and the master p.c.b. pattern to be etched on the underside (full-size).

Fig. 3 (opposite). The layout of the components on the topside of board A, and the interconnections to be made on the underside using the component leads and tinned copper wire. Note the use of Veropins. Cut-out will need to be made to accommodate the selenium rectifier (if used).

SECOND BOARD

Board A components are constructed on a piece of 0·1 inch plain matrix board size 120 × 50mm. The layout of the components on the topside and the interconnections using the component leads and tinned copper wire on the underside are shown in Fig. 3. Veropins are used for all flying lead connections to make construction and wiring up easier. The selenium bridge rectifier will necessitate the enlargement of some holes in the matrix board to allow it to be fitted to the board.

A silicon diode bridge rectifier or discrete diodes (four IN4001s for example) may be used here instead but will require a change in wiring on the underside of the board beneath the rectifiers. Make sure you follow the "+", "−" and "∿" or "a" and "k" (banded end) labels on the device and in Fig. 3.

CASE

In the prototype board A was fitted to the case, using 4BA threaded spacers and screws, one at each end.

The next step is to prepare the case to accept the board mounts and other hardware to be fitted. The case used in the prototype was in two sections: top of vinyl-covered steel, bottom aluminium. It is known as a WB3 and measures approximately 230 × 130 × 65mm.

Drill all the cable feed holes, component and board fixing holes before attempting to fit boards/components.

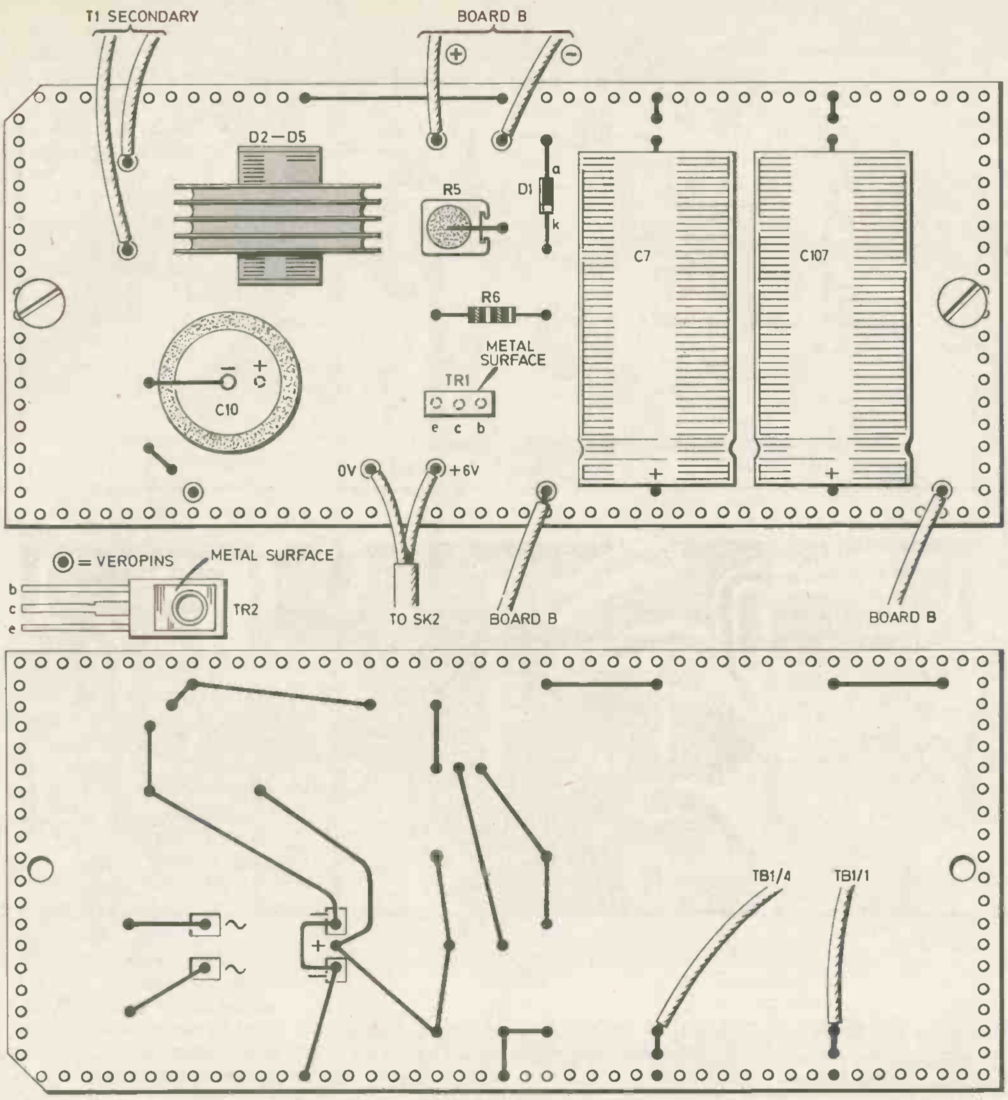
Begin assembly by screwing the transformer T1 in place. Use shake-proof washers on the fixings and fit a solder tag beneath the front fixing. Next position and secure LP1 and S1.

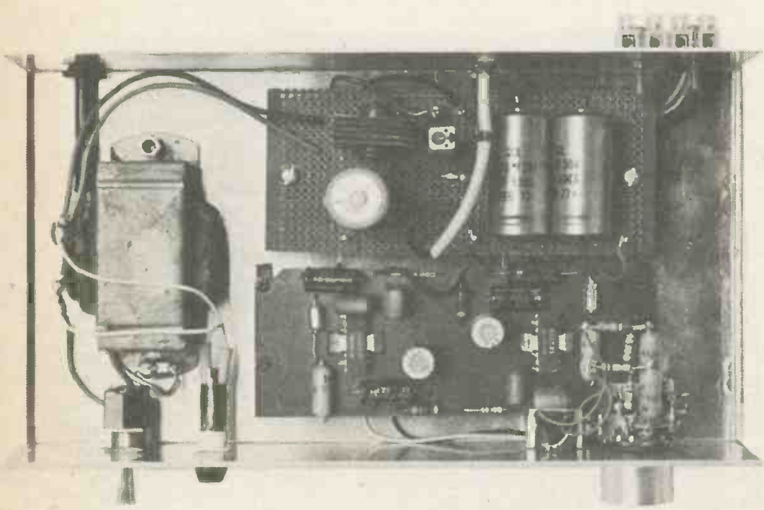
Two 25mm long 6BA screws and bolts were used to hold the screw terminal block in position on the case back panel which should be fitted next.

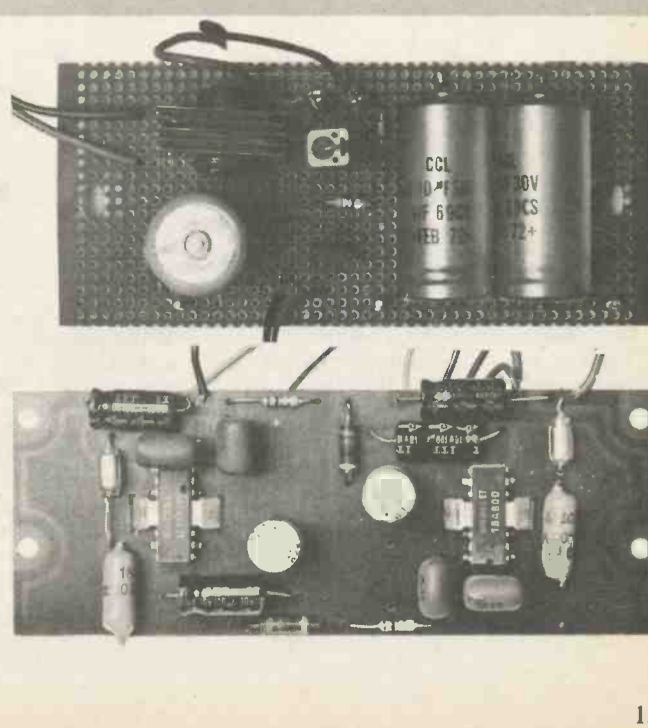
The tone control circuitry is assembled directly on the potentiometer as seen in Fig. 4. Secure VR1 in place on the front panel and wire up as shown.

The wiring that runs to SK1, the input socket, should be made using lightweight stranded covered wire. Only attach at VR1 end at present.

A panel mounting 3·5mm stereo jack socket was found difficult to locate by the author so a p.c.b. type was used. This was glued using Araldite to a small aluminium bracket also glued to the front panel below the front panel entry hole. This arrangement was found to be satisfactory. Alternatively, a different type of panel mounting socket may be used, such as a 3-pin DIN. Fit the chosen socket in place.







Close-up plan view of the completed prototype.

(Right). Close-up views of the two circuit boards fully assembled.

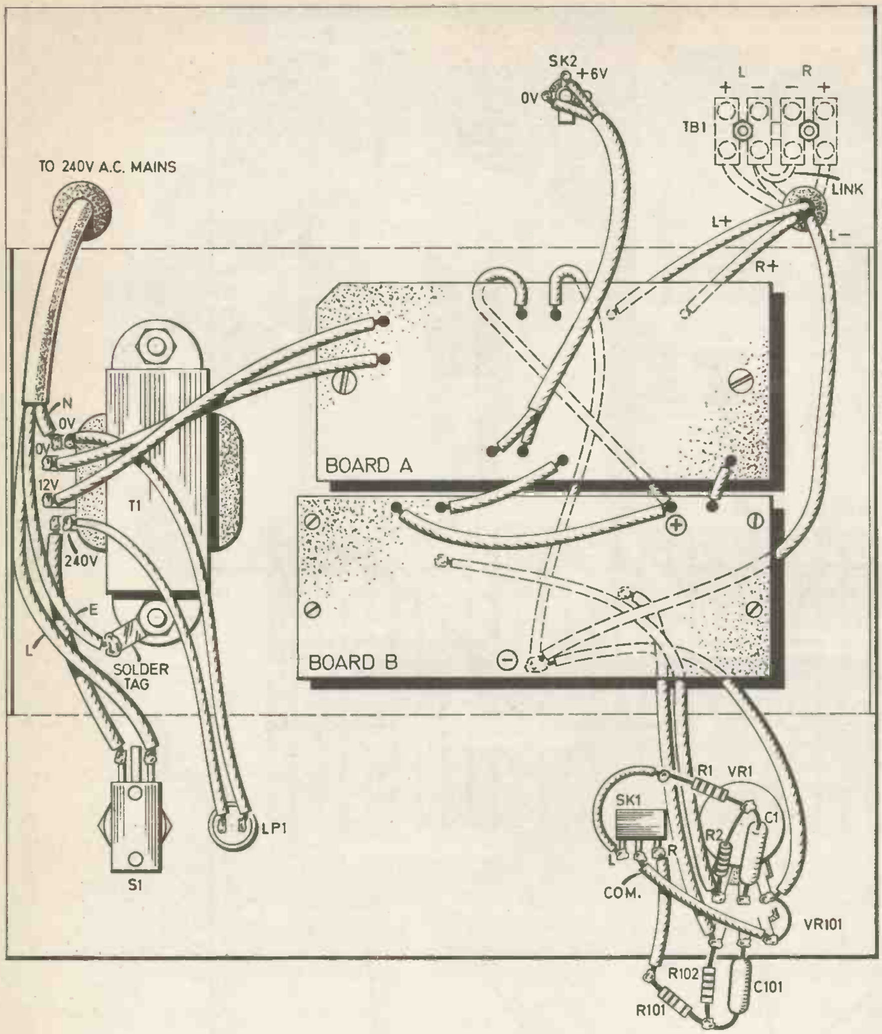


Fig. 4. Layout of the boards and other components in the prototype with complete interwiring details. Front and rear panels have been drawn folded down for clarity. The L-shaped bracket beneath SK1 is not shown.

FINAL STAGES OF ASSEMBLY

Finally fit a socket to the rear case panel for the 6V d.c. supply outlet. Any 2-pole socket may be used here. In the prototype a 2·5mm jack socket was used.

The two boards may now be fitted. Plastic fixings are advised for the p.c.b. and the specified Vero plastic snap fixing stand-off pillars are recommended. The p.c.b. supplied in the kit is quite thin and fragile around its four fixing holes, so be careful when pushing the board onto the pillars. The corners are liable to fracture as can be seen in the photograph. Fit the pillars to the case first.

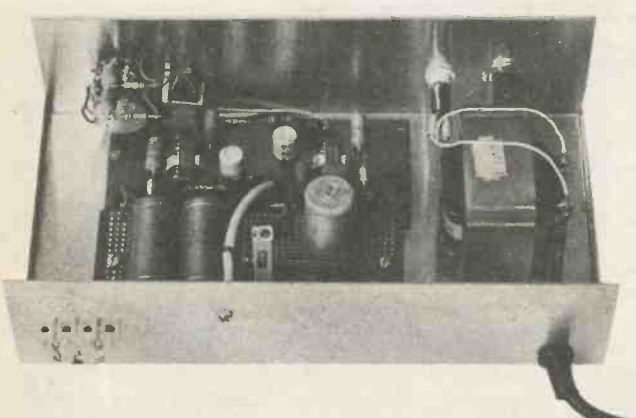
The other board is secured using 4BA threaded spacers/screws/washers. With all items fitted, wire up as shown in Fig. 4. Fit rubber grommets in the cable feed holes to prevent chaffing of the cable and the possibility of a short circuit and unwanted contact at these places.

Before wiring up SK2, check the Personal manual and/or unit and determine power supply polarity. Our unit is wired for tip +ve. A 1-amp fuse should be fitted in the mains plug.

LEADS AND PLUGS

A length of stereo screened cable fitted with a plug at each end is required to connect the headphone outlet socket on the Personal to the input socket on the Amplifier. The length of cable is not critical but should not be unduly long. It is expected that the two units will be within a metre of each other.

A lead will also be needed to connect the 6V d.c. outlet socket to the external power supply socket on the Personal. Miniature screened cable may be found most convenient for this. In fact the stereo cable used for the other lead was used in the prototype with the two signal wires connected to form one wire with the screen as the other.



(Above). Rear view of the opened prototype. The support bracket for SK1, glued to the front panel, can be seen.

(Right). Close-up view of the screw terminal block and its label used for connecting to the two speakers.

SPEAKERS AND CABINETS

The loudspeakers used in the prototype were 8 ohm elliptical types (5 × 3 inches) and were found to give good performance.

The speaker cabinets seen in the photographs were bought ready-built and the speakers fitted on a secondary baffle board which was screwed to the one already in the cabinet. This was found necessary since the cabinets were intended to accommodate a larger speaker.

The enclosure size is not critical and the constructor may already have or know of an inexpensive and suitable cabinet. The cases seen here were of smart veneered appearance but cost nearly £8 each, trade! Details for constructing your own cabinets of similar dimensions to those shown in the photographs are given in Fig. 5. These can be constructed for very much less.

With the speakers fitted in their cabinets, connect suitable lengths of twin "speaker" or bell-cable to each. Use cable clamps to hold the wire to the cabinet to prevent any strain on the soldered connections to the speaker. Identify the wire going to say, the left-hand solder tag on each speaker and call this "+".

This will ensure that the speakers will be in phase when connected as shown in the photograph of the screw terminal block on the amplifier rear panel.

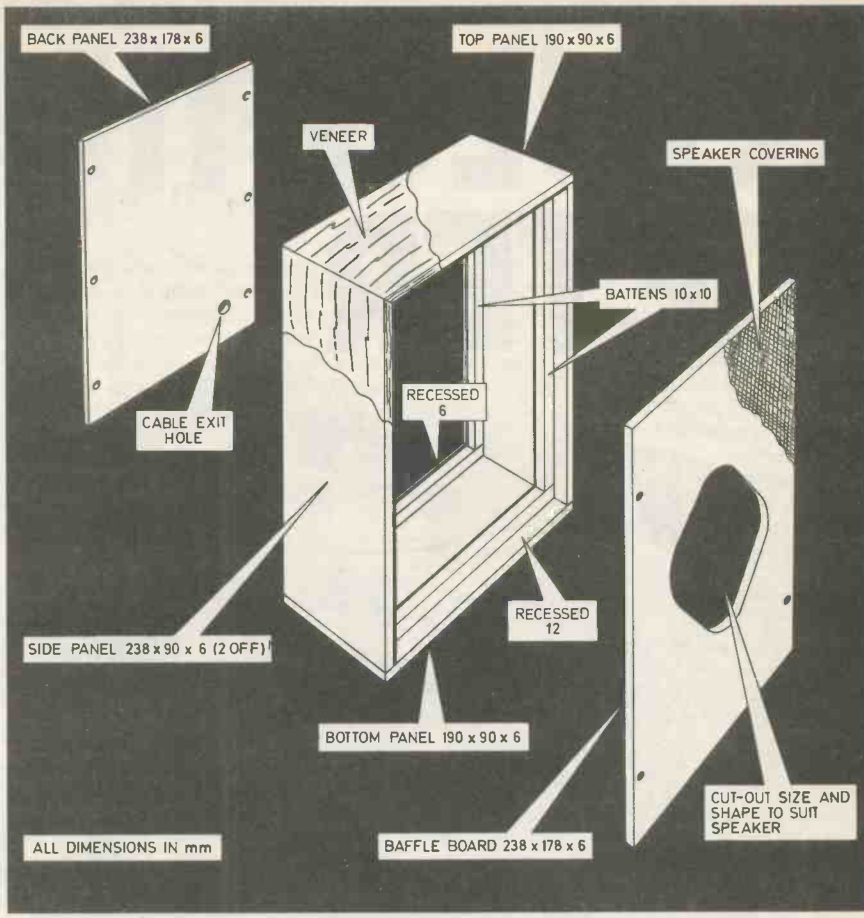


Fig. 5. An exploded view (dimensioned) of a suitable sized cabinet similar in size and shape to those seen in the photographs. This will accommodate the speakers (kit C) specified.

TESTING

Before testing, thoroughly check that all wiring has been carried out correctly. Connect a voltmeter set to 15V d.c. or higher, across the left-hand channel output terminals, TB1/4 and 3. Plug the amplifier into the mains and switch on.

The reading on the voltmeter should be at or very close to 0V. Check for the right-hand channel, TB1/1 and 2 to obtain the same or similar reading. If so, turn off at the mains and connect the two loudspeakers to the amplifier outputs. Turn on the unit. A low level hiss should be heard in the speakers with the tone control fully clockwise.

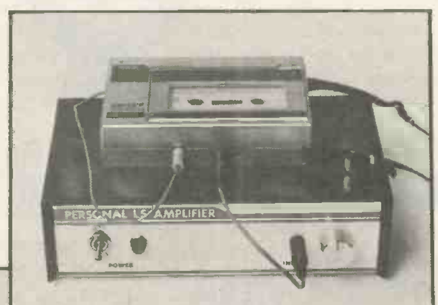
Connect the Personal to the amplifier using your made-up lead. Turn on the Personal and turn up its volume control to hear sound from the loudspeakers. Adjust the tone control, anti-clockwise for more "bassey" sound, clockwise to increase treble.

Turn off and insert the made-up lead into SK2. Turn on again. Check that the output from SK2 is 6V d.c. or very close to this and of the correct polarity to suit your Personal unit. If so push the power supply connector into the Personal. No change should be noticed unless you were previously using "low" batteries in which case an improvement should be heard. The batteries may be removed to check that the mains derived supply is in operation.

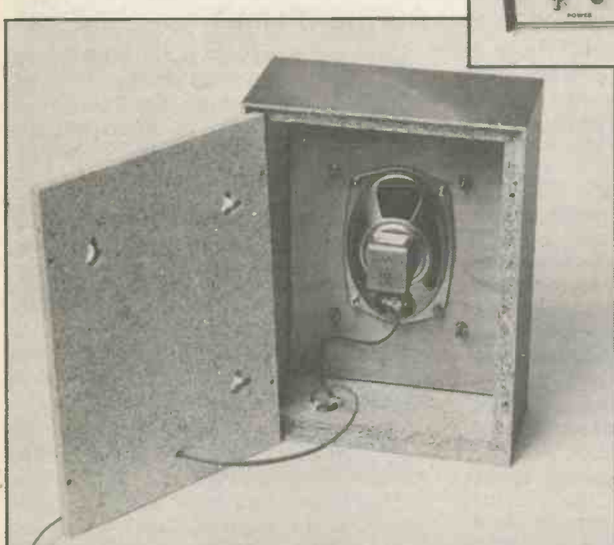
The prototype unit was fitted with a thin cardboard label and covered in Coverseal, a self-adhesive transparent plastic sheet. This provides protection to the design and annotations on the panel.

The graphic design on the prototype was made to look similar to the Personal Hi Fi design with which it was to be used. Double-sided Sellotape held it firmly to the front panel.

It may be advisable to fit the covered front panel design prior to fixing the front panel components and wiring up. □



The "Personal" plugged into the Amplifier and powered by the 6V d.c. outlet socket.



Shows an elliptical speaker fitted into one of the mentioned ready-built speaker cabinets. Note that the speaker is attached to a secondary baffle board which is bolted to the primary baffle board using the speaker (larger) fixings. Note the position of the two cable clips.

COULOMB METER

BY S. MELHUISH, G. RAFFERTY & M. SHILLABEER

IN SCHOOL science experiments, the flow of charge (the number of coulombs) often has to be measured. If the current is constant, it can be measured with an analogue ammeter and if the rate of change is slow enough, the current can be plotted against time, again using the ammeter and a stopwatch.

CONTINUOUS MONITORING

However, in some chemical experiments involving electrolysis, the current can change a great deal during the process, making continuous monitoring impractical. Physics experiments concerned with the charging of capacitors have exponentially varying currents, often too rapidly for an analogue meter to follow.

A meter which indicates the total charge that has flowed during an experiment would solve these problems.

DESIGN CRITERIA

A Coulomb Meter should be capable of meeting all the following design criteria if it is to be made full use of in a teaching situation.

1. Read up to 1000 coulombs (C). This allows for use at up to 1 amp for 15 minutes (900C).
2. Have switched sensitivity from one coulomb per second to 10^{-4} coulombs per second. The latter being suitable for the flow of charge expected in an experiment using a 100µF capacitor at 10V.
3. Have a display easily seen by a school science class in a demonstration.
4. Have a display which can be "frozen" temporarily to allow readings to be taken.
5. Easy connection to experimental circuits and simple controls.

THEORY OF OPERATION

A block diagram of the system is shown in Fig. 1.

The experimental current (i_0) produces a potential difference (u_0) across the input of a voltage controlled oscillator. This acts as a voltage to frequency converter tuned to give an output frequency (f_0) of 81·92kHz when $u_0 = 3$V.

Thus $f_0 \propto u_0 \propto i_0$ ($\propto$ meaning *proportional to*) and therefore output frequency is proportional to input current. The frequency f_0 is then divided by 2^{13} to give a suitable count rate for direct display, f_1(f_1 = 10Hz when $u_0 = 3$V).

The count is equal to the number of cycles at frequency f_1 and is also proportional to the total charge which has flowed during the experiment.

RANGE SELECT

The circuit diagram of the Coulomb Meter is given in Fig. 2. The range select and amplification section of the circuit was designed to provide the voltage-to-frequency converter with an input voltage u_0 of between 0 and 3V.

The input current produces a potential difference across resistor R1, R2 or R3 depending upon the position of S1 and this p.d. is then either coupled directly to the voltage-to-frequency converter or amplified by a factor of 100 by the op-amp, IC1. In this way, using the switching combination of S1a and S1b, a total of five ranges are available.

The five ranges are as follows:

1—100mC per count
2—10mC per count
3—1mC per count
4—100µC per count
5—10µC per count

A sixth, unused position on S1 is provided as a checking facility.

In order to ascertain the total number of coulombs used in an experiment, the display reading is simply multiplied by the number of coulombs per count.

CURRENT LIMIT

The input voltage u_0 is sampled by TR3 via the potential divider R9/R10. When the potential on the base (b) of TR3 exceeds 0·6V, it conducts and switches off TR1, thus cutting out the input to the Coulomb Meter.

This protects the input against excessive currents. When the current limit operates, the OVERLOAD l.e.d., D2 lights.

Diode D1 is included in the input circuit to protect the TR1 against high reverse voltages.

VOLTAGE-TO-FREQUENCY CONVERTER

The voltage-to-frequency converter circuit (also known as a voltage controlled oscillator) uses a 9400CT i.c. (IC2) which has an output frequency linearly proportional to the input voltage, within the range 10Hz to 100kHz.

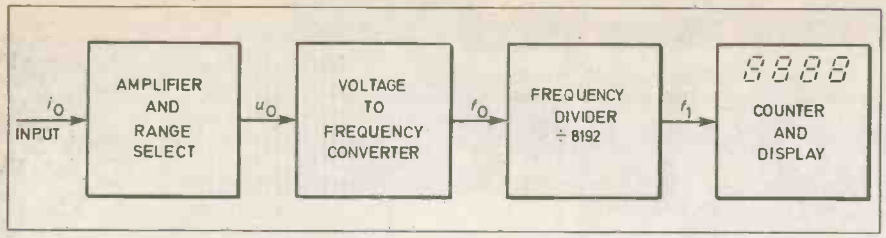


Fig. 1. Block diagram of the Coulomb Meter showing the basic theory of operation. The voltage-to-frequency converter produces an output frequency of 81·92kHz for an input current of 1A.

This i.c., with the aid of a few peripheral components, can perform the necessary functions within the specification of the Coulomb Meter. The values of these components can be calculated as follows:

Input resistance, R_{IN}(R8).

$$R8 = \frac{V_{IN(MAX)} \times 10^6}{10}\,\Omega$$

$$= \frac{3 \times 10^6}{10}\,\Omega$$

$$= 300{,}000\Omega$$

$$= 300k\Omega$$

Reference capacitor, C_{REF}(C1)

Given that

$V_{REF} = -5V$

$R_{IN} = 300k\Omega(R8)$

$V_{IN} = 3V$

$$f_{OUT} = 81{\cdot}92kHz(10 \times 2^{13}Hz)$$

$$= \frac{V_{IN}}{R_{IN}} \times \frac{1}{V_{REF} \times C_{REF}}\,Hz$$

$$= \frac{3}{300 \times 10^3} \times \frac{1}{-5 \times C_{REF}}\,Hz$$

Therefore,

$$81{\cdot}92 \times 10^3 = \frac{3}{300 \times 10^3 \times (-5) \times C_{REF}}$$

(Ignoring minus sign as a capacitance cannot be negative.)

$$C_{REF} = \frac{3}{81{\cdot}92 \times 10^3 \times 300 \times 10^3 \times 5}\,F$$

$$= 24{\cdot}414 \times 10^{-12}F$$

So C1 = 24pF (nearest value 22pF).

For optimum stability,

$$C_{INT}(C2) = 4 \times C_{REF}$$

So C2 = 96pF (nearest value 100pF).

DIVIDER

The voltage controlled oscillator is designed to give an output frequency of 81·92kHz with 1 amp passing through the shunt. So this needs to be divided by 2^{13} (which is equal to 8192) to produce a 10Hz input to the counter section.

This means that in one second, if one coulomb is passed, 81920 cycles are generated by the v.c.o. and this is divided by 8192 to give 10 counts to the counter. Thus the counter has a resolution of one-tenth of a coulomb.

The circuit uses a CMOS 4020 14-stage binary counter/divider to achieve the frequency division, the output being taken

COMPONENTS

Resistors

R1	3Ω (Nichrome wire)
R2	30Ω (33Ω + 330Ω in parallel, 4W)
R3	300Ω (330Ω + 3·3kΩ in parallel, 1W)
R4	990Ω (240Ω + 750Ω) ±1%
R5	1kΩ ± 1%
R6	99kΩ (24kΩ + 75kΩ) ±1%
R7	47Ω
R8	300kΩ
R9	3·3kΩ
R10	1kΩ
R11	100kΩ
R12,13,17,18	4·7kΩ (4 off)
R14,15	10kΩ (2 off)
R16	510kΩ +2%
R19	220Ω

All $\frac{1}{4}$W carbon ±5% unless otherwise stated.

