Easy to build projects for everyone

Everyday ELECTRONICS

JUNE /JULY 80

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M18 Ladies quartz LCD Fashion Watch

Highly functional, but beautifully designed watch, suitable for those special occasions.

Displaying hours, mins, secs, day and date, the watch also has an auto calendar and a backlight.

The slim but strong bracelet is fully adjustable and is available in a silver or gold finish.

M64 Mans dual time quartz alarm chronograph with 6 digits, 5 indicators and 22 functions.

For business people with overseas contacts and responsibilities this is the ideal watch.

Local time is always visible, but in addition the watch can be set, and recall, a second time zone, in either 12 or 24 hour formats, and displays a day and date for each zone.

The chronograph/stopwatch displays up to 12 hours, 59 minutes and 59.9 seconds.

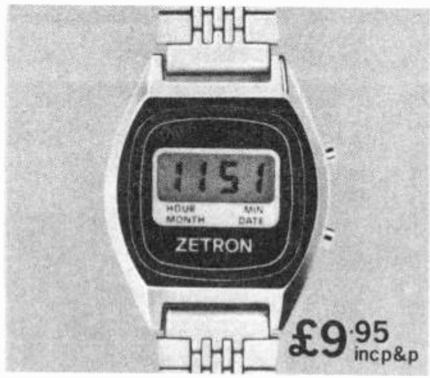
On command, the stopwatch display freezes to show intermediate (split/lap) time while the stopwatch continues to run and neither function affects the normal timekeeping.

The alarm can be set to any time within a 24 hour period.

To complete the functions, there is also a 4 year calendar and a fully adjustable stainless steel strap.

M18 **£15.95** inc p&p
Ladies quartz LCD Fashion Watch

M64 **£14.95** inc p&p
Mans dual time quartz alarm chronograph with 6 digits, 5 indicators and 22 functions.



M15 Ladies quartz LCD Day Watch

This slender watch displays hours, mins, secs, day and date and has an auto calendar and a backlight.

Only 25mm × 20mm × 6mm thick this elegant watch has a bracelet, in silver or gold finish, and is fully adjustable to suit very slim wrists.

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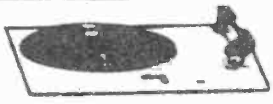

SINGLE RECORD PLAYER

Fitted with auto stop, stereo cartridge. Baseplate. Size 11 × 8½in. Turntable size 7in. diameter, a.c. mains 240V 3 speeds plays all size records. **£9·95**
Two for £18. Post £1 on each.

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This kit is suitable for record players, tape play back, guitars, electronic instruments or small PA systems. Two versions are available. The mono kit uses 13 semiconductors. The stereo kit uses 22 semiconductors Both kits have printed front panel and volume, bass and treble controls Spec. 10W output into 8 ohms 7W into 15 ohms. Response 20c.s. to 30Kc.s. Size 9½ × 3 × 2in. A/C mains operated.

Mono kit **£14·50** Stereo kit **£20** Post £1

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32/500V	75p	16+16/450V	75p	100+100/275V	65p
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3A, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£12·50
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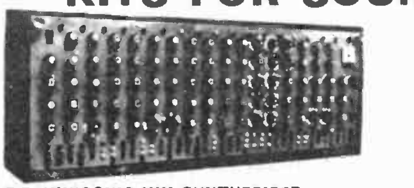

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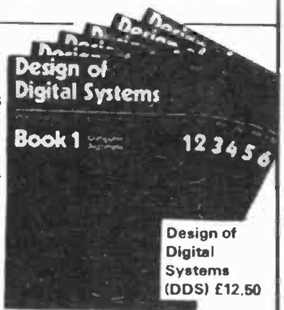

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(The above boards are suitable for all DIL ICs)

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Projects... Theory...

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Sorry you have been kept waiting. Our delayed appearance has been caused by industrial disputes effecting both the printing and the editorial sides of the publishing business.

This issue is dated June/July on account of the lateness in appearing. The contents remain as previously scheduled for June, thus all commitments as announced in our May issue are fulfilled.

A consequence of the recent "troubles" is that Volume 9 of EVERYDAY ELECTRONICS will comprise 11 issues in all, instead of the normal 12. In order to get back to the planned schedule for later this year, it is intended to devote extra space to Teach-In 80 in the next two issues dated August and September. We would assure all followers of Teach-In 80 that this most important series will not be abridged or modified in any way.

Coming back now to this present issue we believe all our readers will find this to have been well worth waiting for. It includes eight projects of varied complexity (or simplicity) and interest.

There are two super sound effects for the pop music enthusiast. They afford yet further examples of the affinity between contemporary pop and technology. Truly the two go hand in hand, the former certainly could not exist but for the latter.

The motorist is equally well looked after. There is a simple but sensible adjunct for the car, with the passenger particularly in mind this time. This gadget ensures that the "courtesy light" really justifies its title. Secondly, the Uniboard Project is a *Voltage Converter* designed to operate a cassette player from a 12V car system.

One or more of those "ever-present needs" is likely to be satisfied by the *General Purpose Amplifier*. Incidentally one of its many possible uses could be as a workbench accessory. Here it will find congenial company with the *A. F. Signal Generator*, *Zener Diode Tester* and *Signal Tracer*.

These three valuable pieces of test gear bring us right into the workshop (be it but an odd corner somewhere) where it all happens. So there let us leave you, fellow constructors, with all these designs to mull over, to do your own thing.

Fred Bennett

Our August issue will be published on Wednesday, July 23. See page 419 for details.

ELECTRONICS

VOL. 9 NO. 6 JUNE/JULY 1980

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

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Certain back issues* of EVERYDAY ELECTRONICS are available worldwide price 70p 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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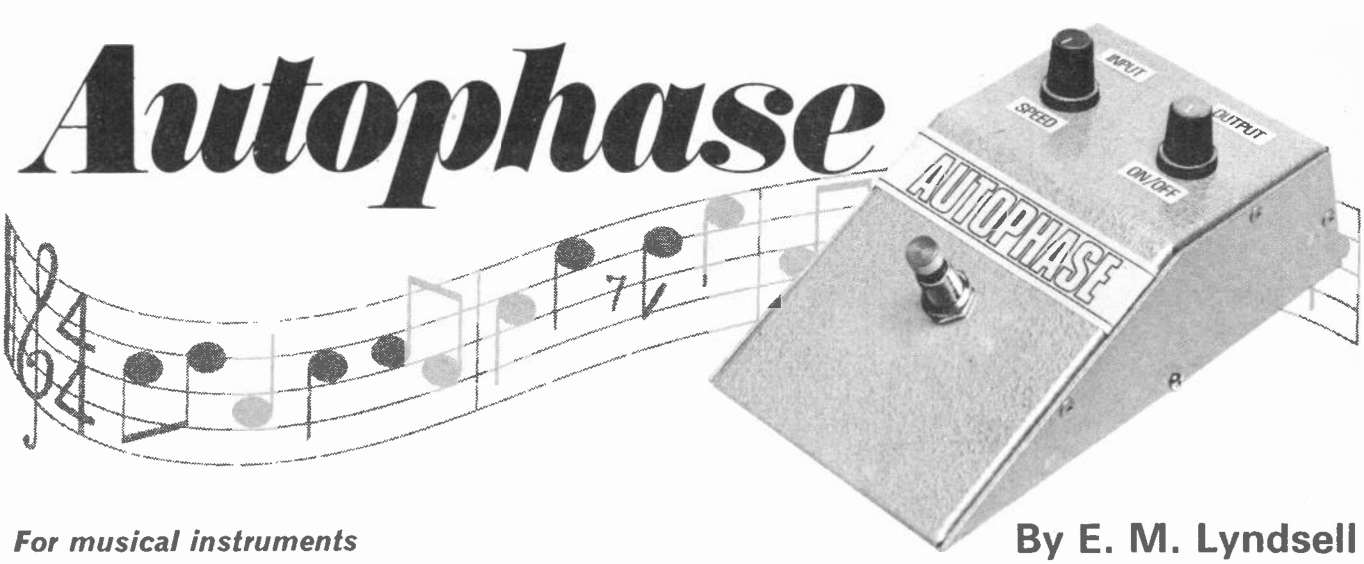
OUR REGULAR FEATURE FOR BEGINNERS
page 437

SQUARE one

Autophase



For musical instruments

By E. M. Lyndsell

ONE OF the more recent additions to the inventory of musical effects units is the phase box. The cost of these is quite high (in the order of £35 and upwards) and in the author's opinion over-priced. However, many musicians own such devices and they continue to be purchased.

This article describes the construction of an automatic phase box whose performance will equal that of commercial units and cost much less.

Two instruments that find most use for the phase effect are the electric guitar and organ, although it can be used with any other instrument for extra-special effect. Vocalists are known to favour its effect but many commercial units produce too much harmonic distortion for this application. The Autophase has a very low distortion figure making it suitable for use by vocalists.

WHAT IS PHASING

When a signal passes through a reactive network (for example a resistor/capacitor circuit), it undergoes a phase change. That is, with respect to the input, the output signal appears to be shifted in time, (delayed) see Fig. 1.

The magnitude of the shift is dependent on the circuit values and the signal frequency. For certain frequencies the phase shift will be equal to or greater than one-half the wavelength of the input signal. When these input and output signals are mixed, certain frequencies will cancel and produce no output at these points. The result is a series of notches along the frequency response curve of the network, see Fig. 2.

By varying the characteristics of the network by external means the notches can be made to sweep up and down the frequency axis of Fig. 2. It is this action that produces the phase effect.

Single-frequency input signals produce minimal effect, merely a change in amplitude as the notch passes its position. Best results occur when the input signal contains multiple frequencies and their harmonics such as those produced by chords. Often the phase effect is enhanced if preceded by a distortion or overdrive effects unit.

Aurally the effect produces a ghostly, space-like shifting sound. For a high sweep frequency the vibrato sound is produced, and at certain settings, simulates the sound obtained from a Lesley speaker system.

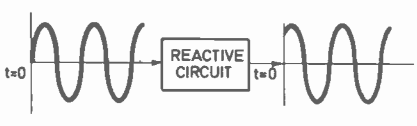


Fig. 1. The effect of a reactive circuit on a sinewave signal is to introduce a phase shift.

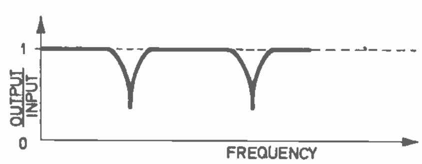


Fig. 2. The frequency response curve resulting from mixing the original signals with the "shifted" signals. Notches indicate 180-degree shifts.

CIRCUIT DESCRIPTION

The circuit diagram of the Autophase is shown in Fig. 3. The heart of the unit is a special i.c., IC1. This is a four-section filter that can be configured in many useful ways whose characteristics are voltage controlled by an external voltage source.

In this particular application the four filters are series connected, each section being an all-pass filter. This has the properties of allowing all signals to pass without affecting their amplitude, but introducing a phase shift according to the signal frequency. The shift is further alterable by a control voltage at pin 7.

By feeding a triangle-wave control voltage into pin 7, an exponential sweep of the notches mentioned earlier is obtained when the filter output is mixed with the original signal.

The input signal is fed into SK1, through d.c. blocking capacitor C5 to a near unity gain buffer amplifier formed by IC2 and local components. The output from IC2 reaches the first of the cascaded filter sections and emerges at IC1 pin 10 phase shifted with respect to the input. The outputs from IC1 and IC2 are mixed through R13 and R26 by IC5 to produce the required effect across VR3. The latter is set to give the required balance between the EFFECT and BY-PASS positions of S1.

CONTROL VOLTAGE

The control voltage is generated by IC4 wired as an astable multivibrator. Output is normally taken from pin 6 in this type of circuit, but the waveform is a square wave which is of no use here. Instead, the output is taken from the charge and discharge curves of C6 which is close enough for this application to the required triangular waveform.

The frequency of this oscillator is controlled by VR2 and is a function of VR2, R22-R24 and C6. These values have been calculated so that VR2 provides the usual phase sweep-rate range.

The voltage developed across C6 is fed to a buffer amplifier IC3 which presents insignificant loading on C6 and acts also as a level shifter. Preset control VR1 allows the output level of IC3 to be suitably positioned below the 0V line, as the filter control voltage needs to be negative with respect to 0V.

The peak-to-peak amplitude of the control voltage to produce the best effect here was found to be about 200mV. This is realised by the attenuator composed of R17, R18

COMPONENTS

Resistors

R1	10kΩ	R10	10kΩ	R19	100kΩ
R2	10kΩ	R11	180Ω	R20	1MΩ
R3	180Ω	R12	10kΩ	R21	100kΩ
R4	10kΩ	R13	10kΩ	R22	10kΩ
R5	10kΩ	R14	100kΩ	R23	10kΩ
R6	180Ω	R15	100kΩ	R24	2·2kΩ
R7	10kΩ	R16	10kΩ	R25	10kΩ
R8	180Ω	R17	1kΩ	R26	10kΩ
R9	10kΩ	R18	12kΩ		

All ¼ watt carbon ± 5%

See **Shop Talk** page 400

Potentiometers
VR1, 3 47kΩ miniature horizontal preset (2 off)
VR2 50kΩ carbon linear law shafted type

COMPONENTS approximate cost £10 excluding case and batteries

Capacitors
C1, 2, 3, 4 4·7nF ceramic (4 off)
C5 0·22μF polyester type C280
C6 100μF 10V elect.

Semiconductors
IC1 SSM2040 4-section voltage controlled filter i.c. (Digisound)
IC2-IC5 741 op-amp 8-pin d.i.l. (4 off)

Miscellaneous
S1 single-pole changeover successional action footswitch
S2 d.p.d.t. rotary
SK1, 2 Standard mono jack socket (2 off)
B1, B2 9V type PP3 (Duracell preferred) (2 off)
Stripboard: 0·1 inch matrix size 38 strips × 30 holes; 16-pin d.i.l. socket, 8-pin d.i.l. sockets—low profile (4 off) (optional); connectors for B1, B2; control knobs; screened cable; board mounts; case; rubber feet.

running to 0V. VR1 is adjusted so that the most positive peak sits at 0V.

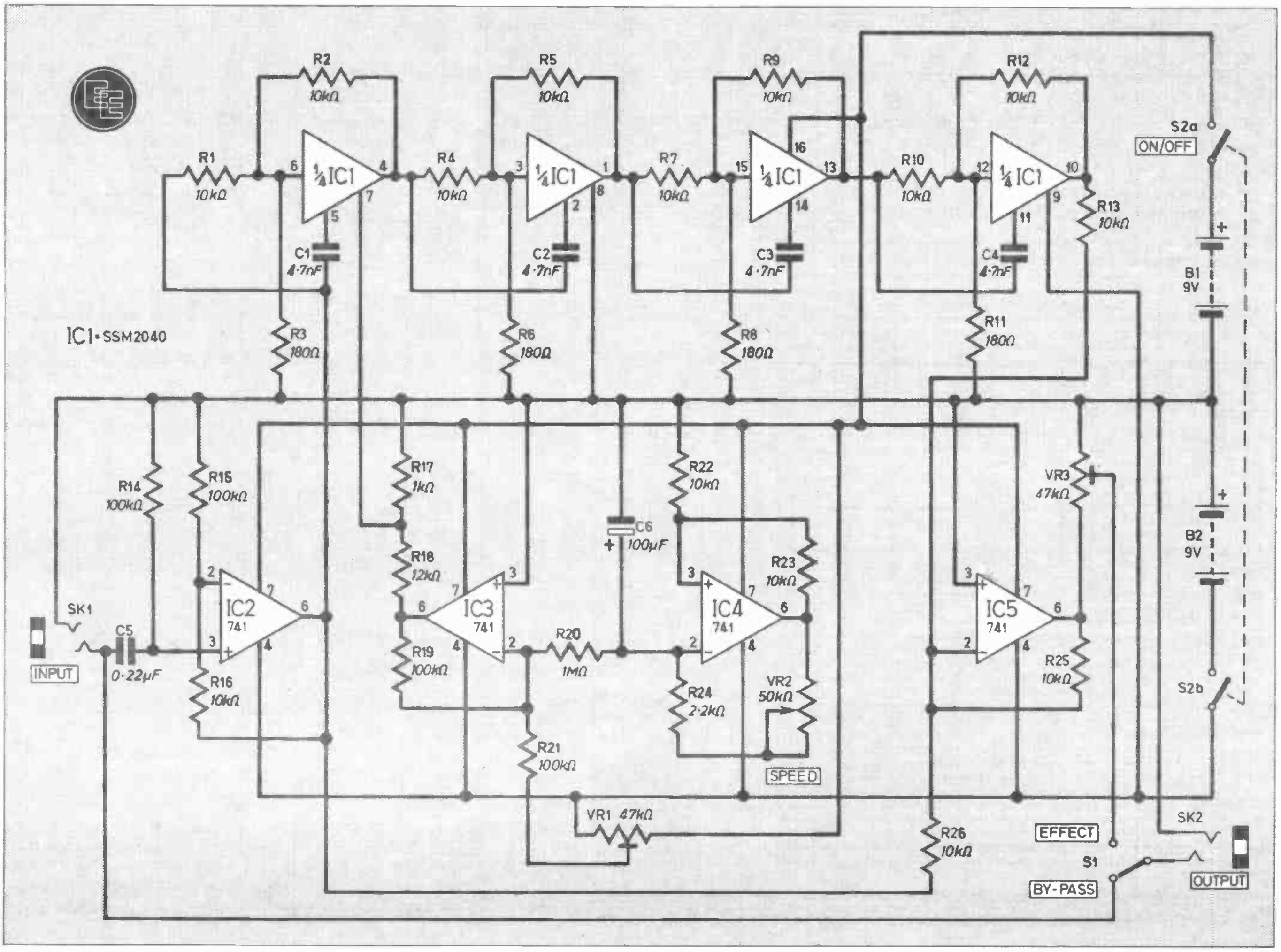
Since IC1 requires a split supply, two batteries are necessary. These are connected in circuit by means of a d.p.d.t. rotary switch which is preferred to the usual jack socket power switching arrangement to prolong useful battery life when the unit is "in-circuit" but not in use.

CONSTRUCTION starts here

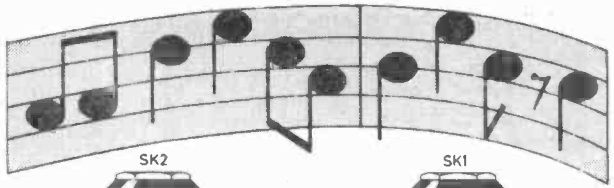
COMPONENT BOARD

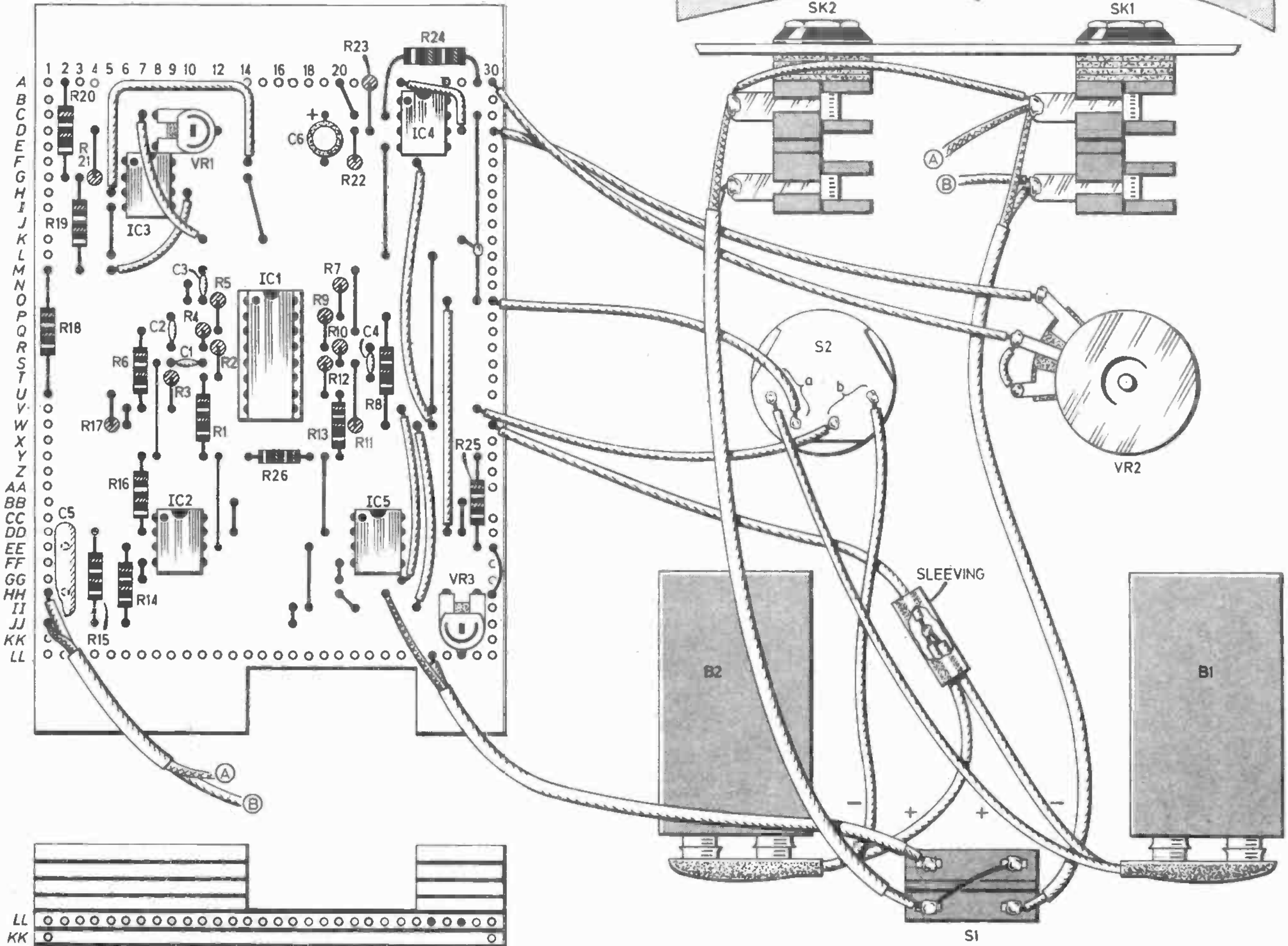
Most of the components are mounted on a piece of 0·1in matrix stripboard size 38 strips x 30 holes. The layout of the components on the topside of the board and the breaks to be made along the copper strips on the underside are shown in Fig. 4.

Fig. 3. The complete circuit diagram of the Autophase.



Autophase





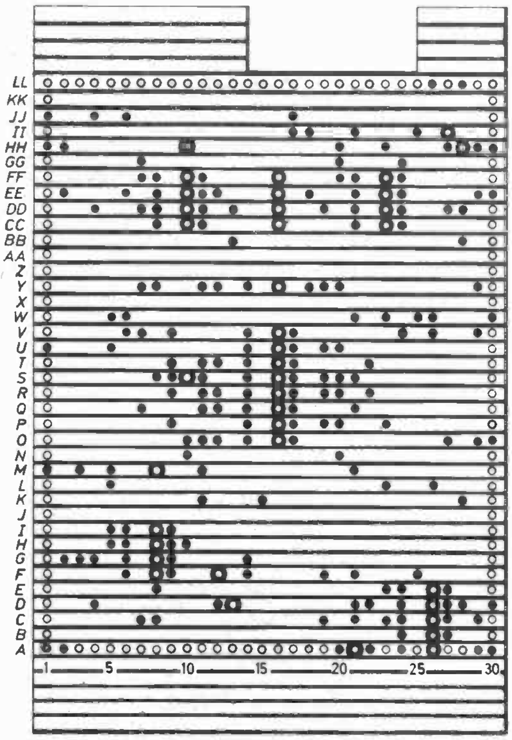
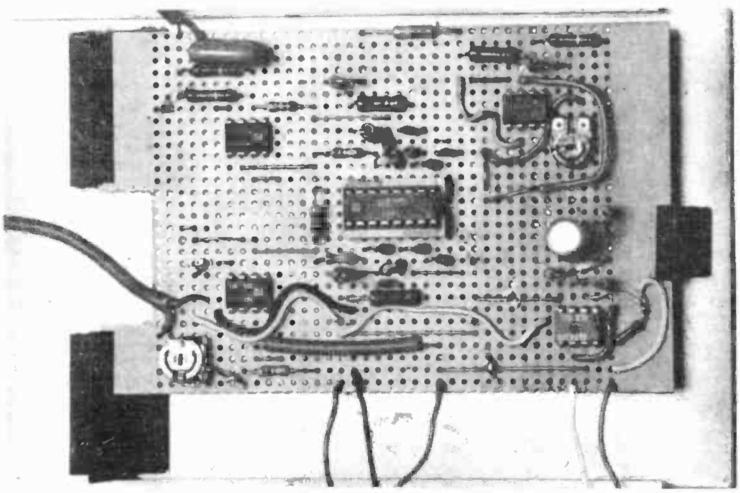


Fig. 4. Shows the layout of the components on the topside of the stripboard and the breaks to be made in the copper strips on the underside. Also shows interwiring between case mounted components (in situ on underside of case lid) and wiring from these to the board. The batteries are held in place with self-adhesive foam.

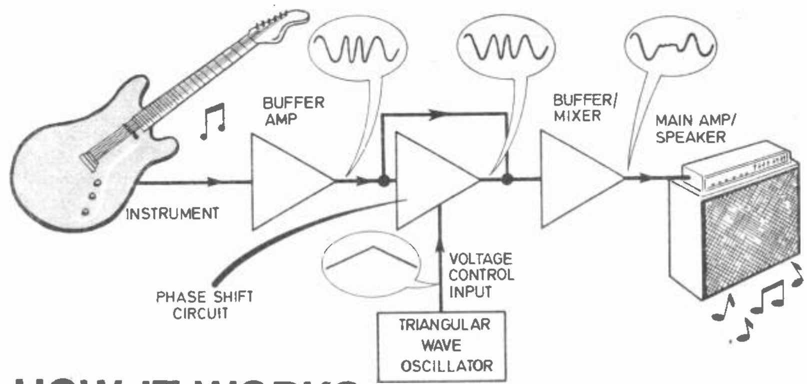


The components mounted in place on the prototype circuit board. Note that some i.c.s. are "can" types. These were used only because they were at hand at the time of construction. Usual plastic types are suitable.

This layout is not critical and may be changed to suit individual requirements. However, the oscillator stage should be kept as far away as possible from the input section to avoid the pick-up of "clicks" due to the switching of IC4. No such effect was heard on the prototype.

As IC1 is fairly expensive, it was thought wise to mount this in a socket on the board, thereby removing the danger of heat damage from the soldering iron. As for the other i.c.s it was not thought necessary to use sockets. However, if this is preferred, low profile types or Soldercon pins are suggested with the layout shown as these occupy less board space than standard types. Board space here is limited around the i.c.s.

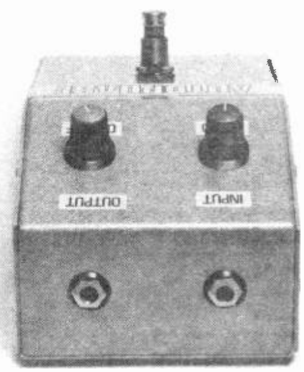
There is a cut-out to be made at one end of the board to accommodate the protruding footswitch fitted to the case top. This may not be necessary with other case designs.



HOW IT WORKS

The signals from the musical instrument after passing through a buffer amplifier, reach a phase shift circuit where they undergo varying degrees of shift according to their frequency. These signals are then fed to a summing amplifier where they are mixed with the original signals. The two interact and a narrow band of frequencies will have been shifted sufficiently to cause cancellation. In other words a notch has been produced in the frequency response of the system.

The voltage level at the voltage control input determines the position of the notch which is made to sweep up and down the frequency axis by the action of the triangular wave oscillator. It is this action that produces the well known phase effect.



End view of the prototype show inginput and output sockets on the back panel.

Begin construction by making any cut-outs and the breaks on the underside of the board. A twist drill is suitable for this. In the prototype self-adhesive board mounts were used. If these are not available other means of support will need to be prepared.

ASSEMBLY

A convenient component to begin assembly with is IC1 socket followed by its neighbouring link wires, resistors and capacitors. Proceed by inserting in turn the remaining i.c.s (or sockets), and their link wires, capacitors and resistors in this order. The p.v.c. covered link wires are best left until last of all. Attach suitable lengths of flying leads (stranded preferred) and screened cable (miniature type more suitable) according to Fig. 4 to reach the case mounted components.

The case used in the prototype was purchased very cheaply from a limited supply of surplus commercial effects units and will probably not now be obtainable.

Secure the components to the chosen case and connect the flying leads to these as shown in Fig. 4.

A s.p.d.t. successional action footswitch as required here is a very difficult component to locate. This is easily made from a double-pole changeover type by a cross link as shown. For precautions against pick-up of noise and hum screened cable was used for input and output feeds. Note that at S1, the outer screen is cut-back and not connected in any way. An earth loop producing unwanted hum may result if these "screens" are allowed to come in contact.