Capacitors

C1	22pF polystyrene ±2%
C2	100pF polystyrene ±2%
C3,4,5	0·1μF polyester (3 off)
C6,7	2200μF 25V elect. (2 off)
C8–10	0·01μF ceramic disc (3 off)

See Shop Talk page 23

COMPONENTS approximate cost £50

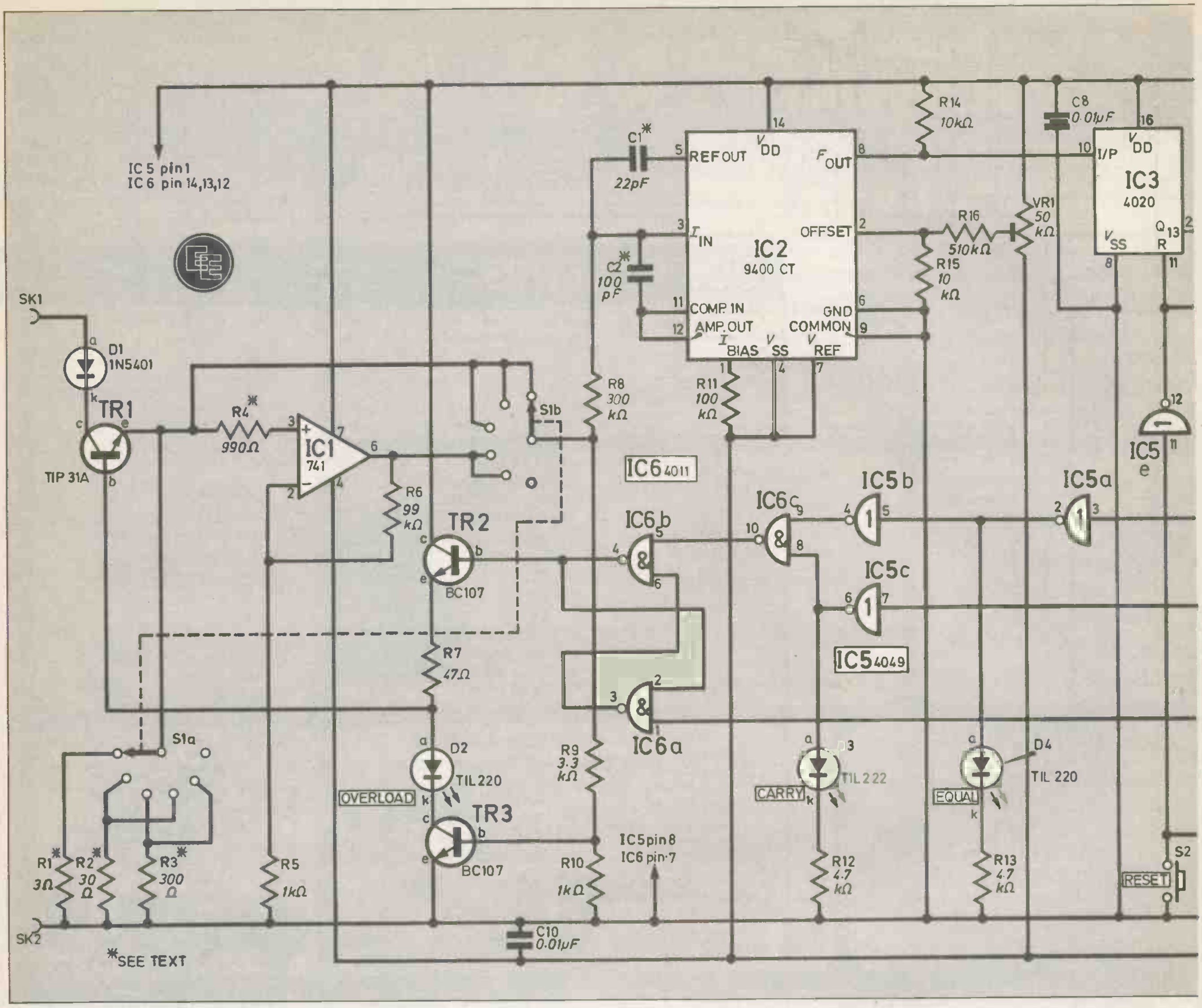
Semiconductors

D1	1N5401 silicon
D2,4,26	TIL220 0·2in. red l.e.d. (3 off)
D3	TIL222 0·2in. amber l.e.d.
D5	TIL221 0·2in. green l.e.d.
D6–21	1N4148 silicon (16 off)
D22–25	WO2 200V, 1A bridge rectifier
TR1	TIP31A silicon *npn*
TR2,3	BC107 silicon *npn* (2 off)
IC1	741 op-amp
IC2	9400CT voltage-to-frequency converter (RS part no. 307–070
IC3	4020B CMOS 14-bit binary counter
IC4	7217 CMOS 4-decade counter/driver (RS part no. 307–749)
IC5	4049B CMOS hex inverter
IC6	4011B CMOS quad 2-input NAND gate
IC7	7805 +5V, 1A regulator
IC8	7905 –5V, 1A regulator
X1	4-digit common anode multiplexed display (RS part no. 587–507)

Miscellaneous

T1	mains transformer, 0–12V, 0–12V, 1A secondaries
S1	2-pole, 6-way midget rotary
S2,3,5,6	push-button change-over, non-latching (4 off)
S4	d.p.d.t. centre off toggle
S7–10	sub-miniature binary coded decimal rotary switch, vertical mounting (4 off)
S11	on-off mains toggle switch
SK1	4mm banana socket, red
SK2	4mm banana socket, black
FS1	1A, 20mm long fuse

Single-sided p.c.b., 120 x 95mm; 0·1in. matrix stripboard, 24 holes by 5 strips (for b.c.d. rotary switches)' diecast box, 186 x 120 x 80mm; 28-pin d.i.l. holder; 16-pin d.i.l. holder (2 off); 14-pin d.i.l. holder (2 off); 8-pin d.i.l. holder; TO-220 transistor mounting kit (3 off); l.e.d. mounting bush (5 off); panel mounting 20mm fuse holder; knob; 7/0·2mm wire; mains lead; grommet; P-clip; rubber feet (4 off).



from the Q_{13} output (divide by 2^{13}). This is IC3 on the circuit diagram.

COUNTER AND DISPLAY

IC4 is a CMOS 7217 4-decade up/down counter/driver i.c., this device being particularly suitable as it fulfils all the design criteria.

The features include a four-digit multiplexed l.e.d. display, indication of zero or underflow/overflow, indication of counter being equal to a pre-settable register and counting up or down.

Since physics laboratories are often fairly dark, a light emitting diode display was chosen in preference to a liquid crystal display.

The display used in the prototype model (X1 in the circuit diagram) is a four-digit common anode multiplexed display with 0·5 inch high red seven segment digits.

This is an RS Components display and can be obtained from RS stockists but *not* directly from RS. Other displays of similar specification can be used, however, the pin number may differ from those given on the circuit diagram.

CONTROLS

The controls of the Coulomb Meter are as follows:

UP/DOWN (S4)—this is connected to pin 10 of IC4 and when toggled between +5V and 0V it dictates whether the count progresses up or down.

PAUSE (S3)—controls the update of the display register. When toggled to 0V the display is constantly updated with the contents of the counter. However, when switched to +5V, the display remains static enabling a reading to be made. The counter continues to count whilst display is held.

LOAD COUNTER (S5)—by taking pin 12 of IC4 to +5V, the data held on the binary coded decimal switches S7 to S10 (DATA PRESET) is transferred to the counter.

LOAD REGISTER (S6)—as above, but the data is transferred to an internal register and the EQUAL output (pin 3) of IC4 goes low when counter equals register.

DATA PRESET (S7 to S10)—these sub-miniature binary coded decimal thumbwheel switches are connected to the b.c.d. INPUT/OUTPUT pins of the counter and are used to preset data into the counter or the internal register.

This enables the Coulomb Meter to either count down from a preset number or up to a value stored in the register. Diodes D6 to D21 prevent cross-talk.

RESET (S2)—this resets both counter IC4, and divider IC3, back to zero.

INDICATORS

Four l.e.d. indicators are included to show various conditions. These are as follows:

OVERLOAD (D2)—illuminates when the input current is greater than the meter can measure.

CARRY (D3)—indicates when the counter overflows when counting up or underflows when counting down.

ZERO (D5)—pin 2 of IC4 goes low when the count equals zero and l.e.d. D5 illuminates to indicate this condition.

EQUAL (D4)—when the count equals the number stored in the internal register, pin 3 of IC4 goes low, and this is indicated by l.e.d. D4.

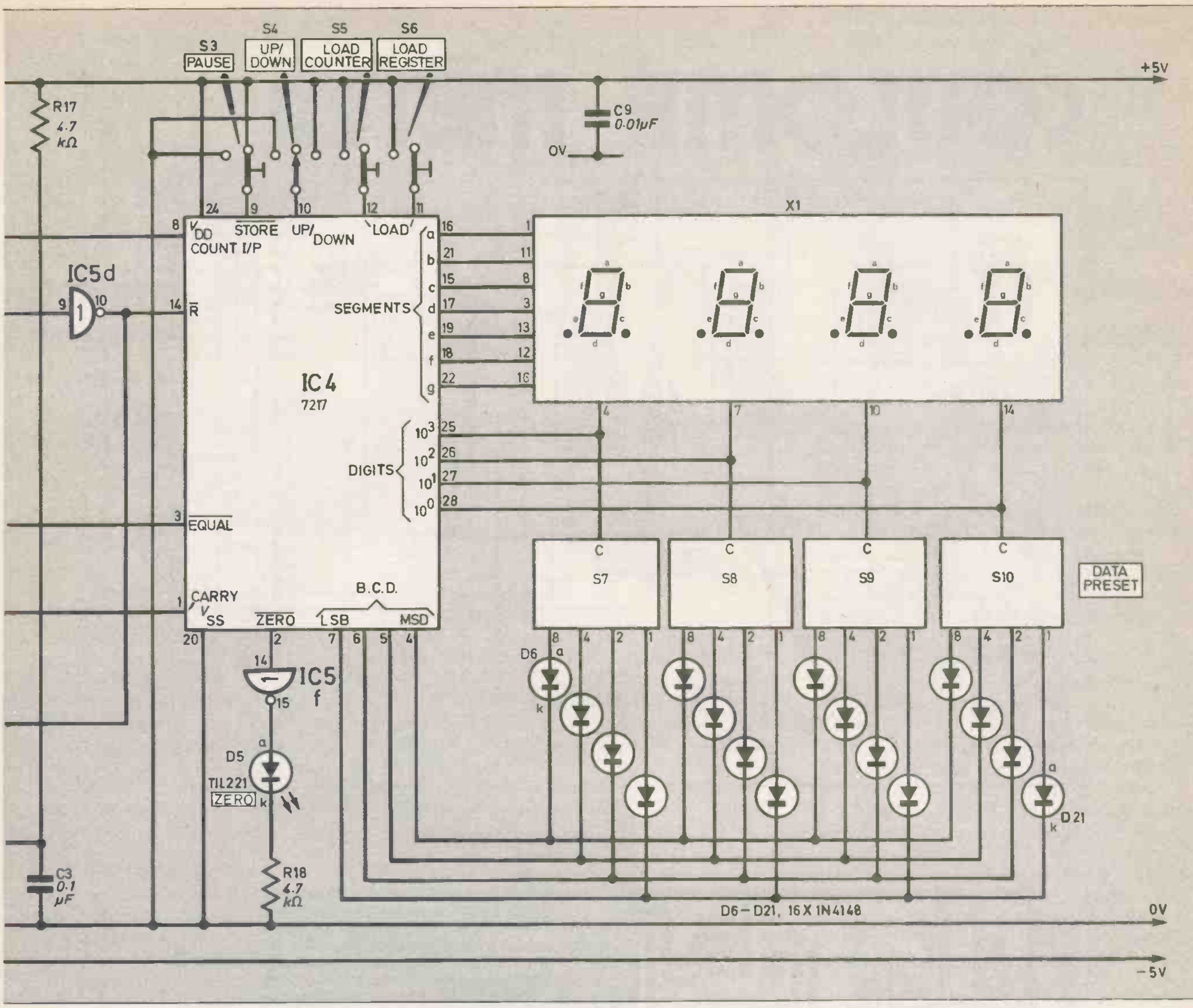


Fig. 2. Main circuit diagram of the Coulomb Meter.

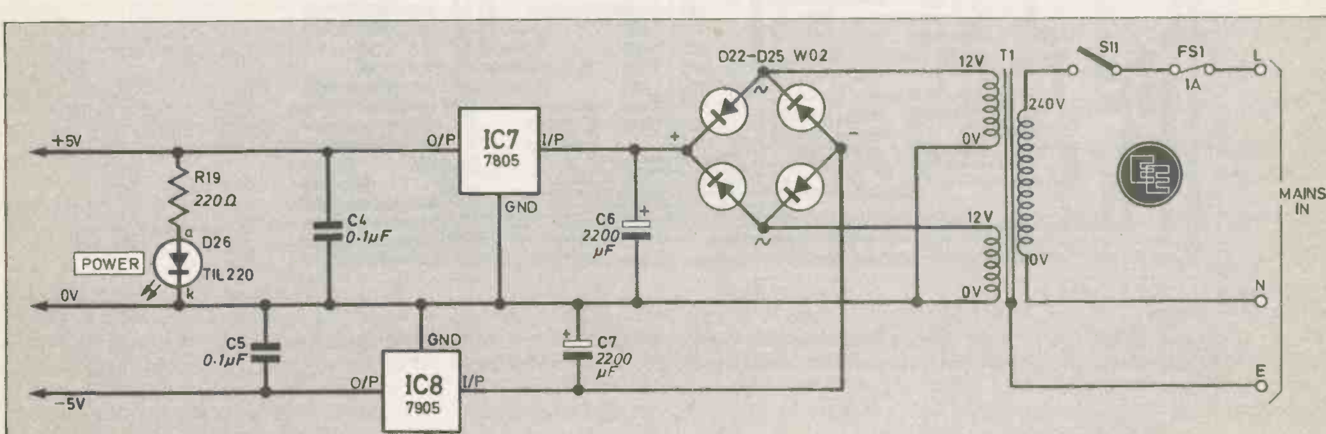
POWER SUPPLY

The Coulomb Meter has its own mains power supply unit and the circuit diagram is shown in Fig. 3.

A mains transformer with two 12V secondaries is used to develop a ±5V supply using two regulator i.c.s, a 7805, +5V device and the 7905, −5V version.

Decoupling capacitors C8, C9 and C10 are included in the design and placed near to the i.c.s to suppress unwanted spikes.

Fig. 3. Circuit diagram of the mains power supply section.



COULOMB METER

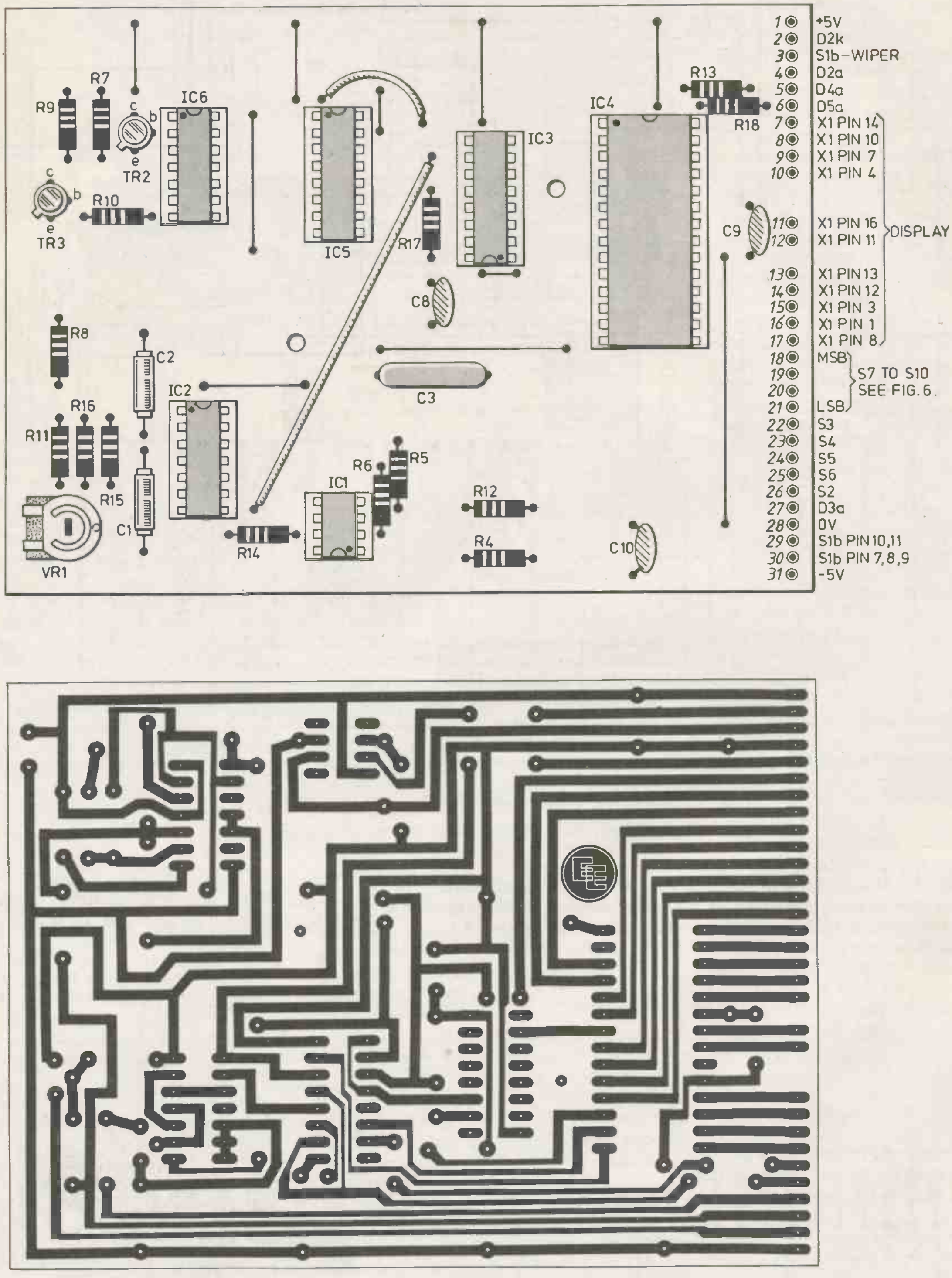


Fig. 4. Full size printed circuit board artwork and component layout for the Coulomb Meter. Note the use of sleeved wire for the long links and Veropins for all wired connections.

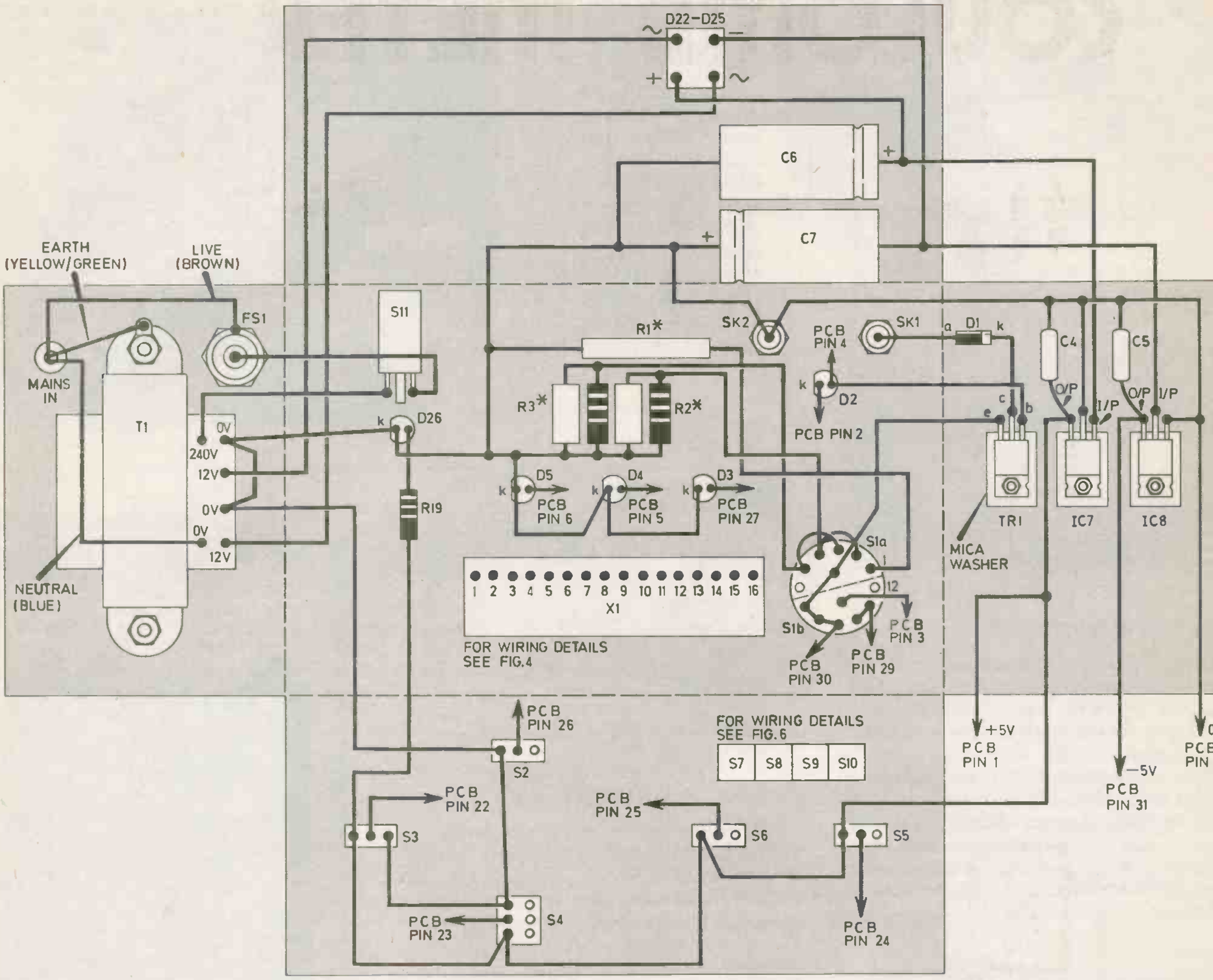


Fig. 5. Interwiring diagram. Note that discrete components are shown in relative positions only and should ideally be mounted on tag strips before being soldered. IC7, IC8 and TR1 must all be isolated from the case and mounted on mica washer insulating kits. See also Figs. 4 and 6 for wiring information of the display, X1 and the Data Preset switches, S7 to S10.

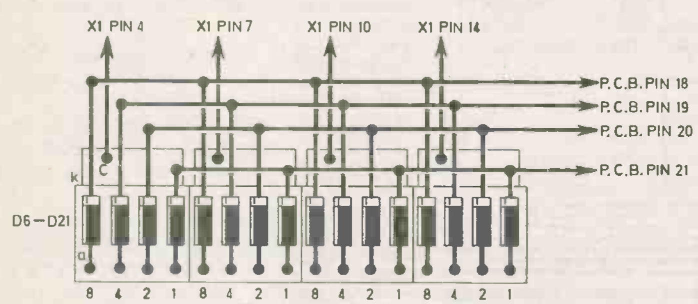
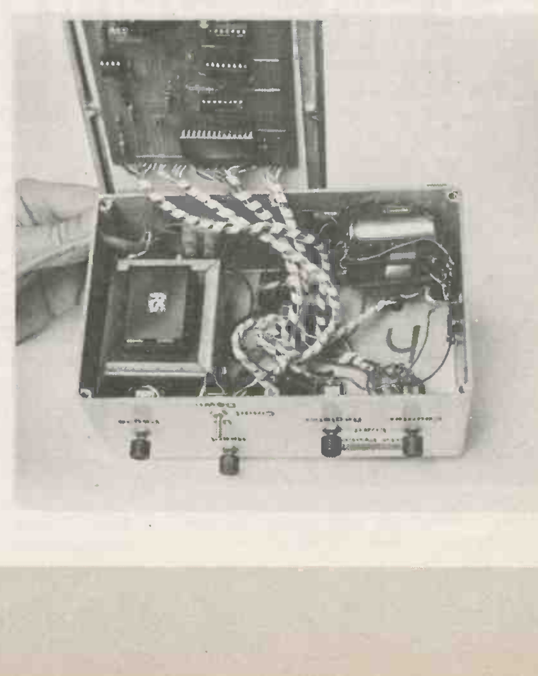
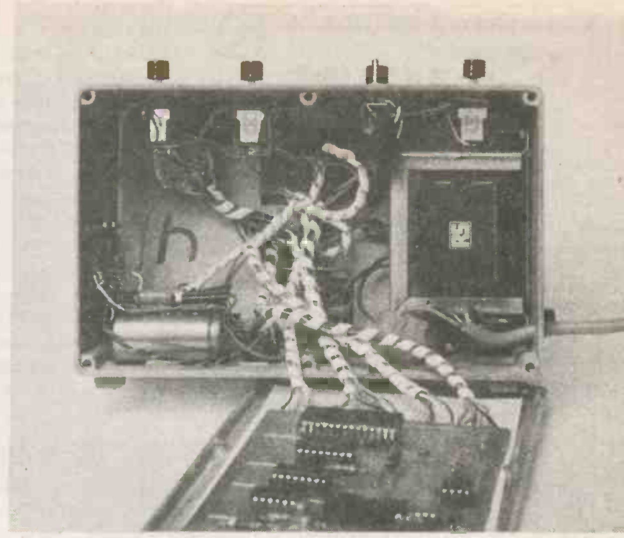


Fig. 6. Wiring of the Data Preset switches with cross-talk prevention diodes. The switches are actually mounted on a 0·1in. matrix stripboard, 24 holes by 5 strips (with suitable trackbreaks), but this has been omitted from this diagram for clarity.

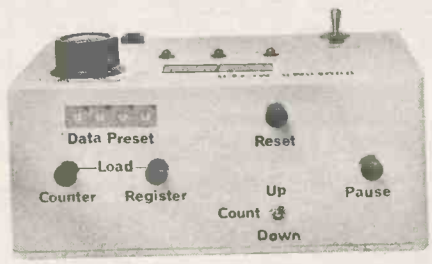
View inside case showing general layout of components and mounting of the p.c.b.



Finished Coulomb Meter showing the marking of the controls. Note how the unit has been designed for use in the classroom with the display visible from the front and controls accessible from the top. Photograph (right) shows the inside of the case and the use of spiral cable wrapping for neatness.



CONSTRUCTION starts here



Teachers' eye-view of the controls.

CIRCUIT BOARD

Most of the circuit was constructed on a printed circuit board, the design of which is given in Fig. 4. This diagram also shows the component layout on the topside of this p.c.b.

Note the position of pin 1 of each i.c., as the orientation varies with some of these devices. Holders should ideally be used for each i.c. and the i.c.s should not be inserted until the board is complete as they are CMOS and as such, are static sensitive.

CASE

The remainder of the components in the circuit are mounted in the diecast box which houses the unit. The p.c.b. assembly is mounted on short pillars on the lid and all other components are mounted as shown in Fig. 5. This diagram gives the relevant positions of all parts of the circuit and shows the wiring information for each.

Note that the four b.c.d. thumbwheel switches are soldered to a piece of stripboard 24 holes by 5 strips and the diodes D6 to D21 are mounted directly to the pins as shown in Fig. 6.

The two regulators, IC7 and IC8, and the power transistor, TR1, are all secured using a mica insulating wash and plastic bush mounting kit.

Finally R1 is made from a piece of nichrome resistance wire, measured to find the correct length for three ohms and then wound around a former and soldered in place.

Resistors R2 and R3 each require two wire-wound resistors to be connected in parallel. R4 and R6 are each made from two resistors connected in series, the details of which are given in the components list.

OPERATING INSTRUCTIONS

The sequence of events is as follows:

1. Plug in and switch on the mains switch. This switch is up for ON as is the accepted standard (allowing for the unit to be speedily "knocked" off in an emergency). The display should be blank and the ZERO indicator illuminated. If not, press the RESET button.
2. For a chemical electrolysis experiment, the circuit is made as shown in Fig. 7.
3. Using a small screwdriver, set up the desired maximum charge on the DATA PRESET switches. Press LOAD REGISTER.
4. Switch on the external power supply and select the best CHARGE PER COUNT position on the range switch. The OVERLOAD indicator should not illuminate when the experiment commences.