In the prototype the batteries were held in place by self-adhesive foam pads that can be obtained from W. H. Smith if not stocked by your component supplier.

Finally solder the two battery connectors to S2 to complete assembly.

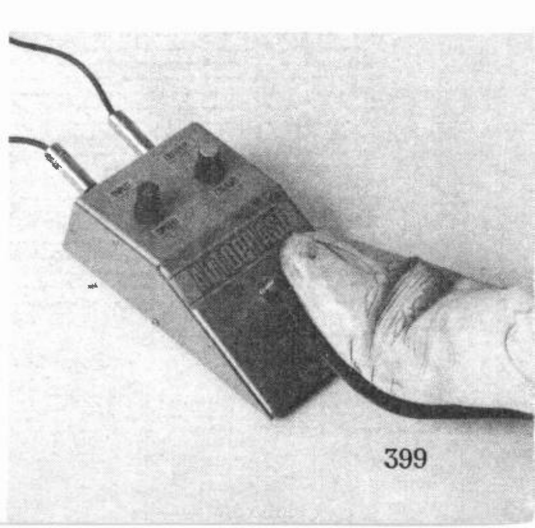
Set VR1 so that its wiper is slightly less than halfway in a clocwise direction; VR3 should be positioned about a quarter turn clockwise.

TESTING AND USE

When certain that construction is complete and correct, the batteries can be attached and the unit tested. Plug a suitable "electric" instrument into SK1, and connect the output at SK2 to the instrument amplifier input and switch on. Incidentally, screened leads must be used for these connections to avoid noise pick-up.

Establish that S1 is in the EFFECT position. Carefully adjust VR1 to produce the phase sound as the instrument is played. The correct position of VR1 will be immediately recognised. When this has been found, S1 should be operated and VR3 then adjusted to produce the desired volume balance.

If all is well, the case may be screwed together and the controls labelled with Letraset or similar transfers. It is suggested that rubber feet are fitted to the case underside to make slip-free contact with the stage or floor. ⌑

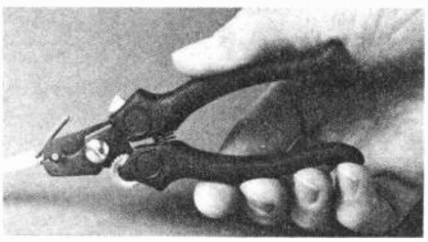


By Dave Barrington

Wire Stripper

No matter how carefully one uses one's penknife, the workshop "old faithful" to most diehards, to strip covered wires, it inevitably results in "nicked" wires. Wires breaking off just as you are soldering the lead in position is often the outcome.

There are several special purpose tools for stripping wires on the market varying from the elaborate and expensive to the very simple and fairly cheap. All are very efficient and will repay their outlay time and again.



MK001 wire stripper from AB Engineering

Probably the most widely known to the amateur is the famous "Bib" stripper from Multicore Solders and available from most components shops. The depth cutting adjustment, according to model purchased, is either by an off-set disc or a rotating varying depth wheel.

Another simple to operate wire stripper and cutter, type AB MK001, has just been introduced by AB Engineering. It features a knurled knob adjustment to control the stripping depth, a retaining clip to ensure it remains in the closed position when not in use and a curved cutting edge which provides a secateur-like action for clean wire cutting.

Further details and stockist of the AB MK001 and other tools available can be obtained from AB Engineering Co. Ltd., Dept EE, Timber Lane, Woburn, Beds. MK17 9PL.

CONSTRUCTIONAL PROJECTS

There are quite a few components that could cause sourcing problems this month and it may also be a case of shopping around for best prices.

A.F. Signal Generator

Looking through components catalogues for the rotary switches S1 and S3 called for in the *A.F. Signal Generator*, the reader has a choice of several combinations of "poles" and "ways". Our unit used 4-pole 3-way switches, however we would recommend that rotary switches with adjustable stops, available from several of our advertisers, be used.

The components list also calls up some close tolerance resistors and capacitors. For the resistors the E24 series would be suitable. Some advertisers may supply ½ watt types and these will be o.k. provided they are 2 per cent or better.

The close tolerance capacitors used in our model were polycarbonate types available from Maplin and Watford Electronics.

The ZN424 op-amp integrated circuit seems to be only listed by Watford but no doubt this device is available from other sources. The thermistor type RA53 would appear to be only available from Electrovalue although they indicate that they may supply the RS Components equivalent.

Voltage Converter

Two types of transistor are listed for TR1 in the *Uniboard-Voltage Converter* project and the BFY51 seems to be most commonly available. However, the 2N1711 is listed by Bi-Pak Semiconductors.

General Purpose Amplifier

The *General Purpose Amplifier* calls for a matched pair of transistors for TR1, TR2, type AC141 and AC142. These are fairly common and stocked by most of our advertisers.

Although an 8 ohm loudspeaker is specified for this project, if a 15-16 ohm type is to hand this can be used with negligible output power loss. It is not recommended that a speaker less than 8 ohms be used.

Autophase/Autowaa

Used in both the *Autophase* and the *Autowaa*, the SSM2040 integrated circuit is new to this country and only available from Digisound Ltd., 13 The Brooklands, Wrea Green, Preston, Lancs PR4 2NQ, for the sum of £5·75 each, inclusive of VAT and p&p. We believe that this is the first time this latest "state-of-the-art" device for musical effects has been used in an amateur constructional project in the UK.

It would be a good idea to use a larger than specified case for the *Autowaa* to ease the mounting of the batteries and the rather dense packing of components. Also, we would suggest that a separate supply on/off switch be incorporated to extend battery life.

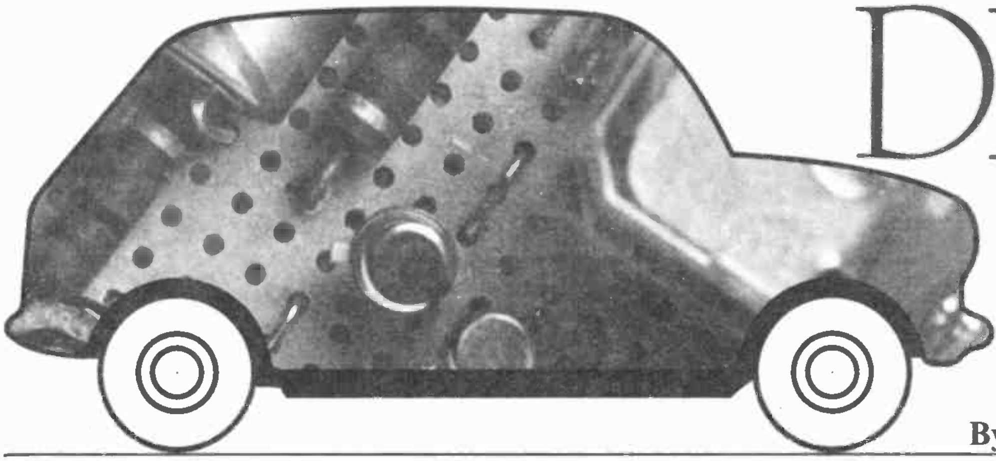
At present, with both jack plugs inserted, the circuit is switched on all the time, even in the by-pass position. If a d.p.d.t. on/off switch is incorporated ordinary mono jack sockets may be used and wired as per the *Autophase* project.

Readers should have no difficulty in locating and purchasing components for the *Courtesy Light Delay*. The relay used is a miniature continental type rated at 12V 185 ohm coil with 2-pole change over contacts.

No difficulty should be experienced in purchasing components for either the *Zener Diode Tester* or the *Signal Tracer*.

JACK PLUG & FAMILY... BY DOUG BAKER

COURTESY LIGHT DELAY



By T. R. de Vaux-Balbirnie

HAVE you ever got into the car and then fumbled in the dark to find the ignition switch? The present circuit allows for a delay in the operation of the light so that the driver and passenger may settle down with doors closed and start the engine before the light goes out automatically. An optional addition is a push-button switch mounted on the dashboard which may be used to operate the courtesy light at any time—a great improvement over the switch on the light unit.

In the prototype, the delay is adjustable from 0 to over 30 seconds. The longer delay might be appropriate in the case of the elderly, the disabled or the non-too-agile.

Providing the car is fitted with the usual type of courtesy light or lights operated by door pillar switches this project may be fitted. The version described is for negative-earth vehicles—these are the most common type on the road today—however it is a simple matter to adapt the unit for positive earth vehicles. In cases of doubt it is a simple matter to check which terminal of the car battery is connected direct to the body of the car—this is "earth".

CIRCUIT

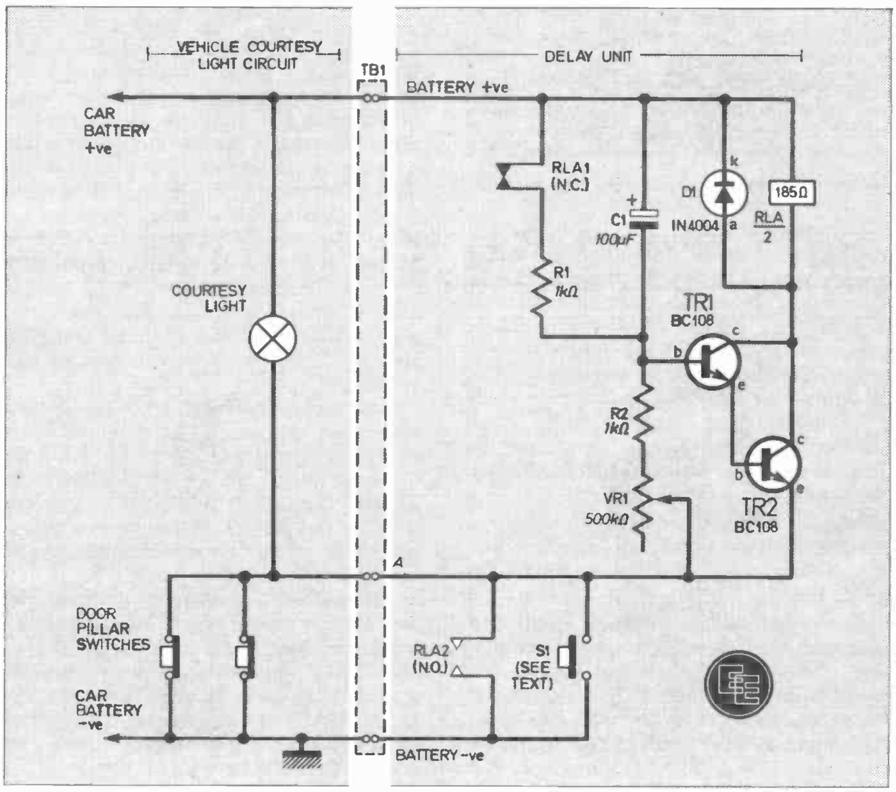
The circuit diagram is shown in Fig. 1. When a door is opened, the pillar switch closes and capacitor C1 charges through R1 and VR1. Transistor TR1 is thus turned "on" and as this is directly coupled to TR2 in a Darlington pair arrangement, TR2 is also held "on". The relay coil is energised and the contacts operate.

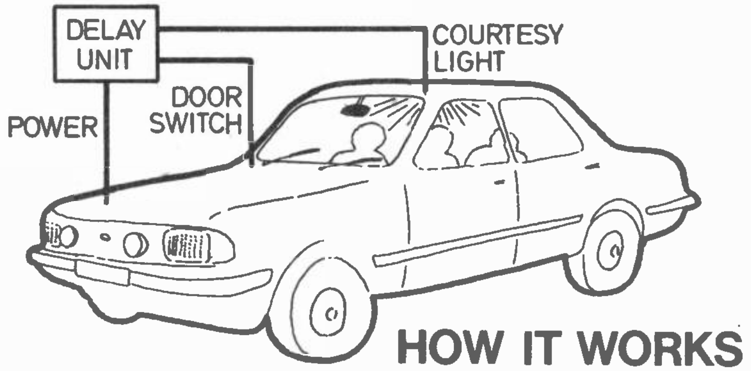
A pair of transistors connected as a Darlington pair behave as a single transistor of exceptionally high gain and as the specified transistors have a high gain to begin with, an extremely low base current in TR1 will keep the arrangement switched "on". This means that little current is drained from C1 so a low value is adequate which saves on space and cost.

The relay uses one set of normally open and one set of normally closed contacts. In fact, the relay specified is a general-purpose type with two pairs of changeover contacts. The normally closed contacts keep C1 discharged through R2 when not in use. R2 is to limit the discharge current to a small value.

The pair of normally open contacts bypass the door pillar switches so that the circuit will continue to operate when the doors have been closed. The relay specified has contacts rated at 1A so up to 12 watts of load may be

Fig. 1. The full circuit diagram of the Car Courtesy Light Delay unit. (Negative Earth version).





HOW IT WORKS

When the door is opened the interior light comes on and causes a capacitor to charge up in the delay unit. When the door is closed again the interior light is held on until the capacitor has discharged and the delay unit switches off. This enables the driver to find the ignition switch and make himself comfortable before the light goes off.

used. Cars with two courtesy lights in parallel should therefore be accommodated.

SWITCH OFF

When C1 reaches a certain state of charge the voltage across it, hence the voltage at the base of TR1, will reach a value which is insufficient to keep it switched "on". When this happens, TR2 switches off and so does the relay. The light goes out sharply and the capacitor is "shorted" and so discharges ready for the next time.

Should the door be left open for a long period the circuit will keep cycling and a click will be heard from the relay every few seconds. This is of little significance. If the user is likely to leave the door open for long periods, a switch could be fitted in the main battery lead for the circuit so that it could be switched off on such occasions.

The delay period will depend on the setting of VR1. The purpose of R1 is to prevent excessive charging current should VR1 be set close to its minimum setting. Diode D1 is connected across the relay coil in the usual way. It allows for the high voltage "spike" generated when the magnetic field suddenly collapse in the relay core to be harmlessly shunted through the the transistor.

In fact, the author operated the circuit many times without D1 and the transistors stood up to it perfectly well.

It is essential to connect D1 in the manner shown—which is apparently the "wrong way round" with its cathode to the positive line (negative earth cars). This is because the voltage spike is produced in the opposite direction to the battery supply.

CONSTRUCTION starts here

ASSEMBLY

The circuit may be constructed on a small piece of 0·1in pitch stripboard 22 holes by 19 strips. Fig. 2 shows the layout used in the prototype. Great care must be exercised when the relay is soldered into position. False connections are easily made here as the pin spacing of the specified relay does not lend itself readily to the 0·1in format. It will be found necessary to open up some of the holes slightly with a 3/32in drill and bend the relay tabs over in order to solder them to the copper strips (see Fig. 2). Of course a relay socket could be used but this would add to the bulk and cost of the project.

Some constructors will, no doubt, use other relays. In particular, a "low profile" relay made for the 0·1in hole spacing would be an ideal choice. It would certainly make the project smaller but would add to the cost considerably and the stripboard layout might need changing.

All soldered connections must be made with great care if trouble is to be avoided. Except where indicated, "bridging" between adjacent copper tracks must be avoided. Where breaks in the tracks are necessary, the special tool made for the purpose may be used or a small twist-drill.

The circuit panel, when complete, must be held securely in its case with the piece of three-way terminal block mounted on top. It is better to use a plastic box than a metal one.

CONNECTING UP

The three external connections, BATTERY POSITIVE, BATTERY NEGATIVE and *A* must be planned carefully. Connection *A* may be made to a door pillar switch itself (where two switches operate the same light it does not matter which switch is used). Before this method is adopted the proposed route for the wire from this point to the unit must be investigated. It may be very difficult.

With luck, the handbook for the car may reveal a nearby connector in the pillar switch wire. If this is the case, do not break the wire then twist the additional one to it taping it up afterwards. This sort of connection will probably fail in service. It is essential to use a proper auto-type connector. It may be found easy to make connection *A* to the light unit itself.

The negative connection will either be made to an existing earth point or a small eyelet may be used by drilling a small hole in a metal part and securing it with a self tapping screw.

The positive connection should be taken from the regulator box. Connect the wire to the tag which is live all the time, not just when the ignition is on. On no account wire the positive lead direct to the battery.

POSITIVE EARTH

All the foregoing has assumed that the vehicle is of the negative earth variety. In particular it will be noted thatthe polarities of C1 and D1 are important. If you have a positive earth vehicle, these should be reversed and BC478 *pnp* type transistors used. The battery negative line will then go to the relay, C1 and D1 anode, and the battery positive or earth will go to S1. Connection *A* is unchanged.

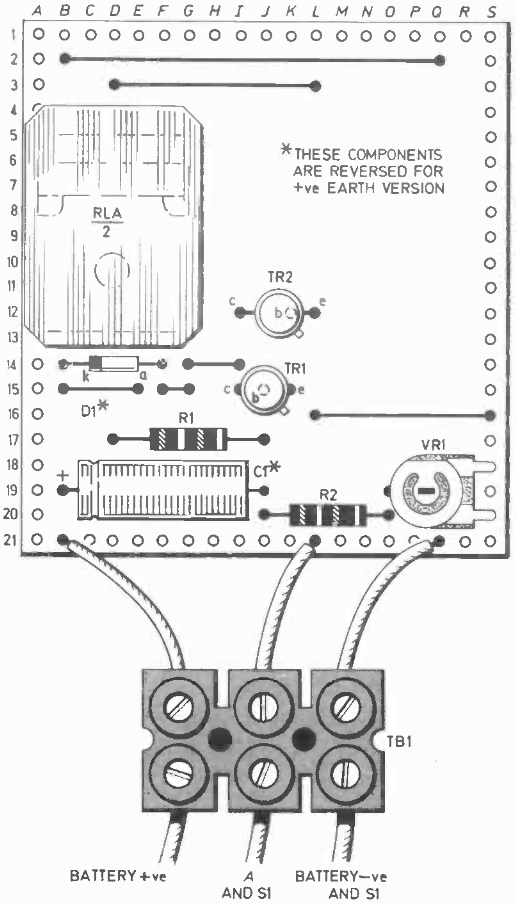
SETTING UP

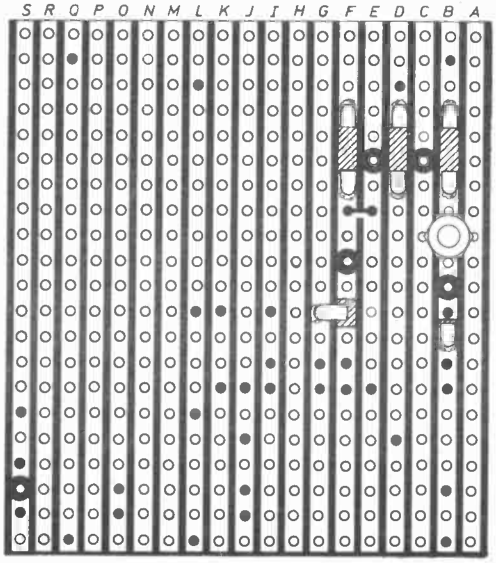
After final testing, VR1 should be set for the required time delay. Remember that new electrolytic capacitors may make a few operations before they settle down to their correct value. Old capacitors which have been in stock for some time may suffer in the same way.

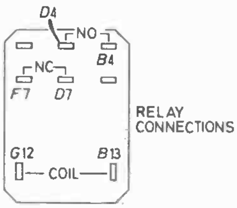
Another point is that the timing begins when the door is *opened* not after it has been closed. Additional time will be required to allow for entering the car and closing the doors.

It will be noted that this circuit cannot distinguish between people entering or leaving the car. When the car is left the courtesy light will stay on for a short time. This may, in fact, help with the locking up. ⌘

COURTESY LIGHT DELAY

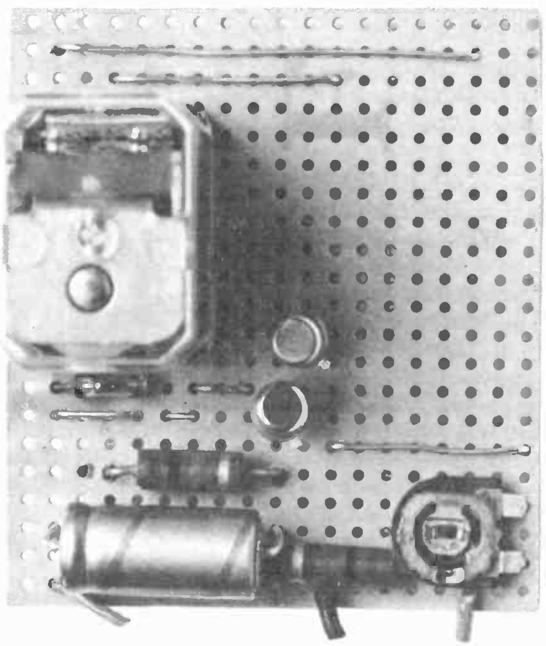






COMPONENTS approximate cost £3.50

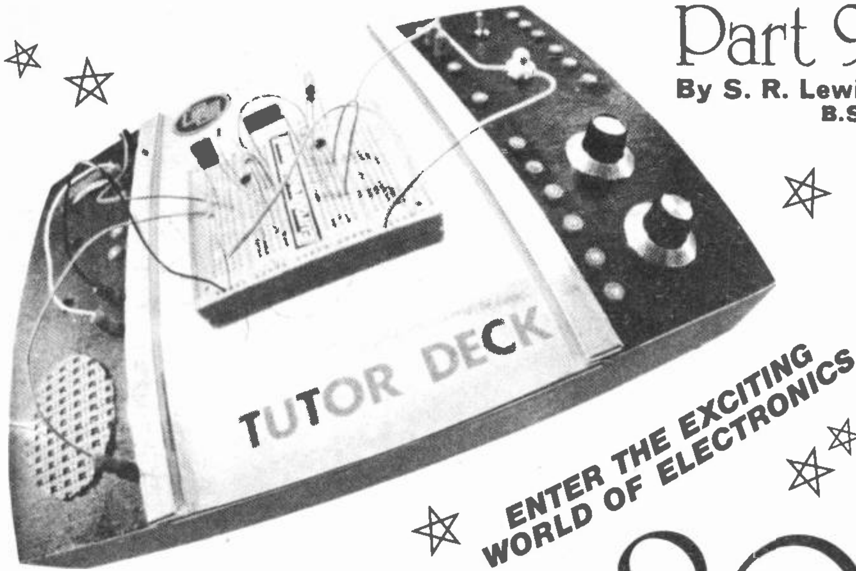
Fig. 2. (above) Circuit board layout for the negative earth version. (See text for positive earth modifications). Note how the relay tags have been bent over in order to be soldered to the stripboard. Care is also needed over the polarities of C1 and D1. The photo below shows the top view of the completed board.



COMPONENTS

R1, 2	1kΩ ½W ±5% (2 off)
VR1	500kΩ miniature horizontal preset
C1	100µF 15V elect.
TR1, 2	BC108 *npn* silicon (for negative earth version) or BC478 *pnp* silicon (for positive earth version) (2 off)
D1	1N4004 small signal silicon diode
TB1	Three-way screw terminal block
RLA	12V relay with 185 ohm coil and one set normally open contacts, one set normally closed contacts
S1	Single-pole push-to-make

Stripboard 0·1 inch matrix, 19 strips by 21 holes; case to suit; mounting hardware; connecting wire.



Part 9

By S. R. Lewis, B.Sc.

TEACH-IN 80

THE USE of transistors as switches was described last month, and the point was made that in this application only a very small part of the transistor's capability was made use of. Providing the transistor could be held **cut-off** or in saturation and the transition between the two states was fast and reliable, then the performance of the transistor during the transition period was not of paramount importance.

When the transistor is used as an **amplifier** (or, to be more precise, a **linear amplifier**) the situation is virtually reversed. The two states of saturation and cut-off are usually avoided as far as possible; it is the region *between* these two states upon which interest is centred.

In this part of the series we see how different configurations have been developed to take advantage of transistor characteristics, and how the "ideal" amplifier can be approached.

THE IDEAL AMPLIFIER

To make any objective assessment of the merits of an amplifier one must have some standard with which to compare. The purpose of an amplifier is basically to carry out the mathematical function of multiplication.

An "ideal" amplifier should take an input signal x and multiply it by the **amplification factor** A to produce an output signal Ax. If the amplifier is indeed "ideal" then the type of the input signal should have no effect on the magnitude of A, in other words the amplification factor should be completely independent of the nature or value of "x".

We can represent the performance of this ideal amplifier in a graphical way as shown in Fig. 9.1. In (b) the amplifier is **non-inverting**, that is the output signal is positive when the input is positive and negative when the input is negative. In (a) the amplifier is **inverting**: the output is the opposite polarity to the input.

For the ideal case the lines in the two graphs should extend to infinity in both directions, indicating that the amplifier can amplify signals of any value.

The graphs are straight lines which is why we call the amplification "linear".

Note that the "input" is not necessarily a voltage though this is probably the most common case. Some amplifiers are concerned with amplifying *current*—the voltage at the output may be exactly the same as at the input but the current flowing is many times greater. Other amplifiers are simply concerned with amplifying power.

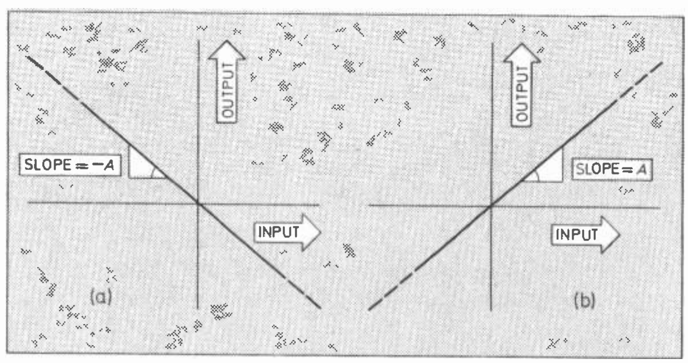


Fig. 9.1. The transfer characteristics of ideal amplifiers. (a) shows an inverting amplifier and (b) a non-invering amplifier. The gain (A) of the circuit is given by the slope of the graph.

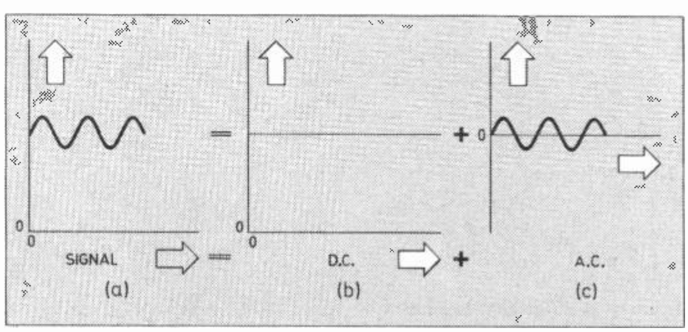


Fig. 9.2. A typical signal in an audio circuit consists of two components, a d.c. level (b) and a.c. signal (a) which is superimposed on top of it (c).

A.C. AND D.C. COUPLING

In the real world of electronics we often find that a complex signal can be broken down into a number of simpler components, making mathematical manipulation much easier.

For instance in an **audio amplifier** (one concerned with amplifying only those signals whose frequencies lie within the range discernible by the human ear) there may be a signal in some part of the circuit which appears as in Fig. 9.2. Here there is a sinusoidal voltage but instead of varying positive and negative with respect to 0V, it is varying positive and negative with respect to some positive voltage.

The only part of the signal that is of interest is the sinusoid not the voltage on which it is superimposed. Fig. 9.2 shows how the signal can be decomposed into an a.c. and a d.c. part.

The d.c. part must be taken into account, for if we were to amplify the d.c. voltage by the same factor by which the a.c. part is amplified then we would find some very large voltages around.

An amplifier which amplifies only the a.c. component of the input signal is called an **a.c. coupled amplifier**. A steady d.c. voltage applied at the input of such an amplifier would produce no output.

A **d.c. coupled amplifier** on the other hand amplifies both the a.c. and the d.c. component of the input signal.

How a.c. coupling and d.c. coupling are used in real amplifiers will become clearer later on.

A ONE-TRANSISTOR AMPLIFIER

A single transistor with a few resistors can be used to make a perfectly good amplifier (though it will have quite a few limitations).

Consider the circuit of Fig. 9.3. This is a circuit which we have encountered before in connection with transistor operation. It is a d.c. coupled amplifier because it amplifies both the d.c. and the a.c. component of the input.

The graph of the output plotted against the input (known as the **transfer characteristic**) is shown in Fig. 9.4 and it is immediately obvious that it is a long way from the transfer characteristic of the ideal amplifier.

First, it is no use at all for voltages which are negative, or positive but below 0·7V: the output is quite steady for this range. Neither is it much use for voltages much above 0·8V; here again the output is unchanging. Only over a very small part of the graph is there a section which even approaches ideal behaviour. Clearly, we need a bit more thought to make a useful one-transistor amplifier.

The main problem seems to be that the transistor needs at least 0·7V to even start conducting. If this 0·7V is provided by the input signal then anything below this voltage will be "lost". Perhaps we can put the transistor into its conducting region by another method.