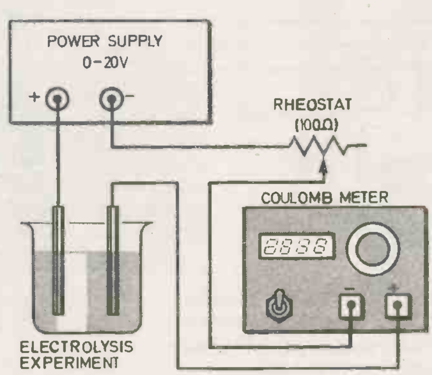
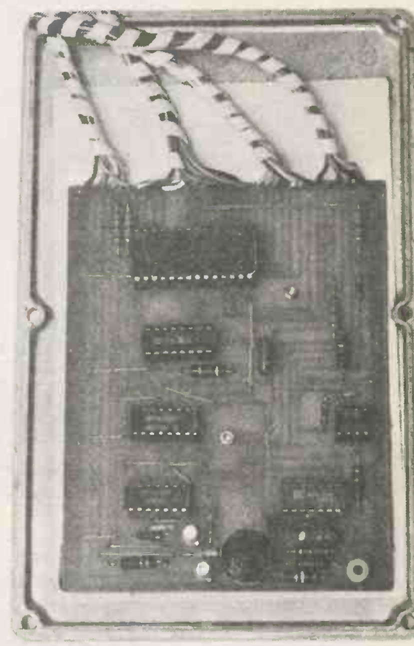


Fig. 7. Set up for chemical electrolysis experiment.



The prototype p.c.b. Note the insulating material beneath the board.

(For this type of experiment, the 100mC and 10mC ranges are suitable.) COUNT switch should be in UP position.

5. Press RESET once again and commence with the experiment. The meter will switch itself off when the preset charge has flowed.
6. For discharge experiments (for example, a capacitor), the COUNT switch should be in the DOWN position and the desired charge entered into the DATA PRESET switches with the small screwdriver. Press LOAD COUNTER.
7. Press RESET and begin experiment. ZERO indicator signifies the completion of the discharge.
8. The PAUSE switch may be used to record data at any time without stopping the counter. □

Catalogues Received

After the last edition of the Maplin catalogue, we have been eagerly awaiting news of the 1982/3 copy as we did not think it possible to make further improvements. Now that it has arrived, the first observation, just from the bulk of the issue, is that the number of pages has been increased considerably.

This "Rolls-Royce" of catalogues now contains 392 well illustrated pages. There are many new lines listed and two new sections.

A new Communications section contains details of CB accessories, intercoms, radios and telephone systems.

The other additional section is, of course, devoted to the world of the Computer. Here, amongst a 37-page section, are listed seven of the most popular home computers on the market and a host of software, including language courses.

Within the resistor section, the $\frac{1}{2}$W 2 per cent Metal Oxide and the $\frac{1}{2}$W 1 per cent Thick Film ranges have been replaced by a high stability, low noise Metal Film range.

These are rated at 1 per cent 0·4W and are cheaper than the ranges they replace (2p each). However, to produce close tolerances below 10 ohms and above 1 megohm is costly and values in these categories are more expensive.

Copies are available from W. H. Smith for the sum of £1.25 or direct from Maplin, price £1.50, including post and packing.

CONSTRUCTIONAL PROJECTS

Personal LS Amplifier

Apart from our regular constructors, the *Personal LS Amplifier* is also likely to appeal to the less experienced reader, so special arrangements have been made with RT-VC to supply selective kits.

The kits are broken down into packages and consist of the following:

- Stereo power amplifier printed circuit board, with all components, £3.50 plus 75p post and packing.
- Power supply £1.95 plus £1.50 post and packing.
- Pair of elliptical speakers—£1.50 plus £1 post and packing.
- Set of plugs and sockets—£1.50 plus post and packing.
- Case for the amplifier—£2.95 plus 80p post and packing.

For two or more kits the postage and packing is £1.75, inclusive.

Note that the parts not "starred" in the components list are readily available items and should not present any problems.

Coulomb Meter

The semiconductor devices called for in the *Coulomb Meter* project are fairly common devices and stocked by most good component suppliers.

However, those devices which could prove troublesome to locate are designated with the RS Components part number in brackets in the components list. Any *bona fide* RS stockists should be able to order these items for you.

If difficulties are experienced in obtaining the Nichrome wire resistor (R3), two 1·5 ohm vitreous wire-wound, i.e. "china", resistors could be used in its place. These resistors should be wired in series.

To obtain the type of accuracy specified for this instrument, all resistance tolerances should be as indicated.

A to D Converter for PET Computers

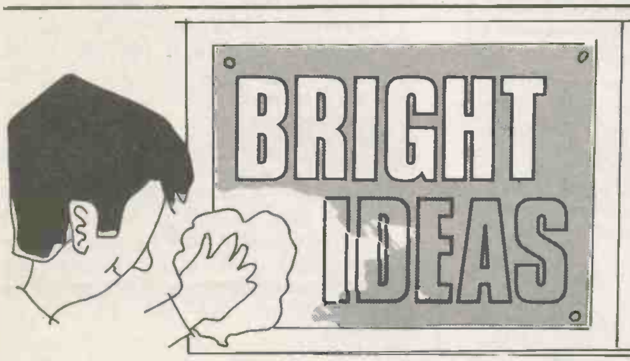
The A to D Converter i.c., Type ZN427E, used in the *A to D Converter for PET Computers* is available from Europa, Rapid, Bradley Marshall and Maplin Electronics.

The interconnecting plugs and sockets are now stocked by most advertisers and usually sold as Inter p.c.b. (printed circuit board) connectors.

Opto Repeater

The photo Darlington transistor, Type 2N5777, used in the *Opto Repeater* should be available from most components shops, but in case of difficulties it is usually stocked by Cricklewood, Maplin and Rapid.

The 10A mains relay is available from Maplin Electronic Supplies and is listed as a Ultra Miniature High Power Mains Relay. This can be ordered as YX97F (10A Mains Relay). Other relays can be used but due consideration to loads being controlled must be taken into account and contact ratings selected accordingly.



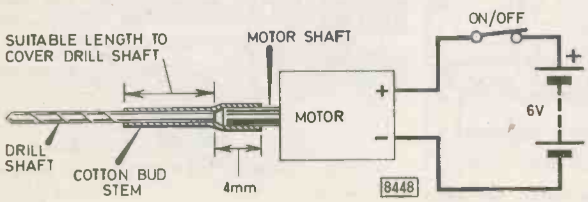
CIRCUIT BOARD DRILL

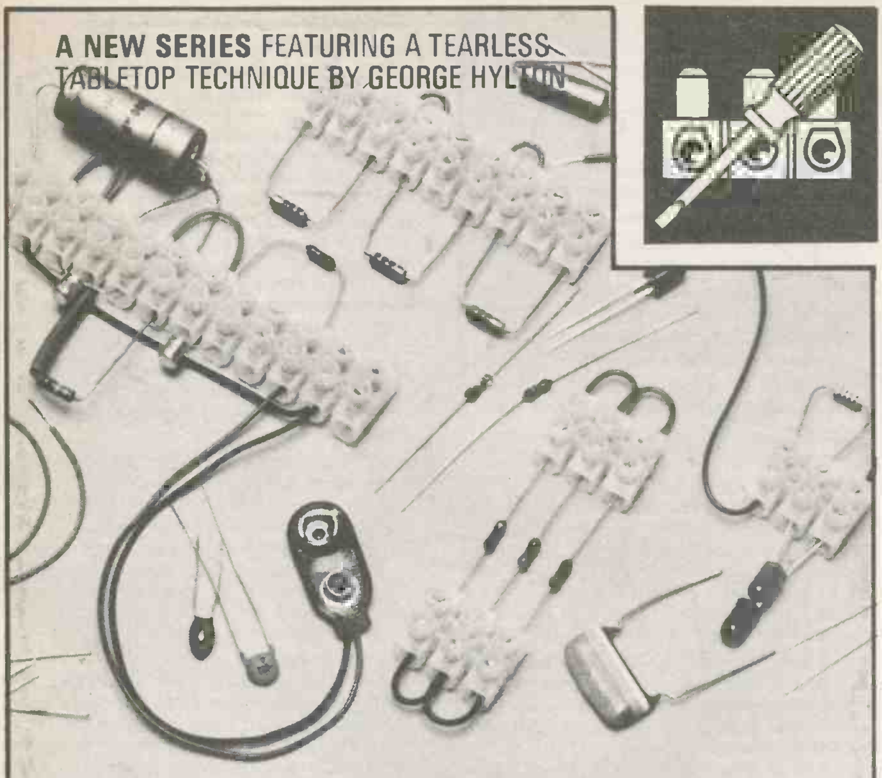
I enclose a simple design for a printed circuit board drill. The drill consists of a cheap d.c. motor (Tandy 273–208) with the drill bit attached to the motor shaft with a length of plastic tubing from a spent cotton bud.

A suitable length of tubing is cut off, and the drill bit made a secure fit in one end, using Araldite if necessary. The other end is enlarged slightly and pushed onto the motor shaft. Several drill bits can be prepared this way and can be removed from the motor shaft after use, leaving the tube on the drill.

The prototype drill runs on four HP2 batteries in series, and can be used with drills up to 1·6mm diameter. It copes effortlessly with 1mm drills and has sufficient torque to drill holes up to 1·6mm diameter.

S. Pearson,
Kidlington,
Oxon.





A NEW SERIES FEATURING A TEARLESS TABLETOP TECHNIQUE BY GEORGE HYLTON

INTRODUCING ELECTRONICS

Part 4 AMPLIFIERS

So far we have made and used transistor amplifiers without worrying too much about how they work. Now it's time to take a closer look. We shan't be going into transistor physics, and only one of the main types of transistor will be used. This is the bipolar transistor, that is, the kind designated *npn* or *pnp*. You can learn about the other main class, the field effect transistors, by following up articles in *EE*.

PREPARING FOR ACTION

We are going to take a close look at ways of turning a transistor on; that is, making collector current flow.

To do so in a controllable way we'll use a potentiometer; to be precise a 10 kilohm *log. law carbon-track volume control*. These are often used in practical circuits so it will come in handy later. If you buy one with a built-in on-off switch it will be even handier, though you won't need a switch at the moment. One with eyelet tags as shown in Fig. 4.1 is preferred. Get a knob for it as well, and if possible a blob of Blu-Tack or Plasticine to anchor it to the table top, plastic tray or other base board you are using.

A resistance of 3·3kΩ appears in one circuit. You could use three 10kΩ resistors in parallel but it's neater to buy the right one. (Better, several. 3·3kΩ is a commonly used value.) Also a 10nF (0·01μF) capacitor, best a polystyrene type with long leads.

By now you may be running out of space on terminal blocks and an extra one will be useful: remember, only the 2-amp type is small enough to accommodate the transistors we are using.

BIASING

Since this series dispenses with soldered joints you have a problem in making connections to the volume control (Fig. 4.1). First make sure the three tags *A*, *B* and *C* are clean and bright, or scrape until they are.

Take three 200mm lengths of fairly thin plastic covered connecting wire (preferably all different colours) and bare about 40mm at one end. Wrap the bared wire tightly round a tag and go on wrapping when you come to the insulated part, putting on a further few turns to hold the bare wire in place. If the tags have holes, finish by threading the loose end through a hole to discourage uncoiling. Bare a short section from the free end of each wire.

Your first circuit this month (Fig. 4.2) provides an adjustable *base bias current* which arrives via the upper part of VR1 then R1. If you have made the connections correctly, the Indicator will light when the knob is turned far enough clockwise. Think of the slider *C* as picking up a portion of the battery voltage from the track *A-B*. With the knob fully anti-clockwise, *C* is at *B* and the voltage picked up is zero.

As you turn clockwise and increase the voltage at *C* a point is reached where there is enough to drive a base current through R1, the base and the emitter and begin to turn on the transistor. The l.e.d. in the Indicator will glow when the voltage at *C* is about 1V.

Since some voltage is expended in R1 it follows that the voltage at the base is less. Typically, this *working base-emitter voltage* (V_{BE}) is 0·7V for a turned-on silicon bipolar transistor. To turn on an *npn* transistor like the BC107 or

A 10-kilohm pot. and control knob.

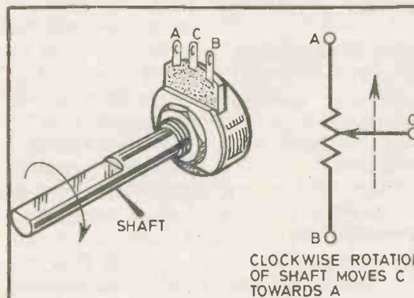


Fig. 4.1. A shafted potentiometer with eyelet tags, and its circuit symbol.

The wired up pot.

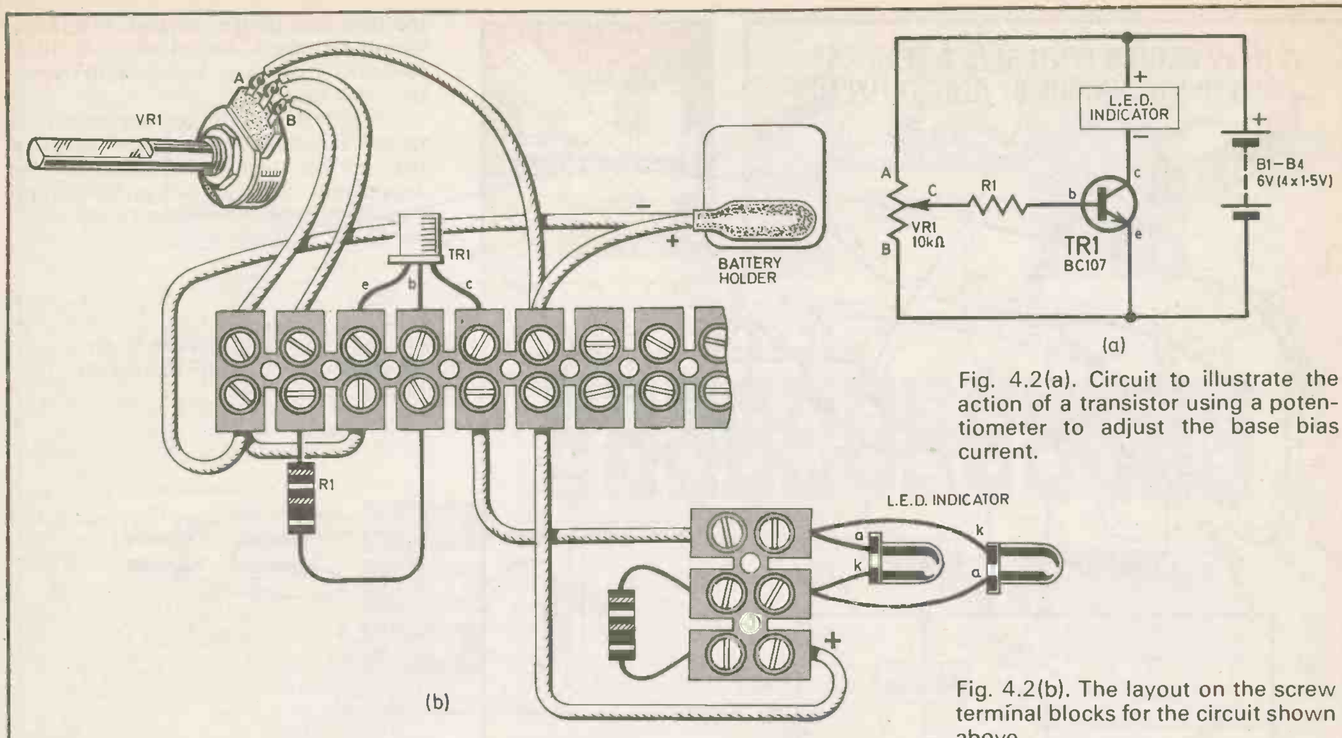


Fig. 4.2(a). Circuit to illustrate the action of a transistor using a potentiometer to adjust the base bias current.

Fig. 4.2(b). The layout on the screw terminal blocks for the circuit shown above.

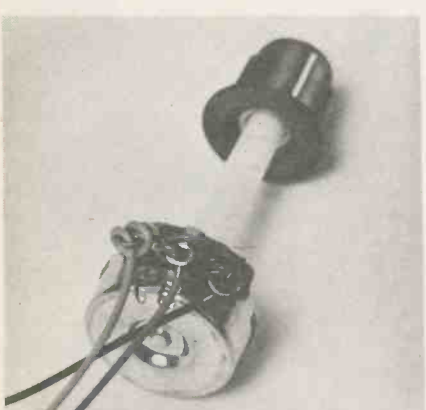
BCY65EP the base must be positive compared to the emitter. With *pnp* transistors everything is reversed and the base must be negative.

V_{BE} doesn't change much with current. It is always roughly 0·7V (say 0·5 to 1V). It falls as the temperature of the transistor rises. Nearly all the behavioural features or parameters of transistors are temperature dependent and circuits have to be designed to avoid malfunction from temperature effects.

THE FINGER TEST

To illustrate this, build the circuit of Fig. 4.3. Here TR1 is turned on as before, but any change at its collector is passed on to the base of TR2 and amplified. So TR2 is a sensitive indicator of changes in TR1.

Close up view of the pot, fitted with extension leads. The ends have been threaded through the eyelets after wrapping to hold firm.



With VR1 slider at *B* the Indicator l.e.d. lights. As the control is turned clockwise (*C* moving towards *A*) the l.e.d. suddenly goes out. This is the reverse of what happens in the circuit of Fig. 4.2 where clockwise rotation turns the l.e.d. on.

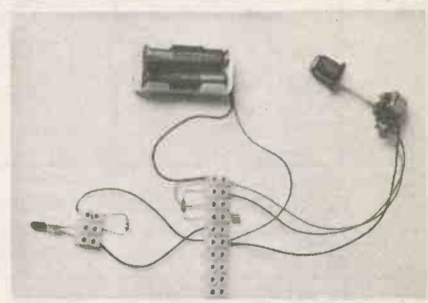
Why? Well, with the slider at *B*, TR1 is not turned on. It passes no collector current. But current can flow freely from battery positive through R2 to the base of TR2, turning it on and lighting the lamp. As VR1 is turned up and TR1 comes on, the flow of its collector current in R2 uses up battery voltage until at some setting of VR1 there is not enough left to turn on TR2.

VOLTAGE INVERTER

Two important facts emerge from this behaviour. First, that TR1 evidently goes on working even when its collector voltage is less than the 0·7V needed to turn on TR2. Since the base voltage of TR1 must be in the region of 0·7V too, it follows that TR1 passes collector current even when its collector is less positive than its base. This is true of *npn* transistors in general.

Secondly, the "TR1 on, TR2 off" behaviour of the circuit illustrates how a single common-emitter stage acts as a *voltage inverter*. That is, a positive-going voltage at the base makes the collector *less* positive. Since TR2 is also a common-emitter stage, it in turn inverts the voltage.

Two inversions restore the original polarity. A positive "signal" to TR1 base produces a positive output at TR2 collector. The two-stage amplifier as a whole is *non-inverting*.



The experiment of Fig. 4.2 in progress.

When, later on, you get around to using the very handy little packages of voltage gain called operational amplifiers you'll find that these give a choice of input terminals, one for "inverting" and one for "non-inverting" amplification. But op-amps need soldered connections so we can't play with them here.

But let's get on with studying temperature effects. Adjust VR1 so that the Indicator just glows distinctly. Squeeze TR1 gently between your finger and thumb for a few seconds. The warmth of your hand makes the l.e.d. go out. Breathing heavily on TR1 may have the same effect. Left alone, the circuit slowly recovers and the l.e.d. glows again. If you can cool TR1 by holding an ice cube against it you can arrange to turn *on* the l.e.d. from the just-off state. The ice cube should be contained in a plastic bag.

TEMPERATURE STABILISATION

We don't want our circuits to be upset by small changes in temperature. We

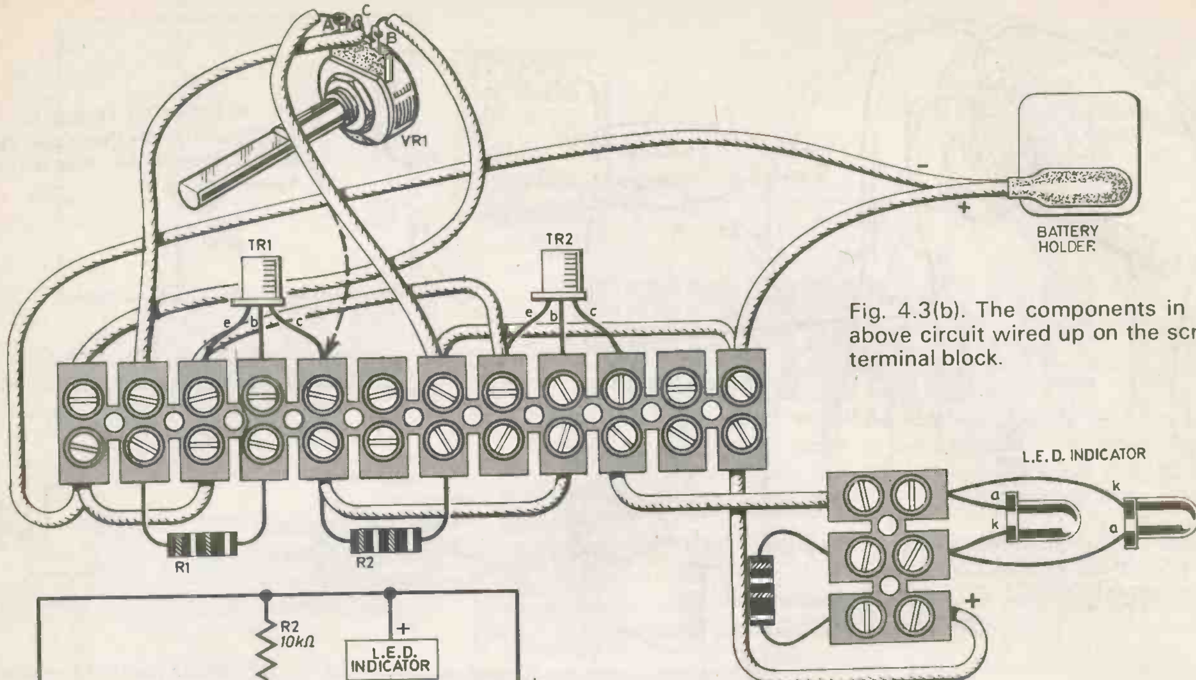


Fig. 4.3(b). The components in the above circuit wired up on the screw terminal block.

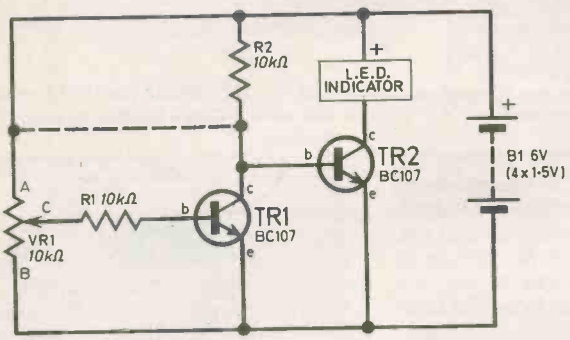
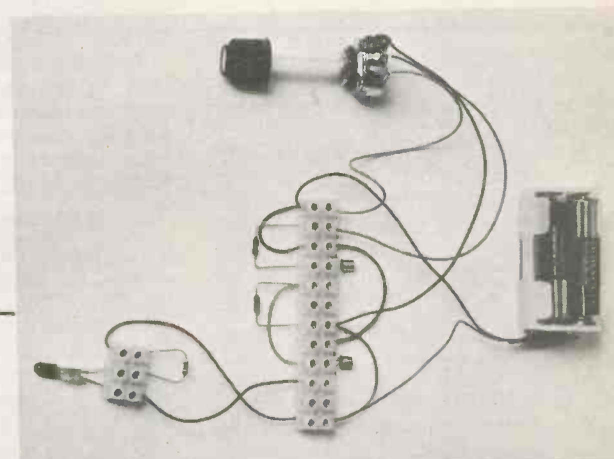
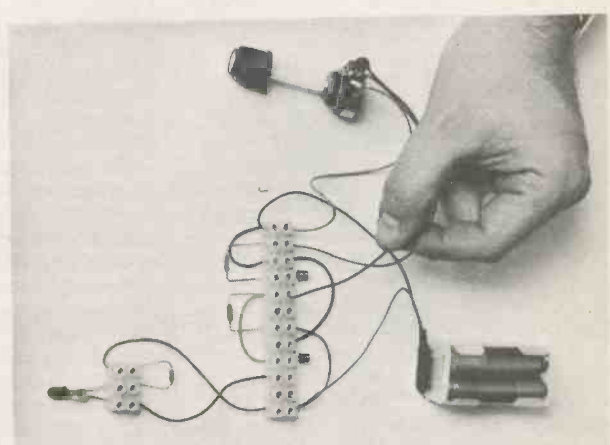


Fig. 4.3(a). A two-stage amplifier circuit. Connecting wire A from VR1 to TR1 collector (dotted lead) instead of B1 +ve introduces negative feedback.



The first part of the experiment of Fig. 4.3.



Introducing negative feedback in the circuit shown in Fig. 4.3.

must stabilise them. One way is to disconnect tag *A* of the pot. from the positive-battery line and re-connect to TR1 collector as shown dotted in Fig. 4.3.

You'll find that the sensitivity to temperature is reduced. The reason is that if a temperature rise causes TR1 to pass more current its collector voltage falls. Since this is now the voltage that supplies current to VR1 the change is resisted.

This is one example of a *negative feedback* circuit: negative feedback reduces the effects of an input "signal", whether it is a "real" signal voltage or current or a spurious change due to temperature.

AUTO BIAS

The practical application to single stages is the "auto bias" circuit of Fig. 4.4, where a fixed bias resistance R1 is used. The rule-of-thumb design formula is to make R1 greater than R2 by the d.c. current amplification factor h_{FE} of the transistor. Thus if R2 is 1kΩ and h_{FE} is 100, R1 is made 100kΩ. The collector voltage then sits at a little over half the battery voltage.

The trouble with the circuit in Fig. 4.3 is that only TR1 is stabilised. It would be better to feed back bias from TR2, to stabilise it as well. This calls for a change in the circuit (Fig. 4.5). Omit C1 at this stage. You'll find that the "Finger Test" now has almost no effect on the l.e.d.

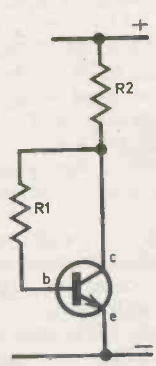


Fig. 4.4. A single-stage transistor amplifier with auto-bias.