BIASING

In Fig. 9.5 one way of achieving this is shown. Resistor R1 is used to provide a current into the base of the transistor so that it is in its conducting state even before the input signal is applied. This resistor is called a **bias** resistor since it biases the transistor into a useful state.

In order to isolate the input signal from the 0·7V which is now present on the base of the transistor we use a capacitor C1.

We can no longer amplify the d.c. component of the input signal since applying a d.c. signal to the input will initially charge the capacitor until no more current flows after which the output will be the same as when no signal is applied.

We can however amplify a.c. signals providing the impedance of the capacitor at the signal frequency is low.

The trouble with this circuit is that we have to be extremely precise in our choice of bias resistor value. If it is too small then the current flowing through it will cause the transistor to saturate and the a.c. signal will have no effect on the output.

In fact, the only useful value of bias resistor is that which makes the output voltage lie exactly halfway between the voltage rails since this allows the greatest peak-to-peak swing at the output.

Assuming this value has been used then we can plot the output against the input (see Fig. 9.6),

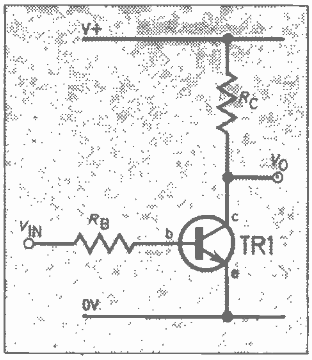


Fig. 9.3. A d.c. coupled amplifier based on a single transistor. The transistor is in the common configuration with no biasing.

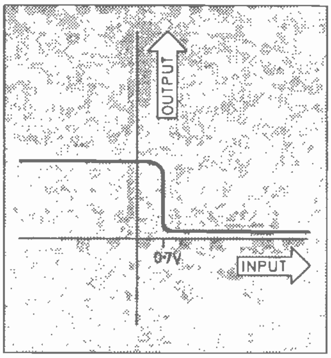


Fig. 9.4. The transfer characteristic of the circuit of Fig. 9.3. Note that all the action takes place over a very small portion of the graph.

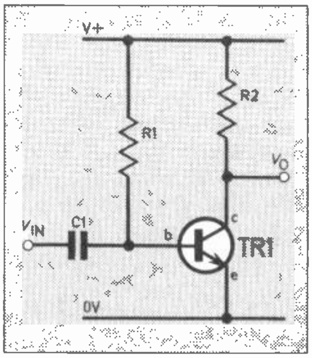


Fig. 9.5. An a.c. coupled, common emitter circuit with simple biasing via R1.

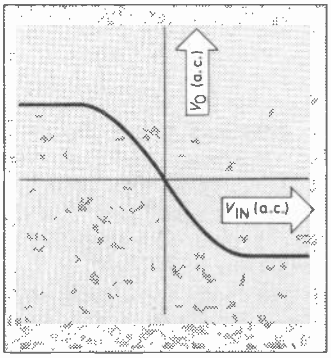


Fig. 9.6. The transfer characteristic of the circuit of Fig. 9.5. This is much more linear than the simpler circuit, but is difficult to achieve in practice.

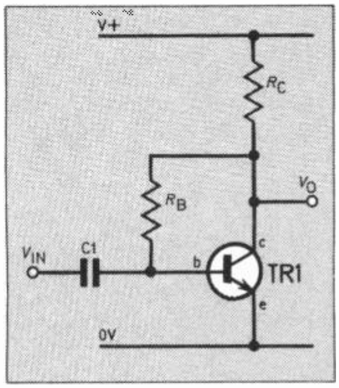


Fig. 9.7. A common emitter amplifier with stabilised biasing.

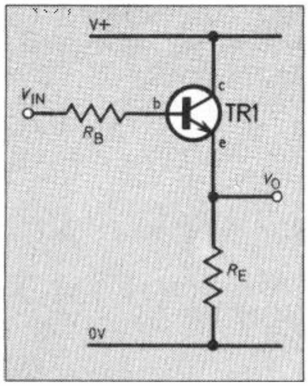


Fig. 9.8. A common collector or emitter follower circuit.

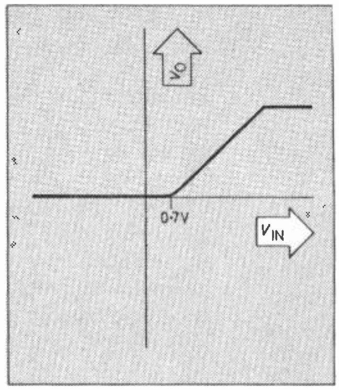


Fig. 9.9. The transfer characteristic of Fig. 9.8. This is very linear but the gain (slope) is only one.

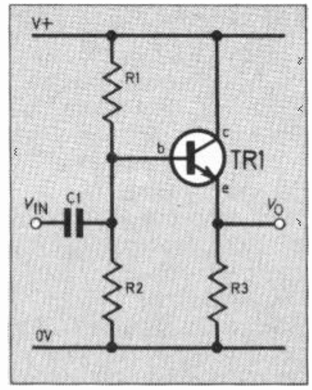


Fig. 9.10 Stabilised biasing arrangement for the common collector configuration.

noting as we do that the graph is only true for a.c. voltages.

The transfer characteristic now looks quite a good representation of the ideal characteristic for an inverting amplifier. Note that the voltages saturate in both the positive and negative directions. This is because the output voltage cannot be any greater than the positive supply or any less than the 0V rail.

This circuit is totally impractical as the bias resistor has to be different for every single transistor since its value depends on the h_{FE} (gain) of the transistor.

The gain of the transistor also changes slightly with temperature so the resistor also has to be varied when the temperature changes—not a realistic situation.

STABILISING THE BIAS

The third attempt at producing a practical one transistor circuit is shown in Fig. 9.7. Here instead of the bias transistor R_b being fed from the power supply rail, it is fed from the output. This has a remarkable stabilising effect on the bias point for the following reasons.

Suppose we choose the ratio of the bias resistor value to the collective resistor value (R_b/R_c) to be equal to the typical h_{FE} of the transistor times two, then the output voltage V_o will lie very close to halfway between the power supply rails (actually at halfway between the power supply voltage and 0·7V).

If the transistor in the circuit has above typical gain what happens? If the base current was the same as with a typical transistor then the output voltage would fall due to the higher gain. However, the voltage on the bias resistor would then be less which would reduce the base current thus counteracting the original effect.

A transistor with below typical gain would cause the output voltage to rise but this would be counteracted by the ensuing rise in base current. Let us look at an example to see how the figures work out.

With a supply voltage of 9V and R_b=200 kilohm and R_c=1 kilohm, a transistor with a gain of 100 would produce an output voltage V_o of 4·8V. If the transistor has a gain of 150 the voltage is 4·02V. If h_{FE} is 75 then the output voltage is 5·44V. Thus a 2:1 change in h_{FE} produces only a 1·42V change in output voltage.

The amplifier we have produced is quite a feasible proposition but the gain is out of our control and the input impedance (see later) is low.

THE EMITTER FOLLOWER

The circuits that we have looked at so far have all been **common emitter circuits** so let us now look at the **common collector circuits.** Fig. 9.8 shows a transistor with an emitter resistor R_e and a base resistor R_b. If we plot the transfer characteristic of this circuit we get a very different graph from that of the common emitter circuit (Fig. 9.9). The one similarity appears to be that this circuit is also no use as an amplifier for voltages below 0·7V.

With an input voltage above 0·7V the output appears extremely linear with respect to the input, only deviating when the power supply is reached.

The only trouble is, the gain of the circuit is one, the output voltage exactly following the input only 0·7V below it. This "following" action gives the circuit its name **emitter follower.**

At first sight there does not seem much point in a circuit with a unity gain until one transfers one's attention from voltage to current. The input current to this circuit is, in fact, amplified by the current gain of the transistor so that the current flowing through the emitter resistor is $(1+h_{FE})$ times the base current.

This circuit is very useful as a **buffer** where we have the situation where a circuit with a low output current capability must be coupled with a circuit which requires an appreciable current.

Like the common emitter circuit, a bias resistor can be added so that the 0·7V base to emitter voltage is not subtracted from the input. However, there is no analogous circuit to the one with the bias resistor taken to the output voltage.

Unlike the common emitter circuit the base voltage can rise above 0·7V so we have the possibility of using a **potential divider** to produce a bias voltage. Such a circuit is shown in Fig. 9.10.

The values of the resistors can be large and the ratio is chosen such that the output voltage lies halfway between the power supply rails. The voltage at the base is now over half the supply voltage so a capacitor must be used to isolate the signal from this voltage.

A PRACTICAL AMPLIFIER

Having looked at single transistors in a rather theoretical way let us now look at a practical single-transistor amplifier as shown in Fig. 9.11. This circuit combines the advantages of the common emitter circuit with its high voltage gain and the emitter follower with its very stable operating point.

As in the emitter follower, the bias is provided by two resistors forming a potential divider, R1, R2. These define the voltage at the base of the transistor and hence at the emitter since this will be 0·7V below the base.

Under static conditions no current can flow through capacitor C2 so the emitter current must be V_e/R4. If we assume that the transistor has high gain, then the base current will be negligible with respect to the emitter current so that it is fair to take the emitter and collector currents as virtually equal.

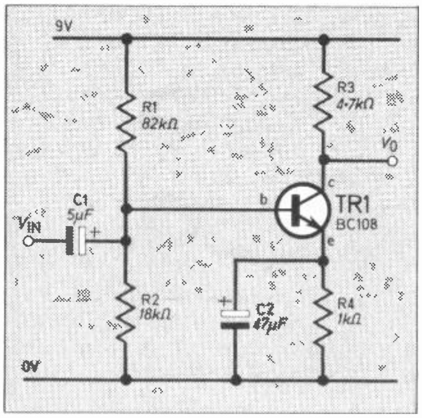
Knowing the emitter current, we can thus define the voltage at the collector as this will be the power supply minus the emitter current times the collector resistor.

This sets the operating point of the transistor. The gain is virtually equal to the h_{fe} of the transistor with a.c. signals of a frequency sufficiently high to make the impedance of C2 low with respect to R4.

The circuit is an a.c. coupled amplifier since it cannot amplify steady d.c. voltages.

DARLINGTON PAIR

Sometimes the gain of a single transistor is too low for a particular application and combining individual circuits is wasteful of components. A simple answer to this problem is to use two transistors connected in what is known as the **Darlington pair** configuration. This effectively forms a composite transistor whose gain is the product of the two transistors.



PART 9 QUESTIONS

9.1. An amplifier has an input signal of 4mV at 1μA. Its output feeds 9V into an 8 ohm load. What is the voltage gain:
a) 2,250 c) 9,000
b) 22,500 d) 400,000

9.2. What is the power gain of the amplifier in 9.1:
a) 1,000 c) 25,000
b) 2·5 × 10[9] d) 10[12]

9.3. What is the current gain of the amplifier in 9.1:
a) 1,000 c) 1,125,000
b) 4,000 d) 1,125

9.4. Two amplifiers are connected in series, one with a gain of 25 and the other with a gain of 100. Assuming they do not interact what is the combined gain:
a) 125 c) 1,250
b) 250 d) 10,025

9.5. An amplifier draws 0·1μA when the input signal is 10mV, what is the input impedance:
a) 100k Ω c) 100 Ω
b) 1M Ω **d) 10M Ω**

PART 8 ANSWERS

8.1. b) 8.2. c) 8.3. c) 8.4. c) 8.5. c)

The circuit is shown in Fig. 9.12. The emitter of the first transistor is connected to the base of the second whilst the two collectors are joined.

The base current in the second transistor will be the base current of the first transistor times (h_{FE}+1). Thus the collector current of the combination will be more than $h_{FE1} \times h_{FE2}$. Gains of over 10,000 are easily achieved by this method.

Packages are available which look just like transistors with their emitter, collector and base terminations but which contain a pair of Darlington-connected transistors.

SYMBOLS FOR TRANSISTOR GAIN

$$h_{FE} = \frac{\text{collector current}}{\text{base current}}$$

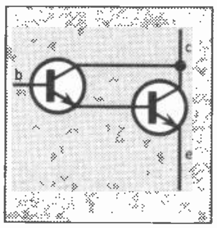
$$h_{fe} = \frac{\text{change in collector current}}{\text{change in base current}}$$

The capital letter suffixes indicate d.c. parameters **(d.c. current gain)** whilst small letters indicate a.c. parameters **(small-signal current gain).**

Fig. 9.11 (left). A more practical single transistor amplifier with stabilised biasing and high gain.

Fig. 9.12 (below). Two transistors connected as a Darlington pair.

Fig. 9.13 (right). A long-tailed pair amplifier. If, instead of being connected to 0V, TR2 base is used as another input then a differential amplifier is formed.



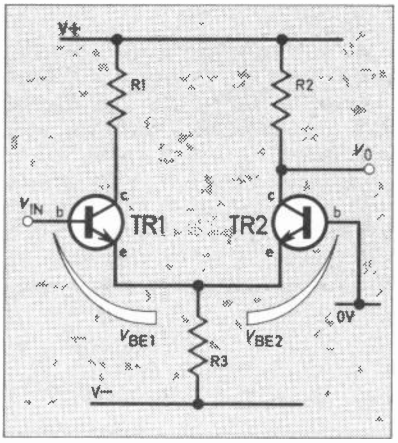
Note that the base to emitter voltage of such a composite transistor will be twice that of a normal transistor since there are two base-emitter junctions in series. This can be a problem where lower power supply voltages are used.

THE LONG-TAILED PAIR

A circuit which is very important in modern electronics is shown in Fig. 9.13. It is known as the **long-tailed pair** and its mode of operation is different from the circuits so far discussed.

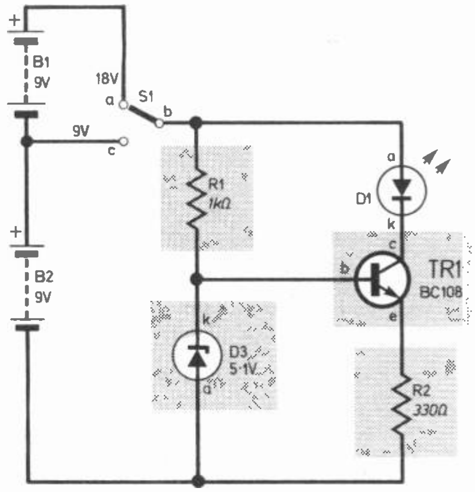
The current flowing through the emitter resistor R3 (the "long tail" of the name) is the sum of the emitter currents of the two transistors. The emitter resistor and the supply voltage are chosen such that small changes in V_{in} do not affect the total current in R3 to any great extent.

If the two transistors are identical then the base to emitter voltage of the transistors will be equal when the emitter currents are the



EXPERIMENT 9.1: CONSTANT CURRENT SOURCE

Components needed: 1kΩ ¼W resistor, 330Ω ¼W resistor, BC108 transistor, 5·1V 400mW Zener diode.



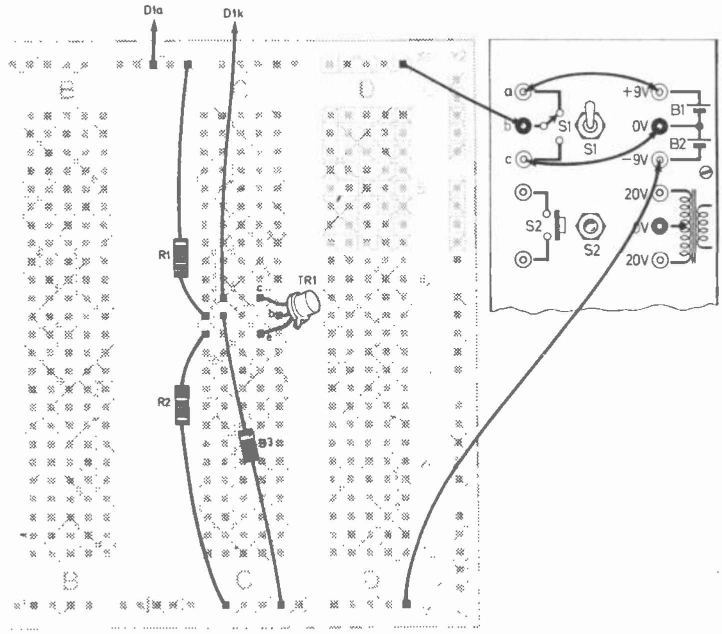


Fig. 9.17 (a). The circuit of Experiment 9.1 and (b) the layout on the Tutor Deck.

The circuit of this simple experiment which demonstrates how the gain of a transistor can be used to stabilise the current through a load (in this case a light emitting diode) is shown in Fig. 9.17a and the layout on the Tutor Deck in Fig. 9.17b.

A Zener diode D3 is used to set the bias voltage on the base of the transistor. The voltage at the emitter of the transistor will therefore be 0·7V below this (about 4·4V). Thus approximately 12mA will flow through the emitter resistor R2.

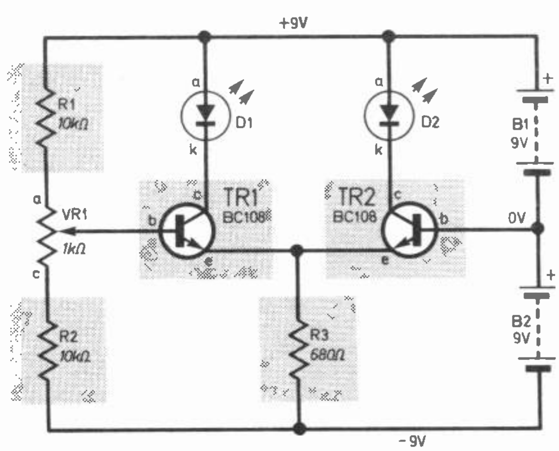
This will be true whether the supply voltage is 9V or 18V since this will only vary the current through the Zener not the base bias voltage. See how little effect altering the voltage using the switch S1 has on the brightness of the l.e.d. D1.

EXPERIMENT 9.2: LONG TAILED PAIR

Components needed: 10kΩ resistor (2 off), 680Ω ¼W resistor, BC108 transistor (2 off).

The circuit for this experiment is shown in Fig. 9.18a and the layout on the Tutor Deck in Fig. 9.18b. The 680Ω emitter resistor R3 sets the total current through the two transistors at about 12mA.

When the potentiometer VR1 is altered the circuit will divert the current from one l.e.d. to the other. When the voltage at the base of the left-hand transistor is exactly 0V the brightness of the two l.e.d.s D1, D2 will be the same.



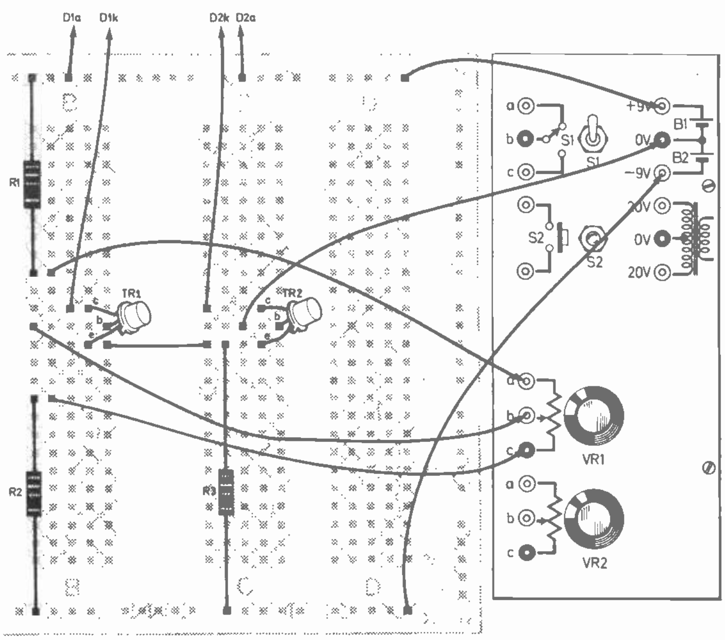
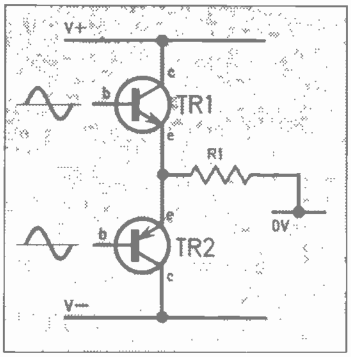
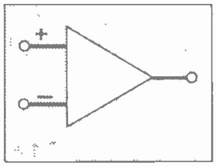


Fig. 9.18 (a). Circuit of Experiment 9.2 and (b) the layout on the Tutor Deck.





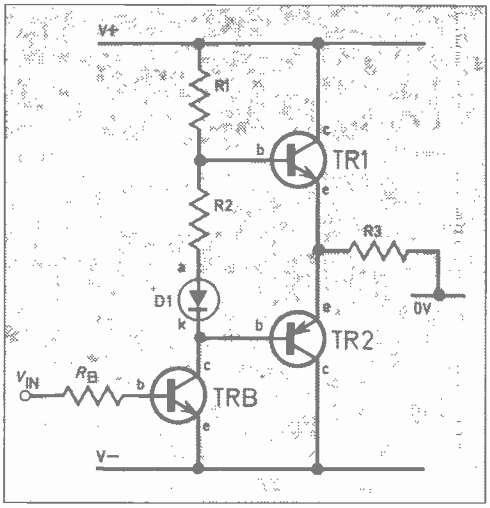


Fig. 9.14 (top left). Two complementary transistors connected to drive a load to 0V. Note that two power supplies are needed but now signals of both polarities can be handled.

Fig. 9.15 (right). A typical drive circuit for the complementary pair.

Fig. 9.16 (above left). The symbol for an operational amplifier.

same. If the emitter current in one of the transistors rises then the base to emitter voltage rises slightly as well.

One of the bases is connected to 0V so that $V_{in} = V_{be1} - V_{be2}$. From the relationship between the emitter current and the base to emitter voltage it can be deduced that a change in input voltage of 240mV is sufficient to change the emitter current in TR2 from 1 per cent to 99 per cent of the current through R3. This is true whether the transistor is silicon or germanium.

When the input voltage is between +120mV and −120mV the circuit is an amplifier whose gain is at a maximum when the two emitter currents are equal.

The base of the second transistor TR2 can be regarded as another input, the circuit then behaving as a **differential amplifier**, that is one that amplifies the difference between its two inputs.

COMPLEMENTARY OUTPUT

Another important two-transistor circuit is shown in Fig. 9.14 though in this case the two transistors are complementary: one is *npn* and the other is *pnp*. It is known as a **complementary output** circuit.

Like the long-tailed pair, the description of the circuit is simplified if the power supply rails are called V+ and V−, and the load (R1) is taken to 0V.

The circuit may be regarded as a combination of two emitter follower circuits one using a *npn* transistor and the other a *pnp* transistor. This means that the limitation which was found with the simple one-transistor emitter follower of not being able to amplify negative signals is overcome since now one transistor handles the positive signal and the other the negative signal.

Correct biasing must be used to set the output voltage and to overcome the 0·7V voltage needed to put the transistors into conduction.

A biasing arrangement which is quite often used is shown in Fig. 9.15. The diode D1 and resistor R2 are chosen so that they drop just over 2 × 0·7V with no signal. The diode compensates to some degree for the change in V_{be} which takes place due to changes in temperature.

CONNECTING STAGES TOGETHER

To produce a practical amplifier it is often necessary to connect stages together to achieve the required gain. If stage *A* has a gain of *x* and stage *B* a gain of *y* then providing the stages do not interact, connecting them in series will give a gain of *xy*. To find out if the stages interact certain facts must be known about them.

To prevent one stage from affecting a previous one its input impedance should be as large as possible. This means that the first stage should behave very much as it did when no load was put upon it.

To give a stage as much chance as possible of being able to drive a subsequent stage its output impedance should be made as low as possible.

A designer will also need to know such things as gain, frequency response (for no amplifier has a gain that does not vary with frequency), maximum allowable voltage swing, whether a.c. or d.c. coupling is required and many other things.

It is not a simple matter just to connect one stage to another.

OPERATIONAL AMPLIFIERS

A class of amplifiers which has found widespread use in recent years is the **operational amplifier** (often abbreviated to **op-amp**).

Operational amplifiers were originally designed for use in analogue computers where there was a requirement for amplifiers with very high gains, very high input impedances, large voltage swings at input and output and low output impedance.

Each has two inputs: one an **inverting input** and the other a **non-inverting input.** The symbol is shown in Fig. 9.16. It is completely d.c. coupled and the output can swing positive and negative.

It was found that all these requirements could be achieved with an integrated circuit (i.c.) and once these devices became popular (and hence cheap) they started appearing in all sorts of applications.

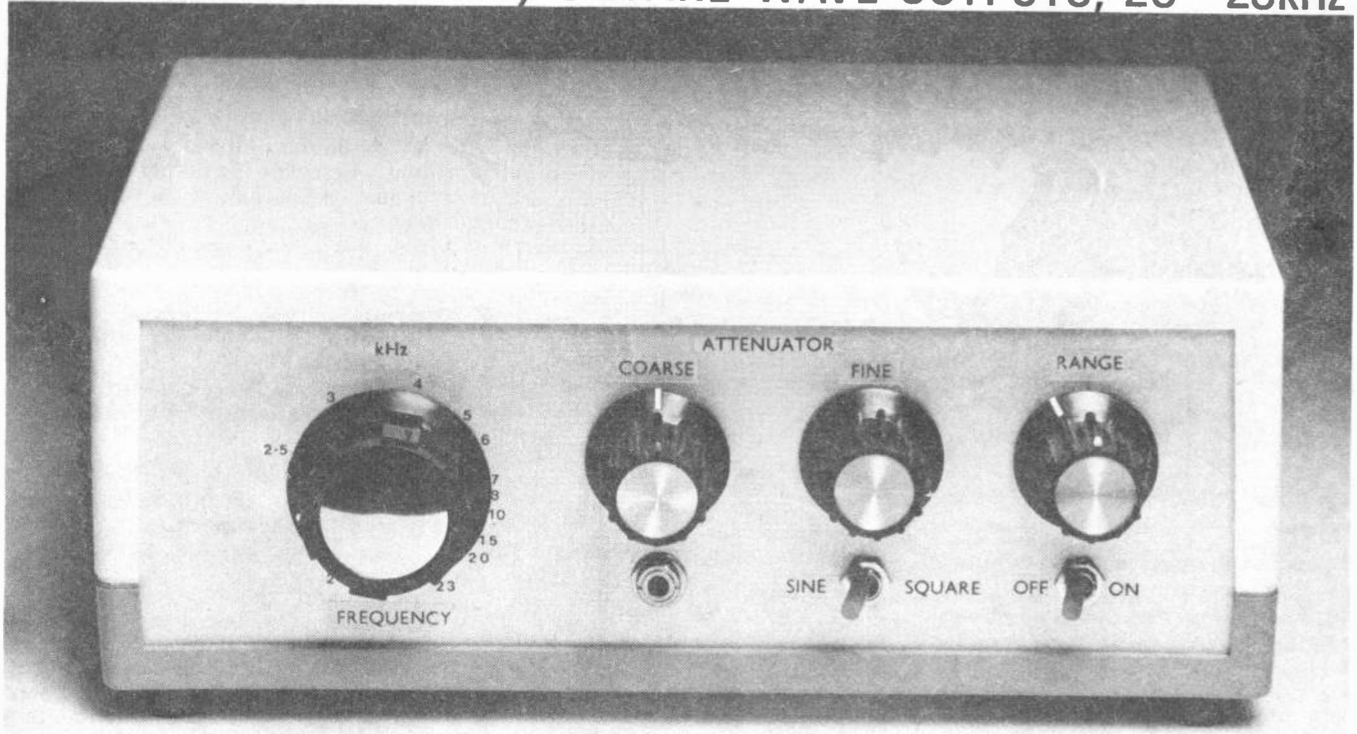
Some of the figures for these i.c. op-amps are really quite amazing. To take a specific example, the CA3140: input impedance 1·5 × 10^9 ohms, gain 300,000, voltage supply range ±2V to ±18V, supply current only 2mA.

The popularity of these circuits is undoubtedly due to the ease with which circuits to go with them can be designed. This takes us into the realm of feedback, a subject which will be covered next month.

Next month: feedback and oscillators.

A.F. Signal Generator

LOW DISTORTION SINE/SQUARE WAVE OUTPUTS, 20 - 20kHz



BY R.A. PENFOLD

A VARIABLE frequency audio signal generator is one of the most useful items of test gear for an electronics experimenter to have in the workshop, and it is virtually indispensable for someone who is primarily interested in audio equipment.

Apart from use in ordinary troubleshooting, an a.f. signal generator is needed in order to measure most of the important parameters of audio equipment (frequency response, gain, etc.).

FREQUENCY RANGE

The unit described in this article covers a frequency range of approximately 20Hz to 23kHz in three ranges, and it therefore covers a little in excess of the audio frequency spectrum. The three ranges are approximately as follows:— Range 1, 20Hz to 230Hz; Range 2, 200Hz to 2·3kHz; Range 3, 2kHz to 23kHz.