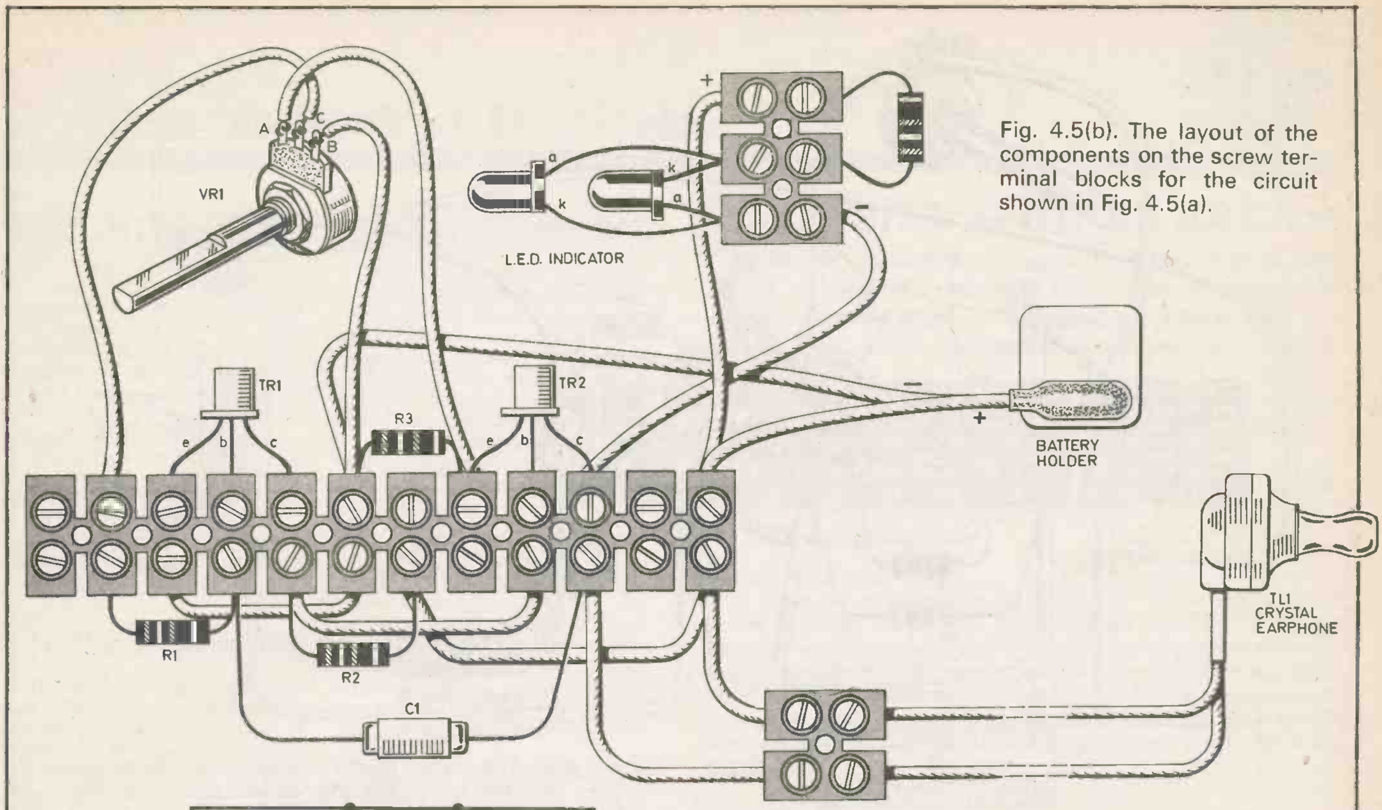
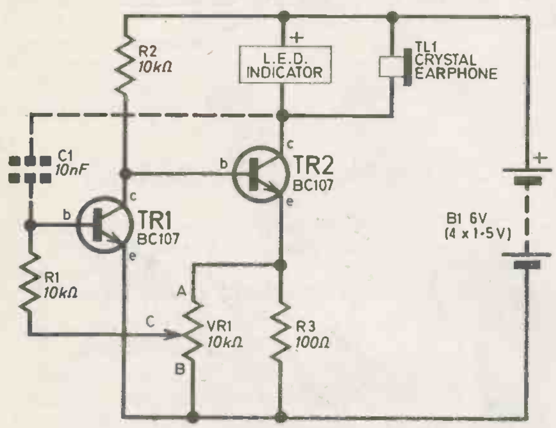
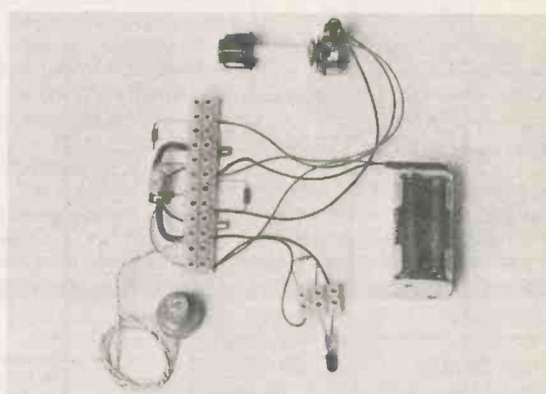


Fig. 4.5(b). The layout of the components on the screw terminal blocks for the circuit shown in Fig. 4.5(a).



(a)

Fig. 4.5(a). The circuit for a simple oscillator. The output tone (heard in TL1) can be varied by VR1.



The circuit of Fig. 4.5 fully wired up.

OSCILLATORS

Connect C1 and a Crystal earphone as shown dotted in Fig. 4.5. Adjusting VR1 produces a whistle whose pitch can be varied (actually between about 1·5 and 4 kilohertz). Whereas the temperature stabilisation of the circuit relies on negative feedback, the oscillation relies on positive feedback.

C1 couples the non-inverted output back to the input. Any change of voltage at TR1 base (the input point) is amplified and fed back via C1 to produce an even bigger change. The circuit runs away with itself and takes the form of an oscillation.

You might suspect that this positive feedback would upset the temperature stability but it doesn't. This is because C1 blocks any steady or d.c. voltages, passing back to TR1 only varying or a.c. voltages.

NOISE

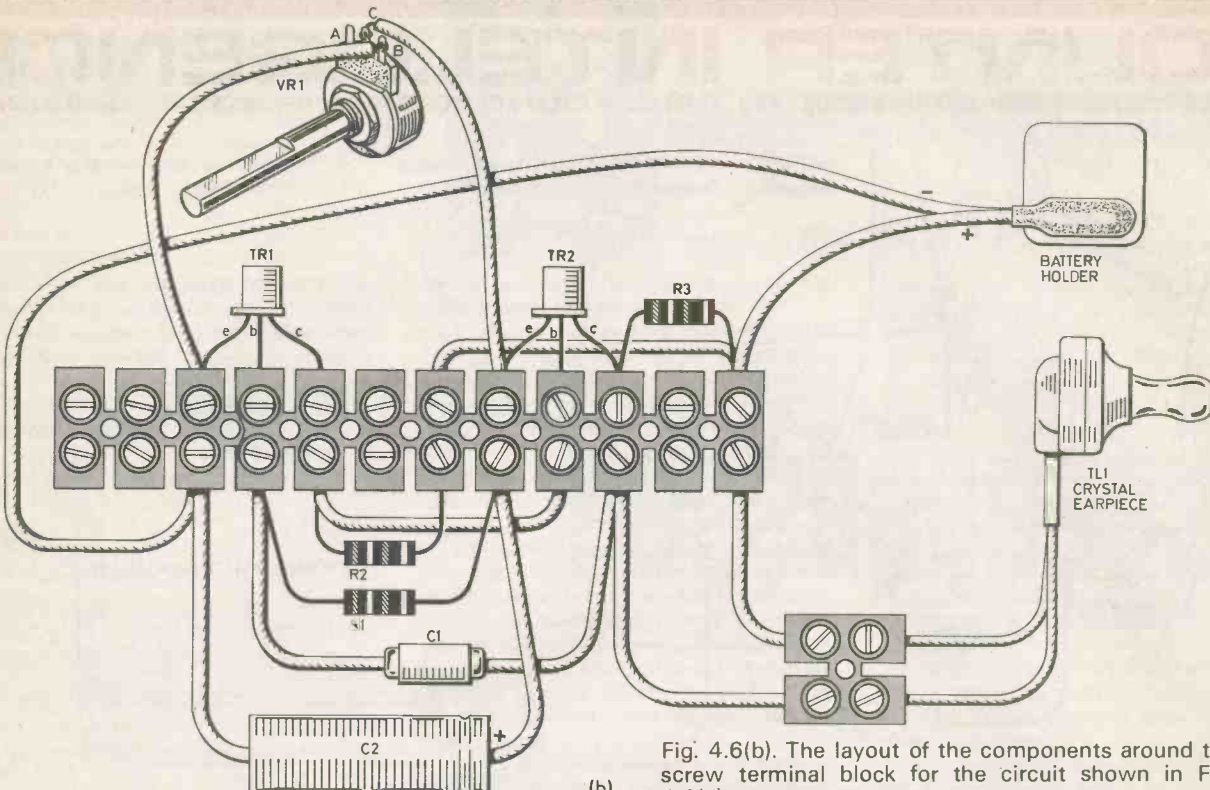
In an oscillator, any a.c. voltages at the input get amplified then passed back then amplified again, and so on for ever, or until the battery runs out!

Clearly, with both TR1 and TR2 turned on ready for action, any voltage, however small, will build up as it goes round and round the circuit until full strength oscillation is produced. You can tell by adjusting the pot. and listening that the build-up is very rapid. (Strictly speaking, I should be talking about "signals" rather than "voltages" since both voltages and currents are involved.) But where does the initial signal come from?

The answer is that every electronic circuit automatically generates minute a.c. signals. They are due to random movements of electrons and they are referred to as "noise". Let's rearrange our circuit to illustrate this, see Fig. 4.6.

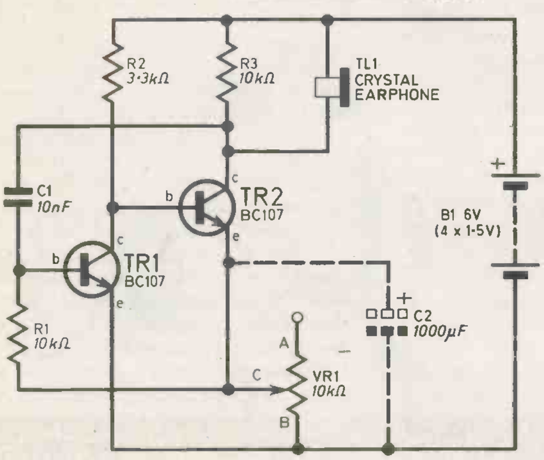
To begin with, leave out C2. The circuit should now oscillate much as before as VR1 is adjusted. Now connect C2 and wait a while. The circuit oscillates more violently. Probably it will turn itself on and off at some settings of VR1. This intermittent oscillation is called "squegging."

When you have finished amusing yourself with these peculiar sounds, disconnect C1. The result is silence. But not



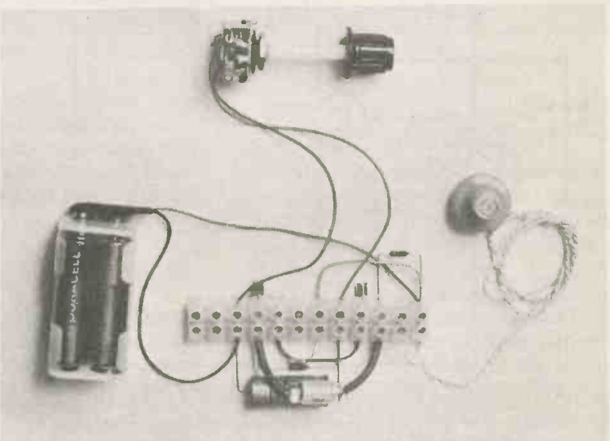
(b)

Fig. 4.6(b). The layout of the components around the screw terminal block for the circuit shown in Fig. 4.6(a).



(a)

Fig. 4.6(a). A simple circuit to produce intermittent oscillations. When C1 is removed, the circuit acts as a white noise generator and amplifier.



The experiment in Fig. 4.6 in progress.

quite. Listen carefully and you'll hear a gentle hiss. That's the noise.

It's often called *white noise.* White light is a mixture of all colours equally. White noise is a mixture of all frequencies equally. When you make the circuit oscillate it doesn't matter what frequency it is tuned to: there's always some of the right frequency in the white noise, so it always oscillates, so long as the amplification is sufficient.

Noise puts a limit on the amount of amplification that can be used. For reasonably intelligible speech, the speech signals must have about ten times the voltage or current of the noise. If the noise voltage is a millionth of a volt (one microvolt, 1µV) the speech must be at least 10µV (for good quality, much more). There's just no point in making an amplifier which will give full output from a speech signal of, say, 3µV because the speech will be smothered by the noise.

Almost the only thing to be done is to restrict the bandwidth as much as possible. Noise happens at all frequencies. Speech doesn't. It contains nothing below about 100Hz or above about 10kHz, so if you can filter out all frequencies outside the band 100 to 10,000Hz you can reduce noise. In fact, you can do better. Speech is still intelligible when the bandwidth is reduced to 300 to 3000Hz. This is the band used in some telephone systems. For Morse code reception an even narrower band is sufficient, which is why Morse or "carrier wave" (CW) signals can get through noise which drowns speech.

To some extent the ears themselves can filter out the noise, but with the aid of electrical filters much greater improvements are obtainable. Note, however, that the penalty for transmitting in the face of noise is a reduced rate of information transmission. Morse is slower than speech.

To be continued

COUNTER INTELLIGENCE

By PAUL YOUNG

Rewarding Hobby

With the approach of Christmas I know we shall see thousands of electronic games appearing. Frankly, they wouldn't hold my interest for more than five minutes, I would just as soon play Scrabble or read a book.

I am equally sure that many a Christmas stocking will have a soldering iron and other similar items sticking out of the top. This is all to the good because electronics is a hobby that can be started at 10 and can last a lifetime, and how many other hobbies can match up to that?

It is particularly important because once a youngster has started on electronics it will not be long before he thinks up his own ideas. As Clive Sinclair stated on television recently, "Our biggest asset was the ability to dream up original ideas".

Company Report

In the last three months I have included write-ups on one or two friends in the electronic business who have made a success of their respective trades. Being Christmas time, I thought I would like to deal with the story of someone, although equally interesting, who hasn't yet made it to the top. I refer to Tom Powell of T. Powell.

When he was a boy, Tom was interested in listening to short-wave broadcasts. He also liked to take things to bits to see how they worked. He made a crystal set and having no soldering iron, twisted all the bare wires together. To his astonishment it worked. At a later date he soldered it and it wouldn't work at all.

He left university at the age of 19 and took a job in the radio department of the Civil Service Stores, a large store in the Strand. Like many of us, he had a turning point that altered his entire future.

Apart from radio he was always fascinated by newspapers and advertising. The centre of all this was, and still is, Fleet Street. This being only a short walk from the Strand, one lunch-time, in 1953, he walked down there and what caught his eye was not the newspaper offices but a firm called ELPREQ (Electronic Precision Equipment).

The window was filled from top to bottom with electronic components, all carefully labelled and priced. Tom couldn't take his eyes off it.

In the centre of the window was a notice saying there was a vacancy for a salesman. He marched boldly in and spoke to the manager, a Mr Kaye. He said he would like the job. With honesty which is typical of him, he added he knew nothing about electronics at all. He was still taken on.

It was during 1960 that he had the idea of making up an electronics kit. He made one up experimentally and put it in the window. Ten were sold the first day. As he received no encouragement he just stored up the idea for future use.

After spells with Radio Traders and Radio Clearance, Tom decided that he now had enough experience to start on his own. In 1967 he founded a company called Elekon, concentrating mainly on mail order.

In 1972 he decided he would travel the country dealing mainly in surplus electronic equipment and for the next few years he could be seen burning up the motorways, Manchester one day and Southampton the next. Although this was highly successful, it was wearing both on the car and the driver.

In 1977 he opened a shop in St Paul's Road, London N1. This proved a great success, and it was then that he revised the idea for doing the projects in the various magazines as kits. As a result he was obliged to move into larger premises to have the necessary space. He then closed the shop.

If times had been normal he would by now be approaching the tycoon status, but the recession was beginning to bite deeply. Orders fell off and he still had rent, rates, lighting and wages to meet. He then made a daring decision to reverse his policy and open another shop.

At the beginning of September 1982 he opened his second shop at 311 Edgware Road, London W2.

This venture looks like being a great success, and I am delighted.

Conundrum Apology

I owe readers an apology. I promised to give them the answer to my riddle the following month, forgetting that that edition had already gone to press. You may remember I asked, how do prisoners communicate between cells by knocking, without knowing the Morse Code?

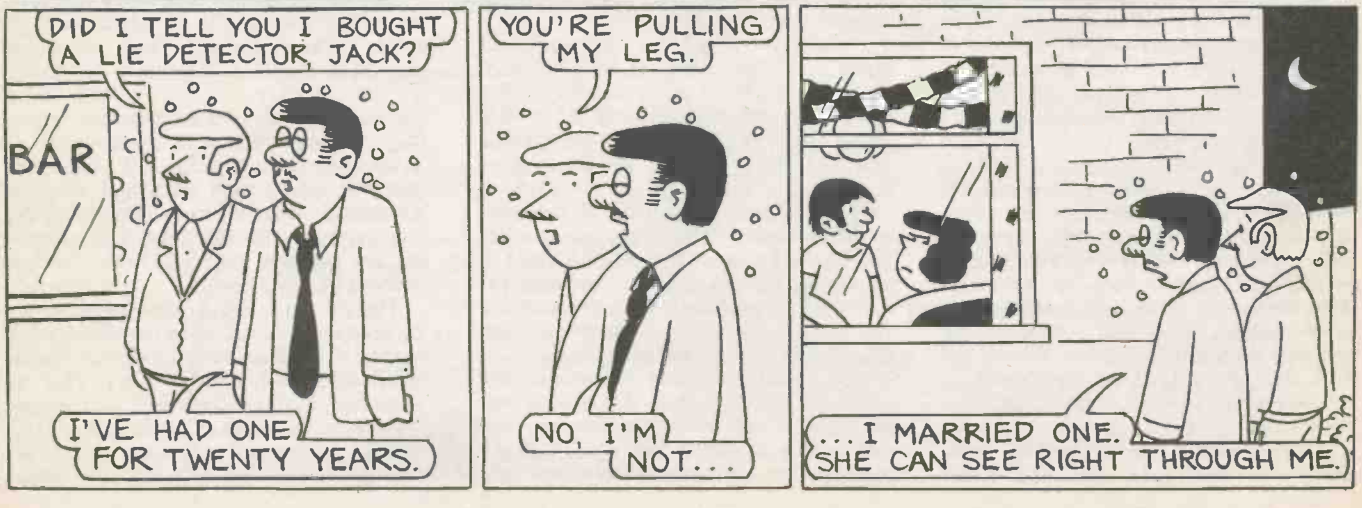
The answer is this. If you draw six vertical lines spaced at about half an inch, and on top of them draw six similar horizontal lines, you will have produced a grid of 25 squares. If you write down the alphabet horizontally in these squares (you will have to miss out one letter, either "Q" or "Z", or a letter that can be substituted by another), you are now ready to make a start.

The first knock would indicate the line, the second the number of spaces along. For example (missing out the letter "Q"), supposing you wanted to send the word, "Radio". It would be 4 taps followed by 2 taps, 1 tap followed by 1 tap, 1 tap followed by 4 taps, and so on.

I do hope you never have to use it. Happy Christmas.

JACK PLUG & FAMILY...

BY DOUG BAKER



—A TO D— CONVERTER FOR PET COMPUTER

BY J. ADLINGTON, L.CHAPMAN AND J. MONK

Many schools are now in possession of one or more microcomputers and it is not, perhaps, generally realised that with suitable interfacing techniques, these machines can be used to access, measure and process analogue data from measurement transducers.

Many existing laboratory instruments for measuring physical parameters provide an analogue output, the size of which is usually indicated by a moving-coil meter. Such instruments include typically electronic thermometers, pH meters, sound level meters, radiation detectors, and so on.

The project to be described here is an Analogue-to-Digital (A/D) Converter which will process such analogue voltages and convert them into an 8-bit digital representation which can be recognised and manipulated by a microcomputer.

The system described is designed for use with the User Port connections of the PET series of microcomputers, although it could be adapted for most of the other popular machines.

The basic unit provides full scale inputs of 100mV, 1V and 10V which covers the output of many laboratory electronic measuring instruments.

CIRCUIT DESCRIPTION

The complete circuit diagram for the Analogue-to-Digital Converter is shown in Figs. 1 and 2, the latter being the mains derived power supply section.

Referring to Fig. 1, the analogue input signal reaches the unit at SK1 where it is scaled down by the potential divider formed by precision resistors R1 to R5. These provide three input amplitude ranges: 100mV, 1V, 10V and are selected by S1.

IC1 is an op-amp used in the non-inverting mode. The voltage gain is set at x25 by the feedback resistors R6 and R7. Close tolerance (1 per cent) resistors ensure that the gain is close to this nominal figure. VR1, a preset potentiometer, provides an off-set null facility for IC1.

The maximum input voltage to the ZN427E converter i.c., IC3 should not exceed 3·5V, otherwise the integrated circuit will be damaged. D1, a 2·7V Zener diode gives protection against this, without interfering with operational amplifier outputs.

A to D CONVERTER

The ZN427E is an eight-bit resolution converter of the successive approximation type, in which the analogue input voltage is compared with "trial" voltages generated within the device. Special registers set the digital output bits at a 1 or a 0 according to the result of the comparison. An eight-bit digital signal gives an accuracy of 1 in 256 or about 0·4 per cent.

The digital output latches of the ZN427E are "tri-state". This means that they can represent a logic 0 or 1 or, when the outputs are not required to be read, they can assume a very high impedance state, thus effectively disconnecting them from the microcomputer. This is important since data appearing at the microcomputer input when not required would cause problems.

PET USER PORT

This digital information is connected directly by multicore cable to the connections PA1–PA8 on the User Port of the PET.

There are three more connections between the Converter and the microcomputer User Port:

SC—Start Conversion
EOC—End Of Conversion
OE—Output Enable. When OE is at logic 1, the data outputs are tri-state.

All of these "protocol" signals are handled by software.

The two CMOS gates IC2a and IC2b are wired as an astable running at about 250kHz. This forms the system clock. The system clock determines the conversion time. The conversion time lasts for nine clock cycles which gives a conversion rate of about 28,000 per second, more than fast enough for most applications.

POWER SUPPLY

The power supply section of the Converter is shown in Fig. 2. Mains voltage enters the unit through panel mounting plug PL4. Switch S2 connects the mains to the primary of T1, a step-down transformer with two independent secondary windings rated at 9V 500mA each.

The operation of each half of the circuitry following each secondary winding is identical, with the top half providing the +ve supplies with the lower half supplying the negative supplies. Only the top half will be described.

The 9V r.m.s. voltage developed across T1 secondary is full-wave rectified by D7 to D10 to produce pulsed d.c. with a peak value equal to about 12V. This is smoothed by C11. Sufficient voltage exists across the series combination of R13 and D2 to cause Zener action to occur: D2 "breakdown", developing 10V across

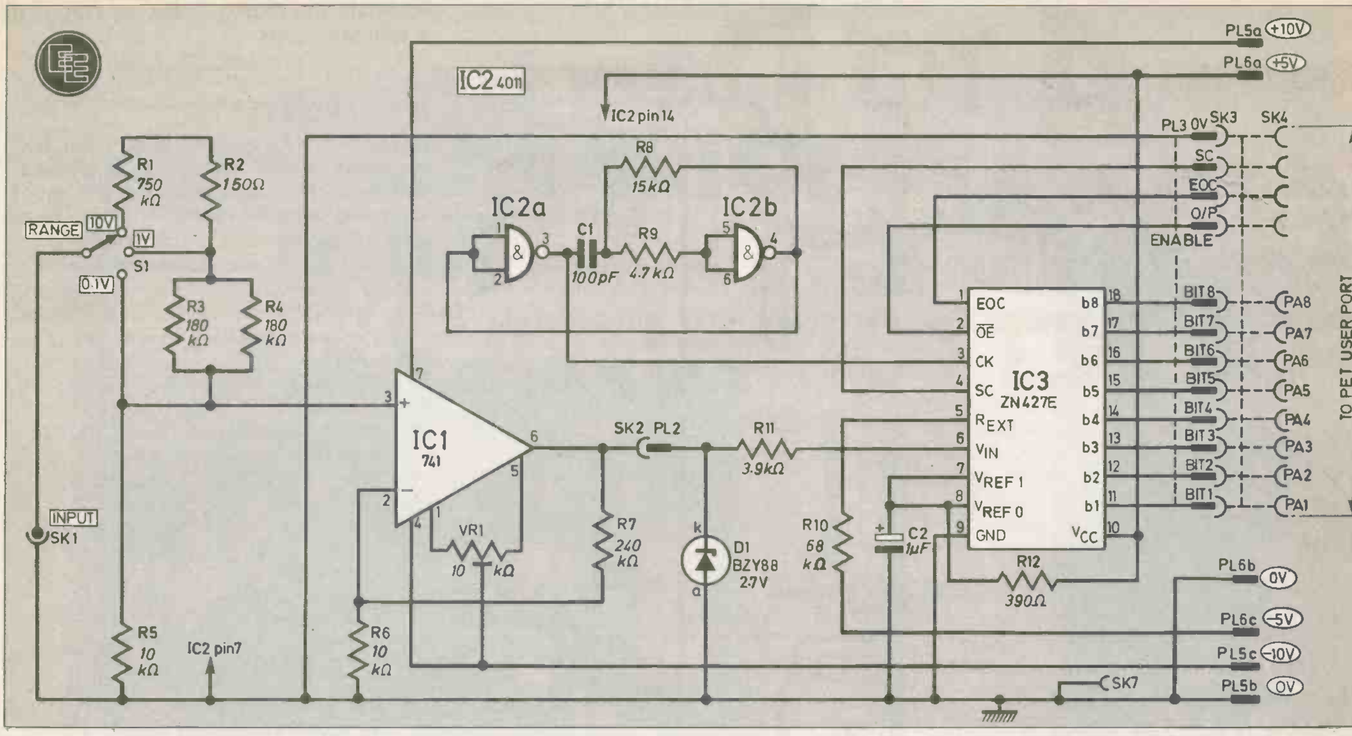


Fig. 1. Circuit diagram of the A to D Converter.

it for varying currents through it. The remaining 2V is dropped across R13. This results in a regulated supply of 10V being available at SK5a, with C4 providing additional smoothing. C3 is a decoupling capacitor and prevents oscillations on the supply lines.

Similar action occurs with R15 and D4 except that here a 5·1V Zener diode is used, providing a +5V d.c. supply at SK6b.

The negative supply is also used to power the "power-on" indicator l.e.d. D6. R17 limits current flow through D6 to a safe level.

The power supply delivers ±10V, 0V, and ±5V lines to power the circuitry in Fig. 1. These are available at floating insulated sockets to mate with board fitted plugs.

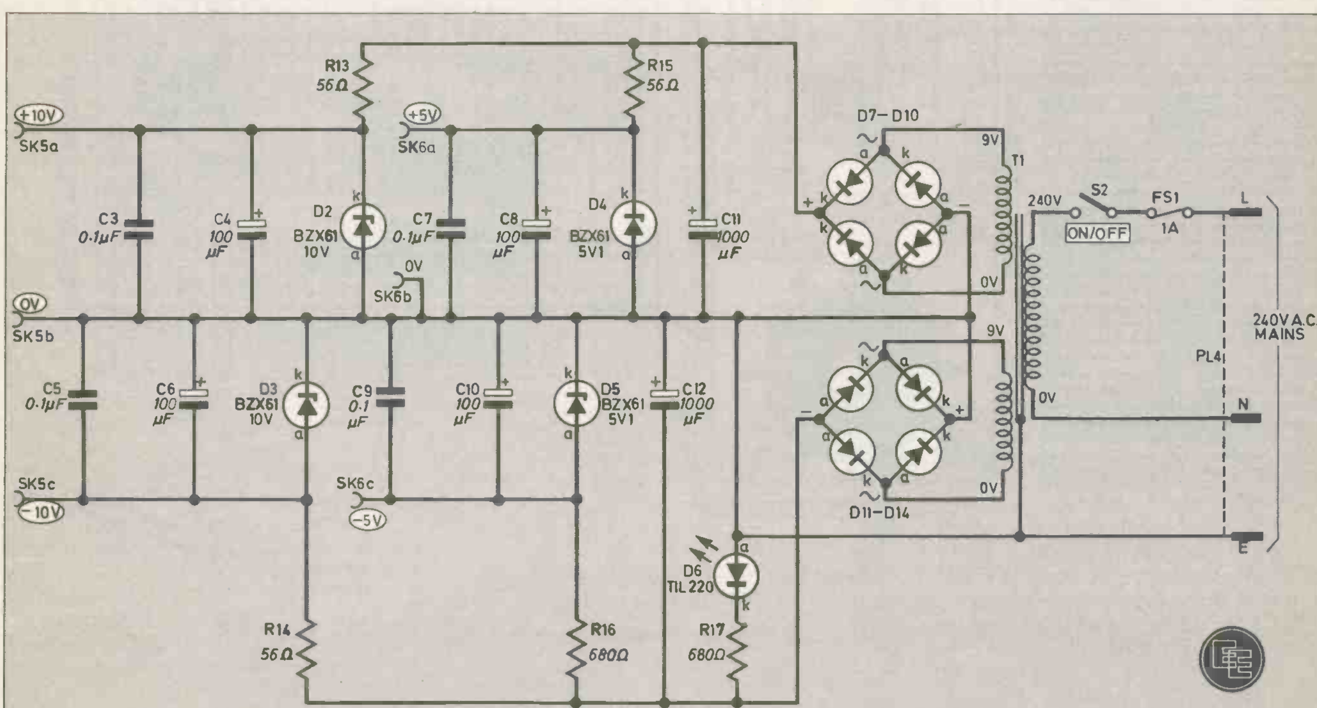
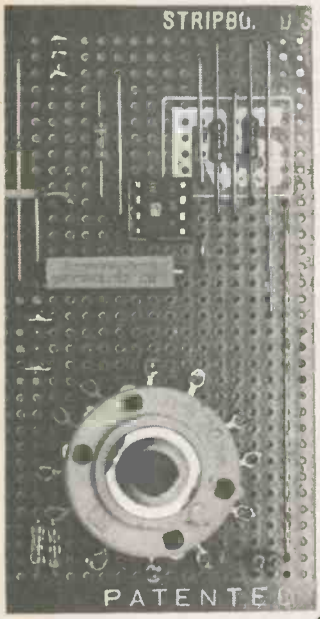
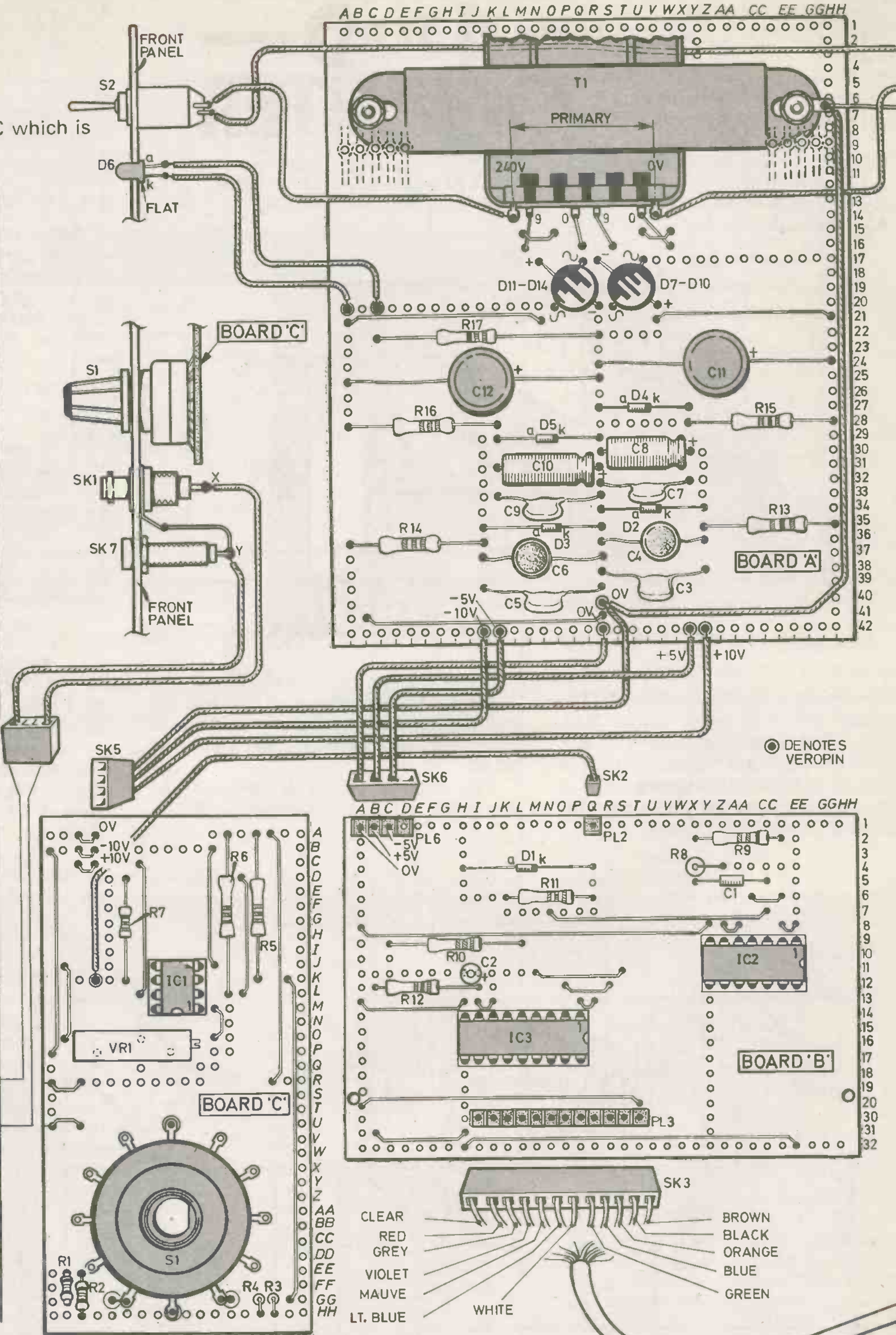


Fig. 2. Circuit diagram of the Power Supply section of the A to D Converter.

Close up view of the board C which is mounted on the front panel.





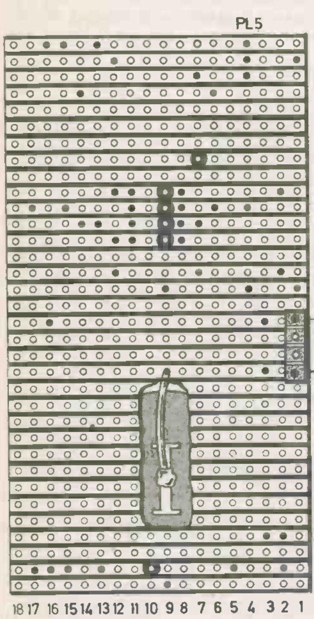
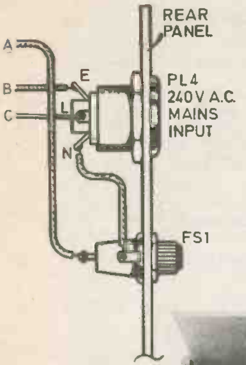
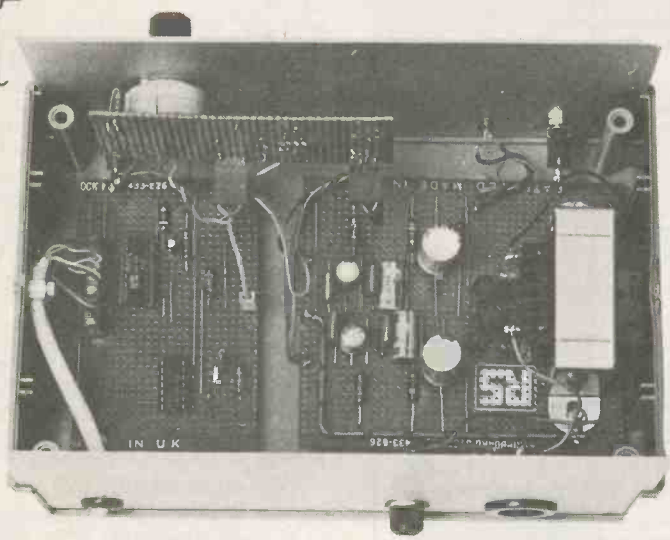


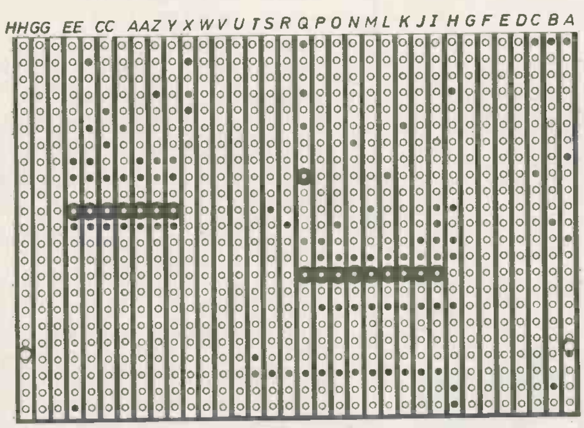
Fig. 3. (Above, top right, bottom right). Full layout and constructional and interwiring details of the A to D Converter and wiring up of the PET User Port connector.

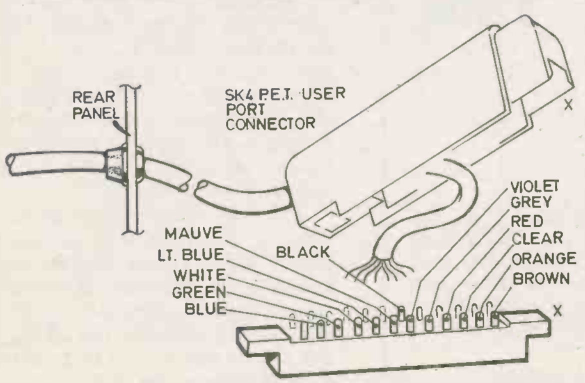


A TO D CONVERTER



View inside the completed prototype with the top section of the case removed.





CONSTRUCTION starts here

CIRCUIT BOARDS

The prototype Converter was constructed using three pieces of 0·1 inch matrix stripboard: board A to hold the power supply stage, board B to accommodate the digital converter section with system clock, and finally board C to hold the input scaling circuitry, see Fig. 3.

This layout is not particularly critical and may be changed to suit. All interwiring between boards is either carried out using board mounted plugs and floating in-line sockets, or soldered connections at Veropins. This technique allows all the components and boards to be positioned in the case and then wired up in situ.

Beginning with board A. The layout of the components on the topside of this board is shown in Fig. 3. The only breaks to be made on the underside of the stripboard (34 strips × 42 holes) are those to isolate the transformer fixings from the rest of the circuitry. These are shown dotted in Fig. 3, board A topside view.

The stripboard is sandwiched between the transformer and the base of the case and held secure by the fixings for T1 which pass through the case base. The transformer is a heavy component and should not be supported by the stripboard alone.

Assemble the components as shown paying special attention to capacitor and diode polarities. Order of assembly is unimportant. Fit the flying leads to the board and attach the in-line sockets.

The transformer needs to be fitted to the board only at first, to allow the sets of winding tags to be connected to the board using tinned copper wire. The transformer is wired up and then the fixings removed and replaced again only this time through the case base as well, and tightened to hold the board secure.

Prepare the front and rear panels to accept the components to be mounted on them, and fit in place. Wire up the mains supply components: PL4, S2, FS1 and D6.

When these have been checked, the mains supply can be connected to the unit and switched on. Check the voltage levels at each of the six socket positions from this board. The voltage levels should not differ appreciably from the values indicated on the circuit diagram, Fig. 2.

It is a good idea to label the in-line sockets with the voltage levels they contain and to indicate which way round they are to mate with the plugs on the other boards.

Board B topside layout is also shown in Fig. 3, together with the breaks required to be made on the underside. The fixing holes are drilled to align with the fixing lugs in the specified Verobox. If fitting in another type of case, these holes will probably need to be repositioned.

Fit the i.c. sockets followed by the link wires, plugs, resistors, capacitors and diode. Secure the board to the case using short self-tapping screws and then fit the integrated circuits paying special attention to polarity.

If these chips are incorrectly orientated they will almost certainly be damaged when the power is turned on. A notch appears on the chip between pin 1 and the highest pin number. A circular indentation is also alongside pin 1 on many i.c.s.

The last board, C, is mounted on the front panel by the fixing nut on S1, the latter being soldered to the board, see Fig. 3.

In the absence of a p.c.b. mounting rotary switch, the eyelet tags on S1 have been splayed out. The switch used and shown here is a 2-pole, 6-way type fitted with a stop to make a 3-way switch. The two poles of the switch were bent flat one on the other and soldered together and to a length of tinned copper wire to reach the Veropin at location U9. This is also soldered to a tag on S1, see diagram.

Begin construction by inserting the Veropins and then secure S1 to the board. Next insert the i.c. socket, linkwires, plugs, resistors and capacitors in this order. Finally connect the flying lead fitted with an in-line socket, SK2 and fit the i.c. in the socket paying attention to its orientation.

With all the boards and panel mounting components securely in place, the unit may be fully wired and plugged as indicated in Fig. 3.

It only remains to wire up the socket SK3 which connects to the cable which goes to the PET User Port connector. Details of the interwiring between SK3 and SK4 are given in Fig. 3.

In the prototype, after the leads had been connected to SK3, the socket topside was filled with Araldite to hold the wires in good contact. A bad contact at SK3 at any time would cause the system to malfunction. With this complete, the unit is now ready for connecting to the PET and final adjustments can be made.

COMPONENTS

Resistors

R1	750kΩ 1%	R10	68kΩ
R2	150kΩ 1%	R11	3·9kΩ
R3	180kΩ 1%	R12	390Ω
R4	180kΩ 1%	R13	56Ω
R5	10kΩ 1%	R14	56Ω
R6	10kΩ 1%	R15	56Ω
R7	240kΩ 1%	R16	680Ω
R8	15kΩ	R17	680Ω
R9	4·7kΩ		

All ¼W carbon ±5% except where stated otherwise.

Capacitors

C1	100pF ceramic or polystyrene
C2	1μF 10V elect. radial leads
C3	0·1μF polyester
C4	100μF 16V elect. radial leads
C5	0·1μF polyester
C6	100μF 16V elect. radial leads
C7	0·1μF polyester
C8	100μF 16V elect. axial leads
C9	0·1μF polyester
C10	100μF 16V elect. axial leads
C11	1000μF 25V elect. radial leads
C12	1000μF 25V elect. radial leads

COMPONENTS approximate cost £30 excluding SK4

Semiconductors

IC1	741 op-amp
IC2	4011 CMOS Quad 2-input NAND gates
IC3	ZN427E A to D Converter i.c.
D1	BZY88C2V7 2·7V 400mW Zener diode
D2,3	BZX61 10V 10V 1·3W Zener (2 off)
D4,5	BZX61 5V1 5·1V 1·3W Zener diode (2 off)
D6	TIL220 0·2 inch red l.e.d.
D7–D10, D11–D14	W005 1A 50V bridge rectifier (2 off)

Miscellaneous

T1	mains primary/0–9V, 0–9V 500mA secondaries
FS1	1A 20mm
VR1	10kΩ ¾ inch multiturn cermet preset
S1	2-pole 6-way rotary switch
S2	miniature ON-OFF toggle
SK1	b.n.c. panel mounting socket
SK2	1-way inter p.c.b. socket
SK3	12-way inter p.c.b. socket
SK4	PET User Port Connector
SK5	4-way inter p.c.b. socket
SK6	4-way inter p.c.b. socket
SK7	4mm insulated panel mounting socket
PL2	1-way p.c.b. straight plug
PL3	12-way p.c.b. straight plug
PL4	3-pin chassis mounting mains plug
PL5	4-way p.c.b. straight plug
PL6	4-way p.c.b. straight plug

See Shop Talk page 23

Stripboard, 0·1 inch matrix: board A 34 strips × 42 holes, board B 34 strips × 32 holes, board C 34 strips × 18 holes; i.c. d.i.l. sockets, 8-pin, 14-pin, 16-pin (1 off each); 4BA solder tag; single-sided Veropins; control knob; 4BA 20mm long screws, nuts and washers (2 off each); small self-tapping screws (2 off); tinned copper wire; sleeving for tinned copper wire; 20mm panel mounting fuseholder; length of 3-core mains cable fitted with in-line socket to suit PL4; length of 12-core cable; Verobox type 202-21036C or similar.

BASIC TEST PROGRAM

```
100  REM BASIC TEST PROGRAM
110  PB=59456:DDRA=59459:
     PCR=59468:PPA=59471
120  REM INITIALISATION
130  POKE PCR, (PEEK(PCR)OR192)
140  POKE PCR, (PEEK(PCR)AND223)
150  POKE PB, (PEEK(PB)OR9)
160  POKE DDRA, 0
170  GOSUB 2000
180  PRINT "",D
190  GOTO 170
2000 REM CONVERSION
2010 POKE PB, (PEEK(PB)AND247)
2020 POKE PB, (PEEK(PB)OR8)
2030 POKE PCR, (PEEK(PCR)OR32)
2040 D=PEEK(PPA)
2050 POKE PCR, (PEEK(PCR)AND223)
2060 RETURN
```

TESTING

Short circuit the analogue input socket, SK1. This is easily done using a short length of wire fitted with crocodile clips at each end and clipping one end to point *X*, the other to point *Y* on SK1 and SK7 respectively, in Fig. 3. Connect the unit to the PET computer. Turn on the Converter and then the computer. The computer should function as usual. If not, switch off and investigate. Load the Basic Test Program. On running the program, a 0 should be printed in the top left-hand corner of the screen.

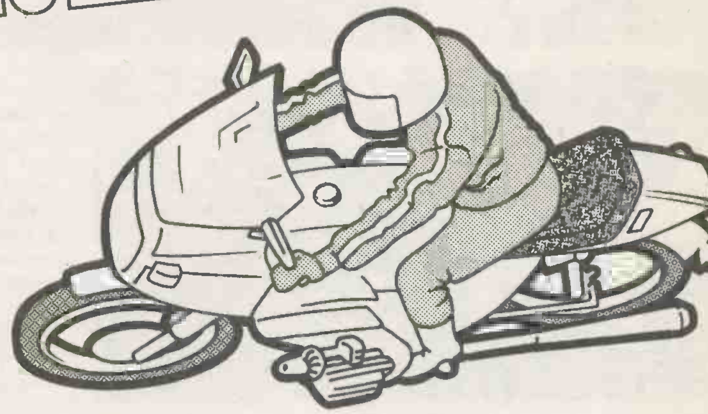
The 741 off-set null control, VR1 on board C should now be rotated until the screen prints values slightly above zero and then backed off until a steady zero is just obtained. Alternatively, if a digital voltmeter is available, the off-set null control can be adjusted to give zero output at pin 6 of the op-amp IC1. □

Everyday ELECTRONICS

FEBRUARY 1983 ISSUE ON SALE FRIDAY, JANUARY 21

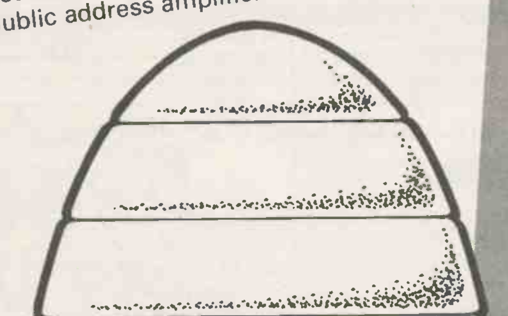
FEBRUARY FEATURES

ALARM for PUSH BIKE or MOTOR BIKE



SPEECH PROCESSOR

Boosts strength of signal by peak-clipping.
Effective battery operated unit
for connection between microphone and
transceiver,
or public address amplifier.



SEDAC PRIZE WINNING PROJECTS

ZX81 SPEED COMPUTING SYSTEM

HIVE TEMPERATURE METER

Everyday News

THE ELECTRONICS FAIR

All the "hustle and bustle" of the fair is evident in this photograph.

Visitors watching model control vehicles being put through their paces in the special display area.

Over 11,000 visitors passed through the turnstiles at the first Electronic Hobbies Fair, held at the Alexandra Pavilion, Alexandra Palace, London.

"Electronics is a Fine Hobby". This was the slogan from one of the stands, to this we would add "The Friendly Fair" and you get some idea of the reception accorded visitors to the Fair.

People from all ages, young and old, found something of interest for them and commented on the bright and attractive appearances of all stands.

Feedback from most exhibitors was one of general pleasure with the design of the stands and fairly brisk business. One of the most popular lines was in cases, this was followed closely by test meters and breadboarding systems.

Computer hardware and software, including "add-on's", was well represented on many stands. Several stands had displays of home computers in operation.

The amateur radio fraternity were well catered for by such items as aerial arrays, transmitters and receivers. Publications and books on radio were also on prominent display.

Live Shows

No show would be complete without a collection of working models, indeed, these were in abundance. In fact, apart from special "live" demonstrations, virtually every component supplier brought along something that would attract attention, albeit a flashing light or sound blaster.

Highlights from the active exhibits were: radio-control models being put through their paces; robots on the move; Royal Signals Army apprentices at work and TV pictures from the Russian Ghorizont satellites. Demonstrations of the capabilities of hollographic displays, electronic organ and piano were also given.

Make a Date

The Electronics Hobbies Fair has now firmly established itself as a major exhibition of the home electronics enthusiast, and it is the aim of the sponsors to make next year's show an even bigger and better event.

So, book your date now! It is 10 to 13 November, 1983.

The old looks down on the new. The aerial dish in the foreground was receiving Russian TV satellite pictures and showing them inside the hall throughout the show.

Just some of the visitors awaiting their entrance to the Electronic Hobbies Fair.

AIRLINE SHOCK

Transatlantic travel for businessmen could become a thing of the past through video conference, by satellite, in which executives in the UK and USA can hold business meetings face-to-face as if they were talking across the same table.

The service will initially be from specially equipped studios but a low-cost terminal with TV camera and monitor screen in a single unit is under development by British Telecom for use from customers' own offices.

In the Sewage!

The water industry in conjunction with electronics companies is proposing that the cabling of Britain can be most economically achieved by laying the cable in sewage pipes which reach 99 per cent of houses.

The cable would be carried in conduits secured by adhesive above the liquid level and probably installed by robots.

Micros in Medicine

Freeman Hospital, Newcastle, is to get six Unibed installations from Oxford Medical Computers to demonstrate the use of micro-electronics in medicine through automatically monitoring a patient's temperature, respiration, heart rate and other parameters.

They are being supplied under the Department of Industry's MAP programme.

COMPUTER PROGRAMME

The Alvey Committee set up to investigate a fifth generation computer programme for the UK has recommended £350 million investment in a five-year programme starting on April 1, 1983.

The Committee suggests a go-it-alone programme for the UK but with selective co-operation with the Japanese, the Americans and with Common Market countries. In effect, keep all options open.

OLD BILL STRIKES BACK

In an unprecendented move, the Government is to have powers to confiscate equipment and powers of arrest under amendments to the Wireless Telegraphy Acts 1949 to 1967.

Crack-down on CB interference expected under new Telecommunications Bill.

Tough control of sales, manufacture and possession of all illegal telecommunications equipment, including CB radio, outlined in Government paper.

The Government Telecommunications Bill, just published, sets out to update penalties for wireless telegraphy offences and introduce new powers to deal with illegal uses.

Sale and Possession

To reduce or prevent interference, the Secretary of State has powers at present to prohibit by order the manufacture and importation of specified equipment except with his authority. But he does not have powers—which the provisions will give him—to control the sale and possession of such apparatus.

This will help control further the availability of illicit CB equipment; at the moment, about 1000 complaints a week concerning interference to domestic TV and radio caused by illegal CB are received by the Radio Interference Service (R.I.S.).

Seizure

The proposed powers of seizure will include a provisio enabling the police or the R.I.S. to apply to the court by way of a civil procedure for the forfeiture of apparatus illegally possessed.

This would give an alternative to prosecution where it appears that nothing useful would be achieved by seeking a criminal conviction. This might be, for example, where a person accepts that he should not have had the apparatus in question and does not appear to be deliberately flouting the law.

Penalties

The provisions in the Telecommunications Bill do not increase penalties for existing offences (other than for two which are made triable-either-way). However, one effect of the Criminal Justice Act 1982 will be to raise the maximum fine for the unlicensed use of a transmitter from £400 to £1000.

More IT *Centres*

The Department of Industry is to set up a further 50 Information Technology Centres at a cost of £12 million. This will bring the total to 150 in about two years time.

The centres are for training young people in computer operation and maintenance.

Fully automated "factories-of-the-future" are forecast to reduce the labour proportion of total production costs from a typical 30 per cent today to as little as four per cent in a few years time.

Water-cooled

Honeywell's new super computer range has such high packing density of chips with consequent heating problems that they are water-cooled.

Water cooling is 100 times more efficient than air say Honeywell who have dubbed the technique Silent Liquid Integral Cooler (SLIC).

BBC engineers are reported to have modified the Crystal Palace BBC2 transmitter to accommodate stereo sound on an experimental basis. But the BBC has not decided whether stereo will be introduced on a regular service.

SUN-POWER

Advanced technology has arrived in the historic land of the Queen of Sheba. In a deep valley 200 miles long in the Peoples' Democratic Republic of Yemen, Marconi has set up a mobile radio system with repeater stations powered entirely from solar cell panels.

The Dutch Connection

As part of a programme of diversification and expansion into new product areas, Electronic Brokers Ltd. has signed an agreement with Philips Electronics Instrument Division for the distribution of a wide range of test and measuring instruments.

This link with Philips, announced in London recently, means that Electronics Brokers will irovide an "off the shelf" service to the professional user of selected items in the Philip's test and measurement instruments. All items are on display in their new purpose-built showroom in King's Cross Road, London.

(right) Some of the Philips test gear being presented by Peter Fraiman (EB) and Ken Wheeler (Philips).

THE ELECTRONICS OF it INFORMATION TECHNOLOGY

PART THREE

BY T.E. IVALL C.Eng., M.I.E.R.E.

In Part 1 we saw how three aspects of an electrical quantity—magnitude, time and space—can be used for representing information coming from the outside world. In the next few sections we are concerned with the dynamic kind of electrical representation—the **signal**—and how these three aspects can be utilised in different ways for transmitting information.

PATHS FOR INFORMATION

Paths for information are basically the physical media, such as cables, optical fibres and electromagnetic wave propagation through space. But in IT we are more concerned with the ways engineers organise the electrical or optical information to travel through these media. So "path" here means a physical medium plus some kind of travelling representation.

Because of this dual nature of the path we must be careful to distinguish between the transmission processes that depend purely on physical laws and those that are introduced by the human engineer.

ASPECTS OF SPEED

In an electrically conducting medium, for example, an event such as a step change of voltage travels at approximately 300×10^6 metres per second (the speed of light). In Fig. 3.1(a) a step occurring at time t_{OA} would take approximately 3·3 nanoseconds to travel along the 1 metre of conducting path AB, arriving at B at time t_{OB}.

This step change could be a transition between two voltage levels representing binary states, part of a stream of digital data. So it could be followed by a similar step, t_{1A}, at an interval T_p after t_{OA}, as shown in Fig. 3.1(b). This would take the same time, 3·3ns, to travel from A to B and would arrive at B at t_{1B}, which is $t_{OB} + T_p$.

The point of this rather elementary analysis is to emphasise that the interval of time required to transmit a particular event such as the step change (for example, the interval $t_{OB} - t_{OA}$) is determined by a physical law associated with the medium, whereas the interval T_p is chosen by the engineer who designs the IT system.

If the engineer used, say, a train of eight pulses to represent an item of information, it would take $8 \times T_p$ for this sequence to be completely transmitted from point A, and $8 \times T_p$ plus 3·3ns before it was completely received at point B. In practical terms T_p might be 1 microsecond—considerably longer than the step transmission time of 3·3ns.

We therefore have to be clear in our minds what we mean when we talk about the "speed" of information transmission.

ELECTRICAL ENERGY

This leads us on to the most common of the physical media used for information paths—the electrical circuit. Here, of course, the fundamental quantity by which information is represented and conveyed is electrical energy—more specifically, the rate of delivery of energy through the circuit, or power. In practice, however, engineers don't usually consider power as representing the information, mainly because it's not very convenient to detect and measure the varying power flowing from A to B in Fig. 3.1.

The measuring instruments most commonly used in electronics responds to electrical quantities proportional to the power, in particular, potential difference and current. This may seem to complicate the picture a bit because in any circuit where charge is moving there must be an e.m.f. and this creates both p.d. and current. Which of these, then, represents the information?

The answer is, simply, whichever one the engineer has chosen to represent it. The other quantity is there as well, in the sense that we have means of measuring it, but it is not taken as significant as a bearer of information.