Sine and squarewave outputs are available, both with a maximum peak to peak amplitude of about 5 volts. A built in attenuator can reduce this to 500mV or 50mV peak to peak, and there is also a continuously variable attenuator.

Although the design is reasonably simple and straight forward it nevertheless has quite a high level of performance. There is no significant variation in the output level with changes in operating frequency and the sinewave distortion level is extremely low, too low to be measured accurately.

Total noise and distortion on the output of the prototype would appear to be no more than about 0·005 per cent. Thus, if the unit should ever be needed for distortion measurement it will be more than adequate for the task.

WIEN NETWORK

In common with most high quality signal generator designs, this unit is based on a Wien bridge oscillator. The circuit configuration of a Wien bridge network is shown in Fig. 1 (a). This is a form of a.c. phase shift network and at most frequencies the output signal will lag slightly behind the input signal. At one frequency though, the input and output signals will be in phase.

In other words, when the input reaches a positive peak the output reaches a positive peak, when the input signal crosses through the zero

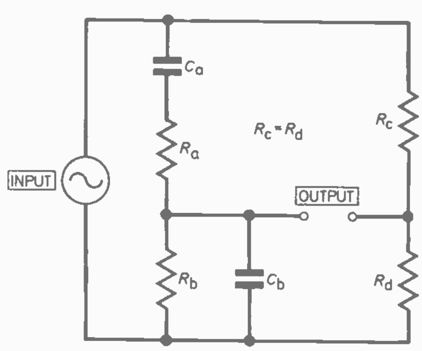


Fig. 1 (a) Basic Wien bridge network.

voltage point so does the output, and when the input reaches its peak negative value so does the output.

In a practical Wien bridge circuit it is normal for R_a to equal R_b, and for C_a to have the same value as C_b. The frequency at which zero phase shift occurs is then equal to $1/(2\pi R_a C_a)$.

In Wien bridge oscillator circuits the simplified Wien network shown in Fig 1(b) is usually used. This provides results which are much the same as the first circuit provided the output is loaded by a high impedance. A low load impedance would obviously shunt R_b and upset the operation of the circuit.

PRACTICAL OSCILLATOR

When used in an oscillator a Wien network is employed in the manner shown in Fig. 1(c). It is connected between the output and non-inverting input of an operational amplifier, and so positive feedback will be applied over the amplifier at the operating frequency of the Wien network.

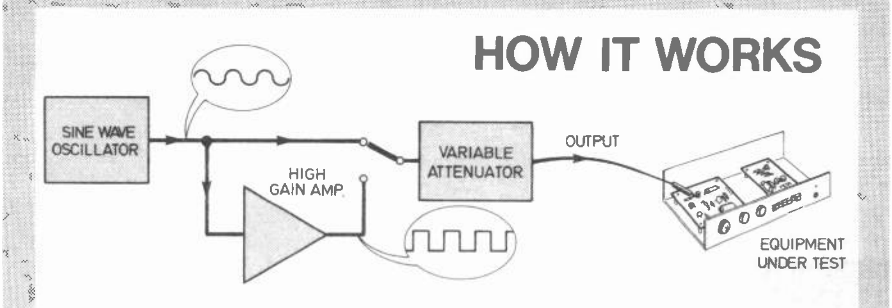
At other frequencies there will be some degree of phase shift through the Wien network, and although there will still be positive feedback at many frequencies, the losses through the network will be higher than at the operating frequency.

For the circuit to oscillate it is necessary for the losses through the positive feedback network to be at least compensated for by an equivalent amount of gain through the amplifier.

GAIN

If the gain of the amplifier is only just sufficient to compensate for losses through the Wien network at its operating frequency (about 3 times is all that is needed), the circuit will oscillate at the frequency of the Wien network.

HOW IT WORKS



A sinewave oscillator provides a fixed gain output which is split in two.

One path is taken to a high gain amplifier which clips the output to such an extent that it produces a near perfect square wave. This is then passed via a selector switch to a variable attenuator.

The other path is direct to the selector switch which decides whether the output will be a sine or square wave.

The output voltage of the unit is controlled by a variable attenuator. This governs the size of the signal that is applied to the equipment under test.

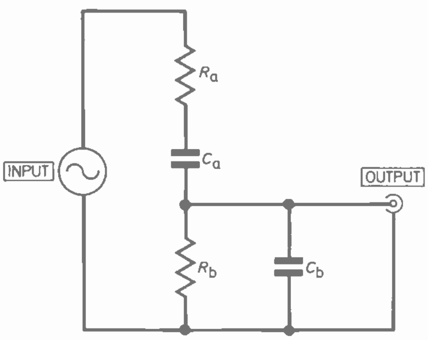
There will be insufficient gain to produce oscillation at any other frequency, and so there will be an output at just the one frequency, and this will be a sinewave.

The voltage gain of the circuit is controlled by the negative feedback loop which is comprised of R_c and R_d. R_c is made variable so that it can be adjusted to set the gain at the correct level.

The above explanation is somewhat idealised in that a practical amplifier, and even the other components, produce a certain amount of noise and distortion, and so a completely pure sinewave output is not produced.

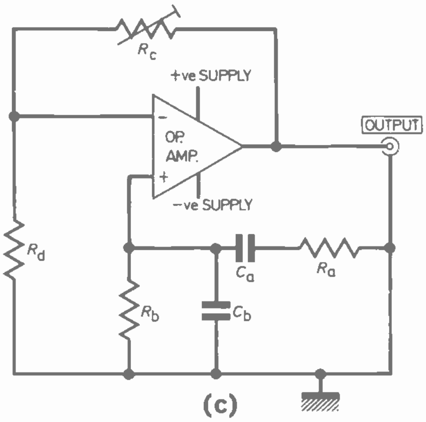
Also, in a practical circuit the gain of the amplifier must be controlled very precisely as the circuit could either oscillate so violently that the output signal becomes so high in amplitude that it is clipped and severely distorted, or oscillations will simply cease altogether.

In a practical circuit the Wien network components are made variable so that the output frequency can be adjusted over the audio frequency range, and the losses through the network are not constant over the frequencies covered. This necessitates the use of some form of automatic gain control in order to obtain a low distortion output of constant amplitude.



(b)

(b) Simplified Wien network.



(c)

(c) Practical oscillator using Wien network.

THE CIRCUIT

The complete circuit diagram of the unit is shown in Fig. 2. The amplifier which forms the basis of the Wien bridge oscillator is made up of IC1 and associated components and the ZN424E device has been chosen as it is has very low levels of output noise and distortion. It is working into what, for an operational amplifier, is a rather low load impedance and an emitter follower buffer stage using TR1 and R5 is therefore used to reduce the loading on IC1 to a satisfactory level.

There are three sets of capacitors in the Wien network (C2-C7, C3-C8, and C4-C9), with one set being selected by S1.

This provides the unit with three switched ranges. The resistive elements in the Wien network are formed by R2 plus VR1a and R3 plus VR1b. Variable resistor VR1 enables the unit to be tuned over the specified ranges.

A.G.C.

The gain of IC1 is controlled by R1 and RTH1. The thermistor provides the a.g.c. action, although this is not

COMPONENTS

Resistors

R1 390Ω
R2 1kΩ
R3 1kΩ
R4 68Ω
R5 820Ω
R6 5·6kΩ ±2%
R7 560Ω ±2%
R8 62Ω ±2%
R9 1·5kΩ
R10 820Ω
All ¼W carbon ±5% except where otherwise stated

See **Shop Talk** page 400

Potentiometers

VR1 10kΩ linear dual-gang carbon
VR2 5kΩ linear carbon

Capacitors

C1 100μF 10V elect.
C2 6·8nF polycarbonate*
C3 68nF polycarbonate*
C4 680nF polycarbonate*
C5 100μF 10V elect.
C6 10nF polyester
* ±5% or better
C7 6·8nF polycarbonate*
C8 68nF polycarbonate*
C9 680nF polycarbonate*
C10 50μF 10V elect.
C11 100μF 10V elect.
C12 10pF ceramic or plastic
C13 100nF polyester

Semiconductors

IC1 ZN424E low distortion op.amp.
IC2 μA748 op.amp.
TR1 BC109 *npn* silicon

COMPONENTS approximate cost £16

Switches

S1 4-pole 3-way rotary (only two poles used)
S2 s.p.d.t. miniature toggle
S3 4-pole 3-way rotary (only one pole used)
S4 d.p.d.t. miniature toggle

Miscellaneous

SK1 3·5mm miniature jack
B1, 2 9V battery type PP3 (2 off)
RTH1 thermistor type RA53
Case, 205 × 240 × 75mm, Verobox type 75-1411D or similar; 0·1 inch matrix stripboard, 18 strips × 25 holes; battery connectors (2 sets); 1 large and 3 medium sized control knobs; mounting nuts and bolts for circuit board; interconnecting wire.

the usual type of device which is designed to sense the ambient temperature. It is contained in an evacuated glass envelope and is mounted on very fine wires so that it thermally insulated from the outside environment.

It is what is termed a self heating negative temperature coefficient thermistor. This means that it responds to the current which flows through it which has a heating effect, and that rise in temperature causes a reduction in its resistance.

When the supply is initially connected, RTH1 will be cold and will have a high resistance. This results in a comparatively low level of negative feedback, and so the gain of the circuit is high and it oscillates violently in consequence.

This causes RTH1 to rapidly heat up, its resistance falls, and the gain of the circuit is reduced to a level which causes the circuit to gently oscillate.

If the oscillations should increase in amplitude for some reason, more current will flow through RTH1, causing it to heat up further and reduce the output to its original level. If oscillation should cease or the output level falls for some reason, RTH1 will cool slightly and return the output level to its former state.

Components C6 and R4 are the compensation components for IC1, and these prevent the device from becoming unstable.

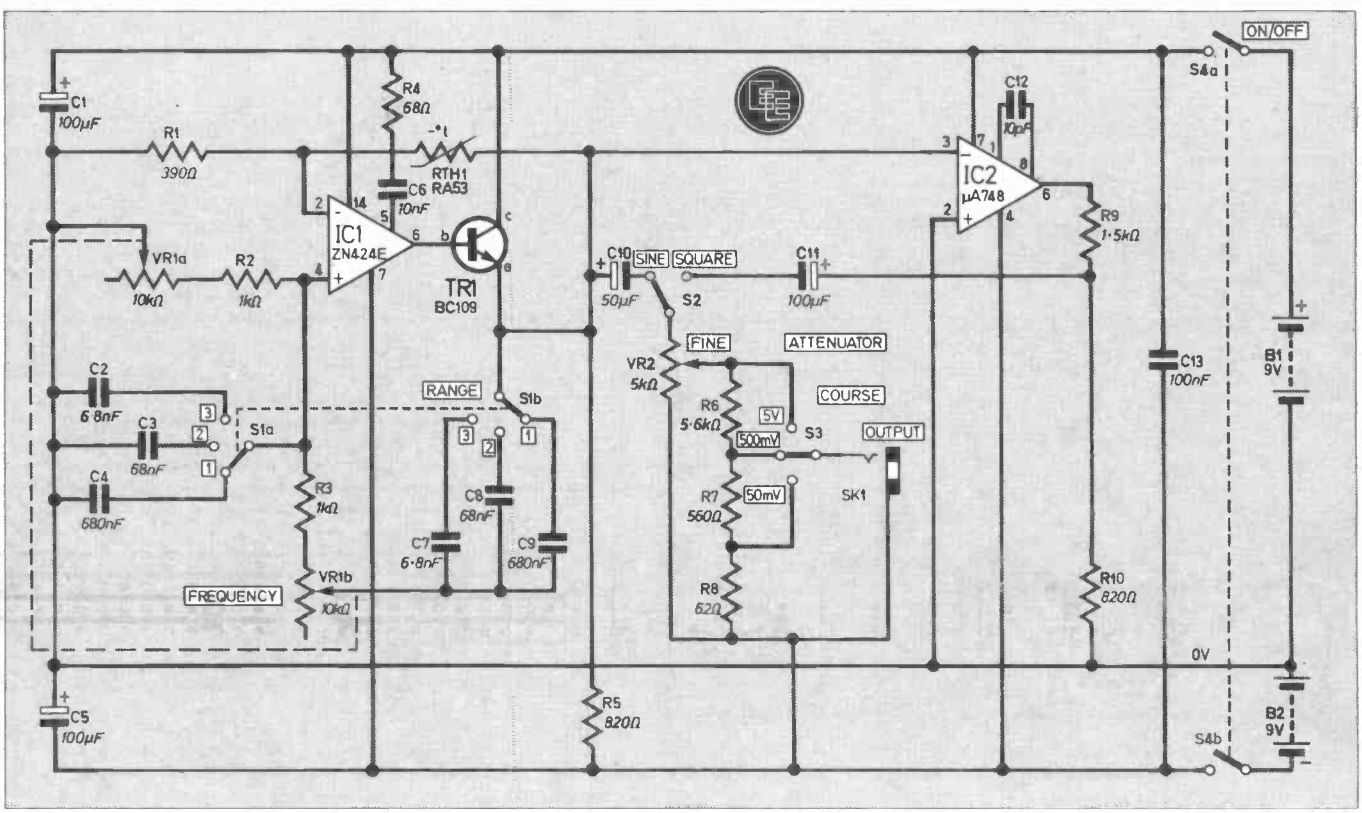
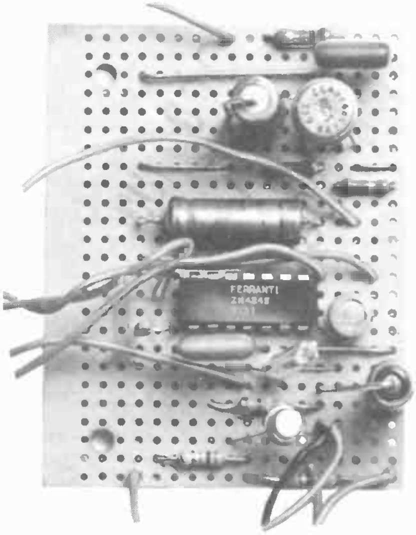
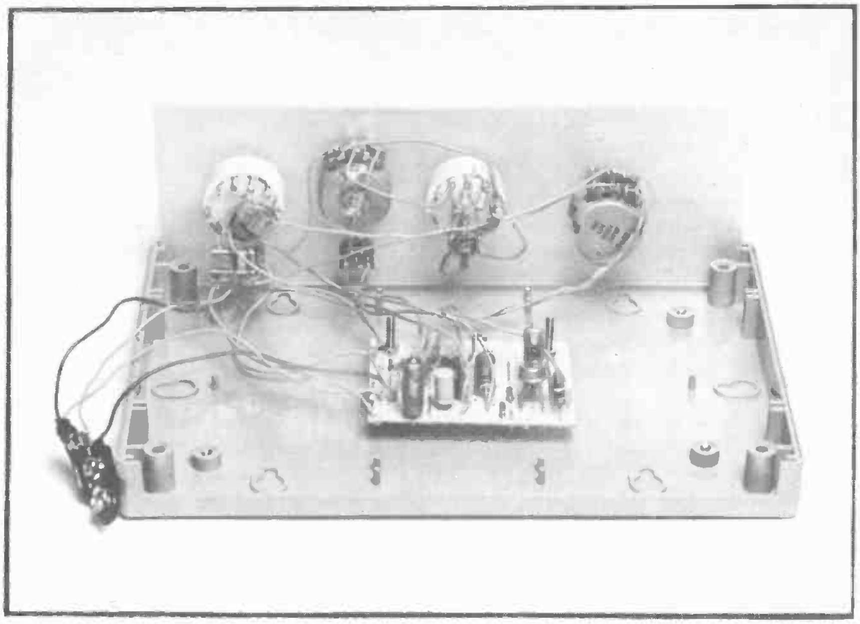


Fig. 2. Complete circuit diagram of the A.F. Signal Generator.

A.F. Signal Generator



Top view of the circuit board.



View from the rear of the completed unit. Note position of the circuit board and front panel controls.

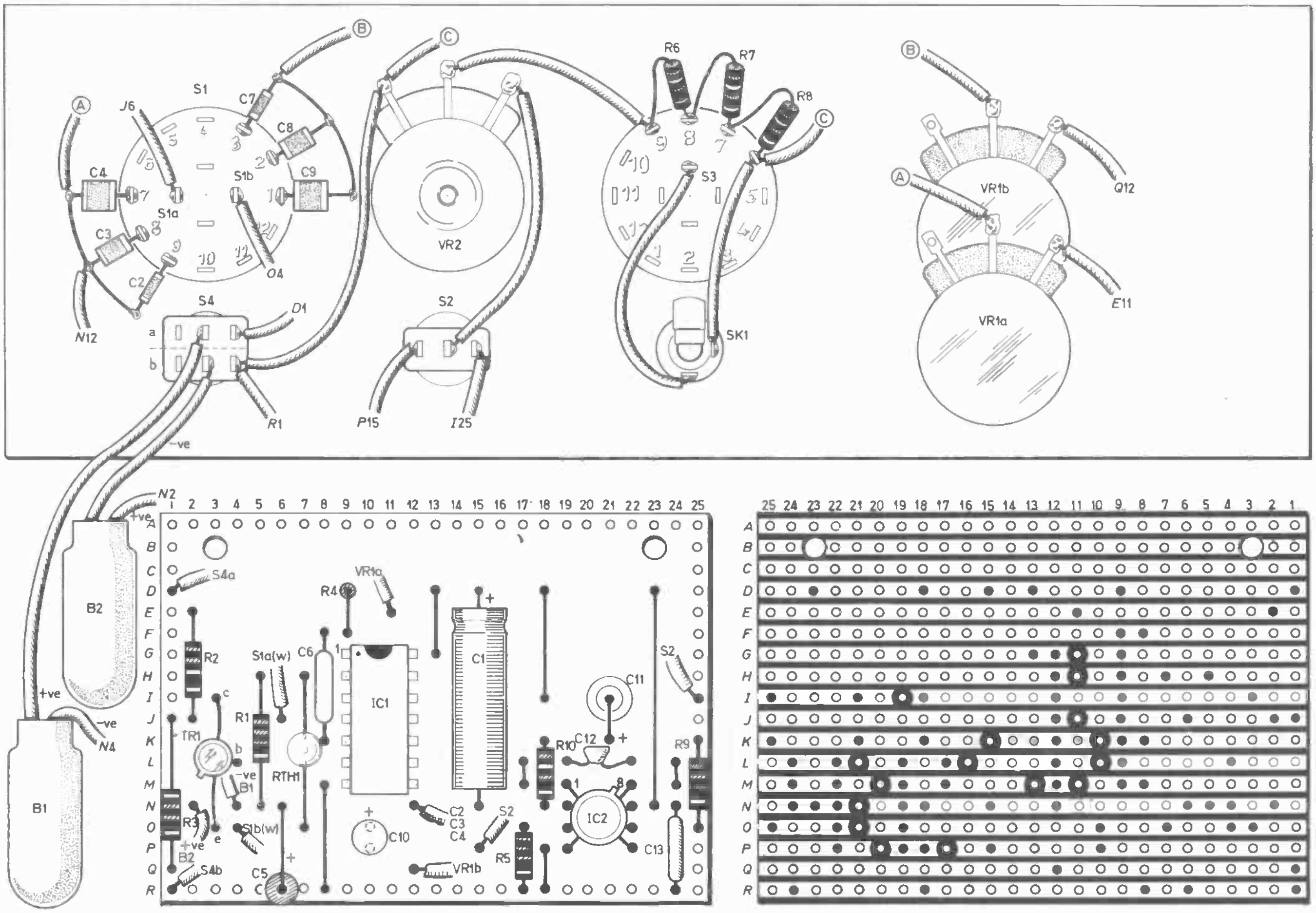


Fig. 3. Circuit board layout and front panel layout of the unit. Note that VR1 is a dual-gang potentiometer and has been drawn this way for clarity.

SQUARE WAVE

The second i.c., IC2 has its non-inverting input tied to the 0V rail and its inverting input is fed from the output of the sinewave generator circuit.

On positive output cycles the inverting input will be taken positive of the non-inverting input. The output from IC2 is equal to the voltage difference across the inputs multiplied by its voltage gain. Since no negative feedback is applied to IC2 it exhibits its full open loop gain of about 200,000 times!

This causes IC2 output to swing fully negative for virtually the entire duration of positive going half cycles. Negative half cycles receive the same very high level of amplification and cause the output to go fully positive.

A squarewave is therefore produced at the output of IC2 and this is attenuated by R9 and R10 so that it has approximately the same peak to peak output level as the sinewave signal.

Switch S4 selects either the sine or squarewave output and couples it to the output socket via the output attenuators.

The circuit is powered from dual balanced supplies with on/off switching being accomplished by S4. Capacitors C1, C5 and C13 are supply decoupling components. The current consumption from each of the PP3 batteries is approximately 15mA.

CONSTRUCTION starts here

CIRCUIT BOARD AND CASE

Most of the small components are mounted on a piece of 0·1 inch matrix stripboard, 18 strips by 25 holes (see Fig. 3). First drill the 3·2mm diameter mounting holes and make the 16 breaks in the strips. Next solder the resistors in place followed by the capacitors, link wires and finally the i.c.s, transistors and thermistor.

A 205 × 140 × 75mm case such as the Verobox type 75-1411D makes a suitable housing for this project. The front panel is laid out as in Fig. 3 and the components associated with the front panel components can then be soldered into place.

At this stage the final mounting position of the circuit board in the case should be determined. Once this has been done, the flying leads connecting the circuit board to the front panel can be cut to length and soldered in position.

To finish off the circuit board is screwed to the floor of the cabinet and the batteries connected. The unit is now ready for calibration.

CALIBRATION

The finished unit requires no adjustment before it is ready for use, but if it is to be of maximum value it is necessary to mark a scale calibrated in frequency around the control knob of VR1.

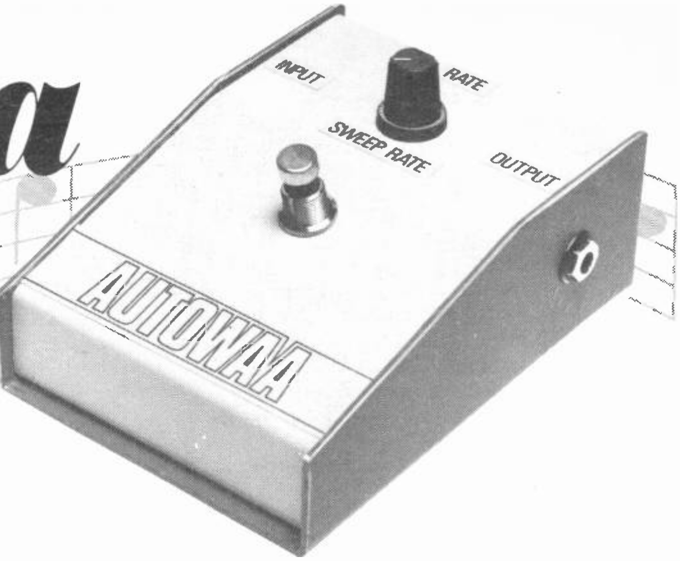
This can be difficult if access to some form of frequency meter or a calibrated a.f. signal generator is not possible. Determining the output frequency is quite straightforward, of course, if a frequency meter is available, and can be achieved with the aid of a calibrated a.f. generator by making an aural comparison.

A similar method is to use a musical instrument to provide a range of known frequencies for comparison purposes. The seven notes from middle C to the B above this are 262Hz, 294Hz, 330Hz, 350Hz, 392Hz, 440Hz, and 494Hz respectively (rounded up to the nearest whole number). A rise of one octave results in a doubling in frequency, and each drop by an octave causes a halving in frequency.

It is only necessary to use one scale for all three ranges since altering the range switch by one position simply raises or lowers the output frequency by a factor of ten. ⌑

Autowaa

By E. M. Lyndsell



For musical instruments

THE waa-waa effect is produced with the aid of a bandpass filter. This has the property, as its name implies, of allowing a selected band of frequencies to be transmitted through the filter with less attenuation (or more gain) than other frequencies above and below this band, see Fig. 1.

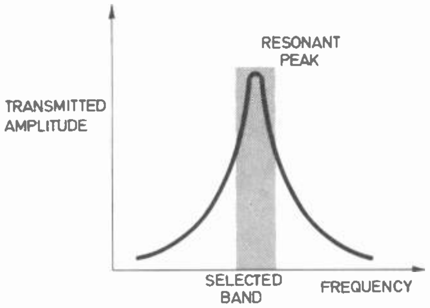


Fig. 1. Frequency response curve for a band pass filter.

The selected band is dependent on circuit values of the filter network, and so by varying one or more of these elements the band can be made to shift its position along the frequency axis of Fig. 1. By moving the band to and fro at a frequency up to a few hertz, the musical signal fed into the filter is modified resulting in the well-known "waa-waa" sound.

The most common method used is to vary the value of a resistance in the circuit by mechanical linkage between a potentiometer (wired as a variable resistance) and a foot-pedal. The unit to be described here has no "moving parts". It uses an i.c. specially designed and manufactured for use in musical equipment, in particular synthesisers.

The low noise, low distortion i.c. has four separate filter sections that can be exponentially voltage controlled over a range of 10,000 to 1. The filters can be used in virtually all active filter designs including high pass, low pass, all pass and as here, bandpass.

The control voltage in the Autowaa is derived from an in-built variable frequency oscillator relieving the user of the difficulty of simultaneous use of hands and feet.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Autowaa is shown in Fig. 2. It consists of five distinct sections and we shall deal with each of these in turn: input buffer, bandpass filter, output buffer, triangular wave oscillator and voltage control level shifter.

The input buffer amplifier consists of IC1, an operational amplifier arranged as a near unity gain non-inverting high input impedance amplifier suitable for most guitars and organs. Resistors R4 and R5 act as an attenuator which has been included to allow input signals in the order of 1V, such as might be available at the output of an organ or preamplifier/tone control stage. The latter would be capable of producing a richer tonal effect. Input signals to the filter stages should be kept below about 20mV r.m.s.

For normal guitar output signals (about 50mV) this means that the input to the filter stage has an amplitude of 1mV and less but this is acceptable due to the excellent noise figure of the SSM2040.

The bandpass filter is made by combining IC2a connected as a low pass filter and IC2b connected as a high pass filter with IC3 providing the necessary feedback. The "Q" or sharpness of the band is decided by the value of R10 and related by:

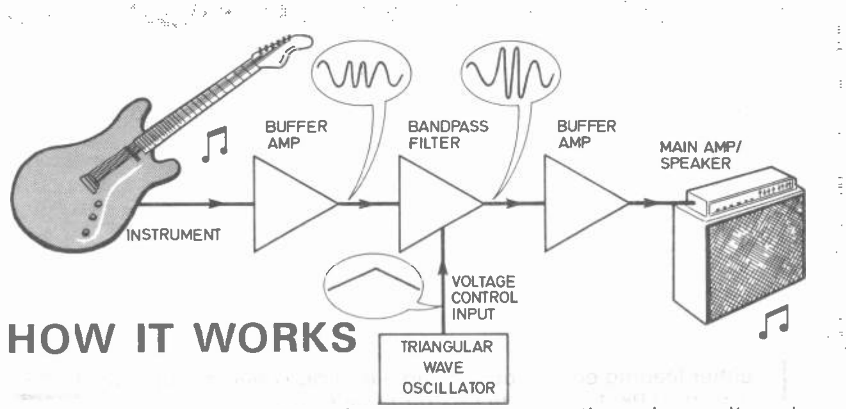
$$Q = \frac{R10}{(2 \times R10) - 10k\Omega}$$

where R10 is greater 5 kilohms.

With R10 as specified, Q is approximately 4·5 which was found to be most suitable.

The outputs of IC2 are not short-circuit proof, so for safety reasons a

HOW IT WORKS



The signal from the musical instrument passes through a unity gain buffer amplifier and then to a bandpass filter. The resonant peak of the filter is controlled by the voltage generated by the triangular-wave oscillator. This has the effect of sweeping the resonant peak up and down the frequency spectrum which produces the "waa-waa" sound. The resulting modified signal is inputted to the main amplifier via a second buffer stage.