CURRENT SIGNIFICANT

As an example, Fig. 3.2 shows the basic principle by which information may be transmitted from one unit to another using current as the significant quantity. It can be seen that there is a complete electrical circuit passing through part of the transmitting unit and part of the receiving unit. Current flows in this circuit as a result of an e.m.f. existing at

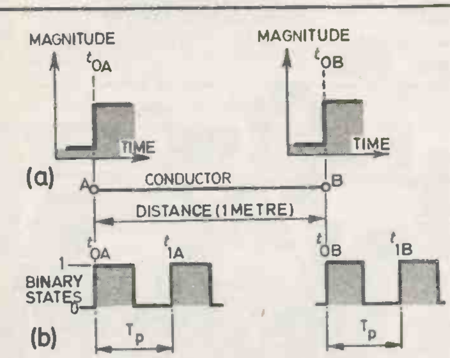


Fig. 3.1. Illustrating the difference between transmission time due to the physical nature of the medium—electrical conduction in the wire AB at (a)—and transmission time due to engineering parameters—such as the interval T_p between transitions in the binary data sequence (b). For convenience, time and distance scales are made to coincide at A and B.

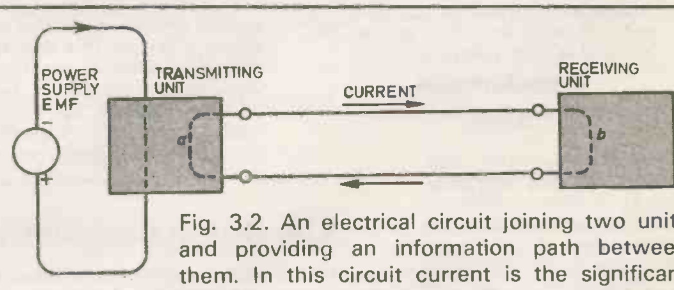


Fig. 3.2. An electrical circuit joining two units and providing an information path between them. In this circuit current is the significant quantity.

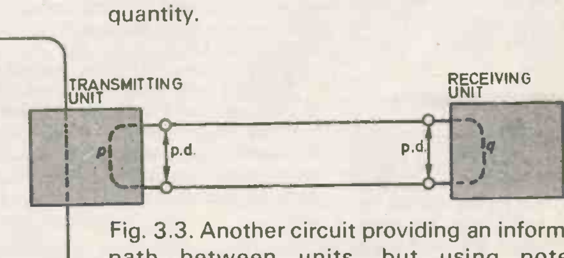


Fig. 3.3. Another circuit providing an information path between units, but using potential difference as the significant variable.

point *a* in the transmitting unit. (Without going into details, this originates from the e.m.f. source supplying power to the unit.) The current varies with time and this variation represents information (Part 1).

In the receiving unit, at section *b* of the circuit, there is a means of continuously responding to the value of the current. Thus the information represented by the current variation is conveyed into the receiving unit.

It would be possible, of course, to detect a potential difference (resulting from the e.m.f. at *a*) between the two output terminals of the transmitter, or between the two input terminals of the receiver, but this in itself is not significant because current has been chosen as the information bearing quantity.

POTENTIAL DIFFERENCE SIGNIFICANT

Figure 3.3 shows how information may be transmitted using potential difference (p.d.) as the significant quantity. Here again is a circuit completed through two units. There is a p.d. between the output terminals of the transmitting unit, resulting from an e.m.f. existing at *p*, and it is the variation of this p.d. which represents the information.

The input terminals of the receiver, being connected to the output terminals of the transmitter, have the same p.d. between them. (*Analogy:* the water level in a water gauge is the same as the water level in the tank to which it is attached.) This p.d. is present at *q*, where there is a means of continuously detecting it, so that the information represented by the variation of p.d. is conveyed into the receiving unit.

Again there is a current flowing in the circuit, but here this current is not significant as an information bearer. In some electronic systems designed to use p.d. as the significant variable the current flowing is extremely small, perhaps less than a microampere. In such cases, one can think of the information as being conveyed virtually by a variation of p.d. alone. In other cases the circuit is not completed at *q* (imagine the broken line absent) and the receiving unit detects the information as an electric field created by the p.d. at the input terminals.

VARIATIONS

Whether p.d. or current is the significant quantity, the information is conveyed by variations in this quantity (Part 1). The simple electrical circuit in Figs. 3.2 and 3.3 is used with continuously varying quantities such as voice signals and also with abrupt changes, like those in Fig. 3.1(b), produced by switches, pulse generators or other two-state devices.

INFORMATION CARRIERS

A motor car is a good form of transport on the open road, but on a

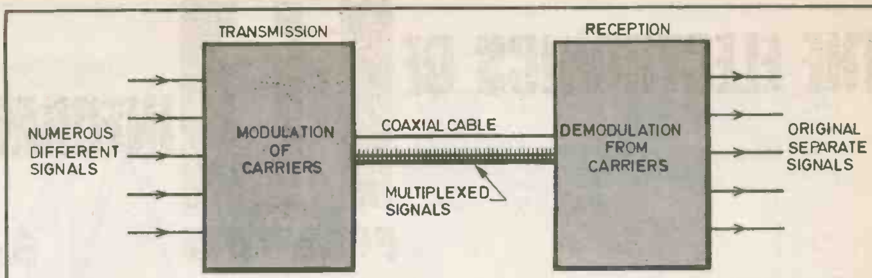


Fig. 3.4 (above). Basis of a carrier transmission system as used in telecommunications for multiplexing different signals on a common medium such as a coaxial cable (known as frequency division multiplex). For two-way transmission, modulation and demodulation of carriers is needed at both ends.

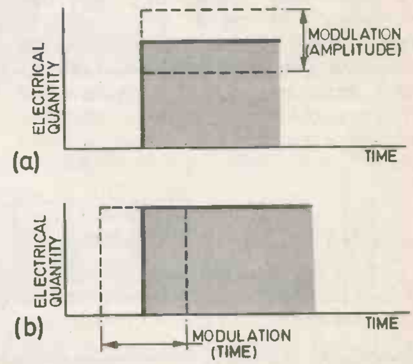


Fig. 3.5. How a periodic change can be used to carry information: (a) by modulation of amplitude; and (b) by modulation in time. The process in (b) is the basis of frequency modulation and phase modulation.

rocky track going up a mountain-side a mule is greatly superior. Similarly with the transport of information. Analogue and digital representations, as described so far, can be sent directly through some physical media but not through others. To cope with this the engineer uses **carriers.**

HIGH AND LOW FREQUENCIES

A radio transmitter, for example, depends on the use of an electrical oscillation to propagate electromagnetic waves through space: this oscillation functions as a carrier.

The public telephone network is not very suitable for transmitting directly the abrupt changes between steady voltages used as digital codes in data communications equipment. So the engineer uses oscillations near enough at voice frequencies—for which the network was originally intended—and conveys the code as changes between steady frequencies (a method called frequency shift keying). These oscillations, too, are carriers.

A trunk telecommunications system conveys a large number of different signals through a single, common medium such as a coaxial cable without mixing them up (Fig. 3.4). One of the main techniques for this multiplexing, employs a number of oscillations of different frequencies. (In a comparable way, many different radio signals are transmitted through the same volume of space but are nevertheless separable because of their different frequencies.) This is an example of using carriers to make the best use of the physical medium.

OSCILLATIONS

To understand the fundamentals of these techniques we have to look at two aspects of oscillations: how they can act as carriers of information; and the properties that enable them to be distinguished from each other.

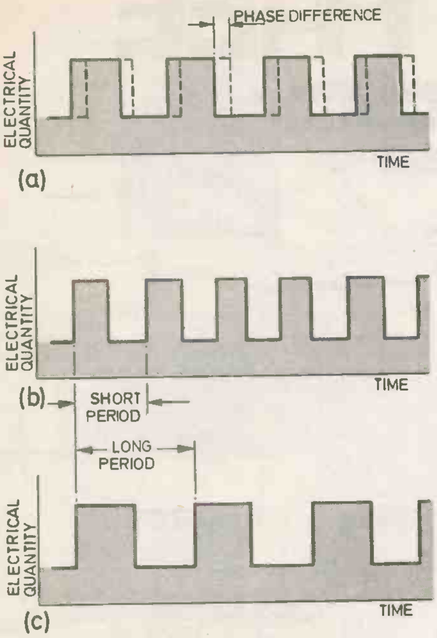
Since an oscillation is an electrical quantity that is changing with time periodically, it offers two possibilities for carrying information. We can vary the *extent* by which the electrical quantity is periodically changing; and we can vary the *time* at which a periodic change takes place.

This goes back to Fig. 1.3 in Part 1, which is repeated here for convenience as Fig. 3.5. At (a) the broken lines show how the extent, or amplitude, of the change may be varied; at (b) the broken lines show how the time of the change may be varied. In both (a) and (b) the process of varying a property in accordance with the information to be carried is termed **modulation.**

METHODS OF MODULATION

The general principle of being able to vary the timing of a periodic change can be used in several ways, to give oscillations with distinct properties. Some examples are shown in Fig. 3.6.

We can control the instants at which the electrical quantity rises and falls in such a way that the whole graph is displaced, as shown at (a). This produces a phase difference—the broken-line waveform has a different phase from the full-line waveform.



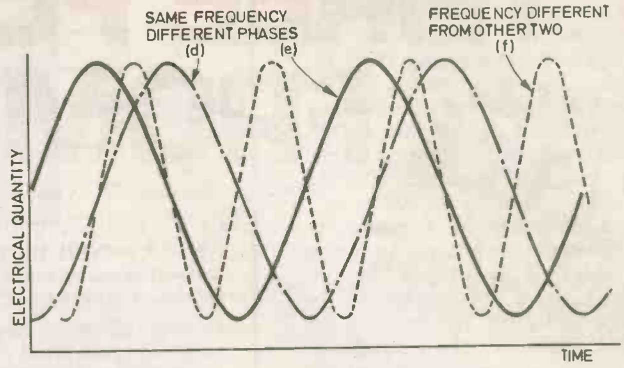


Fig. 3.7. Sinusoidal oscillations differing in phase only are seen at (d) and (e), while (f) has a different frequency from both of them. All the waveforms have the same amplitude, so are not distinguishable from each other in that way.

Fig. 3.6 (left). Square-wave oscillations illustrating fundamental properties of a periodic waveform: (a) shows a timing or phase difference, while (b) and (c) with their different periods show a frequency difference.

Alternatively, we can control the instants at which the rises and falls occur in such a way that the time intervals between the changes—the periods—are different from those in (a). This is shown in (b), which has shorter periods, and (c), which has longer periods. As a result, oscillations (b) and (c) differ in frequency from those in (a)—and, of course, from each other.

Figure 3.6 brings out two things. First, it shows us practical methods of modulation derived from the principle in Fig. 3.5(b): that is, phase modulation (a) and frequency modulation, (b) and (c). Thus, with the amplitude modulation in Fig. 3.5(a), we have three methods altogether. (There are in fact others, but they are all based on the fundamental processes illustrated in Fig. 3.5.)

DISCRIMINATION

Secondly, Fig. 3.6 shows us properties by which several oscillations travelling through a common medium may be distinguished from each other—notably the properties of frequency and phase. Of these, frequency is the most widely used—for example, tuning a radio receiver to stations on different frequencies.

The property of phase discrimination is utilised in systems which enable two different signals to be transmitted simultaneously with the same carrier frequency and yet be separated when received*. It is also used in trunk telecommunications, in transmission systems which depend on timing relationships for multiplexing different signals.

SINUSOIDAL OSCILLATIONS

What we have discussed so far has been illustrated by square-wave oscillations. Fig. 3.7 shows how these principles apply to sinusoidal waveforms, which are the most common form of carrier oscillations. The oscillations (d) and (e) differ in phase though they have the same frequency. Oscillation (f) differs from (d) and (e) in its frequency. (Note that a difference in frequency inevitably means a difference in timing, or phase, as well, but that a phase difference can exist without a frequency difference.)

DEMODULATION

The different frequencies of oscillations used as carriers enable the carriers to be distinguished and separated from each other. Various devices are used. They respond selectively to the different periods of the oscillations and so can separate the carriers, and the signals they carry, from each other. Then the original voice, data or other signals must be removed from the carriers by demodulation (right-hand side of Fig. 3.4), the opposite process to the modulation principle described above.

For data communications, a demodulator usually works alongside a modulator, since both are needed at each end of a system to allow two-way transmission. The two are normally combined into a single unit termed a modulator-demodulator, or **modem**.

To be continued

* For example, in colour television, to carry two different sets of colour information on the same subcarrier frequency (4·43MHz in the British PAL system).

SPECIAL OFFER DECEMBER ISSUE

— *MINI 20 MULTIMETER* —

Readers will observe that an error occurred in the coupon (page 789) where £19 was quoted. The Special Offer announcement made clear in large type the correct price of £19.50.

The correct amount of **£19.50** should be forwarded with orders for this multimeter.

We apologise for this error.

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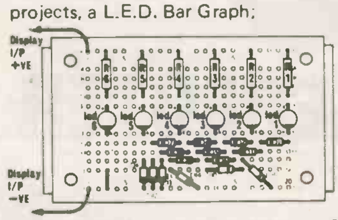

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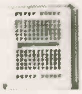

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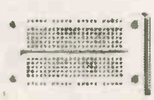

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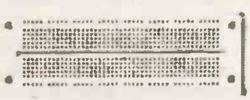

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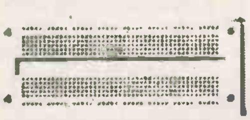

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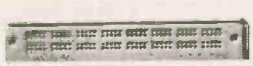

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TO COMPLEMENT
THE SECURITY
VARI-LIGHT

OPTO REPEATER

BY A.R.WINSTANLEY

THE Opto Repeater is designed for use in conjunction with the Security Vari-Light project (last month) and serves to present a more realistic overall illusion to the prospective prowler.

Although the Security Vari-Light will operate a single lamp (or combination of lamps not exceeding 500W), the disadvantage is that only one room can be controlled in this manner.

The Opto Repeater utilises a phototransistor to detect when the main Security Vari-Light is on and, when illuminated by the main lamp, operates a secondary lamp for a preset period.

OPTICAL COUPLING

Thus a system of optical links are used to enable the "master" lamp to control lights in other rooms, so that a larger section of the household appears to be inhabited at night.

The design has been kept simple, the use of complex logic circuitry having been avoided, since the constructor may well wish to assemble more than one unit for use around the home. The low cost of the Opto Repeater will help him to do this.

CIRCUIT DESCRIPTION

Fig. 1 illustrates the circuit diagram for the Opto Repeater. TR1 is the remotely located photo-transistor connected via PL1 and SK1 to the trigger input (pin 2) of IC1. This integrated circuit is a 555 timer wired as a simple monostable, the period of which is determined by R2 and C1. This *RC* network sets the time period to about 8 minutes or so but this may vary in reality, due to quite large manufacturing tolerances on C1.

When TR1 is in darkness, it in effect exhibits a high resistance, such that pin 2 is virtually at the supply potential. However, as light starts to fall upon the photo-transistor the voltage at its collector will fall, bringing down with it the trigger input of IC1 until it triggers.

Thus when the Security Vari-Light illuminates, the position of TR1 will be such that the phototransistor will be illuminated as well, causing IC1 to trigger.

When the i.c. commences timing, its output (pin 3) rises to a little less than the supply rail voltage and this causes a mains-rated relay RLA to activate. Consequently the contacts RLA1 close and complete a circuit between the mains supply and the remote lamp plugged into SK2.

The timer i.c. will then continue with its timing cycle and under normal circumstances the relay will deactivate at the end of the timing period, thereby extinguishing the remote lamp.

In fact, for *normal* operation to occur it is necessary that the triggering period is less than the timing period set by R2 and C1. This means that the Security Vari-Light must illuminate TR1 for a period less than the timing period of IC1.

If the trigger time exceeds the *RC* timing period then the i.c. will re-trigger and commence timing again until the trigger signal diminishes, that is, the master lamp extinguishes. The Opto-Repeater's timer will then reset itself also.

MAINS POWER

The Opto Repeater is mains powered through T1, a centre-tapped transformer which steps down the mains voltage applied to its primary winding to about 12V a.c. This is full-wave rectified by D3 and D4, and is then smoothed by C4 to produce a d.c. potential of approximately 16V within the maximum rating of the timer i.c.

R3 and C3 form a filter which reduces the ripple present after smoothing, to give an improved supply rail quality.

Mains power is switched by S1. In the SECURITY mode, the Opto Repeater operates as dictated by the light falling upon the phototransistor; in the BYPASS position, power is routed straight through to SK2 via F2 so that the electronic circuit is disconnected and the lamp is continuously illuminated. In the centre OFF position, both lamp and timer are disabled.

However, the presence of an arc suppressor, X1, means that some power may be transmitted through it when S1 is in the BYPASS mode. This means that although the transformer primary may appear to be disconnected, the electronics may in fact be partially operative, but this is nothing to worry about.

Phototransistor mounted in a clear fronted plastic box.

COMPONENTS

Resistors

R1	100kΩ
R2	4·7MΩ
R3	15Ω

All ¼W carbon ±5%

Capacitors

C1	100µF, 25V elect, radial lead
C2	0·01µF polyester C280
C3,4	470µF, 25V elect, radial lead (2 off)

Semiconductors

D1,2	1N4148 silicon (2 off)
D3,4	1N4001 silicon (2 off)
TR1	2N5777 *npn* photo-darlington
IC1	555 timer

Miscellaneous

T1	Miniature mains transformer, 12V-0-12V, 100mA secondary
S1	d.p.d.t. centre-off miniature toggle
SK1	3·5mm jack socket
SK2	Mains panel mounting socket
PL1	3·5mm jack plug
PL2	Shrouded pin mains plug (for SK2)
FS1	20mm, 500mA fuse with chassis mounting holder
FS2	20mm, 2A fuse with p.c.b. mounting clips
LP1	240V mains neon indicator with integral limiting resistor
X1	Mains R-C contact suppressor
RV1	Mains transient suppressor Z250D
RLA	Ultra miniature high power mains relay, 12V, 400Ω coil, contacts rated at 240V, 10A

Console type case, 215 × 130 × 78mm (rear) × 47mm (front)—BIM type 1006; clear plastic box, 60 × 45 × 25mm (for phototransistor); single sided glass-fibre p.c.b. 92 × 45mm; 8 pin d.i.l. holder; 24/0·2mm wire (for mains wiring); 7/0·2mm wire; 3-core, 6A mains cable; twin core cable (approx. 4m); 3-way tag strip (2 off); grommet; P-clip; standard 3-pin mains plug with 5A fuse; self-adhesive feet (4 off); Veropins; mounting hardware (nuts, screws, washers and p.c.b. guides).

See **Shop Talk** page 23

COMPONENTS approximate cost £18 excluding p.c.b.s, & case

LP1 is the POWER ON indicator formed by a neon bulb with integral limiting resistor. It may light up when S1 is in the BYPASS setting; this can be attributed to the location of X1, and be disregarded.

RV1 is a mains transient suppressor but this, along with X1, is optional and may not prove entirely essential. Both the transformer and lamp are fuse-protected by FS1 and FS2 respectively.

CONSTRUCTION starts here

PRINTED CIRCUIT BOARD

Since both mains and low d.c. potentials are intermixed in the circuit, the unit has been constructed on a single printed circuit board, see Fig. 2.

Construction is straightforward with the following possible exceptions. RLA is an "Ultra Miniature High Power Mains Relay", available from Maplin, part number YX97F, and other types may not be pin-for-pin compatible with the holes drilled in the p.c.b.

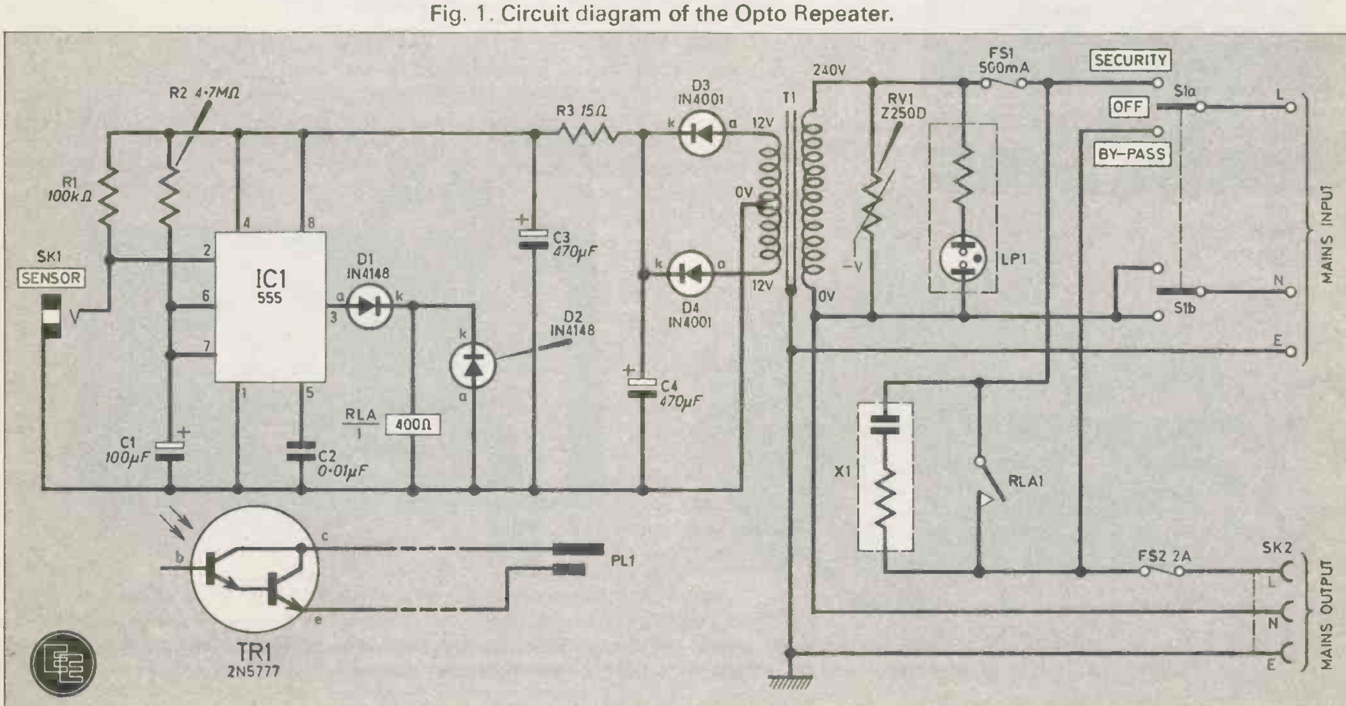
FS2 is a printed circuit mounting type 20mm fuse clip and four 1·5mm diameter holes are required in the circuit panel, as indicated. It may also be wise to use an 8-pin i.c. holder for the timer.

CASE

The case chosen for the project was a plastic console, type BIM1006 which measures 210 × 125 × 41mm (front) × 62mm (rear), with an aluminium top panel. SK2 was fixed on one side of the box with the jack socket SK1 fitted to the rear. The neon lamp and toggle switch were fitted on the front panel.

Four mounting holes, one in each corner, are shown in the p.c.b. which permit mounting by M2·5 or 6BA screws, nuts

Fig. 1. Circuit diagram of the Opto Repeater.



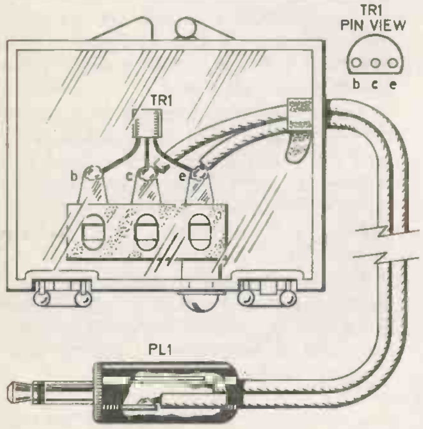
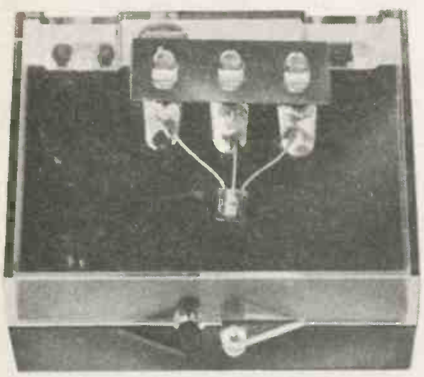
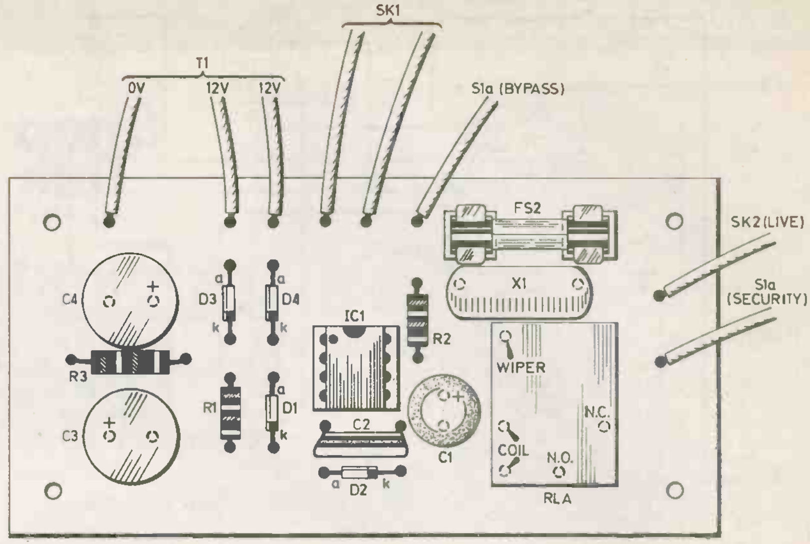


Fig. 4. Assembly of the phototransistor unit. Note that the curved face of TR1 is photosensitive.



Plastic "stylus" box housing tag strip and TR1.



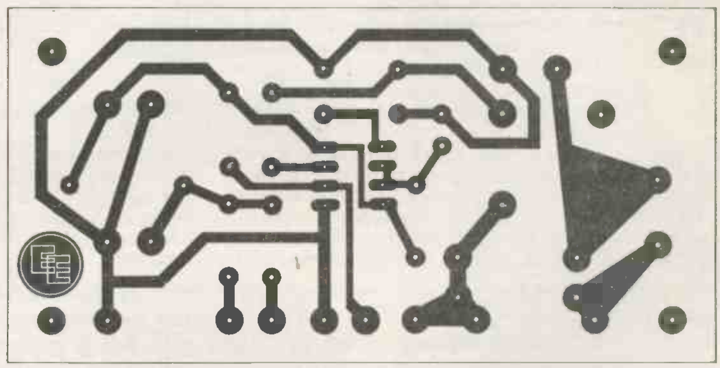
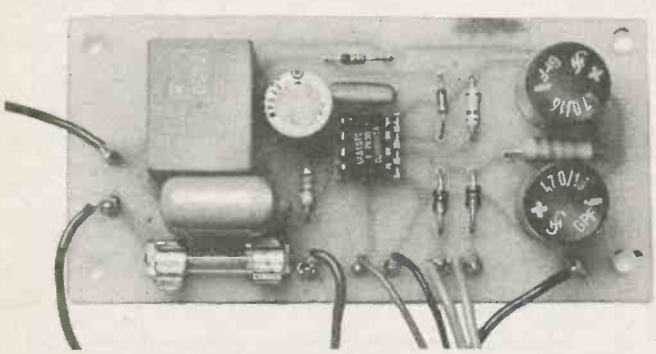
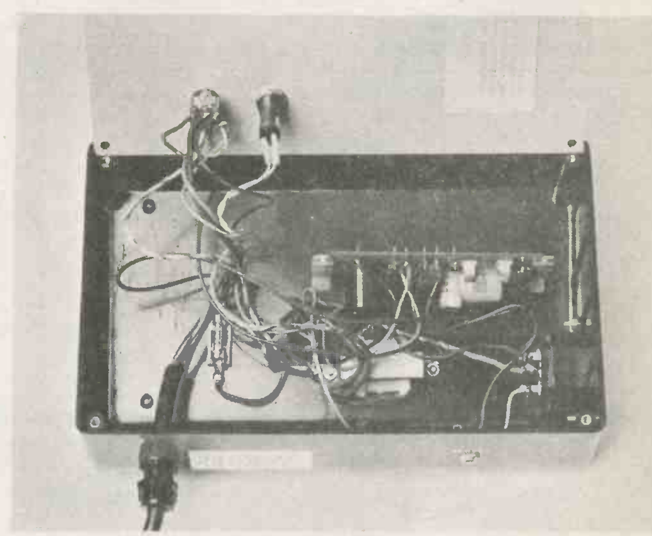


Fig. 2. Full size track pattern and component layout for the Opto Repeater circuit board. Note that the board is designed to accept the Maplin "ultra miniature high power mains relay".