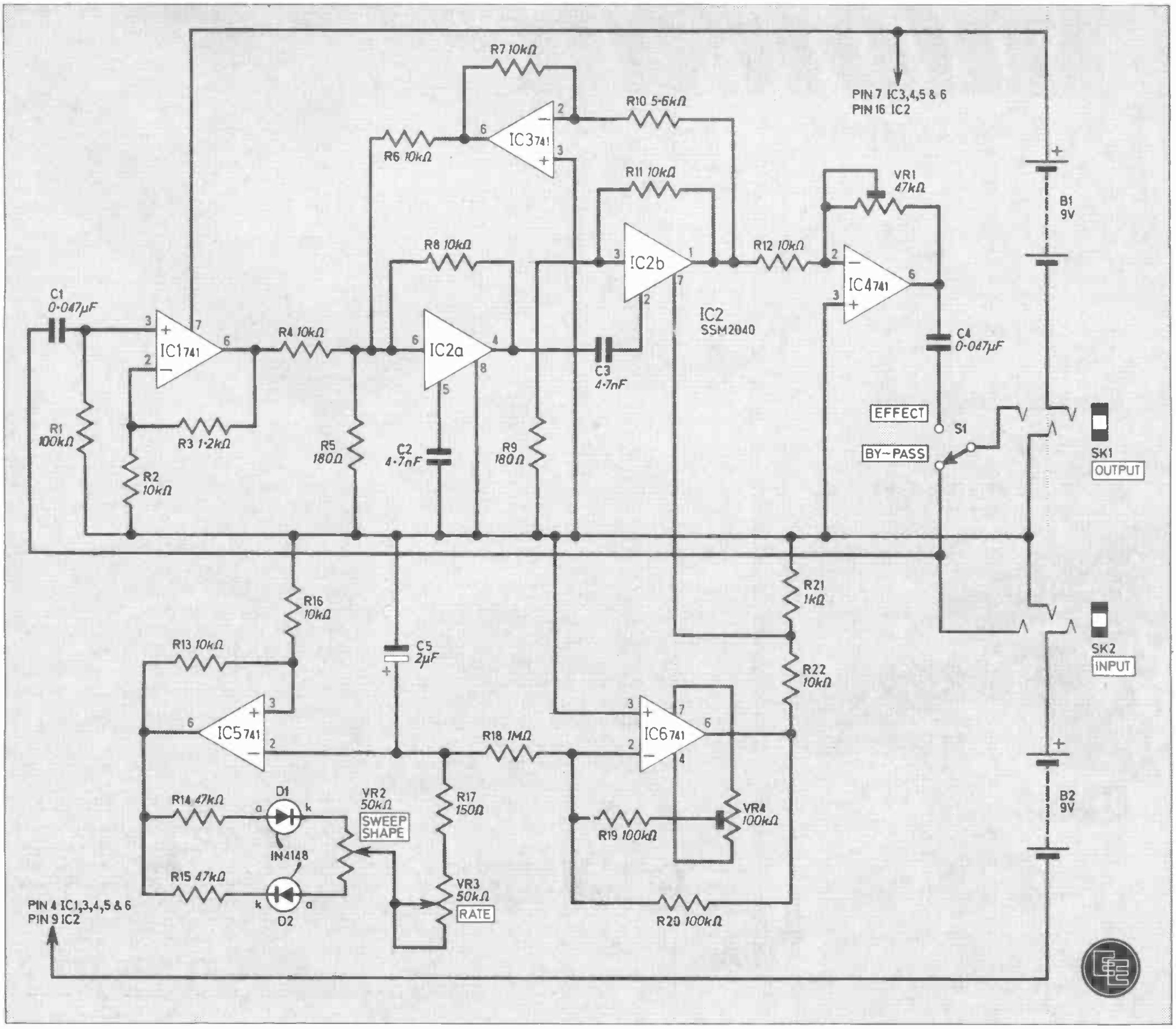


Fig. 2. Complete circuit diagram for the Autowaa.

buffer stage comprising IC4, R12 and VR1 is included in the design. This has a high input impedance and short circuit protected low impedance output making it suitable to feed all known guitar amplifiers.

CONTROL VOLTAGE OSCILLATOR

The oscillator comprises IC5 and local components, and is a multivibrator circuit with a squarewave output at pin 6. The frequency is governed by the values of C5, VR2, VR3, R14 and R15.

Initially the output at pin 6 is high and C5 charges up via R14, D1, VR2, VR3 and R17. When the voltage across C5 (at pin 2 IC5) exceeds that at pin 3 (set by the potential divide effect of R13 and R16 across pin 6) the output drops low and the capacitor begins to discharge through R17, VR3, VR2, D2 and R15 until a lower threshold is reached when the charging action resumes as before.

This process repeats for as long as power is supplied. The charging and discharging times are controlled by the position of VR2 with the steering diodes D1 and D2. The frequency is externally controlled by VR3.

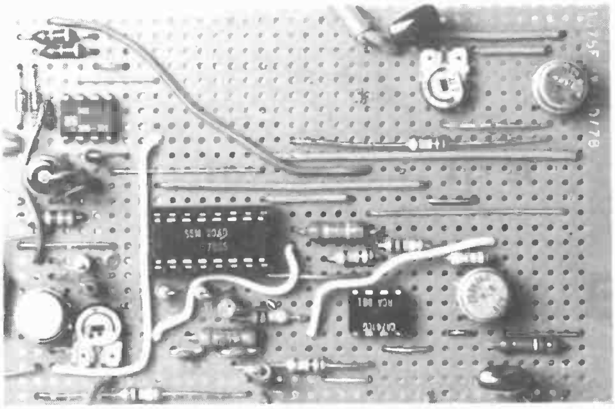
The triangular-like voltage waveform across C5, formed by the charge and discharge curves, is used as the control voltage for IC2. This voltage is fed via R18 to IC6 arranged as a high impedance inverting amplifier whose gain is set by the ratio of R20/R18. This thus acts as an attenuator with a factor of 10. Preset VR4 sets the d.c. level at the output, pin 6. Further attenuation is achieved by R21, R22 to provide the required control voltage range to pin 7, IC2. This simultaneously controls both filter sections.

The values of R21 and R22 have been calculated to provide a peak-to-peak swing of 150mV at pin 7 with VR4 adjusted to fix pin 6, IC6 at −100mV with respect to the 0V rail. This produced the best effect for guitar. Should greater sweep range be required for other instruments, R21 should be increased accordingly.

Footswitch S1 allows the output socket to be connected to either the output buffer or the input signal at SK2, effectively by-passing the circuitry when the effect is not required.

A split supply is required and two PP3 batteries provide this. Stereo jack sockets are used for input and output. The rear tags on each are connected to function as battery on-off switches when mono jack plugs are inserted. Both jack plugs must

Autowaa



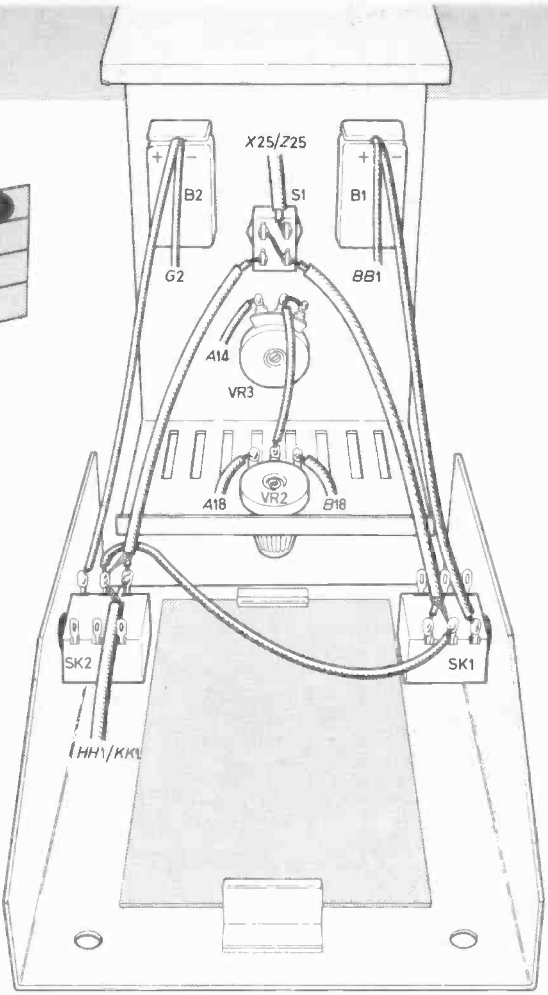
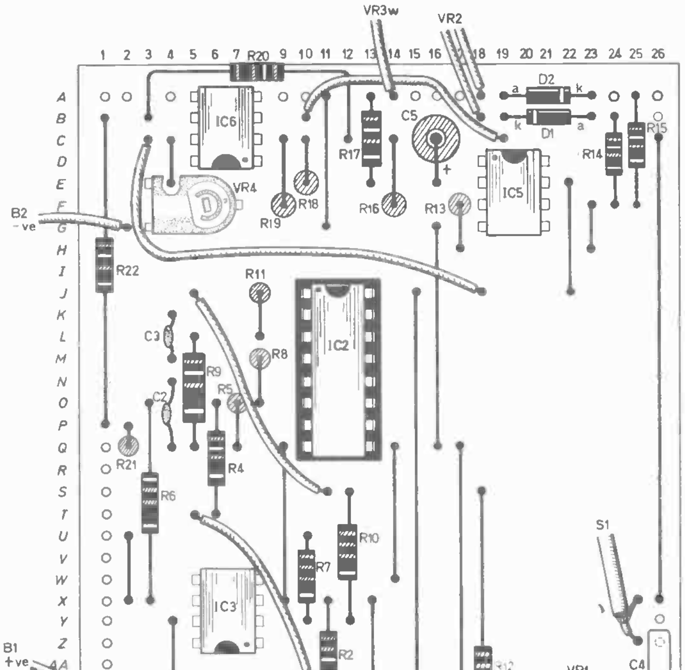
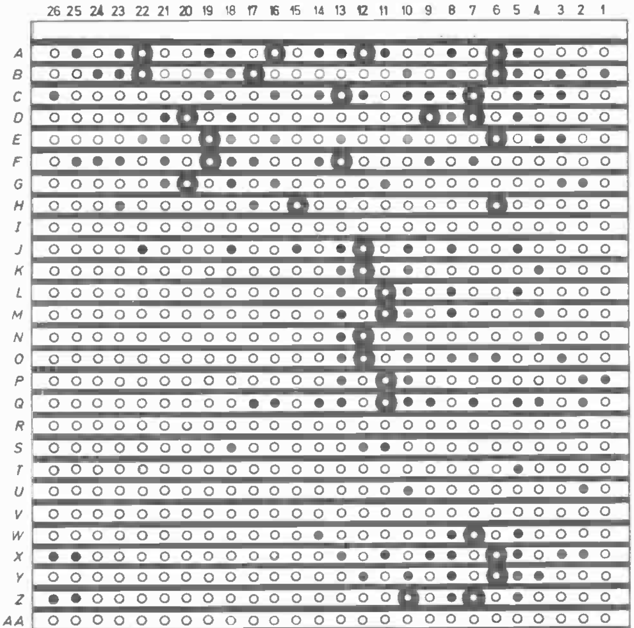
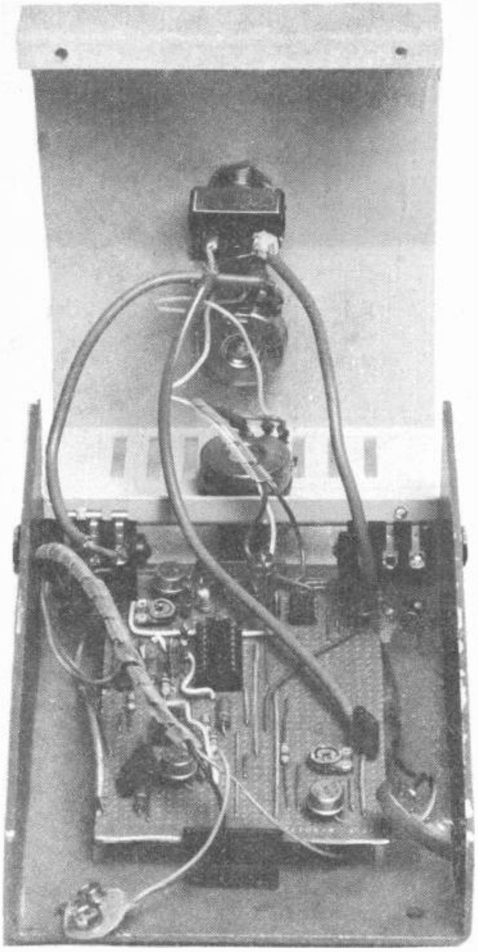


Fig.3. (below) show the layout of the components on the topside of the board and the breaks to be made on the underside; (top right) complete wiring between board and case mounted components; (above) prototype circuit board.







The completed Autowaa with upper case section removed.

be removed when the unit is not in use to disconnect both batteries from the circuit.

One disadvantage of this arrangement is that current is being drawn all the time the jack plugs are inserted whether the effect is being used or not. A d.p.d.t. switch could be incorporated to overcome this if desired.

CONSTRUCTION starts here

CIRCUIT BOARD

Most of the components are mounted on a piece of 0·1in matrix stripboard size 38 strips by 26 holes. The layout of the components on the topside of the board and the breaks to be made on the underside are shown in Fig. 3. The completed board in the prototype was fixed to the case by means of self-adhesive board mounts. If other fixings are to be used, these should be decided at this stage and if necessary the board dimensions enlarged to suit.

Begin by making all the necessary breaks along the copper strips on the board underside.

It is recommended that a socket is used to hold IC2 as this is an expensive device and risk of damage by the heat from the soldering iron is avoided. For the layout shown, this socket should be a low-profile type as these occupy less board area; alternatively Soldercon pins could be used. This also applies to the other i.c.s if it is desired to house them in sockets.

With reference to Fig. 3, position and solder in place the i.c. socket(s), link wires, resistors, presets, capacitors, diodes and i.c.s in this order, paying attention to orientation of polarity conscious components (i.c.s D1, D2, C5). Now attach suitable lengths of cable to reach the off-board controls, sockets and batteries.

CASE

The prototype used a Bimbox type 7151 two-section metal case with approximate dimensions 140×100×50mm which should be regarded as a minimum size to accommodate the components.

Prepare the case to accept the pots, switch and sockets and secure these in position. Fix the circuit board in place and wire up as shown in Fig. 3. Screened cable is used on input and output connections to reduce pick-up of noise and hum. Notice that in the connection of these cables to S1, the outer screen has been cut-back and is not connected.

When complete the wiring should be thoroughly checked before inserting the i.c.(s) and connecting the batteries. In the prototype the latter were held in place using self-adhesive foam pads. Alternatively a bracket can be designed for this.

TESTING

Set VR1, 2, 3 and 4 to their midway positions. Plug the guitar (or other instrument) into SK2 and connect SK1 to the input of a suitable amplifier. With S1 in the BY-PASS position, the guitar sound should be heard unaffected. Switch S1 to the EFFECT position. Adjust VR4 by turning slightly anticlockwise while strumming the guitar until the waa-waa sound is heard. Clockwise rotation of VR3 should increase the sweep rate.

With VR3 at midway VR2 can be tested. Rotation in either direction should not affect the sweep frequency but only the "up-sweep" and "down-sweep" times which are equal for midway setting of VR2. The effect of VR2 is reduced with lower sweep frequency.

Finally, set VR1 for the required balance between BY-PASS and EFFECT and the unit is ready for use.

Rubber feet fitted to the case will enhance the appearance and prevent sliding when operated. The controls can be labelled with Letraset to complete the unit. ⌑

COMPONENTS

Resistors

R1	100kΩ	R9	180Ω	R17	150Ω
R2	10kΩ	R10	5·6kΩ	R18	1MΩ
R3	1·2kΩ	R11	10kΩ	R19	100kΩ
R4	10kΩ	R12	10kΩ	R20	100kΩ
R5	180Ω	R13	10kΩ	R21	1kΩ
R6	10kΩ	R14	47kΩ	R22	10kΩ
R7	10kΩ	R15	47kΩ		
R8	10kΩ	R16	10kΩ		

All ¼W carbon ±5%

See Shop Talk page 400

Potentiometers
VR1 47kΩ miniature horizontal preset
VR2, 3 50kΩ carbon lin. shafted type (2 off)
VR4 100kΩ miniature horizontal preset

Capacitors
C1, 4 47nF plastic or ceramic (2 off)
C2, 3 4·7nF ceramic plate (2 off)
C5 2μF 10V elect.

COMPONENTS approximate cost £10 excluding case and batteries

Semiconductors
D1, 2 1N4148 small signal silicon (2 off)
IC1 3, 4, 5, 6 741 differential op-amp 8-pin d.i.l. (5 off)
IC2 SSM2040 4-section voltage controlled filter i.c. (Digisound)

Miscellaneous
S1 single-pole double-throw successional action push footswitch
SK1, 2 stereo jack sockets (2 off)
B1, 2 9 volt type PP3 (Duracell preferred) (2 off)
Stripboard: 0·1 inch matrix 38 strips × 26 holes; battery connectors (2 pair); control knobs (2 off); self-adhesive board mounts; miniature screened cable; case Bimbox type 7151 or other suitable case.

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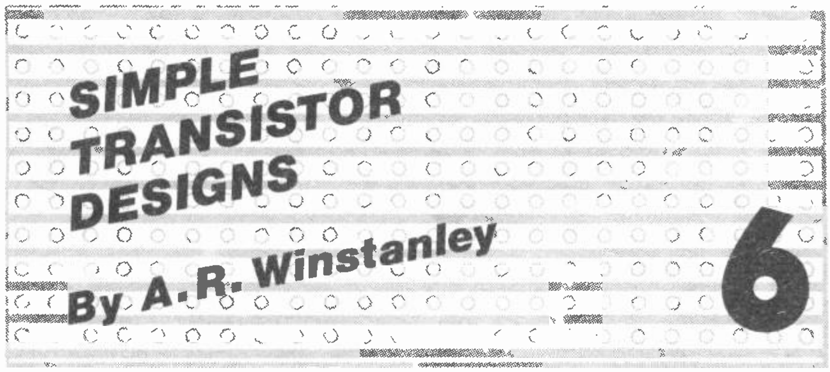


VOLTAGE CONVERTER

The unit to be described here is a simple two-transistor circuit which is designed to operate a cassette player from a 12 volt car electrical system.

The majority of cassette players operate from either 6V or 7·5V batteries, and so cannot directly be connected to the car's electrics. The Voltage Converter reduces the 12V to that required by the cassette unit.

The Voltage Converter is short-circuit proof and automatically limits the output current to 500mA which is suitable for the vast majority of cassette machines. Also the output voltage is regulated; that is, no matter what the output current is, the output voltage remains virtually unchanged.

CIRCUIT DESCRIPTION

Fig. 1 shows the circuit diagram of the adaptor. D1 protects the circuit from a reversed supply connection, and +12V is applied to its anode. R2 and D2 form a stable reference voltage which clamps the base of TR2 to 8·2V. The emitter of TR2 is therefore at a voltage of 8·2V less the 0·6V or so which appears across the base-emitter junction of the transistor, i.e. approximately 7·5V. C2 serves to remove any spurious Zener noise which may be impressed upon the output.

Remembering that the maximum output current required is about 500mA, it would be impracticable to simply use a voltage-reducing Zener diode only (with series resistor) to provide this current. An emitter-follower transistor (TR2) is therefore utilised to greatly increase the peak current available. This means that the only "output current" the Zener needs to supply is the base current for TR2, 15 to 20mA or so.

Light-emitting diode D3 (with series resistor R3) is connected across the output and illuminates when the unit is operating.

CURRENT LIMITING

Components TR1 and R1, limit the maximum current which can flow through the load. Notice that the base-emitter junction is connected across R1 which is placed in series with the negative rail. As the current through the load (and hence through R1) increases, so the voltage drop across R1 will rise. When this voltage approaches 0·6V, TR1 will start to switch on because the base-emitter junction is forward biased.

With TR1 on, this diverts current away from TR2 base and causes TR2 to switch down, reducing the current through the load. The maximum current available to the load is, in fact, equivalent to 0·6V/R1, i.e about 500mA.

CONSTRUCTION

The circuit is built on a standard-sized piece of 0·1 inch matrix stripboard, 10 strips × 24 holes as can be seen in Fig. 2. There should be no problems as assembly of the component board is straightforward.

Two 4BA clearance holes are required in the stripboard to take the mounting pillars. Also seven breaks are required in the copper strip; these can be made with a hand-held twist drill or the purpose-built Spot Face Cutter. Proceed now with the soldering of the two link wires and then the components themselves (according to Fig. 2).

The two wirewound resistors R1 and R2 should be "stood off" slightly to permit some circulation around them when they run warm. TR1 is fitted with a TO-5 push-on heatsink—fix this on *before* soldering the transistor into position.

As usual, take care not to overheat the semiconductors during soldering. A heatshunt clipped onto the lead being soldered may help prevent any thermal damage arising.

The prototype was built into an aluminium box of approximate dimensions 100×65×50mm. Any *metal* box of similar measurements should suffice. Using two 4BA threaded spacers, the circuit board is firmly fixed to one of the walls of the box. The power transistor TR2 is bolted down with a 6BA bolt to the removable lid of the box. A TO-126 mica insulating washer must be used to insulate the power transistor from the case: a smear of silicon grease or a similar compound will increase the heat transfer to the lid, employed as a heatsink, and so aid cooling of the transistor.

Wiring between board and other components is shown in Fig. 2. Mounted externally is a 4-way screw terminal block which forms the connector for the 12V input and 7·5V output. Flying leads should be taken from the circuit board and through a hole in the aluminium box adjacent to the terminal block; the hole must have a small grommet fitted.

Finally, the l.e.d. D3 can be mounted on the front of the box using the special black plastic clip and bush normally provided with it. All interconnecting can be made with stranded general purpose hook-up wire; try to ensure that none of the wiring touches either of the power resistors once the lid is in place.

Once completed, check out all wiring carefully. Particularly the flying lead connections to TR2 and D3. If a variable power supply is available then 12V d.c., of appropriate polarity, can be connected to the input of the unit (the l.e.d. should light) and the output can be measured on a 10V d.c. f.s.d. voltmeter.

The output should be seen to be between roughly 7·2V and 7·9V. If everything appears to be in order, the unit can be installed in the car and tested with the cassette machine.

It is desirable that the Voltage Converter be mounted carefully in the interior of the car, rather than under the bonnet where conditions in the engine bay are rather punitive. The box should be mounted with reasonably strong brackets.

6 VOLT OUTPUT

The unit can be modified to give a 6V output: R2 should be increased to 180 ohms wirewound, and D2 replaced by a BZX61C6V8 Zener diode. R3 is then reduced to 390 ohms.

COMPONENTS

Resistors
R1 1·2Ω 3 watt wirewound
R2 150Ω 3 watt wirewound (7·5 volt version)
180Ω 3 watt wirewound (6 volt version)
R3 680Ω ½ watt carbon (7·5 volt version)
390Ω ½ watt carbon (6 volt version)

Capacitors
C1 1µF 35V tantalum bead
C2 0·1µF mylar or polyester

Semiconductors
D1 1N4001 or similar silicon diode
D2 BZX61C 8·2 volt 1·3W Zener (7·5 volt version)
6·8 volt 1·3W Zener (6 volt version)
D3 TIL220 or similar light emitting diode
TR1 2N1711 or BFY51 *npn* silicon
TR2 BD135 *npn* silicon

Miscellaneous
Stripboard: 0·1 inch matrix size 10 strips × 24 holes; 4-way screw terminal block; TO-5 push fit heatsink for TR1; mounting clip for D3; TO-126 insulating kit for TR2; aluminium case type AB11 size 100 × 65 × 50mm or similar; small rubber grommet; 4BA 15mm long threaded spacers; 4BA and 6BA nuts, bolts and washers.

Approx cost **Guidance only**
£2.50 (see page 400)

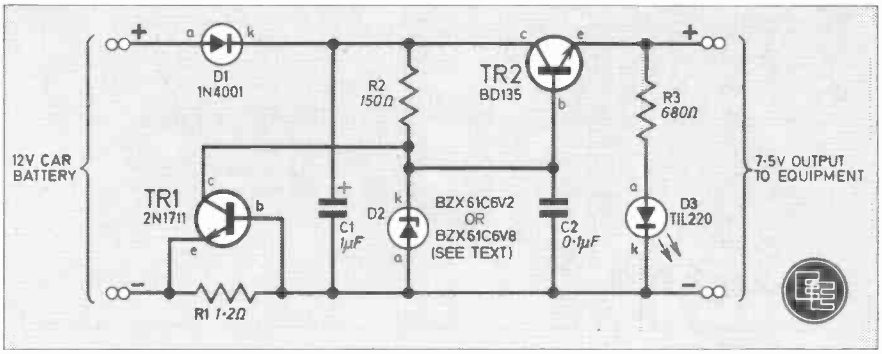
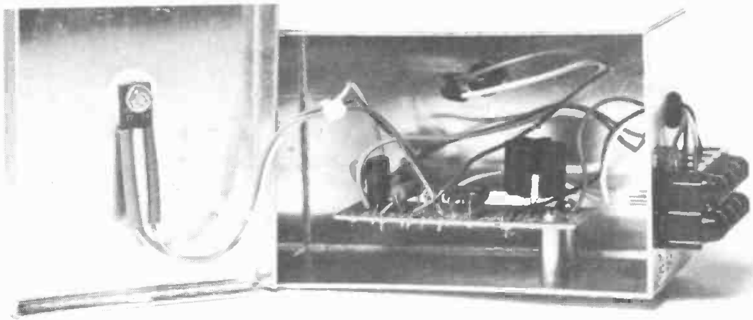


Fig. 1. The circuit diagram of the Voltage Converter. Note the Zener diode change for the 6V version.



The completed prototype with lid folded back showing method of mounting the board; spacers are used.

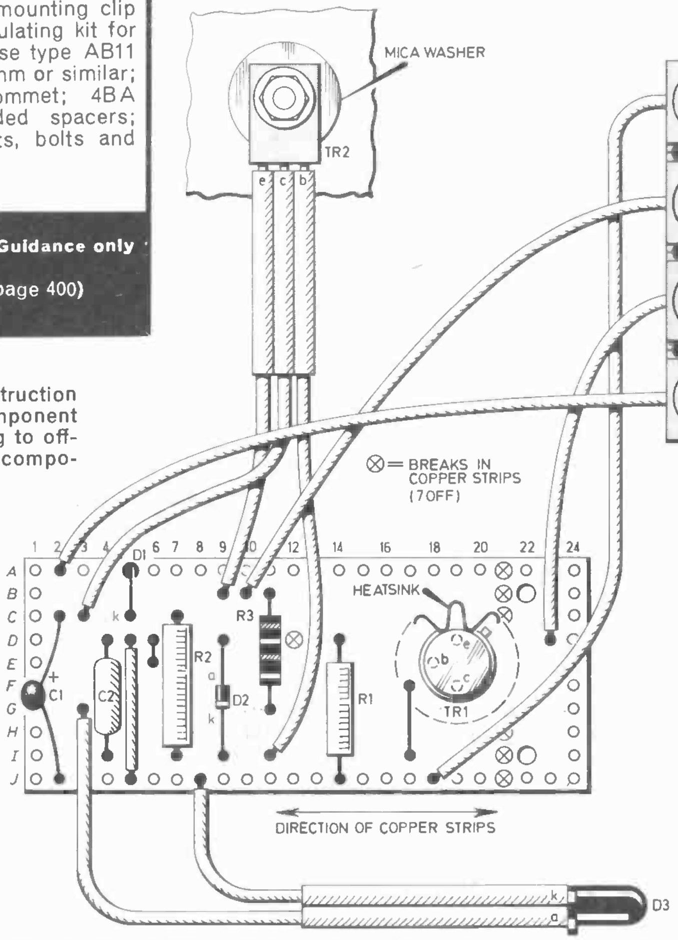
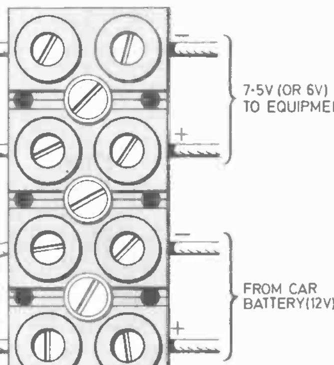
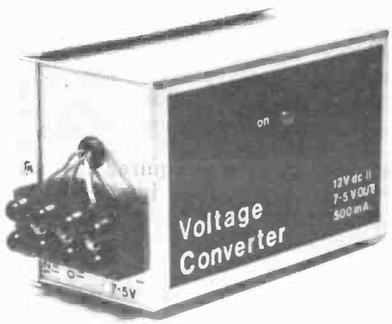



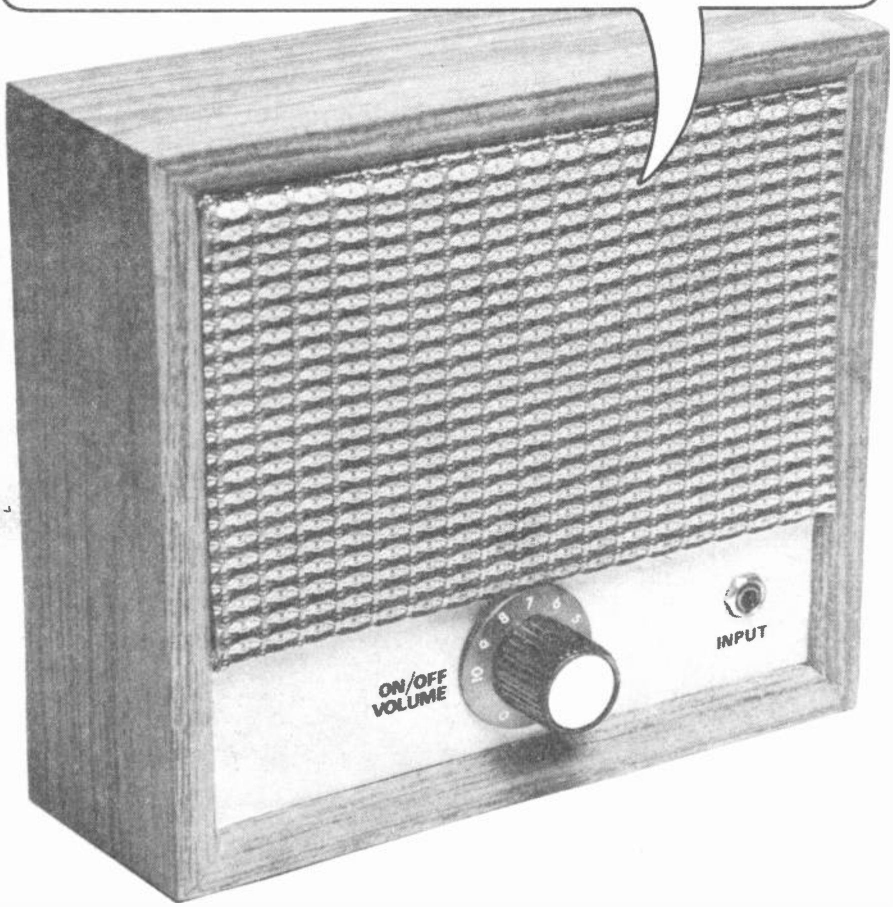
Fig. 2. Complete construction details showing component board layout and wiring to off-board case mounted components. Note the mica washer insulating TR2 from the case. D3 should be mounted in an l.e.d. panel clip. Attention is drawn to the number of breaks on the underside of the board. There are seven, see key. Fit TR1 heatsink before soldering TR1 in place.



The completed unit ready for installation.

GENERAL PURPOSE
AMPLIFIER

BY F.G. RAYER



This unit is particularly suitable for use in conjunction with many of the earphone type radio receivers featured in our pages from time to time, to provide considerable boost to audio power and allow the sound to be heard in a loudspeaker. It can of course be used in many other applications, for example as a guitar practice amplifier or a bench amplifier in the workshop.

CIRCUIT DESCRIPTION

The complete circuit diagram of the General Purpose Amplifier is shown in Fig. 1. The input signal appears across VR1 which functions as a gain or volume control. The on-off switch S1 is ganged to this control.

The required level of audio signal passes to the base of TR1 via VR1 and d.c. blocking capacitor C1. TR1 acts as an amplifier and driver for the push-pull output transistors TR2 and TR3.

The three transistors are directly coupled, and direct current feedback from the emitters of TR2 and TR3, at R4 and R5, through R2, helps stabilise working conditions throughout. TR2 and TR3 are a complementary pair operating in push-pull. Output to the loudspeaker is from C2.

This type of circuit requires relatively few components, needs no transformer, and provides very good results.

Each output transistor deals with about one-half of the audio cycle, one being cut off when the other is driven into conduction. This is economical on battery current, which is quite low with moderate volume, rising as volume is increased.

CIRCUIT BOARD

The components are fitted to a piece of 0·15 inch matrix stripboard size 9 strips x 25 holes as shown in Fig. 2. Component leads pass through the holes where indicated, and are soldered to the foils on the under side of the board.

There is plenty of space to work with 0·15 inch matrix board, but do not use so much solder that short circuits arise to any adjacent foils. Excess length of lead is snipped off after soldering. Note the correct polarity of C1, C2 and C3.

Breaks in the copper strips should be made before component assembly. Check that these breaks are complete and that fragments do not touch adjoining strips.

Wiring of the board is completed by soldering on red and black flexible leads for positive (via S1) and negative supply, two leads for the speaker and two wires for VR1, as shown.

The board can be fixed by screws through the holes, with rubber grommets underneath to give clearance.

CASE

The case in the prototype model was home made from plywood (sides) and hardboard (front). The approximate size was 170 × 200 × 70mm. An aperature was cut in the front panel to suit the chosen speaker then covered with speaker fabric. The remainder of the cabinet was covered with wood grain self-adhesive Contact.

Constructors may wish to use a commercial plastic or metal case. This should be chosen according to speaker obtained with ample room for the PP9 battery required.

Prepare the case of your choice and fit the case mounted components. Secure the board in place and wire up as shown in Fig. 2. Connect the battery to complete the unit.

IN USE

In use with earphone receivers an audio lead will need to be made up. One with a 3·5mm plug at each end is required. A screened lead is not essential but connections have to be correct—tip to tip, outer to outer.

If the amplifier is to be permanently connected to a piece of equipment running from a 9 volt supply, this supply can also be used for powering the amplifier.

The input socket can of course be changed to any other connector to suit the equipment being amplified.

Finally, a 15 or 16 ohm loudspeaker can be used in place of the recommended 8 ohm unit with negligible reduction in output power. ⌘

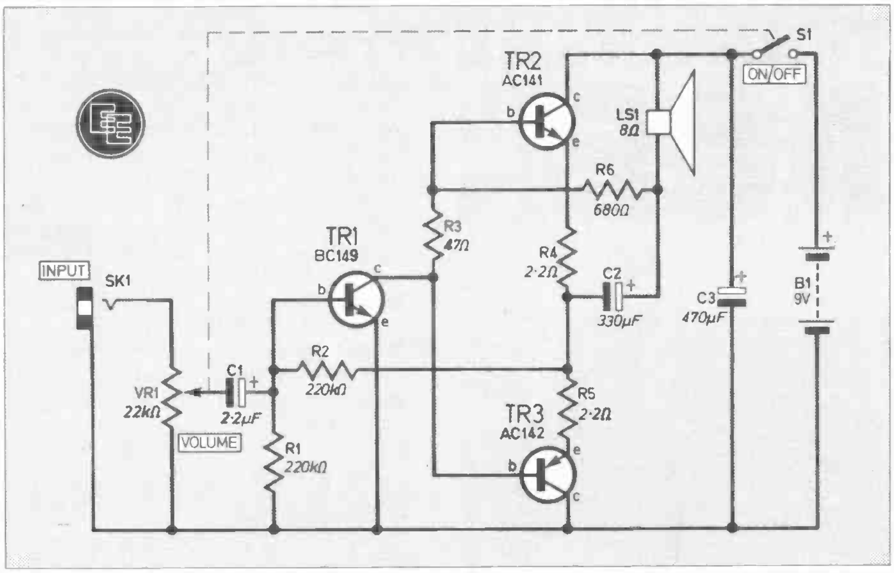


Fig.1. The complete circuit diagram of the General Purpose Amplifier

COMPONENTS

Resistors
R1 220kΩ
R2 220kΩ
R3 47Ω
R4 2·2Ω
R5 2·2Ω
R6 680Ω
All ¼W carbon ±5%

See Shop Talk page 400

Capacitors
C1 2·2μF 10V elect.
C2 330μF 10V elect.
C3 470μF 10V elect.

Transistors
TR1 BC149 silicon *npn*
TR2 AC141 germanium *npn*
TR3 AC142 germanium *pnp*

Miscellaneous
VR1/S1 22kΩ carbon log.law potentiometer/switch
LS1 8 ohm moving coil loudspeaker
B1 9V type PP9
SK1 3·5mm jack socket
Stripboard, 0·15 inch matrix, 9 strips × 25 holes; control knob for VR1; PP9 battery connectors; cabinet or materials for same.

Approx. cost Guidance only £3.50

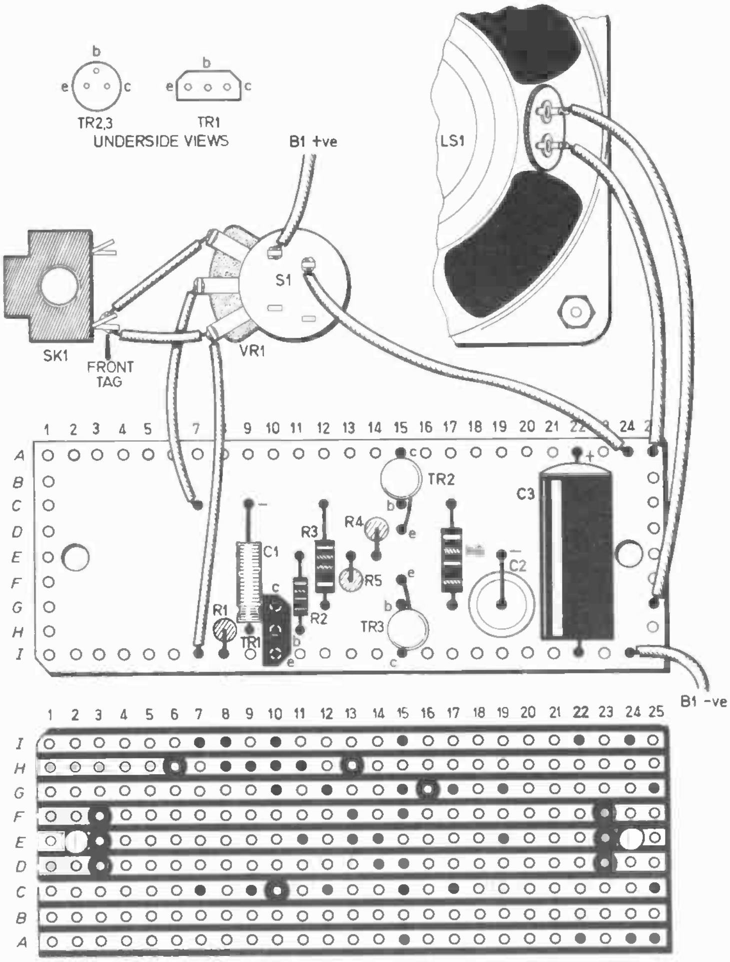
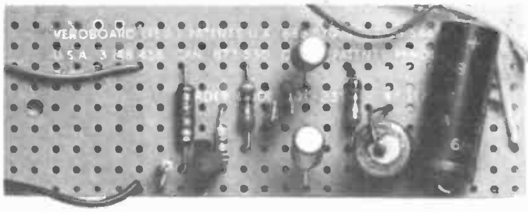
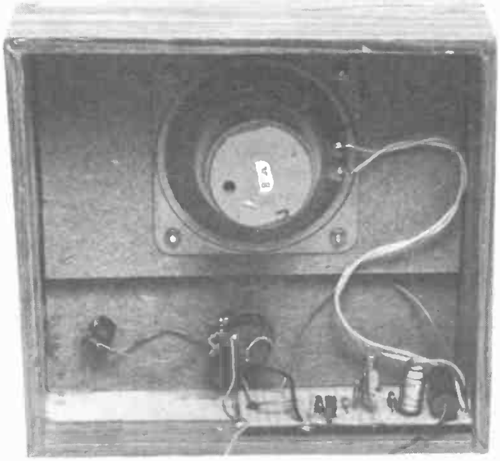


Fig. 2. The layout of the components on the topside of the board, breaks to be made on the underside, and wiring up details to the case mounted components.

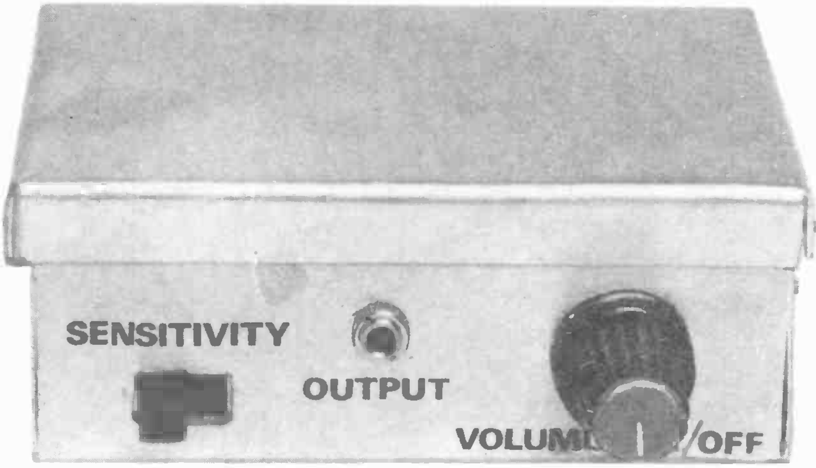


The prototype circuit board.



The prototype with case rear panel removed.

signal TRACER



By D. J. Edwards

THE bane of every electronic repairman's life is the piece of equipment that sits on the bench, apparently dead, and refuses to function.

Provided fuses are not blown, you can check out the offending apparatus easily by switching it on, connecting a signal source to the input and then following the signal with a signal tracer through the various stages.

There are numerous circuits for signal tracers, often two transistor devices employing signal distortion so as to detect r.f. signals as well as audio. The distorted signal can often be extremely irritating when listened to for any length of time and usually you can never be sure just what the signal is composed of.

If you are trying to ascertain, for example, where distortion or noise is getting into an audio amplifier, then you stand little or no chance of finding out. The device to be described provides low distortion monitoring of audio signals.

DESIGN

The heart of the signal tracer is a 741 op-amp with a transistor output stage for extra amplification. This provides the tracer with a high degree of sensitivity for detecting small signals. To ensure the unit is not overwhelmed by large signals, a series resistor R1, and a volume control is incorporated. The resistor can be switched out if very high gain is required.

One important feature of the tracer is its high input impedance. This minimises the loading effect on equipment under test.

THE CIRCUIT

The full circuit diagram of the unit is shown in Fig. 1. The op-amp IC1 is connected as an inverting amplifier, the gain of which is set by the ratio of R4 to the portion of VR1 connected between IC1 and C1. The resistors R2 and R3 are connected to pin 3 of IC1 in such a way as to maintain this at half rail potential. This enables the op-amp to be run off a single rail supply. The negative feedback capacitor C5 reduces the high frequency gain to reduce possible instability.

The transistor TR1 provides extra gain and further phase reversal. The input level is controlled by a variable resistor VR1 which is ganged to the on/off switch S2. Power is provided by a PP3 battery, B1. Due to the sensitivity of the unit and the fact that the output is in phase with the input, screened cable is used on the input lead.

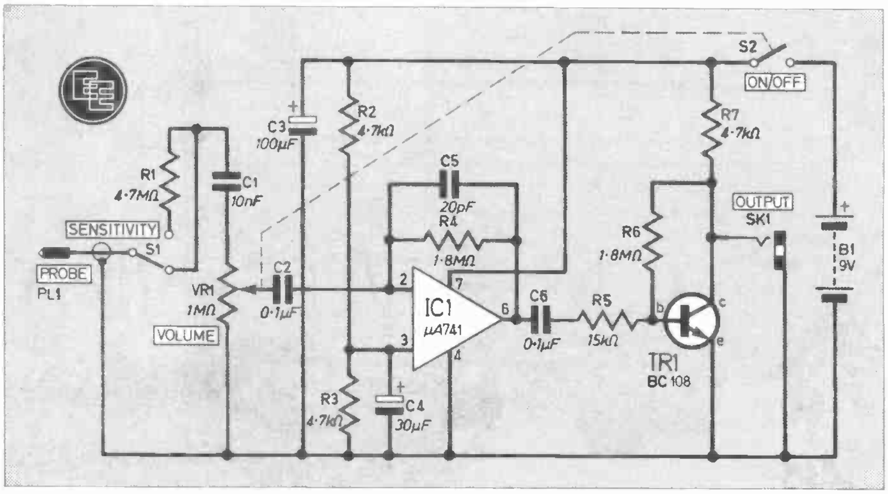
CONSTRUCTION starts here

CIRCUIT BOARD

The small components with the exception of C1 and R1 are assembled on a piece of 0·1 inch matrix stripboard, 27 holes by 15 strips. The component layout and the underside view of the board are shown in Fig. 2. It would be advisable to leave IC1 until last unless you are using a suitable i.c. socket, in which case the i.c. should not be inserted until the board is finished.

The larger components, VR1/S2, S1 and SK1 are then mounted in the box. A 100 × 70 × 40mm metal container is most suitable as this will also provide additional screening.

Fig. 1. Complete circuit diagram of the Signal Tracer.



signal TRACER

COMPONENTS

Resistors

R1 4·7MΩ
R2 4·7kΩ
R3 4·7kΩ
R4 1·8MΩ
R5 15kΩ
R6 1·8MΩ
R7 4·7kΩ
All ±5% ¼W carbon

Potentiometer

VR1/S2 1MΩ log. with ganged double pole on/off switch

Capacitors

C1 10nF ceramic or plastic
C2 0·1μF polyester
C3 100μF 10V elect.
C4 30μF 10V elect.
C5 20pF ceramic
C6 0·1μF polyester

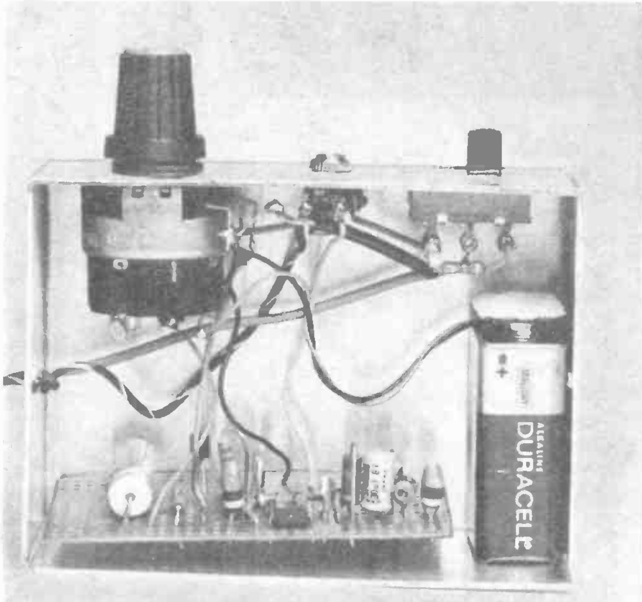
See Shop Talk page 400

Semiconductors

IC1 μA741 op-amp 8 pin d.i.l.
TR1 BC108 *npn* silicon

Miscellaneous

S1 s.p.d.t. slide switch
SK1 3·5mm jack socket, or other, suitable for earpiece
PL1 Thin plug for probe (such as 2·5mm jackplug)
B1 9V type PP3
Aluminium box, size 100 × 70 × 40mm; 0·1 inch matrix stripboard, 15 strips by 27 holes; PP3 battery connector; crystal earpiece; knob; screened lead for probe; connecting wire; rubber grommet; 4BA nut, bolt and spacer; crocodile clip.



Inside view of completed unit.

COMPONENTS approximate cost £4·00

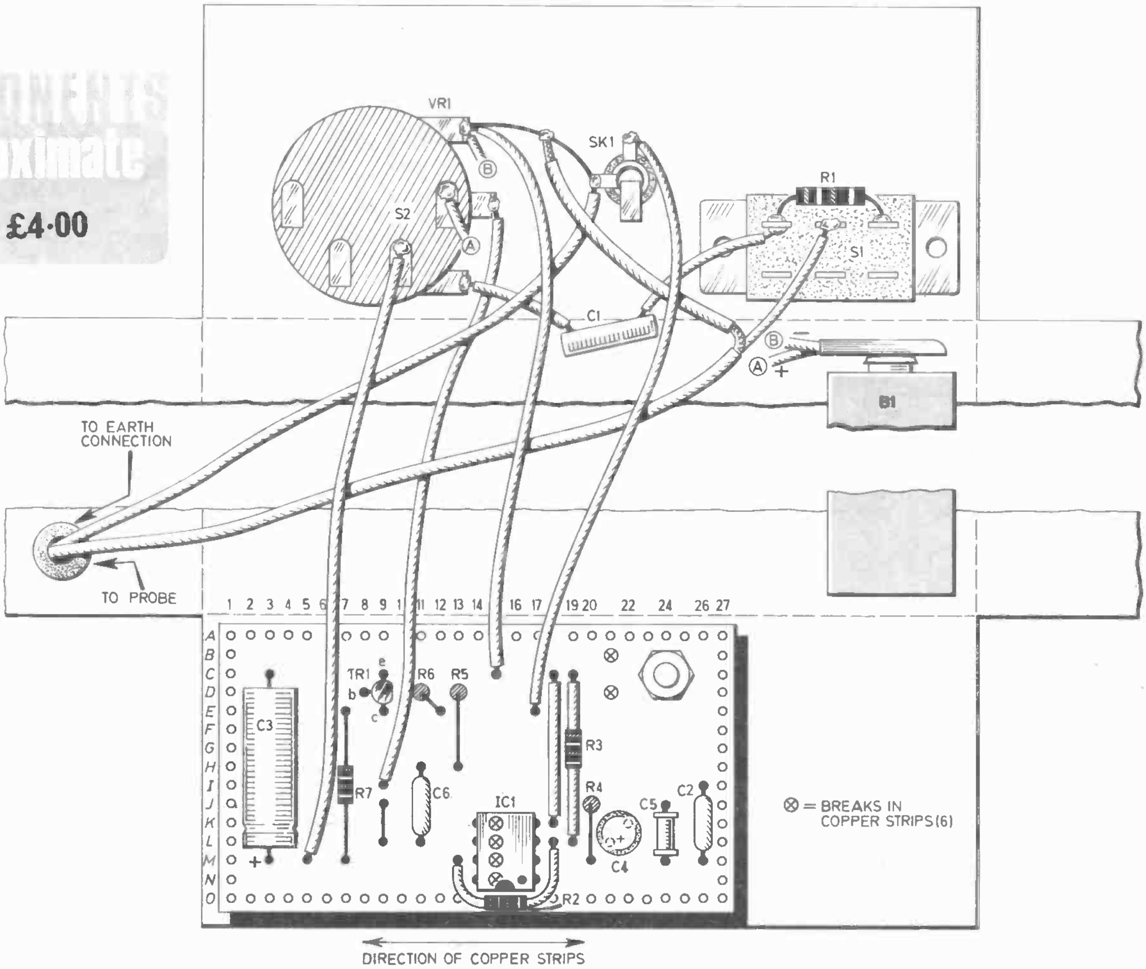
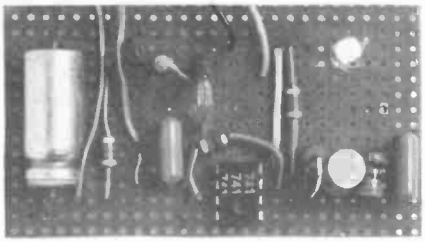


Fig. 2. Circuit board layout and component interwiring.



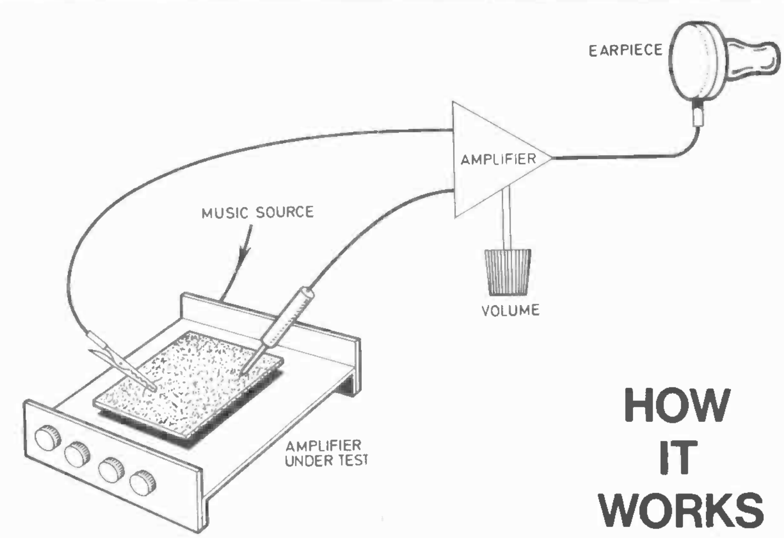
Completed circuit board.

Finally the board is secured in position using a 4BA nut, bolt and spacer and the interwiring is completed.

CONNECTING LEADS

Two flying leads are also required. One is an earth connection and consists of ordinary insulated wire terminated with a crocodile clip. The other end of this is soldered to the earth tag of SK1 as shown in Fig. 2.

The other lead is the probe and should consist of the probe itself (a 2·5mm jack plug was used in the prototype) connected by screened cable to the unit (see Fig. 2). The screen in the cable is only connected at the signal tracer and not to the probe.



HOW IT WORKS

An audio signal is fed into the faulty amplifier on test. The sections that are working will allow the signal to pass through them normally. However the sections that are faulty will degrade or interrupt the signal.

The signal tracer consists of a high gain amplifier and can be used to pick up the signal as it passes through the various stages of the equipment under test. By judicious use of the probe, the precise location of the fault can be determined and suitable steps may then be taken to cure it.

IN USE

The earth lead should be clipped onto the earth rail of the equipment under test and an audio signal fed into the input. Then using the probe, work from the input stage to the output stage noting where the signal deteriorates. The fault has now been localised and you can attack it with experience which, unfortunately for some, is invaluable in fault finding.

A signal tracer cannot pinpoint which component is faulty, but only indicate an area for investigation. The signal tracer is only an aid and not a cure-all.

The 4·7 megohm input resistor R1, which can be switched out for extra sensitivity, may be found to be a little too large and some experimentation with the value could be worthwhile.

Crystal earpieces are not renowned for their high fidelity and there is no reason why the output could not be taken to an external amplifier and loudspeaker via a 0·1μF coupling capacitor. ⌑

---

in My Class

by T.R. de Vaux-Balbirnie

IN my class we run a two-year examination course in electronics. The first year is always rather like starting a car on a cold morning—hard work. Eventually, though, the engine "fires" then everything becomes much easier.

The students begin to develop a real interest in the subject, buy magazines, and start building their own projects at home. This is all actively encouraged, of course. It also brings in a steady stream of odd questions in the art of real-life construction work.

John came to see me the other day. His plans specified a 1,000 mfd electrolytic capacitor. This he could understand. He could not see, however, why there was a voltage figure given for the capacitor—in this case 25 volts.

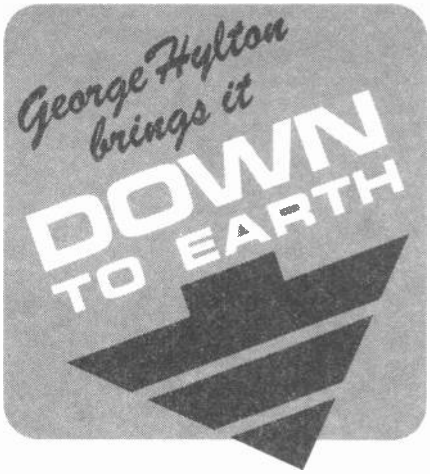
In particular, he wanted to know whether a capacitor which he already had, marked "1,000 mfd 63 volts", would do. I told him that the short answer was probably "yes" but that he had better sit down while I explained.

Any capacitor is only able to withstand a certain voltage across it, I told him. This is called the "breakdown voltage" and if it is exceeded the capacitor conducts d.c. furiously and becomes useless.

I explained that the voltage rating marked on the capacitor was not the breakdown voltage but the maximum safe working voltage. The breakdown voltage would generally be much greater.

I suggested that it is always most unwise to exceed the voltage rating because, although the capacitor will not actually breakdown with a small overvoltage, the capacitor will begin to leak current badly and become much less reliable.

It would be far better to err on the other side if at all—to use a capacitor with a higher voltage rating than specified. However, I explained, a capacitor with a larger voltage rating would probably be larger in physical size and so would not necessarily fit if a definite plan was being followed. It would also tend to be more expensive.



Transistor "Spreads"

A NEW ZEALAND reader asks about the variations in current amplification which occur among transistors which are nominally of the same type. How far is it necessary to measure the actual performance of a transistor in order to make sure that it will work in a particular circuit?

It depends how particular the circuit is! Modern transistors are so adequate with regard to gain and frequency response that in low-frequency circuits it is hardly necessary to make measurements. The circuit designer—if he's any good at his job—will ensure that his circuits work properly with *any* specimens of the transistor types named. In this way, allowance is made for the fact that the transistor maker cannot produce uniform products.

Current Gain

This lack of uniformity is most obvious in regard to what is often called "current gain" but which strictly speaking should be the current amplification factor. The gain is what is obtained in an actual circuit. The amplification factor is what could be obtained, in theory, in an ideal circuit. It never is, in practice.

The most common value specified on data sheets is called h_{FE}. When suitable d.c. supplies are provided, then pushing a particular current into the base of a transistor causes a greater current to flow through the collector. The quantity: h_{FE}, tells you how much greater. It is usually quoted for some particular value of collector current which is relevant to the sort of circuits in which the transistor is likely to be used.

For a general-purpose small transistor this might be 1mA. So if $h_{FE} = 100$ at $I_c = 1$mA then the base current needed to cause 1mA to flow in the circuit is 1mA ÷ 100 = 0·01mA = 10μA. However, large numbers of transistors cannot all be made with an $h_{FE} = 100$. Large variations between transistors occur.

So the manufacturer has a problem. Shall he sell transistors with a very broad specification. For example, an h_{FE} = 10 to 1000 thereby making sure that every transistor will "meet the spec", or shall he sort the transistors into groups, with restricted ranges of h_{FE}; 10 to 500 and 500 to 1000?