The completed prototype p.c.b. assembly. Note the use of an i.c. holder for IC1 and Veropins for all wired connections.



View inside the console case showing the relative positions of the main components.

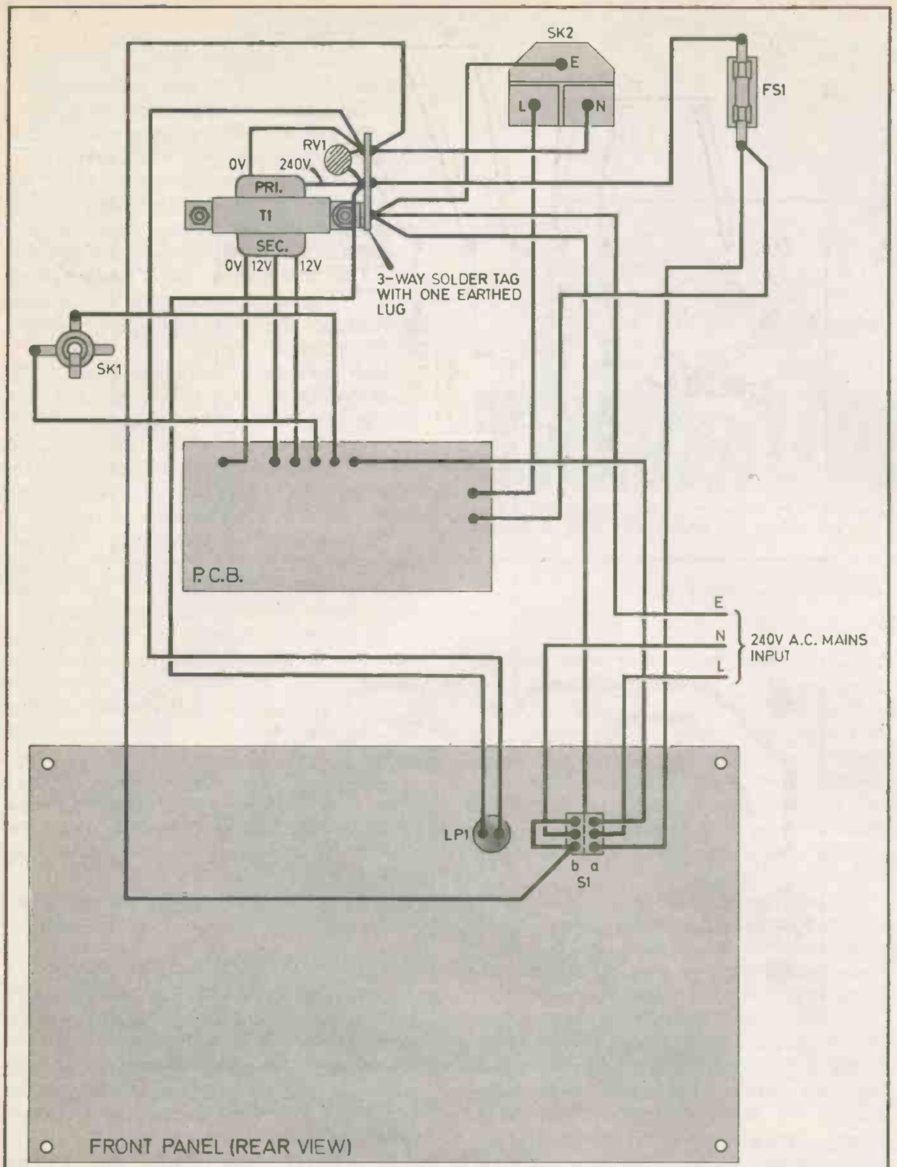


Fig. 3. Interwiring diagram. Mains input cable must be securely clamped with a cable clamp or strain relief gland.

and spacers but the prototype was mounted vertically using special plastic clip-in guides.

It is *essential* to ensure that if the p.c.b. is fitted vertically, there is no possibility whatsoever of the fuseholder FS2 coming into contact with the metal front panel. It is desirable therefore to place the p.c.b. such that FS2 is downwards, against the floor of the non-conductive case.

WIRING

Full interwiring details are given in Fig. 3. Mains wires must have a rating of 4·5A 250V a.c., typically a 24/0·2mm wire. It is a good idea to insulate all mains soldered joints with p.v.c. sleeving to avoid accidental shocks.

Other wiring can be completed with 7/0·2mm general purpose wire. Several flying leads come from the p.c.b., some of which are mains-rated, and the point at which they connect with the board, terminal pins should be used.

A three-way tag strip carries connection for the neon lamp and mains transformer as shown in the construction diagram, and one of the tags is earthed and screwed to one of the transformer mounting screws. Thus it is through the tag strip that the transformer is earthed.

It is necessary to earth the metal front panel of the console and this can be achieved by soldering an earth wire to the metal body of the switch, or by placing a large automotive-type tag under S1 mounting nut inside the case.

Furthermore, it is important that precautions are taken to ensure that the three-core mains cable is secured so that it cannot pull out. A grommet should be fitted at the point of entry and some form of retention clip must be used to secure the cable.

PHOTOTRANSISTOR

The phototransistor was soldered to a three-way tag strip and then bolted into an old hi-fi stylus box which had a transparent front. The curved face of the transistor must point outwards since this is the light-sensitive side of the device. See Fig. 4 for details.

Twin-core cable can then be used (maximum length of about 4 metres) to connect TR1 to the console by means of a 3·5mm jack plug and socket.

TESTING

With construction now completed, check the wiring thoroughly, especially those sections of the assembly which are at mains voltage. Connect a suitable mains lamp (500W maximum) to the 6A Euro-type plug and insert this into the console. Also connect the phototransistor unit but place it in complete darkness, for example, in a light-proof box. Plug the Opto Repeater into the mains, with a suitably fused 5A plug.

Set S1 to the SECURITY position and the lamp may illuminate straight away. However, after a delay of up to about 10 minutes it should extinguish. By temporarily exposing the phototransistor to light, the mains lamp should illuminate for a controlled time period.

If this period is too long, in excess of 15 minutes, then the method of correcting this is to reduce the value of R2 on the printed circuit board.

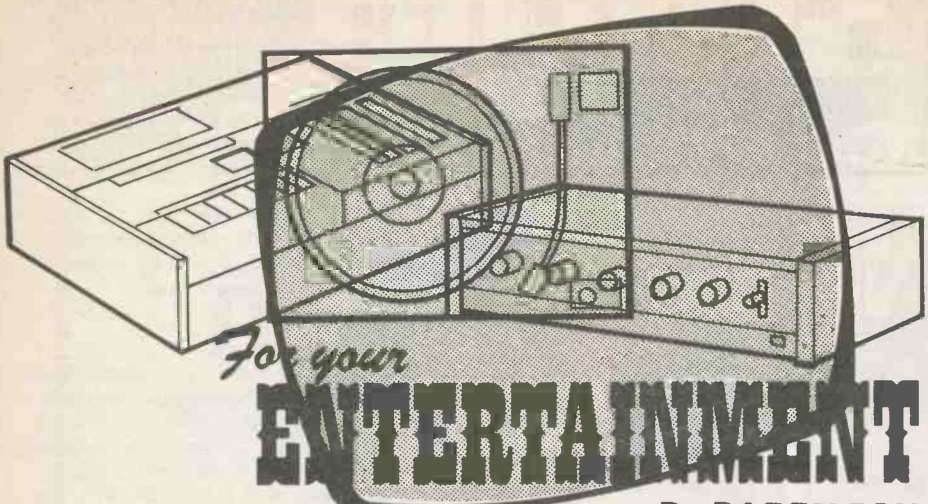
If illumination of TR1 does *not* cause the mains lamp to operate, then check that the wiring of TR1, both at the tag strip *and* the jack plug. Also make sure that TR1 is facing the right way. You should also hear the relay click on and off—this indicates that the phototransistor is triggering the i.c.

INSTALLATION HINTS

It is obvious that the main Security Vari-Light needs to be positioned first and then the location of the phototransistor controlling the Opto Repeater can be determined. The phototransistor must be placed so that when the main lamp is extinguished it is in relative darkness, and when alight it is exposed to that light. Tests carried out on the prototype showed that the distance between the sensor and main lamp can be up to about four metres.

It is important that light from the "remote" lamp does not fall onto the phototransistor controlling it. If this should happen, the Opto Repeater will latch, so that the remote lamp will be continually alight.

If a bedside lamp is used in conjunction with the Opto Repeater, and this is the author's anticipated application, then it is desirable that the console is placed by the bedside with the lamp to enable the user to switch the bedside lamp on and off using the BYPASS facility. Then it is essential that the phototransistor is placed *outside* the bedroom so no optical feedback problems should arise. □



For your ENTERTAINMENT

By BARRY FOX

Cordless Call

You will probably have seen reports in the press that cordless telephones are now to be made legal in Britain.

A cordless phone, which uses a two-way radio link between a base station connected to the phone line and the handset, has until now been taboo on two counts. British Telecom has refused to authorise cordless connection to British phone lines and the Home Office has refused to allocate any frequencies for the radio links or issue any licences for their use.

British Telecom is empowered to disconnect the exchange line of any subscriber who uses unauthorised equipment, and anyone using an unlicensed radio link is liable to prosecution under the Wireless Telegraphy Act. The penalty under the WT Act is up to £400 in fines and/or up to three months in jail.

By a quirk of British law it's not illegal to sell cordless telephones, only to use them. And because cordless phones can be legally used in America they are now mass produced in the Far East and the price has dropped sharply.

A couple of years ago the minimum cost of a cordless phone offered by mail order or from specialist gadget shops was at least £250. But over the last year it's been easy to buy a cordless phone for under £100.

For a year now Tandy has had one in its catalogue for £79.95. A small note at the bottom of the Tandy advertisement reads *"Not GPO approved"* but it's unlikely that this deters anyone from using it. Also there's no warning from Tandy about the penalties which the user may incur under the Wireless Telegraphy Act.

Clear Distinction

The situation became even more confusing last year with popular press reports that the use of radio telephones had become "entirely legal" under the new laws liberalising British telephone systems. This is by no means the full story because it's important to draw a clear distinction between radio telephones and cordless telephones.

Until late 1979 the only means of directly calling, or receiving a call, from a mobile phone, for instance in a car, was on a system rented from the Post Office. But some enterprising firms, such as Securicor, provided private mobile radio links which enabled their customers to relay messages over the phone by radio.

The subscriber called in by mobile radio link to the private firm whose operator then acted as an intermediary for telephone messages. But there was no direct radio hook-up with the phone network.

In the Autumn of 1979, the Post Office started to allow private firms like Securicor to patch their incoming radio calls direct into the British telephone system. At around the same time the Post Office, which changed its name to British Telecom, expanded its own mobile phone system.

Originally Post Office mobile phones were purely manual, that is to say the subscriber in a car had to call up a British Telecom operator who then manually patched the call into the British telephone network. But in early 1981 British Telecom started to provide an automatic radio phone service which allowed people in cars to dial, or more accurately key, calls direct into the British telephone network.

An automatic car phone is used exactly as if it were a phone at home or on the office desk. But the private services still remain manual, that is to say a mobile caller in a car has to go through a patching operator.

These private, and British Telecom, services are expanding all the time and to provide more air space a chunk of the UHF spectrum at around 900MHz has been allocated, half to the private sector and half to British Telecom. But curiously there are still no firm plans to follow the lead set by America and Japan, and provide similar direct dialling from pay phones on trains. Mobile radio in Britain remains a luxury for the rich businessman.

Almost Legal

But those budget cordless phones, which enable subscribers to take and make calls from the garden or while wandering round the office unencumbered by a trailing cord, are now to become legal. Well, almost!

The recent announcement, from the Department of Industry and Home Office, authorising the use of cordless extension telephones in Britain is *very* unsatisfactory. The only reason that it has produced little critical response is that few people understand the true significance of the announcement!

After repeatedly protesting that no frequencies were available for cordless phones, the Home Office suddenly "found" channels between 1362kHz and 1792kHz for the base station transmitters and channels between 47·45MHz and 47·55MHz for the handset transmitters.

The low frequency base station channels exactly match those used on the foreign cordless phones which have for several years been widely on sale in Britain. But these cordless phones use handset frequencies of around 49MHz, whereas, the Home Office allocations are of around 47MHz. So, everything that's been sold in Britain over the last few years will remain illegal.

Is this just bureaucratic spite, or is there a good reason for legalising a frequency range just 2MHz away from that which has become a *de facto* standard, albeit unauthorised? The Home Office can only say vaguely that "49MHz has a greater potential for interference".

Only Temporary

Even more surprising is a warning, buried deep in the tortuous wording of the Government's official statement. Even the allocated frequencies are only *temporary*. Other quite different frequencies will be allocated for cordless phones over the next couple of years.

At any time after 1986, the cordless phones which the Department of Industry and Home Office are now authorising, *will* become illegal again. So cordless phones sold over the next few years will quite literally have to be junked at some (yet to be specified) time after 1986!

The Home Office and Department of Industry can say only vaguely that they have consulted with the trade over this and the trade doesn't seem "too concerned or too worried about the temporary nature of the frequencies". Who did the Department of Industry and Home Office consult? Over 30 firms, all on the Mobile Radio Committee, were consulted. They included GEC, Philips, Plessey, Marconi, Pye, AEG Telefunken, Redifusion and Motorola.

Realistically I doubt whether any of these firms will be selling cheap cordless phones anyway, so it's not surprising that they aren't too worried about what happens after 1986. But how will the public, and trade, feel when they wake up to the fact that equipment sold with Government authorisation over the next few years will have to be replaced long before it wears out?

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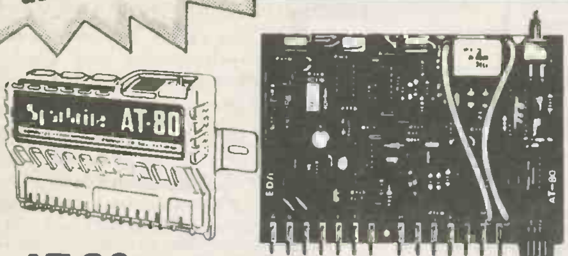

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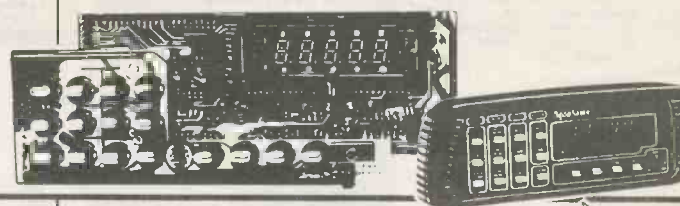

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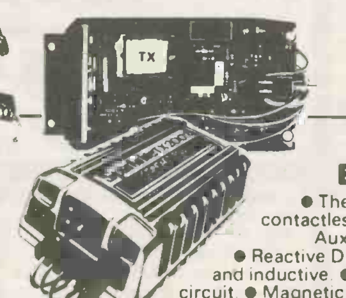

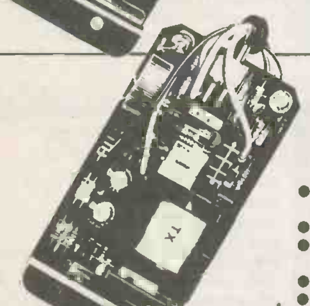

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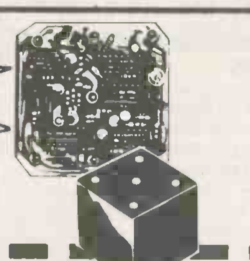

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RADIO WORLD

By Pat Hawker, G3VA

Cost of TV

The prospects of 30 or more cable television channels in the UK in this decade, endorsed by the Hunt Committee, has certainly opened up "a winter of debate". Can highly regulated broadcasting exist alongside virtually de-regulated cable? Will the prospect of 30 channels along co-axial cable or fibre-optics kill stone dead the possible demand for home receivers for 12GHz direct broadcast satellites? Does more mean better?

What about the cost? The net revenue of the ITV programme companies has been estimated as about £650-million. The highly ingenious method of financing Channel Four means that it will have about £100-million a year to spend on programmes, that is about £30,000 per hour.

Like BBC-2 it has limited hours of operation. By comparison, production costs of "commercials" can be astronomical. For example Birdseye have revealed that the average cost of their commercials rose from £9000 in 1970 to £50,500 in 1980, which would represent a per-hour cost of several million pounds. In practice television drama costs around £100,000 per hour.

A recent study by A. S. C. Ehrenberg and T. P. Barwise of the London Business School has been published on "How much does UK television cost?" This is concerned not with the cost of producing the material but with what it costs the viewer.

The authors find that it costs the viewer roughly 2p per hour to watch BBC programmes (paid for by the licence fee) or about 1·5p per hour to watch ITV. This is calculated on the basis that advertisers spend about 3p per viewer per hour but about half of this results from advertisers spending less on other forms of marketing.

Thus, in effect, it costs viewers an extremely modest sum in relation to the cost of the programmes—but this, of course, is because there are many millions of viewers. It is why it costs so much less to watch a major star-studded film on television than in the cinema where the cost can approach £1 per hour.

Cable Vision

The cable operator, particularly without "pay-as-you-view", is going to find it difficult to provide many channels of high-quality programmes unless he charges considerably more than the £10 per month that has been suggested. And as the price goes up, the number of people willing to subscribe is likely to go down. Viewers who want more choice than they can get from four broadcast channels are likely to already have video cassette recorders or video discs.

What this could mean is that cable will attract just enough subscribers to reduce the broadcast audiences, and hence the money available for programmes, but without themselves generating enough revenue to permit the production of good new material. The store of old feature films is finite and all the signs are that production of high-cost films for the cinema is rapidly falling—in 1981 Hollywood made only about 120 major films and the 1982 figure is likely to be under a hundred.

Ehrenberg and Barwise point out that "although advertising is a cost-effective way of paying for ITV, there is no scope for major increases in the amount of TV, funding by advertising is limited. Direct competition for the same source of revenue would also produce unwanted side-effects on the range and quality of programming."

I shall believe in 30 worth while cable programmes only when I can see them. Before I subscribe I shall want to know a lot more about how much it will all cost me. than I have been told at present!

Secret Moves

The Radio Society of Great Britain, the national society of British radio amateurs, was founded as the Wireless Society of London way back in 1913, although since going "national" it has often been accused of being too London orientated. For its first quarter-century it had offices in Victoria Street close to the Houses of Parliament. On the outbreak of World War 2 these were closed and for a few years the society was run from the north London home of its then general secretary, the late John Clarricoats, G6CL.

In 1943 it came back to central London, this time to Little Russell Street, close to the British Museum in Bloomsbury. Then in the mid-sixties it moved a half-mile or so to Doughty Street. Now it has suddenly moved out of London to larger premises at Alma House, Cranborne Road, Potters Bar, Herts. For reasons best known to the society, the move was kept secret from the members until just a day or two before it happened.

It is often said that to a Londoner the "north" begins at Watford. I see that Potters Bar (near Barnet) is slightly north of Watford so the move should please north-country members!

British amateurs are now permitted to use all three of the new h.f. bands at 10, 18 and 24MHz although very severe restrictions have been placed for the time being on 18 and 24MHz. At present all three bands are largely confined to Morse or teleprinter operation (18 and 24MHz by Home Office regulations, 10MHz by voluntary band-planning agreements).

There are also still a lot of commercial stations operating within these bands, particularly in the 10·1 to 10·15MHz band. Indeed it would sometimes appear that there is considerably less commercial activity outside the 10MHz band than inside it.

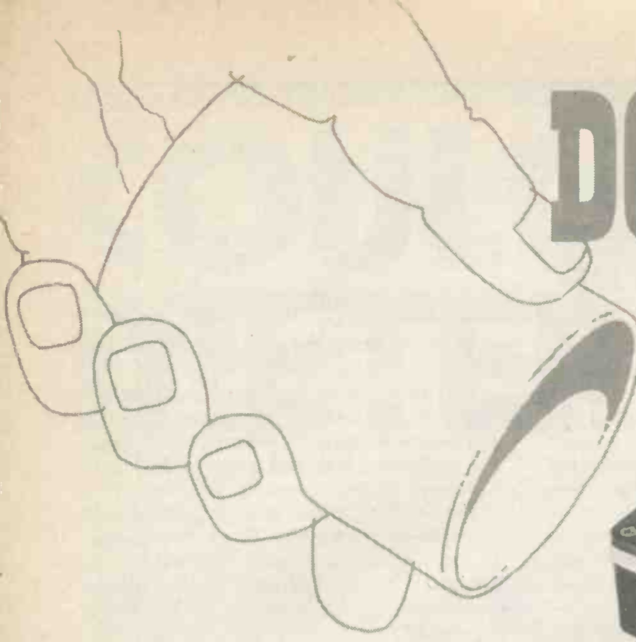
Nevertheless, it is proving an interesting band with a mixture of European and long-distance working. At present amateur activity on 18 and 24MHz is still very low.

CB Success

The first anniversary of legal CB in November served to underline the extent to which this non-examination, two-way, radio facility has already merged into the general background of consumer electronics. About 350,000 licences, costing £10 each and covering up to three units, represent a sufficiently high figure to show that the demand was really there and the CB is here to stay. Admittedly, it is not the "millions" that a few rash people suggested—but it represents a total some ten times that of British amateur radio licences that have been available for many years, but only to those prepared to pass the examinations.

Interference by CB, particularly from the illegal amplitude-modulated transmitters, continues to be a problem for the users of other consumer electronics, though in many instances this reflects the poor electro-magnetic compatibility (e.m.c.) of the domestic receivers and audio equipment rather than any deficiency in the CB equipment. Legal CB is already becoming "respectable" and it is from such operators that now come the most vehement complaints that the authorities should do more to enforce their own rules and stamp on bad language, deliberate interference and the use of high-power s.s.b. transceivers. Some claim that unless more is done they will forget to renew their CB licences and revert to "pirate" operation.

The British communications industry appears to have concluded that there is little hope of competing successfully with the imported 27MHz equipment. However, at least one small British firm is now making 934MHz equipment—virtually an interference-free if short-range band—retailing at about £250.



DOUBLE DICE

BY D.W. CRABTREE

THIS article describes the construction of a unit that was primarily designed as a novelty item for use in board-games and other games normally played using one or two dice. It may also be found useful for more serious purposes where digital pulse generators and random generators are required.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Double Dice is shown in Fig. 1. It can be seen to consist of two sections (upper and lower) identical except for timing component values in the early stages of each section. Both sections are powered by the same PP3 battery B1, and S1 connects this to the circuitry.

Diode D15 is provided to prevent any supply being incorrectly connected to the rails if someone tried to attach the battery leads with the connector reversed. This is very easily done when replacing batteries, and would damage the CMOS i.c.s.

The operation of each section is the same and only the upper section will be described. The difference between the two is that the upper circuit operates with pulses running at about 5kHz, while the lower has pulses running at about 10kHz.

When S1 is pressed, IC1 (and IC2), a 555 timer i.c. connected as an astable ("free running" oscillator) will give a continuous output pulse train at pin 3. When S1 is released, the output pulses cease.

The pulses reach IC3 which is a CMOS octal counter with 8 decoded outputs. Only one output is on (high) at any one time which corresponds to the number of pulses inputted to IC3 at pin 14. Since only outputs 0 through to 5 are required (only six equally possible dice states), they are connected to reset after output 5 is reached. This is achieved by feeding output "6" to the reset pin on IC3. These six outputs are then used to derive the required dice displays in various combinations to imitate the conventional dice "spot patterns". See Table 1.

The six outputs from IC3 need to be encoded to realise the appropriate display pattern as outlined in Table 1. This is accomplished with the aid of the gates contained in i.c.s. IC5 and IC6.

The outputs from these CMOS gates are not able to supply the necessary current to light the l.e.d.s (D1 to D7) direct. Transistors TR1 to TR4 are required to supply the necessary current boost being driven from the gate outputs via base resistors R5 to R8. As the transistors are turned on, the appropriate l.e.d.s connected to its collector lights up.

When S1 is not operated, two numbers will be displayed on the l.e.d. arrays. When S1 is pressed, the oscillators are activated. Since these are running at a high frequency the counter outputs are changing rapidly through 1 to 6 and all l.e.d.s appear to be on dimly. On releasing S1, the oscillators are turned off and the current count in IC3 decoded and displayed on D1 to D7.

The running frequencies of the oscillators may be altered by changing one or more of the timing component values, R1, R2, C1 (or R3, R4, C2). The values may be calculated from the formula:

$$f = \frac{1}{0{\cdot}7(R1 + 2R2)C1}\ \text{Hz}$$

R in ohms, C in farads.

COMPONENTS

Since the device was intended to be battery operated, the choice of CMOS devices was essential for reasons of economy. Standard 555 timers were chosen although CMOS 555s were considered to give even longer battery life. Unfortunately l.e.d.s require a lot of current compared to that taken by CMOS devices, so, any saving from using CMOS 555s would be negligible.

Any oscillator frequency could be chosen but the higher the frequency, the more random the result becomes.

It was decided at the outset to use 0·1 inch matrix stripboard for this project to help keep final costs at a minimum, but for anyone with p.c.b. making facilities it would probably be better to design a p.c.b. and thus save space and reduce wiring complexity.

Table 1: Display Pattern Generation

Dice Display	L.E.D.s Required Lit	Transistors On	Decode Output (Pin No. in brackets)
1	D4	TR1	0 (2)
2	D1, D7	TR2	1 (1)
3	D1, D4, D7	TR1, TR2	2 (3)
4	D1, D7, D3, D5	TR2, TR3	3 (7)
5	D1, D7, D3, D5, D4	TR1, TR2, TR3	4 (11)
6	D1, D7, D3, D5, D2, D6	TR2, TR3, TR4	5 (4)

COMPONENTS

Resistors

R1,2	4·7kΩ (2 off)
R3,4	15kΩ (2 off)
R5–12	3·3kΩ (8 off)
R13	56Ω

All $\frac{1}{4}$W carbon ±5%

Capacitors

C1	0·01μF plastic or ceramic
C2	1500pF plastic or ceramic

Semiconductors

D1–14	TIL220 0·2in red l.e.d.
D15	1N4001
TR1–8	BC214 silicon *pnp*
IC1,2	555 timer i.c.
IC3,4	4022 CMOS octal counter
IC5–8	4000 CMOS dual 3-input NOR plus inverter

Miscellaneous

B1	PP3 9V
S1	Push-to-make push-button
S2	Single pole slide or toggle

Stripboard: 0·1in matrix size 34 strips × 12 holes, (2 off), 11 strips × 22 holes, clips for l.e.d.s (14 off); i.c. sockets d.i.l. 14-pin (6 off), 8-pin (2 off).