Grouping

In practice both systems of marketing are used—broad specification and grouped. However, no manufacturer in his right mind is likely to split up the transistors I am talking about into the groups mentioned, that is 10 to 500 and 500 to 1000.

The first objection to these comes when you consider a particular transistor with an $h_{FE} = 501$. It should go into the 500 to 1000 group. But suppose there is a small error in the manufacturer's transistor tester, and the h_{FE} is really only 499. Then his customers will complain that he's selling transistors which are "below spec".

To guard against the effects of small errors in measurement (or small "drifts" of h_{FE} after testing) the maker always sorts into *overlapping* groups. Suppose he tries to sort into the groups given here, but sells as 10 to 600 and 400 to 1000. Then the borderline cases can be put into either group and nobody will complain.

Percentage Variations

The other objection to 10 to 500 and 500 to 1000 is more subtle. At first sight these are sensible groups. One is "below 500", the other "above 500" which seems to divide the transistors at somewhere near the middle value of h_{FE}. But look at it in terms of proportions. If you buy the "10 to 500" group, and get a specimen with an $h_{FE} = 10$, then its gain is only one fiftieth of the gain of a transistor at the high limit (500). It is very hard to design circuits which will accept transistors with a 50 to 1 gain variation.

Looking at the other group you can see that the worst gain variation there can only be 2 to 1 (1000 compared with 500) which is much more reasonable. With transistors in this group the designer could work to some average value such as 750. A transistor with an $h_{FE} = 500$ still has two-thirds of this average gain, which is easily allowed for in the circuit design. Even this is not quite the best approach, because 750 is 1·5 times 500, but 1000 is only 1·33 times 750. Looked at this way, 500 is 50 per cent low while 1000 is only 33 per cent high. To make the percentages equal it is better to assume an average of about 700. This gives about 40 per cent low for 500 and about 40 per cent high for 1000.

I say, about 40 per cent, because 700 is not quite the right "average value". If you have a pocket calculator which can do square roots then you can easily compute the best "average".

What you do is multiply the high and low values: 500 × 1000 = 500,000 then take the square root. This comes to 707, which is the real "best average".

Averages

This kind of average is called the *geometric mean*. If we now turn back to the 10 to 500 group we find that its geometric mean is 70·7. This is about 7 times the lowest value (10) and about one-seventh of the highest value. So if the designer using the 10 to 500 group uses 70·7 as his "average" he must ensure that his circuits will accept h_{FE} variations of about 7 to 1. That's a lot less than the 50 to 1 of the extreme limits but still rather too big for comfort.

For this reason manufacturers tend to sort their transistors into gain groups which all give roughly the same percentage variation in gain. For example you might find groups like 10 to 30, 20 to 60, 50 to 150, 100 to 300, 200 to 600 and 400 to 1200. These allow for an even greater overall "spread" of gain (120 to 1) than before, yet no transistor need be more than 73·2 per cent high or low in its group.

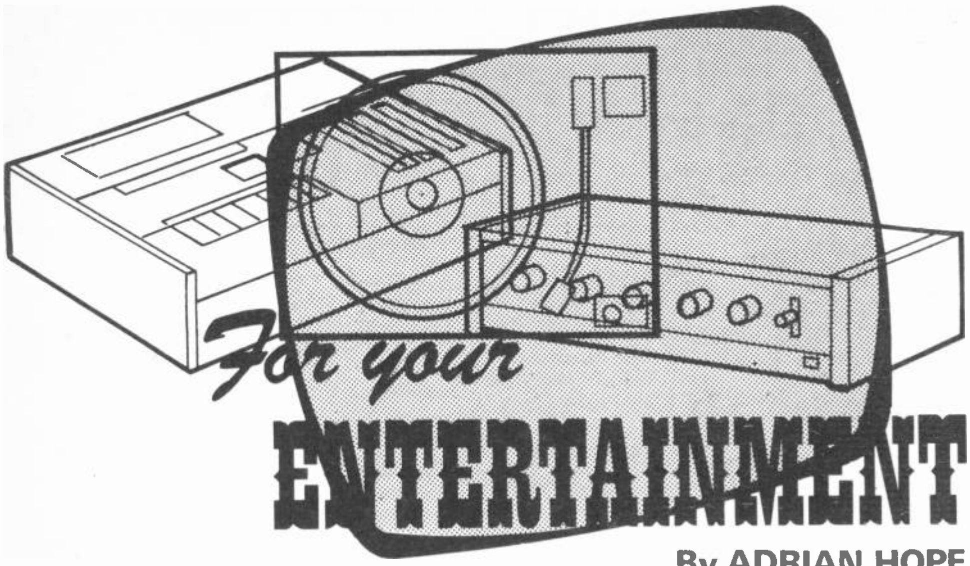
The effects of this degree of variation are easily "ironed out" by applying some form of negative feedback in the circuit design. This sacrifices gain in exchange for uniformity, insofar as d.c. negative feedback is used merely to stabilize the operating conditions. In an a.c. amplifier this is no sacrifice at all.

The a.c. gain can be kept unaffected by the d.c. feedback. In a.c. amplifiers, however, it is quite usual to sacrifice an a.c. gain, too, in the interests of consistent performance. Fortunately a.c. gain is just about the cheapest thing in electronics. It is usually no great hardship to start with, say 10 times as much as you need and exchange the surplus for consistency in performance. Indeed, much larger sacrifices are commonly made.

Overkill

Taking 100 as a typical gain for one transistor, then an audio amplifier with 4 stages *could* have a gain of 100 × 100 × 100 × 100 = 100 million. In practice the gain required may be only enough to turn a 1mV output from a tape head into say 20V at the loudspeaker. This means a gain of 20,000.

The "overkill" of 500 is available for use as negative feedback to ensure consistent performance and better quality.



For your ENTERTAINMENT

By ADRIAN HOPE

What's the attraction?

A few months ago controversy rocked the angling world. Fishermen started to wonder why they were catching more fish in water under electric power transmission lines and pylons. From correspondence in the angling press it emerged that although most people agree that there are more fish to be caught under power lines, no-one can agree on a likely explanatoin.

One suggestion, was that the power lines create a magnetic or static field and produce ions which "dissolve in the water under the pylons to attract fish" or "set up some sort of vibration which the fish find pleasant". Another theory was more basic; that birds sit on the power lines and their droppings attract fish to the water below.

A spokesman of the Central Electricity Generating Board was approached by the angling press and dismissed the idea of electrical attraction. I phoned the CEGB Press Office but never did hear back from the promised "expert". Here then are some basic facts on which EE readers might like to base a few theories of their own.

In the UK, overhead power transmission is at mains frequency, i.e. 50Hz. The bugbear of all power transmission is voltage loss. One solution is to make cables of very thick cross section copper, so as to offer very little electrical resistance. But this is expensive.

The cheaper approach is to carry the mains at very high voltage, i.e. several tens or hundreds of kilovolts, because a high voltage means a low current and less drop. If for instance you double the voltage, twice as much power is transmitted with the same current value and the same voltage loss. It is, of course, far easier to step voltages up and down if the current is alternating rather than direct, and this is why a.c. is now virtually standard for power transmission throughout the world. When cable routes are planned they are kept well clear of any other electrical conductors because there is always a risk of electromagnetic induction. The fluctuating magnetic field created by the 50Hz power line can couple with any nearby conductor, such as a telephone line, and act as a giant transformer. So a 50Hz e.m.f. is induced in the "secondary" conductor.

This is why some anglers with carbon fibre rods have felt them tingle underneath a pylon. Impure, and thus conductive, water underneath a pylon is also likely to be electromagnetically coupled with the power line.

Electro Fisher

This, now raises the question of whether the fish are responding to the magnetic field or the induced voltage. Here I can only offer two, somewhat contradictory, clues. There already exist "electro fisher" devices which inject 400 volts d.c. into the water of a river between two electrodes spaced around 10 or 20 yards apart. The positive anode electrode is built into the metal handle of a landing net, and fish in the water between the two electrodes apparently have no choice but to swim towards the anode and thus into the net where they are caught.

This suggests a neuro mechanism in the fish which is directly sensitive to a polarized electrical gradient. So, who knows, perhaps the 50Hz alternating gradient likely to be found under a power line confuses the fish and they swim round in circles waiting to be caught.

On the other hand there is increasing evidence that animals respond directly to magnetic fields. Homing pigeons, bees and bacteria are all believed to get their bearings from a built-in magnetic compass.

Magnetic materials, such as magnetite, occur naturally and can easily find their way into the body of an animal. These magnetic particles will then try to orientate themselves in line with the earth's magnetic field and point towards the North Pole. This provides a permanent reference for the animal, wherever it is, comparable to our inner ear balance organs which sense gravity.

Clearly, if the animal is bathed in a magnetic field stronger than the natural earth's field then its bearing mechanism will be confused. Presumably the poor beast will be even more confused in a 50Hz fluctuating field.

What's the Catch?

So, any views? Do fish give themselves up more easily under power lines because they are bewitched by a fluctuating voltage gradient, bothered by an alternating magnetic field or bewildered by a combination of both? Or is there perhaps some other explanation?

Save It

Advertisements are currently appearing in the American press for a new electronic gadget which is claimed to save between 30 and 60 per cent of the electrical energy consumed by motor driven electrical equipment, such as refrigerators, washing machines, dishwashers and so on. The gadget, which costs anything between 30 and 200 dollars (depending on where you buy it) was invented by Frank Nola while working for NASA, the National Aeronautics and Space Administration.

NASA isn't only concerned with moon rockets and space shuttles, but is heavily involved in sourcing and saving energy, for instance with sophisticated windmill generators. Full details of the energy saving motor control circuit are to be found in USA Patent No. 4 052 648 and you can read a copy for free or, buy a photo copy for nominal cost, at the foreign section of the library attached to the British Patent Office just off Chancery Lane, London.

The Power Chopper, as it is known, continually monitors and adjusts the power being fed to an a.c. induction motor so that it always runs at maximum efficiency. Motors of this type are used in a great number of domestic devices and run at a constant fixed speed which is determined by the mains frequency.

As they draw more or less the same current whether loaded or unloaded the efficiency at low loads, with the motor coasting, is poor because spare electrical energy is converted into heat in the motor windings. In other words when the motor is over-rated for its load, electricity is wasted.

Unfortunately, because the starting load for a refrigerator or washing machine is always much higher that the running load, the motor has to be over-rated for average use or it will burn out when first switched on. The obvious solution is to change the motor rating with the load but this has always proved easier said than done.

The NASA inventor's brainwave was to monitor the motor load by comparing phase relationships in the motor windings. Under heavy load the current is nearly in phase with voltage, but under light load the lag between voltage and current increases. From here it is a short step to automatically reducing the average input voltage until the phase lag returns to normal again. In this way the chopper maintains optimum motor rating for the actual load at any instant.

At first electronics engineers in the USA were sceptical over the claims made for energy saving with the circuit. But over forty different types of motor were tested with a NASA Chopper and the cynics were satisfied that 40 or 50 per cent power reductions really are routinely possible with many motor systems, and that a full 60 per cent is sometimes available.

Already one American electronics magazine had published a Chopper project and plug-in Chopper modules, for easy insertion between a refrigerator or washing machine and the mains plug, are already available on mail order for as little as 30 dollars.

Everyday News

BRITISH MICROPROCESSOR COMPETITION

The results and prizes for the British Microprocessor Competition, jointly sponsored by the National Research Development Corporation and The National Computing Centre, were announced and presented by The Secretary of State for Industry, Sir Keith Joseph, in London recently.

The first prize of £10,000 in the working model category was won by Sinar Agritec Ltd for a Portable Grain Moisture Meter. Second prize of £5,000 in this category was awarded to a team of researchers at the University of Manchester Institute of Science and Technology (UMIST) for a Programming System for NC Lathes. Third prize of £2,000 in this category is won by Grundy Terminals Ltd for a Stock Control System.

In the ideas on paper category, first prize of £2,000 went to MDB Electronics (UK) Ltd for a Portable Electrocardiograph. Second prize of £1,000 goes to Mr Chris Goss for an aid designed to help people with severe speech handicaps.

Special Prize

The judges recommended that a special additional prize of £500 be awarded to two pupils at the Royal Grammar School, Newcastle-upon-Tyne, for a Theatre Lighting System. The judges felt that the school entry showed both inventive flair and a good understanding of microprocessors.

With the full backing of the School, two pupils developed a fully operational, theatre lighting system for their school drama society, using a microprocessor terminal with a novel interactive graphics display. The computer-controlled memory array enables the operator to adjust and store sophisticated lighting effects that would not otherwise be possible.

It is interesting to note that over 50 per cent of entries received were from private individuals and just over half of the 218 entries were accompanied by working models.

ROBOT POPULATION EXPLOSION

Today's European population of about 2,400 industrial robots is expected to swell to 20,000 by 1990 according to the US research company Frost & Sullivan. Main impetus is rising wage costs of real people.

A robot at £20,000 can work 24 hours a day, doesn't need a canteen, paid holidays or a retirement pension. It also doesn't complain of a dirty or noisy environment. It can go sick (i.e. break down) but robot enthusiasts say that on average it is more "healthy" than humans.

In 1959 Hong Kong had two factories making transistor radios. Twenty years later the industry is 100,000 times larger with over 1,000 electronic factories employing nearly 100,000 people.

Their largest customer for electronic products is the United Kingdom taking 36 per cent of all Hong Kong exports.

BREADBOARD EXHIBITION

This year's Breadboard '80 *will be held at the Royal Horticultural Hall, Westminster, London, from 26 to 30 November and will be managed by Modmags in conjunction with Trident International Exhibitions Ltd.*

GRANTED

The University of Birmingham has again been awarded a Wolfson Grant from the Wolfson Foundation.

The grant, totalling £110,000, has been made to Prof. G. T. Wright and Dr. P. W. Webb of the Department of Electronic and Electrical Engineering for use in the design and evaluation of silicon "chips" for the British microelectronics industry.

The grant will be used by the Solid State Electronics Group to set up an infrared diagnostics facility for the scanning thermal microscopy of semiconductor devices and integrated microcircuits.

HOPPING AHEAD

It is now almost certain that Racal's revolutionary Jaguar frequency-hopping v.h.f. military radio will be the first such system in the world to enter service.

By continually hopping from one frequency to another in a pseudo-random manner at the rate of 100 or so hops a second, Jaguar defeats attempts at interception of messages and protects the network against enemy jamming.

ANALYSIS

ELECTRONIC MAIL

The other day in pouring rain the postman delivered seven damp limp letters. My seven correspondents had first to originate their messages, find envelopes, stick on the stamps and deliver them to the post box.

Some time later a postman collects them and they are sorted into towns, put into mail bags, taken to the station, collected at the destination station, re-sorted again into postal rounds. The delivery postman, in my case, then takes them by van to the addresses, start-stop, start-stop, burning fuel in the most inefficient way and, on that particular morning, soaking the postman and my letters into the bargain.

In a way the system is a miracle of organisation. But surely in 1980 there should be a better method. It hasn't changed since the Penny Post was introduced 140 years ago and, if anything, it is slower in delivery than in those far-off days.

The answer lies in electronic mail. This cuts out all the manual sorting, all the transport, all the postmen. It is much faster and nobody gets wet.

The basic requirement for electronic mail is that we should all be on the telecommunications network. The rest is technology.

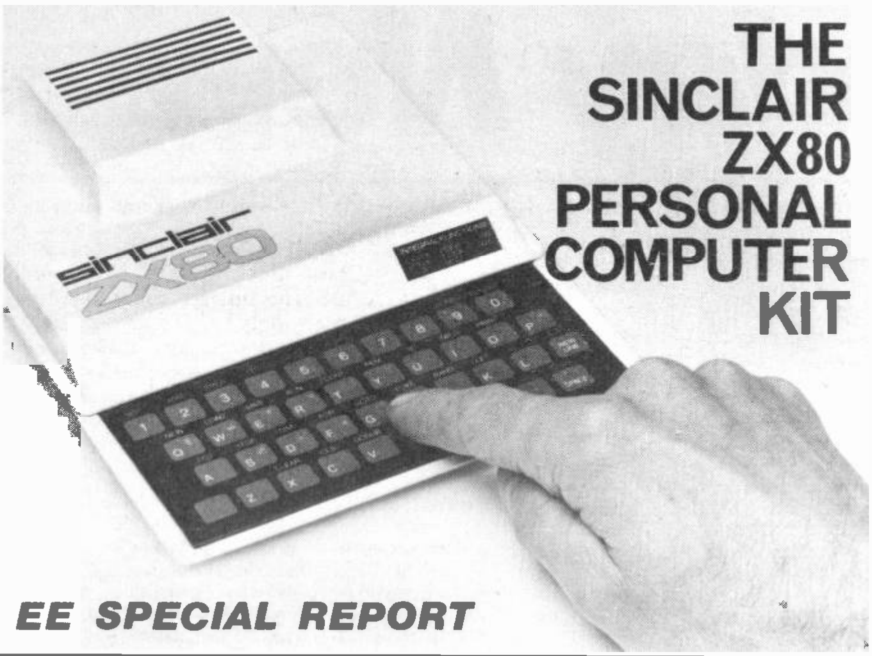
The idea of transmitting the written word over telephone lines is ancient. Teleprinters and BPO Telex service have been around for years. What is new is the VDU electronic terminal, its associated printer, its capability of word processing and the power of the computer. And another old friend, the facsimile machine (FAX), has now been brought into the equation.

In the United States electronic mail for business users has already "second generation" status on the Tymnet network with the introduction of an interface unit which automatically converts VDU code to FAX code either for Group 1 FAX operation at 4 to 6 minutes per page or faster Group 2 machines which operate at a speed of 2 to 3 minutes a page. This new development allows access to 95 per cent of over 200,000 FAX machines in the USA from VDU terminals as well as VDU to VDU correspondence.

The beauty of electronic mail is that you can compose and edit your letter on the VDU or call up a standard format, just adding the variables, and transmit it to one or even a hundred addresses almost instantaneously.

The reason why such systems are available in the USA and not here in the UK is not because the Americans are clever but because there is no monopoly of communications over there. They can be much quicker off the mark with bright ideas.

Brian G. Peck



THE SINCLAIR ZX80 PERSONAL COMPUTER KIT

EE SPECIAL REPORT

HERE it is at last! Cheap computing with a vengeance. The Sinclair ZX80, unveiled a few months ago to a blaze of publicity, costs less than £100 and claims to offer all the facilities of machines costing three or four times the price.

Delving a bit deeper we discover that in fact two versions are available; one ready built and one in kit form. Needless to say, the kit is substantially cheaper—surprisingly so considering how little work is involved in building the unit.

One essential "extra" required is a power supply as this is not an integral part of the ZX80. However, on-board regulation is provided so any unregulated 9V supply would do. A u.h.f. TV is also required to act as a VDU.

THE KIT

Assuming you've decided to go for the kit, what do you get for your money? Well the single most important item is the circuit board. This comes complete with a pre-assembled touch sensitive keyboard and appears to have been put together with some thought and care. However it is intriguing to know why there are so many apparently redundant tracks and holes. Perhaps Mr Sinclair has one or two secrets yet to be revealed.

Apart from this, you get 22 i.c.s, 32 resistors, 13 capacitors and eight diodes plus the case and a few extra sockets, television and tape recorder connector leads and a few extra bits of hardware. Sockets are provided for every i.c. (apart from the voltage regulator), a feature which should help to eliminate heat sinking problems when putting the thing together.

Of course no kit is complete without assembly instructions and this one is no exception. A detailed assembly sheet is provided together with a 130-page instruction manual.

CASE AND KEYBOARD

At this stage it is fairly easy to see where some of the costs have been saved. The case, to say the least, is pretty basic—just a thin plastic tray with an even thinner plastic top, held together with rather inadequate plastic rivets. In fact we replaced these with small nuts and bolts on the test sample.

Another cause for concern is the keyboard. On a machine at this price a full pushbutton keyboard is obviously out of the question. However what you do get is a sheet of conductive plastic printed with keyboard symbols on one side laid over the specially prepared p.c.b. area with a perforated rubber matrix interspersed between the two.

Touching a particular area of the plastic short circuits two pads on the p.c.b. underneath and completes the circuit. This arrangement works reasonably well but can be prone to failure and intermittent operation.

ASSEMBLY

Actual assembly of the kit is pretty straightforward provided a few simple rules are followed. The first, and most obvious, is to read the assembly instructions before touching anything.

The right tools are also important, these being a soldering iron with a fine bit, a sharp pair of sidecutters and a magnifying glass. The latter is particularly useful when checking for solder bridges and other irregulari-

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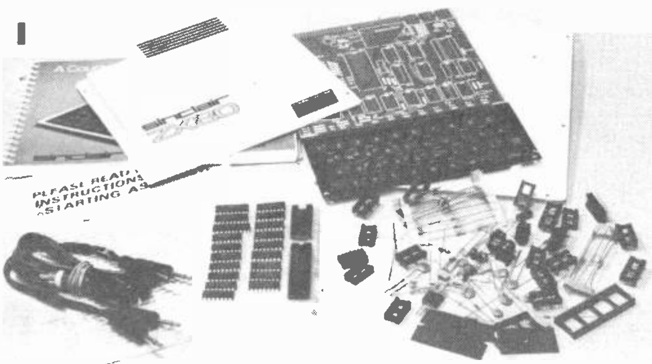

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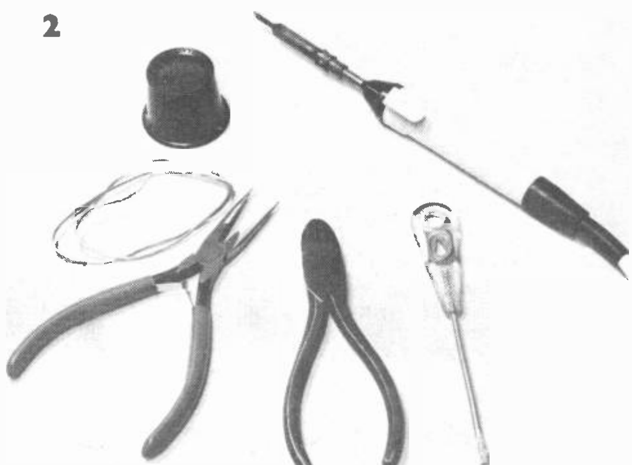


1. The ZX80 kit unpacked.
2. Tools required to build the ZX80.
3. Main circuit board before assembly.
4. Completed circuit board.
5. The ZX80 in action.

ties as there isn't much room to manoeuvre on the reverse of the circuit board.

In fact the instruction sheet is extremely helpful right down to identifying the resistors by their colour codes and giving the various number combinations that identify the capacitors. A suggested construction order is given and it would seem reasonable to follow it although this is by no means vital and as all components go straight onto the board there is no messy interwiring to confuse the would be constructor.

There are several components marked "not used" and you have to be careful not to put any components into their spaces on the p.c.b.—easy to do when you're not concentrating. All in all you can expect to have the computer built and running in a matter of three or four hours.

BLACK ON WHITE

The computer is plugged into the aerial socket of a u.h.f. TV tuned to channel 36, which in many instances will be the domestic "box". This interconnecting lead could be longer for convenient armchair use.

Assuming the computer has been constructed correctly, the first thing that strikes you when you turn it on is the fact that everything comes out black on white on the TV although you can convert the ZX80 to the more usual white on black if you prefer.

If the computer doesn't work first time there is a limited fault finding list in the assembly instructions and failing that Sinclair will service the unit for you and get it working for a flat rate of £10.

Perhaps the most disconcerting aspect of the ZX80 is the fact that the TV picture jumps or flickers every time a keyboard entry is made. Apparently this is caused by using the microprocessor to control TV display as well as other functions and can be a little disturbing after prolonged use of the computer.

USING THE COMPUTER

At this stage you may be asking yourself, "Well, I've built the thing, what can I do with it?" The short answer to that is, "whatever you like!" Indeed the ZX80 is a powerful, full facility computer. Its working language is BASIC (the ZX80 uses its own particular form of the language) and for the uninitiated, a well written and detailed 130 page manual comes with the kit. This explains the more common aspects of computer programming and points the way to more advanced uses of the computer.

When entering a program, each line appears at the bottom of the screen and cannot be entered into a program unless it is syntactically correct. If you do make an error, a syntax error marker shows you exactly where you've gone wrong.

Another important innovation is single key entry of command words such as PRINT or LET. The computer can sense when a command word is due and a single touch on the relevent key will automatically input that command and print it on the screen. Single line editing is also possible.

The use of graphics is catered for on the ZX80 by 24 standard symbols, all reversible. Added to this are several integral functions which are accessed by typing in an appropriate code. These include a random number generator and the PEEK function as well as character generation by using specific codes.

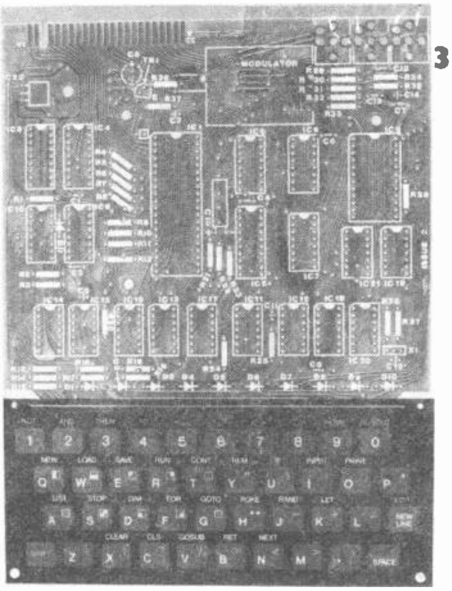
Facilities exist for saving programs on tape cassettes and reloading them back into the computer. Although this is fine in theory, the practice is rather more tricky and if your cassette recorder uses DIN input sockets you could have a bit of trouble. Ideally a cheap recorder with 3·5mm jack inputs is best and when tested gave consistently good results.

PERFORMANCE

So how does the ZX80 actually perform? The answer must be "very well" with only a few reservations. Apart from the picture flicker mentioned earlier, the keyboard takes a little getting used to. Also, the calling of program output beyond the initial 24 lines involves the operation of three keys before the next 24 lines of output can be viewed, with the program itself appearing in the meantime. The program can be as long as memory allows although finding your way around a big program involves some tricky manipulation with the edit locate keys, with editing itself being a laborious process. It is hoped that in time these shortcomings will disappear with the introduction of new hard/firmware.

But what exactly makes the ZX80 so cheap? Well, quite apart from economising on such items as the keyboard and case, the component count has been substantially reduced by the use of a single super ROM containing the BASIC interpreter, character set, operating system and monitor, and the microprocessor is also used much more efficiently. This leaves much more of the RAM to the user.

Memory expansion boards are available. These will accept up to 3K bytes of extra memory and cost £12 for the board and £16 for each extra 1K byte RAM chip. The ZX80 kit costs £79·95 or £99·95 for the ready built version and the mains adapter is £8·95. All prices include VAT and P/P. ⌑



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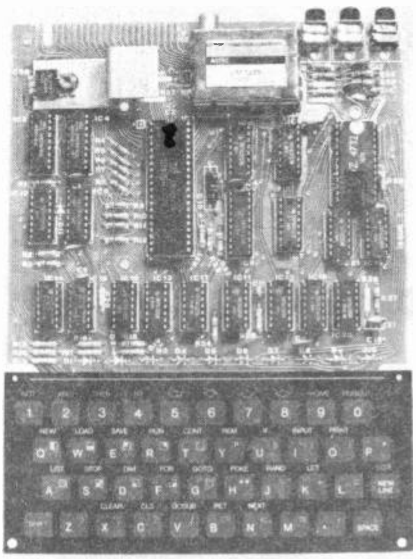

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zener DIODE tester

R.A. PENFOLD

The unit which is described in this article can be used in conjunction with an ordinary multimeter to measure the operating voltage of almost any Zener diode, and to give some idea of the efficiency of the component under test. The unit should prove to be useful to have around the workshop, and it is especially helpful when sorting out a batch of "unmarked and untested" devices.

ZENER TESTING

The basic method of testing a Zener diode for operating voltage and efficiency is shown in Fig. 1. Diode *D* is the Zener under test, and it is fed from a voltage source via a fixed resistor and a variable resistor which are series connected. The voltage source must provide a potential that is higher than the operating voltage of the Zener under test. Also, the supply must be connected with the polarity indicated in the diagram so that the diode is reversed biased.

Normally, the diode would block any current flow in the circuit, of course, but a Zener diode will only offer a high reverse resistance if its operating voltage is not exceeded. Here this voltage is exceeded, and so a current will flow

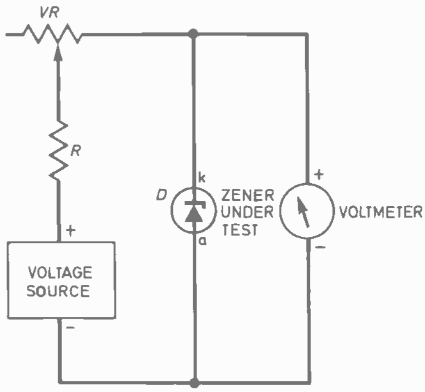


Fig. 1. The basic test for a Zener.

in the circuit. It is only necessary to slightly exceed the Zener voltage in order to cause the effective impedance of the diode to fall to a very low level.