Approx. cost Guidance only £8

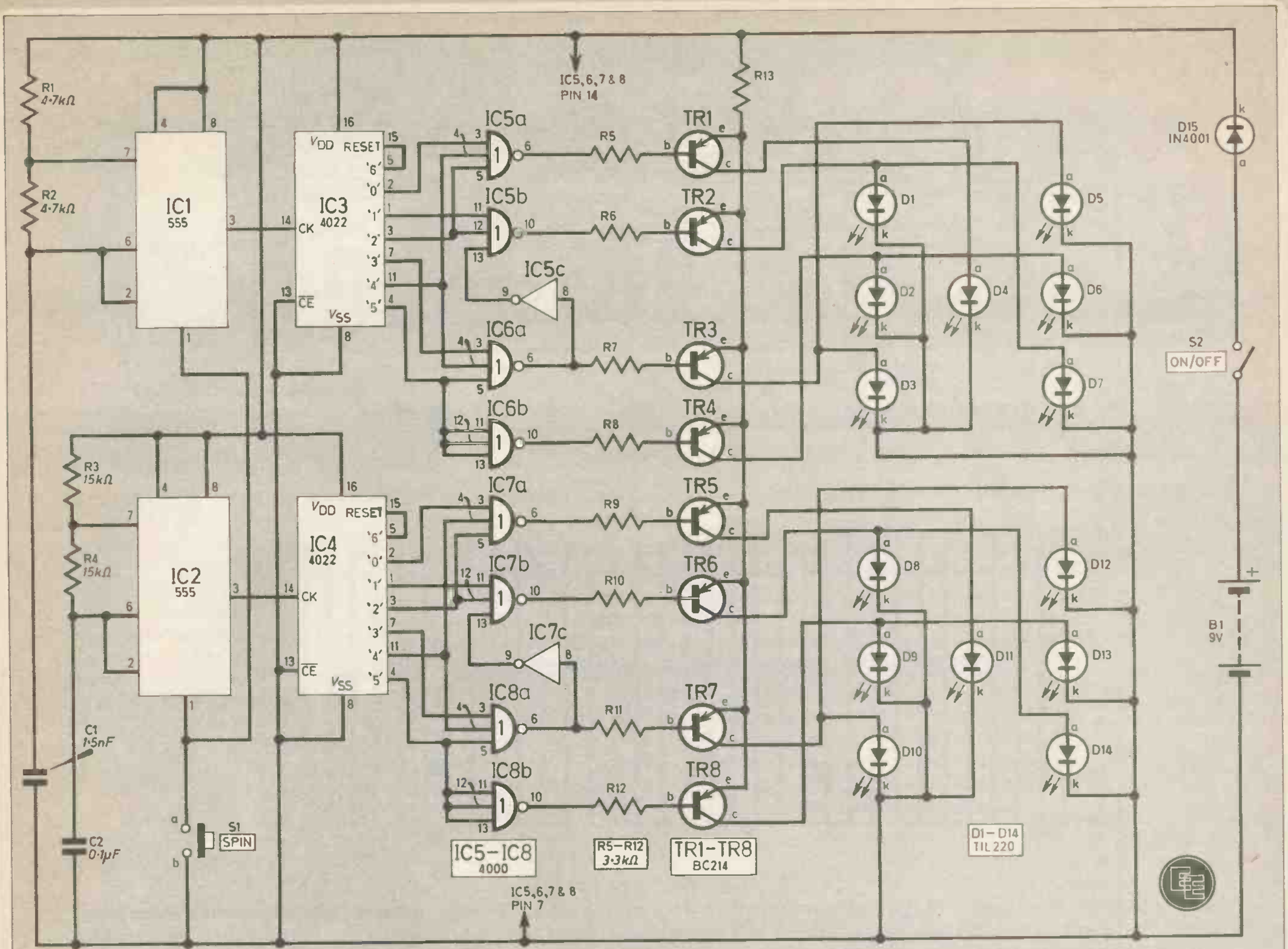


Fig. 1. The complete circuit diagram for the Double Dice.

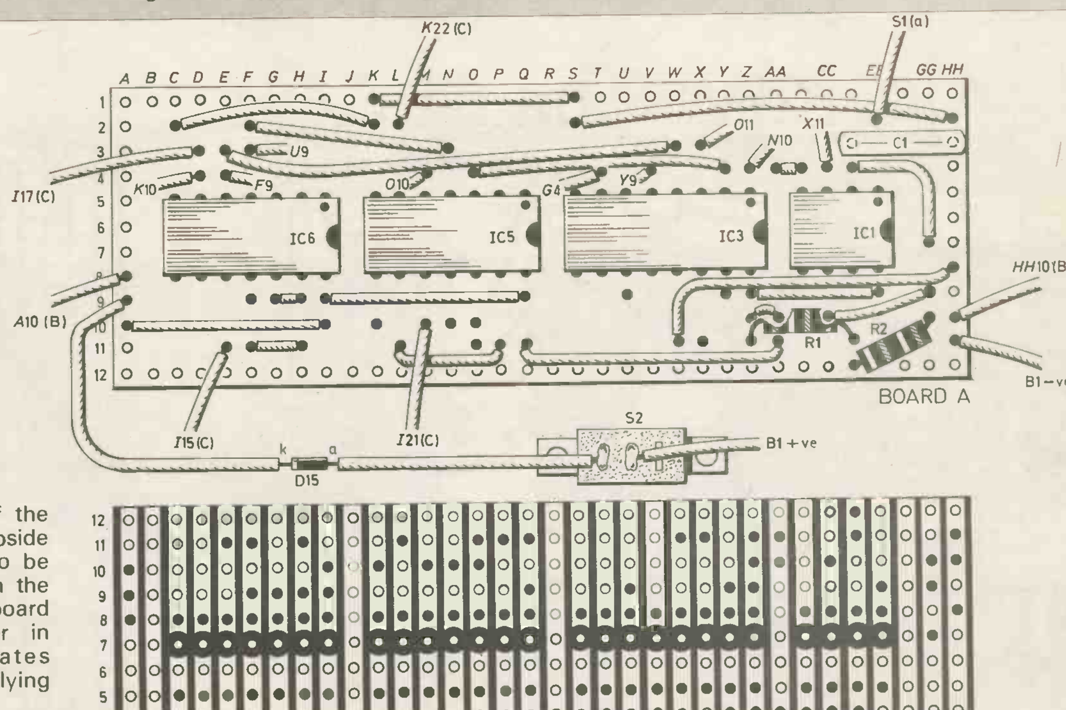
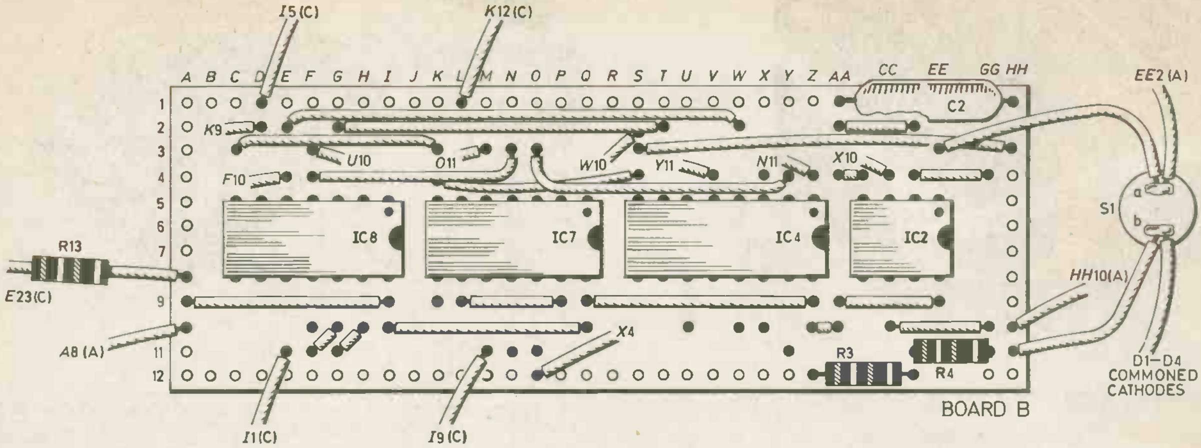


Fig. 2. The layout of the components on the topside of board A, breaks to be made in the strips on the underside and interboard wiring details. Letter in parenthesis indicates board destination of flying leads.



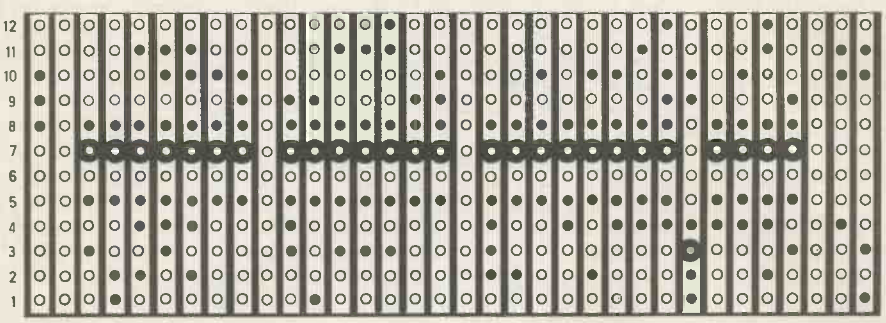
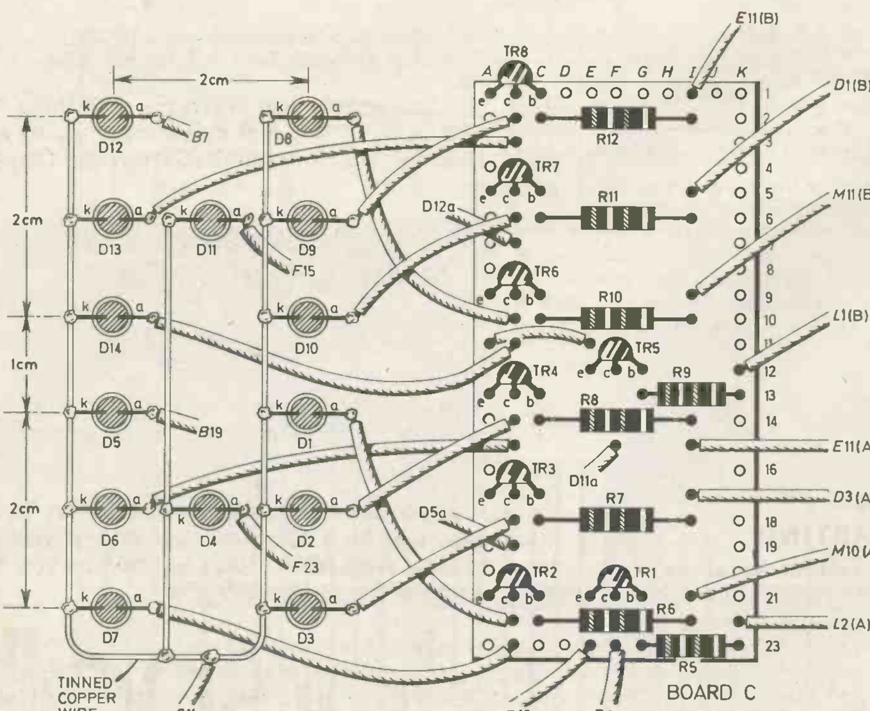
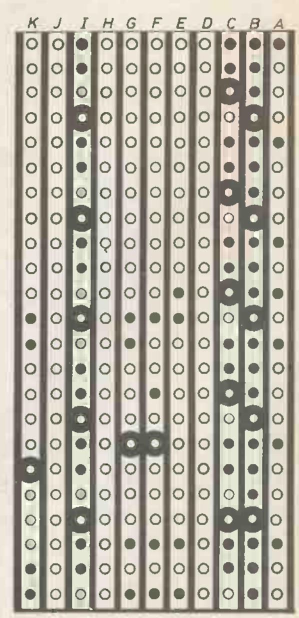
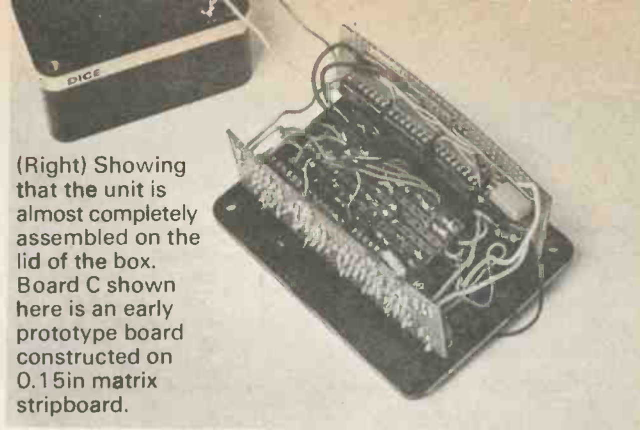


Fig. 3 (Above). The layout of the components on the topside of board B, the breaks to be made on the underside and interboard wiring details. Below shows the component layout and wiring details for board C and the breaks to be made on the underside. Also shown is the matrix of display l.e.d.s and complete wiring details to board C.





Prototype Double Dice clearly showing the l.e.d.s secured by their plastic fixing clips.



(Right) Showing that the unit is almost completely assembled on the lid of the box. Board C shown here is an early prototype board constructed on 0.15in matrix stripboard.

CONSTRUCTION

The prototype unit was constructed on three separate pieces of 0·1 inch matrix stripboard as shown in Figs. 2 and 3. Boards *A* and *B* contain the oscillators and counter decode circuits for each dice.

Begin by cutting the boards to size and then make the breaks along the copper strips. Assemble the components on boards *A* and *B* as shown beginning with the i.c. sockets, followed by the link wires, resistors and capacitors. Do not insert the i.c.s at this stage.

Make the necessary breaks on the underside of board *C* and then position and solder the transistors and resistors in place. Attach sufficient lengths of flying leads to reach the l.e.d.s to be fitted to the lid of the case. Drill the lid of the case to accept the fourteen l.e.d.s and fit these in position and hold secure with fixing clips. Also fit the two switches at this stage. Position a length of tinned copper wire around the l.e.d.s to meet with the cathode terminal on each and solder. The cathode lead is identified by a flat on the body of the l.e.d.

Connect the flying leads from board *C* to the anodes of the appropriate l.e.d.s fitted to the front panel. Inter-wire boards *A* and *B* and then wire to board *C* as indicated in Fig. 2. Finally connect the battery clip and solder the two switches in circuit as shown.

The box used to house the prototype was equipped with board mounting slots which were used to hold boards *A* and *B*. Board *C* is fitted in between the other two boards and separated from the l.e.d. array using a small piece of foam sponge. The battery can be wrapped in foam sponge inside the case.

USING THE UNIT

The unit is extremely easy to use. Switch on at S2. A pair of numbers will be displayed. Pressing and releasing S1 then produces another set of numbers. Always turn off at S2 when not in use for a long period, or better still remove the battery. □

BOOKS in BRIEF

A HISTORY OF ELECTRIC LIGHT AND POWER

Author	Brian Bowers
Price	£25 hardback. £15 paperback
Size	150 x 230mm. 278 pages
Publisher	Peter Peregrinus Ltd
ISBN	0 906048 68 0 Hardback 0 906048 71 0 Paperback

THIS very readable book has been written by Brian Bowers of the Science Museum to mark the recent centenary of electric power supply to the public. (The first installation was at Godalming in Surrey in 1881.)

In addition to light and power there are chapters on early electrical experiments and developments such as the electric telegraph. We learn, for instance, that the Morse code was really invented by Samuel Morse's helper, Alfred Vail.

Non-mathematical explanations of electrical engineering principles are given, and good use is made of informative (and often amusing) historical material, such as the advertisement published in London in 1894 for an electric cooker.

G.S.

TECHNICAL TRAINING IN INDEPENDENT BROADCASTING

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G.H.

SQUARE one FOR BEGINNERS

LIGHT EMITTING DIODES (l.e.d.s) are nowadays the commonest kind of indicating lamp. They have the attractions of small size and low current. When used properly they should have a long life.

L.e.d.s are semiconductor diodes. They are, however, made from quite different materials from the silicon and germanium diodes used for rectifying a.c. and "detecting" radio signals. The red, green and yellow l.e.d.s currently available are all made from compounds of gallium. Gallium arsenide phosphide (GaAsP) gives either red or yellow light. Gallium phosphide gives green light. Blue l.e.d.s use some other compound such as silicon carbide.

SAFE OPERATION

It must be stressed that if you try to light up a l.e.d. in the same way that a torch bulb is lit, that is by connecting a battery to it, you will end up with a dead l.e.d.

A torch bulb has a filament of fine tungsten wire. When a power supply is connected, the filament gets hot and glows. This also makes the resistance of the filament increase, and this in turn limits the current. Increasing the voltage does not produce a proportionate increase in current, and small variations from the nominal lamp voltage are permissible, as when in a car with a nominal 12V battery the voltage may rise to say 14V on occasions.

L.e.d.s are quite different. If a low voltage is applied no current flows. If the voltage is gradually increased there comes a point where current begins to flow. After that, quite a small increase in voltage produces a huge increase in current. Unless something is done to restrict the current the l.e.d. is destroyed.

The simplest current-limiting device is a resistance (Fig. 1). Here, R1 is chosen so that the current is limited to the correct amount to suit the particular l.e.d. What is this? The usual small diodes are designed to run at 20mA. The current which flows is called the "forward" current and designated I_F on data sheets.

"Forward" means that the current is flowing in the normal or "easy" direction, in at the anode and out at the cathode. (The cathode lead-out is often marked by a "flat" on the case.) In these circumstances the voltage across the diode is called the forward voltage, V_F. For red l.e.d.s it is about 1·6V and for green and yellow about 2·7V. It follows that the battery voltage V_{CC} must be more than 1·6V to light a red l.e.d. and more than 2·7V for green or yellow. If possible, it should be much more, because the circuit then becomes less sensitive to battery voltage variations.

If the battery gives 6V and the l.e.d. is a green one consuming 2·7V, this leaves 3·3V to be spent in the resistance R1.

For a 20mA I_F, the required R1 is 3·3V/20mA and this comes to 165 ohms. Since 165 ohms is non-standard, to be on the safe side the next highest standard value is used (180 ohms in the usual E12 set of resistances). It is not essential to use the full permitted current: a l.e.d. will still light dimly at a reduced current.

A.C. OPERATION

Being a diode, a l.e.d. will normally allow current to flow only in the forward direction. If a reverse voltage (anode to negative, cathode to positive) is applied, no current flows. Unfortunately this is not quite true. If a large enough reverse voltage is applied a damaging reverse current flows and yet another l.e.d. bites the dust.

A typical maximum permissible reverse voltage is 5V, but for some l.e.d.s it is less and the safest thing is not to apply any at all.

Just a small selection of l.e.d.s showing the numerous shapes available.

This requires additional components in a.c. circuits where the voltage keeps reversing. The cheapest a.c. safe circuit (Fig. 2) adds an ordinary silicon diode connected so that it conducts when the l.e.d. gets a reverse voltage. This means that the l.e.d. passes current only half the time and lights less brightly than in the Fig. 1 type of circuit. To restore the brightness, R1 can be reduced.

A more elegant (but more expensive) alternative (Fig. 3) is to connect a second l.e.d. in place of the silicon diode. Each l.e.d. now lights on the half-cycles when the other is out. The reverse voltage is the same as the forward voltage of the lit diode.

DISPLAYS

L.e.d.s are used in combination in the displays of calculators and other numerical or alphabetic devices. In the well known "seven segment" display, l.e.d.s form bars of light which can be combined to make the numbers 0–9. Selecting the appropriate segments calls for logic circuitry and this is sometimes built into the display device.

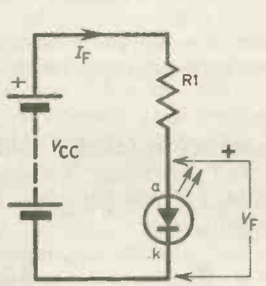

Fig. 1. L.e.d. circuit showing the usual symbols.

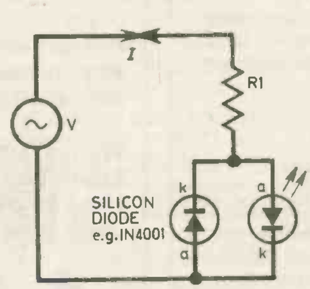

Fig. 2. A.c. circuit. Reverse current is removed from the l.e.d. by a silicon diode.

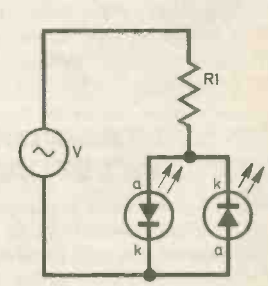

Fig. 3. Two-l.e.d. a.c. circuit. The l.e.d.s light alternately.

Sinclair ZX Spectr

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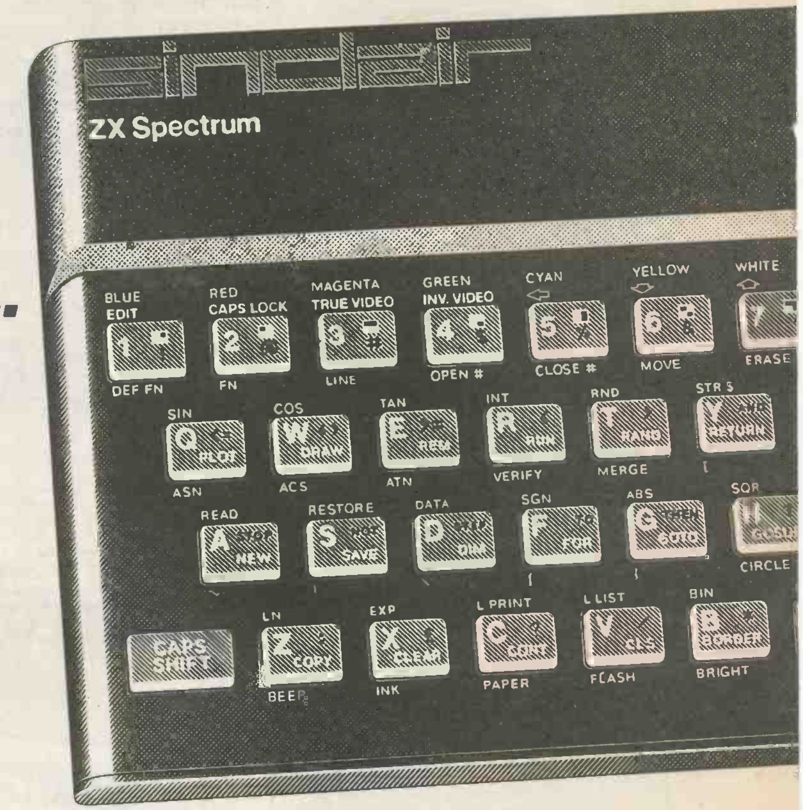

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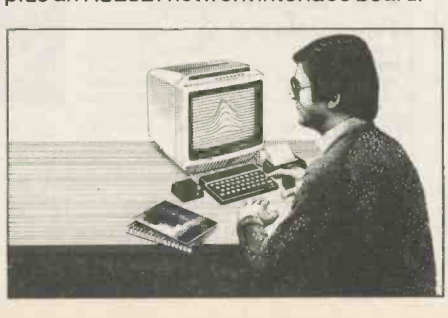
There's no need to stop there. The ZX Printer–available now–is fully compatible with the ZX Spectrum. And later this year there will be Microdrives for massive amounts of extra on-line storage, plus an RS232/network interface board.



Key features of the Sinclair ZX Spectrum

- Full colour–8 colours each for foreground, background and border, plus flashing and brightness-intensity control.
- Sound–BEEP command with variable pitch and duration.
- Massive RAM–16K or 48K.
- Full-size moving-key keyboard–all keys at normal typewriter pitch, with repeat facility on each key.
- High-resolution–256 dots horizontally x 192 vertically, each individually addressable for true high-resolution graphics.
- ASCII character set–with upper- and lower-case characters.
- Teletext-compatible–user software can generate 40 characters per line or other settings.
- High speed LOAD & SAVE–16K in 100 seconds via cassette, with VERIFY & MERGE for programs and separate data files.
- Sinclair 16K extended BASIC–incorporating unique 'one-touch' keyword entry, syntax check, and report codes.

rum

The ZX Printer – available now

Designed exclusively for use with the Sinclair ZX range of computers, the printer offers ZX Spectrum owners the full ASCII character set – including lower-case characters and high-resolution graphics.

A special feature is COPY which prints out exactly what is on the whole TV screen without the need for further instructions. Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The ZX Printer connects to the rear of your ZX Spectrum. A roll of paper (65ft long and 4in wide) is supplied, along with full instructions. Further supplies of paper are available in packs of five rolls.

The ZX Microdrive – coming soon

The new Microdrives, designed especially for the ZX Spectrum, are set to change the face of personal computing.

Each Microdrive is capable of holding up to 100K bytes using a single interchangeable microfloppy.

The transfer rate is 16K bytes per second, with average access time of 3.5 seconds. And you'll be able to connect up to 8 ZX Microdrives to your ZX Spectrum.

All the BASIC commands required for the Microdrives are included on the Spectrum.

A remarkable breakthrough at a remarkable price. The Microdrives are available later this year, for around £50.

ZX Spectrum software on cassettes – available now

The first 21 software cassettes are now available directly from Sinclair. Produced by ICL and Psion, subjects include games, education, and business/household management. Galactic Invasion... Flight Simulation... Chess... History... Inventions... VU-CALC... VU-3D ...47 programs in all. There's something for everyone, and they all make full use of the Spectrum's colour, sound and graphics capabilities. You'll receive a detailed catalogue with your Spectrum.

RS232/network interface board

This interface, available later this year, will enable you to connect your ZX Spectrum to a whole host of printers, terminals and other computers.

The potential is enormous. And the astonishingly low price of only £20 is possible only because the operating systems are already designed into the ROM.

sinclair

Sinclair Research Ltd, Stanhope Road, Camberley, Surrey GU15 3PS.
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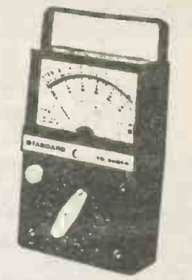

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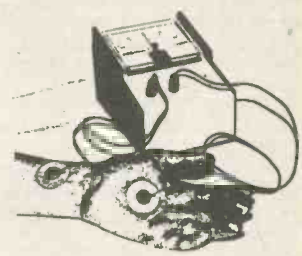

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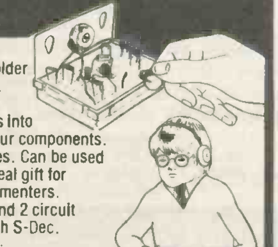

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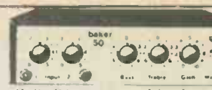

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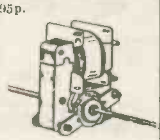

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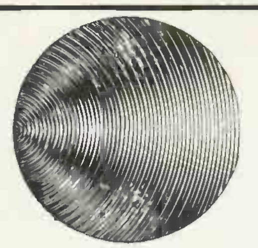

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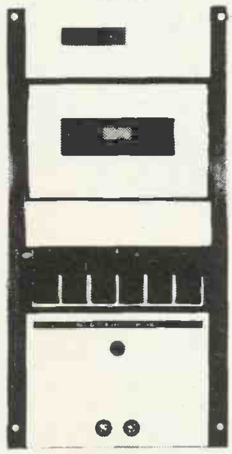

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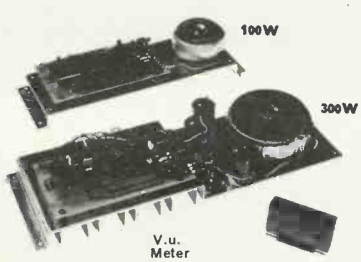

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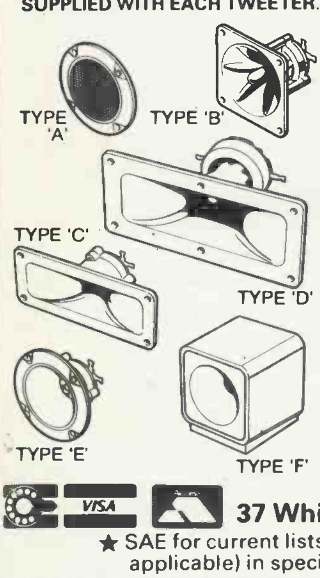

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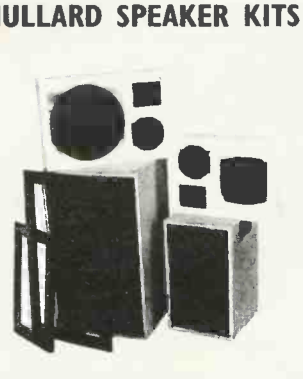

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