It is for this reason that the fixed resistor must be included in the circuit, as without it a large current could flow in the circuit with the Zener being burnt out in consequence. A current limiting resistor such as this is employed in all practical circuits that use a Zener diode voltage stabiliser.

IMPEDANCE

An important feature of a Zener diode is that the more its operating voltage is exceeded, the lower its effective impedance becomes. Therefore, if the variable resistance is adjusted for maximum resistance a small current will be forced through the circuit, and a voltage will be developed across the resistance in series with the Zener.

The current flowing in the circuit will be just sufficient to cause the voltage drop across the series resistance to leave a voltage across the Zener equal to its operating voltage. This must be so as any increase in the current through the circuit would result in an increase in the voltage across the series resistance, and a decrease in the voltage across the Zener. This decreased voltage would decrease the Zener impedance and would therefore reduce the current flowing in the circuit.

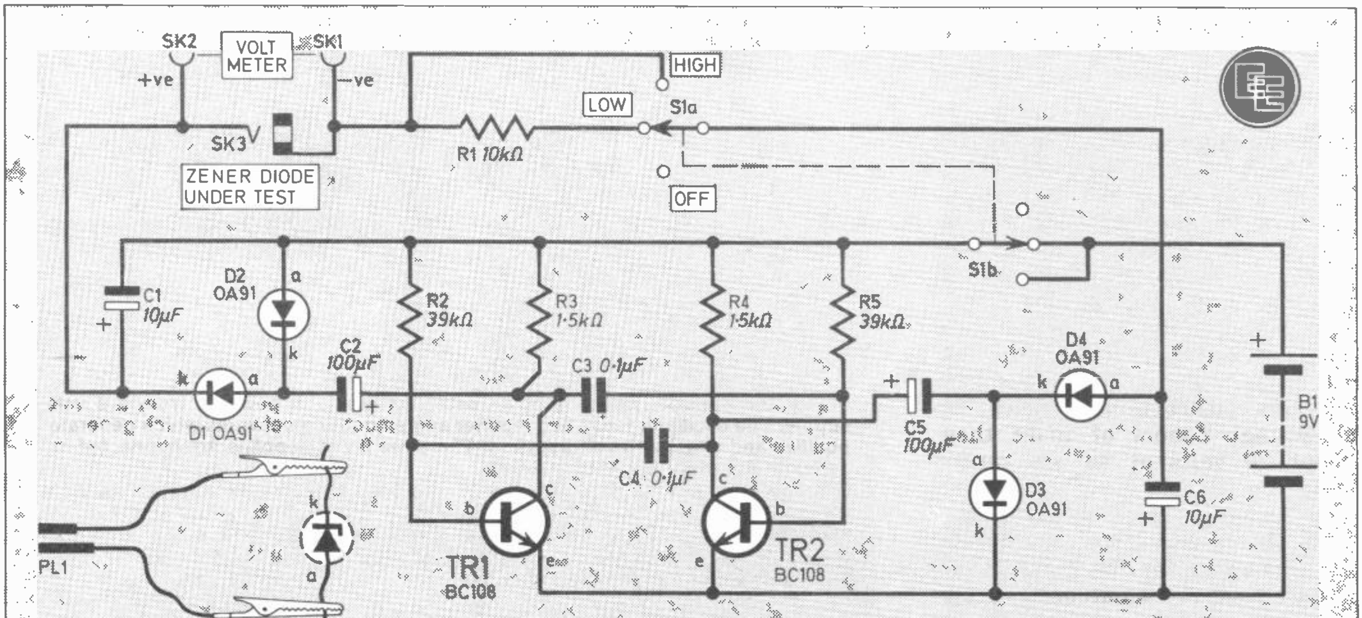
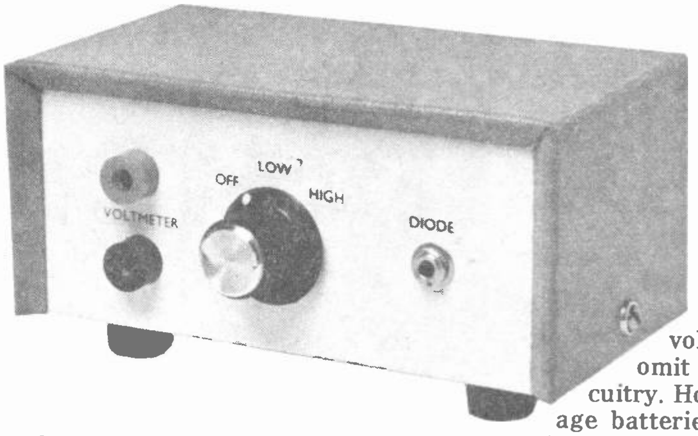


Fig. 2. The complete circuit diagram for the Zener Diode Tester.



This reduction in current would counteract the original increase.

Conversely, any attempt to reduce the current flow would reduce the voltage across the series resistance, and increase the voltage across the Zener. The Zener would counteract this by conducting more heavily. A Zener thus acts as a very effective voltage stabiliser when used in conjunction with a series resistor.

A Zener diode is not a perfect device. If, for example, the variable resistor was to be adjusted to reduce the total series resistance by half, the Zener would need to conduct twice as heavily so as to double the current flowing in the circuit. The circuit voltages would then be as before. While most Zeners would nearly achieve this, there will inevitably be some increase in the voltage across the Zener.

A voltmeter connected across the Zener enables the operating voltage to be measured and the effect of altering the setting of the variable resistor to be monitored.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Zener Diode Tester is shown in Fig. 2. The bulk of the circuitry is used to generate the source voltage. Although Zener diodes having operating voltages of a hundred volts or more are available, higher voltage types are very rarely used in circuits for the amateur. In fact, a search through previous constructional articles will show that Zeners of more than about 20 volts or so are rarely encountered.

A voltage source of about 25 volts should therefore be suitable for testing by far the majority of Zeners that the amateur is likely to come across.

SUPPLY

This unit obtains a nominal 27 volt supply from a standard PP3 9 volt battery. It might at first sight seem to be better to simply use a high voltage battery and omit the step-up circuitry. However, high voltage batteries tend to be expensive, and they also tend to be either rather bulky, or difficult to use in other ways. A PP3 battery and step-up circuit is quite practical therefore.

Transistors TR1 and TR2 are used in an astable multivibrator, and this is a simple form of oscillator. Outputs are available at the collectors of both TR1 and TR2, and both outputs are used to feed rectifier and smoothing circuits. The collector of TR1 is used to feed a rectifier and smoothing network which comprises D1, D2 and C1. These produce a positive d.c. output of about 9 volts, and the negative output is common to the positive input supply rail.

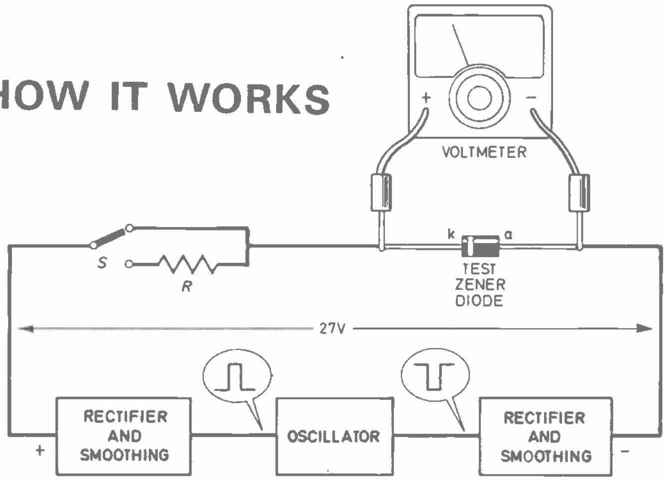
Components D3, D4 and C6 form the rectifier and smoothing circuit that is fed from the collector of TR2. These produce a negative output that has the positive side common to the negative supply rail. Again, the output potential is about 9 volts.

Thus there are three 9 volt supplies connected in series (two smoothed and rectified a.c. signals plus the basic 9 volt battery supply), and they produce a combined potential of 27 volts. This 27 volt supply is available between the positive terminal of C1 and negative terminal of C6. It is from these two points that the Zener under test is connected, via current limiting resistor R1.

Switch S1a can be used to bypass R1 and so increase the current supplied to the Zener. There is no danger of the Zener being damaged by excessive current when R1 is switched out, as the fairly high source impedance of the 27 volt supply limits the maximum available current to a safe level.

The unit could have a built-in voltmeter, but meters are relatively expensive these days, and presumably anyone constructing this device will already have a test-meter (which should undoubtedly be given priority over any other items of test gear). For this reason the unit is designed to feed an external voltmeter which connects to SK1 and SK2. The device under test is connected to SK3.

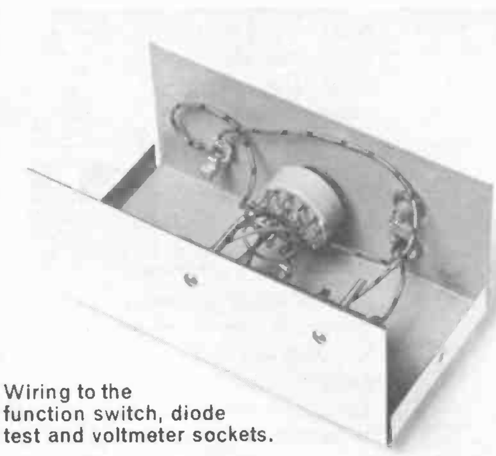
HOW IT WORKS



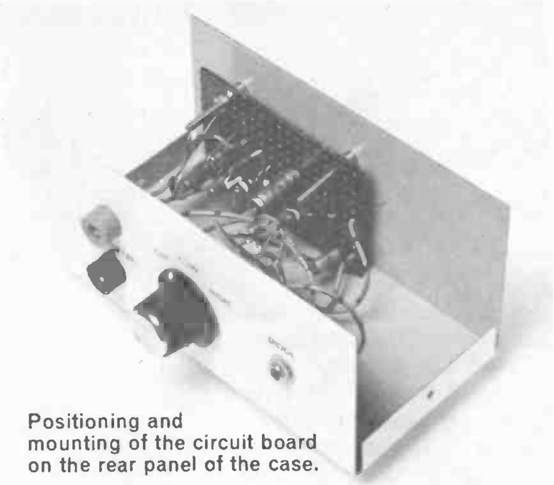
The unit consists basically of an oscillator which is powered from a 9 volt supply. The oscillator feeds two rectifier and smoothing networks which generate positive and negative 9 volt supplies. The three 9 volt supplies are connected in series to economically obtain 27 volts.

This supply is fed to the Zener diode under test and a multimeter is used to measure the Zener operating voltage. A current limiting resistor, *R*, can be switched out of circuit so as to increase the current supplied to the Zener diode. Any significant increase in the meter reading then indicates that the test component is an inefficient device.

zener DIODE tester



Wiring to the
function switch, diode
test and voltmeter sockets.



Positioning and
mounting of the circuit board
on the rear panel of the case.

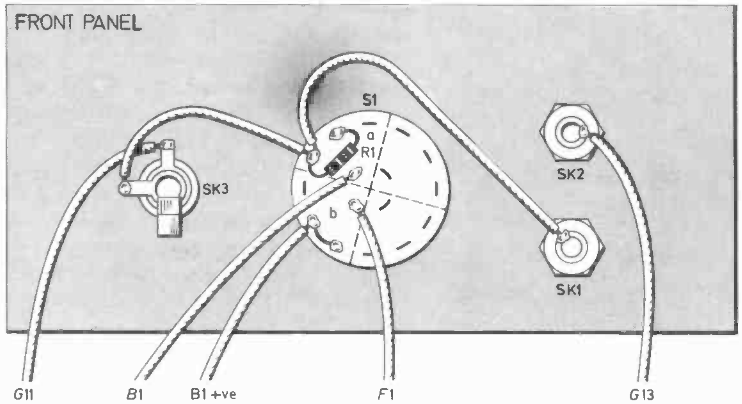


Fig. 4. Layout of components on the rear of the front panel and interwiring details to the circuit board.

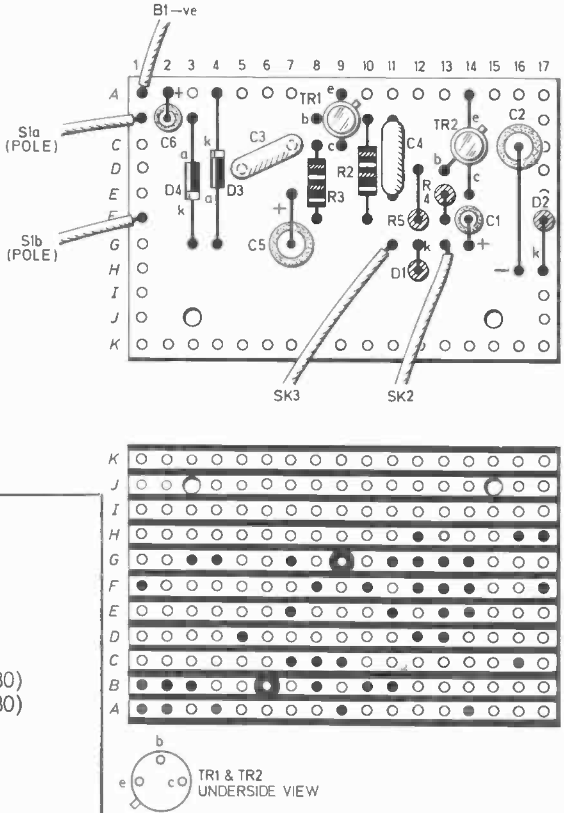


Fig. 3. Component layout on the stripboard together with details of breaks to be made along the copper strips on the underside of the board.

COMPONENTS

Resistors
- R1 10kΩ
- R2 39kΩ
- R3 1·5kΩ
- R4 1·5kΩ
- R5 39kΩ
- All ¼W carbon ±5%

Capacitors
- C1 10μF 10V elect.
- C2 100μF 10V elect.
- C3 0·1μF polyester (C280)
- C4 0·1μF polyester (C280)
- C5 100μF 10V elect.
- C6 10μF 10V elect.

Semiconductors
- TR1, 2 BC108 silicon *npn* (2 off)
- D1 to D4 OA91 small signal silicon (4 off)

Miscellaneous
- S1 2-pole 3-way rotary switch
- SK1, 2 single-pole insulated panel sockets (2 off)
- SK3 3·5mm jack socket
- B1 9V PP3
- PL1 3·5mm jack plug

Stripboard: 0·15 inch matrix 11 strips × 17 holes; case size approximately 127 × 64 × 57mm; clips for B1; knob; 6BA fixings and spacers (2 sets); test leads to suit SK1, 2 (pair); crocodile clips (2 off); test lead to suit PL1.

See **Shop Talk** page 400

COMPONENTS approximate cost £4·20

CONSTRUCTION starts here

CASE

The prototype is housed in a ready made metal instrument case which has outside dimensions of approximately 127 x 64 x 57mm, but virtually any case of about the same size should make a suitable housing for this project.

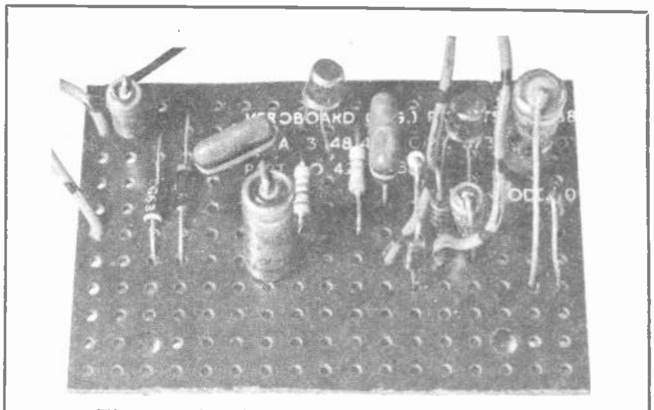
The front panel layout can be seen from the accompanying photographs, although the layout is not critical. Socket SK3 is a 3·5mm jack socket, SK2 is a red wander socket, and SK1 is a black wander socket.

CIRCUIT BOARD

Except for R1, which is mounted on S1, all the other small components are wired up on a 0·15 inch matrix stripboard panel which has 17 holes by 11 copper strips. Details of this panel and the other wiring of the unit are provided in Figs. 3 and 4. Commence construction of the panel by cutting out a piece of the correct size using a small hacksaw, and then file up any rough edges that are produced.

Then the two 6BA clearance mounting holes are drilled using a 3·2mm drill bit. Finally, the component leads are inserted into the board, cut to length, and soldered in.

Mount the completed component panel on the rear panel of the case. Short spacers are used to hold the panel a little way clear of the case. The remaining wiring must be completed before the component panel is finally bolted in place, Fig. 4.



The completed circuit board for the tester.

OPERATION

Most multimeters are fitted with test prods that can be connected direct to SK1 and SK2. If this does not prove to be possible a couple of connecting leads can be made up. These would each consist of a short lead fitted with a wander plug at one end and a crocodile clip at the other. A similar set of leads are used to connect the Zener under test to the tester, but these leads are terminated in a single 3·5mm jack socket rather than wander plugs.

In both cases it is necessary to ensure that the polarities of the leads are correct and clearly marked (use red wander plugs and clips to indicate "positive", and black ones to indicate "negative"). With SK3 connected as shown in Fig. 4 the inner connector of the jack plug will be the positive output.

The multimeter should be switched to read 30 volts f.s.d., or the lowest d.c. voltage range of more than 30 volts. If the unit is fitted with a fresh battery, a reading of about 28 volts or so should be produced on the 'meter. As the battery ages this reading will gradually drop, and the battery will need to be replaced when the reading falls below about 24 volts.

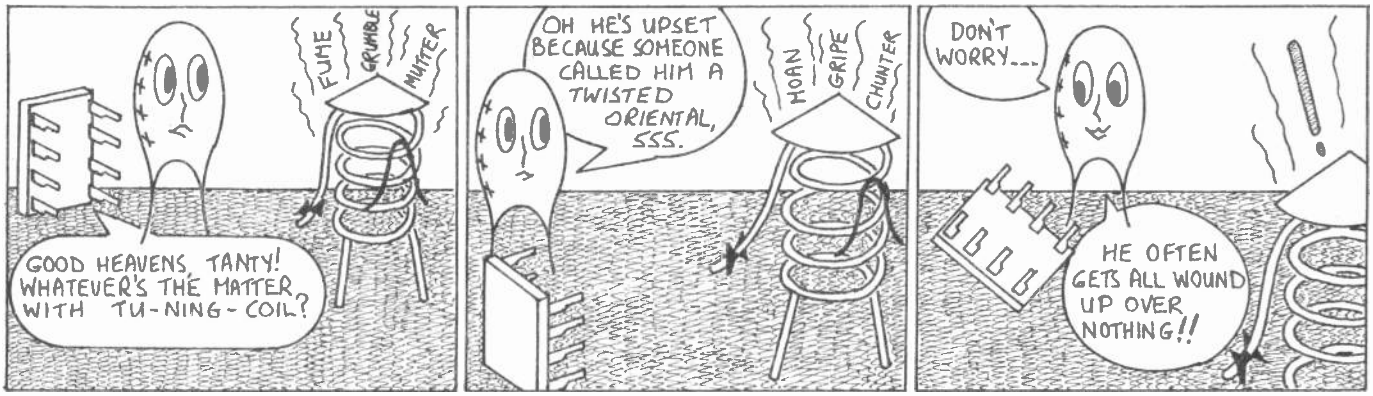
In order to test a Zener it is merely necessary to connect the component across the test leads and then read the operating voltage on the meter, but the Zener must be connected the right way round. The cathode connects to the positive output lead, and the cathode is usually indicated by a coloured band around that end of the component's body.

An idea of the test component's efficiency can be obtained by switching S1 to the HIGH position. This should result in the meter reading either remaining unaltered, or increasing only very slightly. The exception to this is when a Zener having a voltage of about 6 volts or less is being tested.

A somewhat larger (but still small) increase may then be noticed. The reason for this is merely that low voltage Zener diodes are usually comparatively inefficient. ⌘

The Adventures of Tanty Bead

By Matthew Reed



RADIO WORLD

By Pat Hawker, G3VA

Progress in space

Fifteen years ago, early in 1965, I was fortunate enough to go with a party of European journalists to the space satellite plant of Hughes Aircraft at Culver City, Los Angeles. This was just before the launching of their *Early Bird* synchronous satellite, which later became *Intelsat I* and which was the first "bird" in the now world-wide Intelsat system.

At the time there was still a profound lack of enthusiasm on the part of the European telecommunications authorities for the synchronous or geostationary orbit where the satellites appear to an observer on the ground to be "standing still". Although the advantages of this unique orbit had been pointed out in 1945 by the science-fiction writer Arthur C. Clarke, the British Post Office was far keener on medium-altitude orbits, with all its problems of tracking and handing-over the satellites; they claimed that the time-delay involved when using geostationary orbits would make them unsuitable for two-way conversations.

The *Early Bird* satellite proved them wrong, although it is true that at first the echo-suppressors were not capable of their task. I remember, when the Post Office provided a free telephone call to New York to mark the opening of the service, that the degree of echo did make conversation difficult. Much better echo-suppressors are used today although as far as possible the longer time delays of double-hop satellite circuits are avoided.

The satellite could nominally carry 240 two-way telephone circuits, although in practice it had sufficient bandwidth to allow it to carry colour television pictures across the Atlantic. The estimated cost per circuit for each year of its useful life was estimated (for telephone circuits) at some $30,000.

Today we await the launching of the first *Intelsat V* bird; although this was originally scheduled for late 1979 or early 1980, the dates have slipped and it will probably be the end of the year before the first of the new generation of "big birds" goes into orbit.

By comparison with *Early Bird*, *Intelsat V* is enormous, with large solar panels giving it an overall length of some 15 metres; it will have an in-orbit weight of 950 kilograms, some 25 times that of *Early Bird*. Instead of 240 two-way telephone circuits, it should prove capable of handling 12,500. But even more impressive in these days of rising costs is that the estimated cost per circuit per year work out to about $700, a fortieth that of *Early Bird*.

Unfortunately, of course, this does not mean that we have now reached the era of those 2·5p telephone calls to Chicago that used to be forecast for the space age. The *Intelsat* system is still very expensive to use, particularly if you need a broadband television circuit across the Atlantic.

Such circuits, in spite of a number of reductions in charges over the past decade, can still cost more than £1,000 for ten-minutes. Far, far cheaper to use are the American "domestic" commercial satellites such as *Westar* and *Satcom* on which television programmes can be distributed throughout the United States for costs of about £200 an hour (and considerably less for long-term leasing).

A hint of what could be possible in Europe was the opening last March of a data circuit between the Rutherford Laboratories near Oxford and the European Nuclear Research Centre in Geneva using Marconi 3-metre terminals and the experimental *OTS* satellite. Similarly the IBA's transportable 2·5m terminal with 1·5kW 14GHz transmitter has been used during the past year to provide the first space links from the Channel Islands, from Eire and recently from a North Sea oil rig.

Wind and Sun power

Last month we noted the various "alternative" sources of electricity now being use for telecommunications and broadcasting in remote areas where no electric-mains are available. These included the use of solar generators and the more traditional wind and heat generators.

An ingenious combination of wind *and* sun is now being used by the French television service TDF in the South of France. Initially three low-power local relay transmitters were supplied by a solar generator in conjunction with a battery, but this has recently been supplemented by installing a wind generator at the same site, with the output from both used to keep a 1050Ah capacity battery charged. This seems a most logical arrangement for a part of the world that is famous both for its sunshine and its mistrals.

Apparently the French are intending to use solar generators at quite a large number of its low-power relay stations. Such television stations often use very low power (many UK u.h.f. transmitters have an r.f. output of less than 0·5 watt, less than that of a torch bulb).

Some of the French stations are sited high up in the Alps; for example last summer all materials for new high-power v.h.f./f.m. radio aerials had to be transported by helicopter to a site almost 3,000 metres above sea level (over 9,800ft). This extremely high site is being used not only for radio and television but also for the new Eurosignal paging system.

Keeping tabs on frequencies

The BBC maintains an elaborate programme monitoring receiving station at Caversham, near Reading, but a few years ago closed down the station at Tatsfield, Kent which specialised in the very accurate measurement of the frequencies of broadcast transmitters; this work is now carried out at Caversham. A number of frequency-measuring stations exist in Europe, including one run by the European Broadcasting Union in Belgium.

The Italian broadcasting organisation, RAI, recently marked the 50th anniversary of the opening of its first monitoring laboratory at Sesto Calende, Varese and nowadays has a main station at Monza and an auxiliary station near Sorrento in southern Italy. Monza was one of the stations that monitored the Indian direct-broadcast satellite experiment a few years ago but more normally keeps tabs on the frequencies of medium wave and v.h.f. radio transmitters.

Less happy has been the experience of the Arab States Broadcasting Union which in 1978 brought into service a very modern technical monitoring station in Khartoum but this was destroyed by fire in December 1979.

Broadcast transmitters have to be maintained very accurately on frequency, often to within a few hertz. But the requirements will become even more stringent if eventually the single-sideband mode of transmission (s.s.b.) is adopted for h.f. broadcasting, as is currently being sought by a number of European countries, in spite of the decision made at the World Administrative Radio Conference last year not to allocate frequencies for this purpose.

Broadcast s.s.b. requires extremely stable transmission in order to prevent distortion of music programmes, a much more critical requirement than for speech communication. It may call for transmitters to be stable to within about 0·1Hz and even domestic receivers will need to keep within about 2 to 3Hz of the correct frequency—existing "short-wave" broadcast receivers often drift several *kilohertz* in a matter of minutes, and often even more when first switched on.

If we are to have s.s.b. broadcasting it will call for the development of new techniques to provide high frequency stability combined with easy tuning. This would be possible with modern microelectronics, but still very difficult!

Morse made easy?

To obtain an amateur transmitting licence for the h.f. bands it is necessary to pass a Morse test of 12 words per minute. Those learning Morse are normally advised always to start by using a simple hand key, even if they intend later to use one of the currently popular "electronic keyers" which are capable of providing very accurately timed dits, dahs and inter-symbol spaces (though they still send the *wrong* characters if inexpertly used).

Rather interestingly, I see that an American amateur (who has trained a lot of operators) has come out firmly in favour of *starting* novices on electronic keyers, claiming that this results in better "fists", more enjoyment in learning and later using Morse, and good training in the sound of perfect Morse. He regards the use of hand keys as being as old fashioned as using a horse and plough rather than a tractor.

Gosh! That puts me in my place since I still use two hand keys: one made in 1914, the other in the 1940s—but even so manage to enjoy Morse!

SQUARE one FOR BEGINNERS

ABBREVIATIONS

ABBREVIATIONS are an indispensable "shorthand" and are widely used in text and diagrams.

Some will be very familiar, even to those new to electronics: for example, h.t., d.c., m.w., and f.m.

Others will be completely strange and so the following list will be valuable for reference purposes when reading articles in this and other electronics publications. *Excluded from the present list are those abbreviations that relate specifically to the microcomputing area of electronics.*

COMMON ABBREVIATIONS

It will be noted that the majority of common abbreviations are formed from the initial letter of each word in the term. Small letters separated by full stops are generally used—but capitals if the punctuation demands, as at the commencement of a sentence.

Some abbreviations depart from this general rule, and appear as capitals without full stops. For example, BA, CMOS, DIN and TTL.

UNIT SYMBOLS

"Single-capital" abbreviations are used as symbols for electrical quantities: V (volt), A (ampere) and F (farad), for example.

Prefixes are commonly used with such symbols to divide or to multiply the standard unit, as required:

mV—millivolt (one thousandth of a volt)
kΩ—kilohm (one thousand ohms)
MHz—megahertz (one million hertz)

Note that submultiple indicators are in small letters:
c (centi)
m (milli)
μ (micro)
p (pico)

Multiples use capitals:
T (tera)
M (mega)
but small k is used for kilo.

CAPACITANCE

It will be discovered that there are alternative ways of expressing a particular value or quantity. This applies particularly with capacitance, which is measured in farads (F).

This is much too big a quantity for practical purposes, and the actual values used in practice are submultiples of the farad: pico-farad (10^{-12}F), nanofarad (10^{-9}F) and microfarad (10^{-6}F).

One of the larger values of capacitor frequently encountered in electronics is 100μF. This could also be expressed as 100,000nF or as 100,000,000pF. Clearly the first method is the most sensible.

An intermediate value of capacitance such as 0·01μF equals 10nF or 10,000pF.

The very small value of capacitance of 1pF equals 0·001nF or 0·000001μF.

From all this it will be deduced that smallest values are best expressed in pF's, intermediate values can be in any of the three forms, and larger values in μF. The following table offers general guidance in this respect.

It would be a useful exercise to calculate the equivalents in nanofarads and microfarads for each capacitance range given in Table 1.

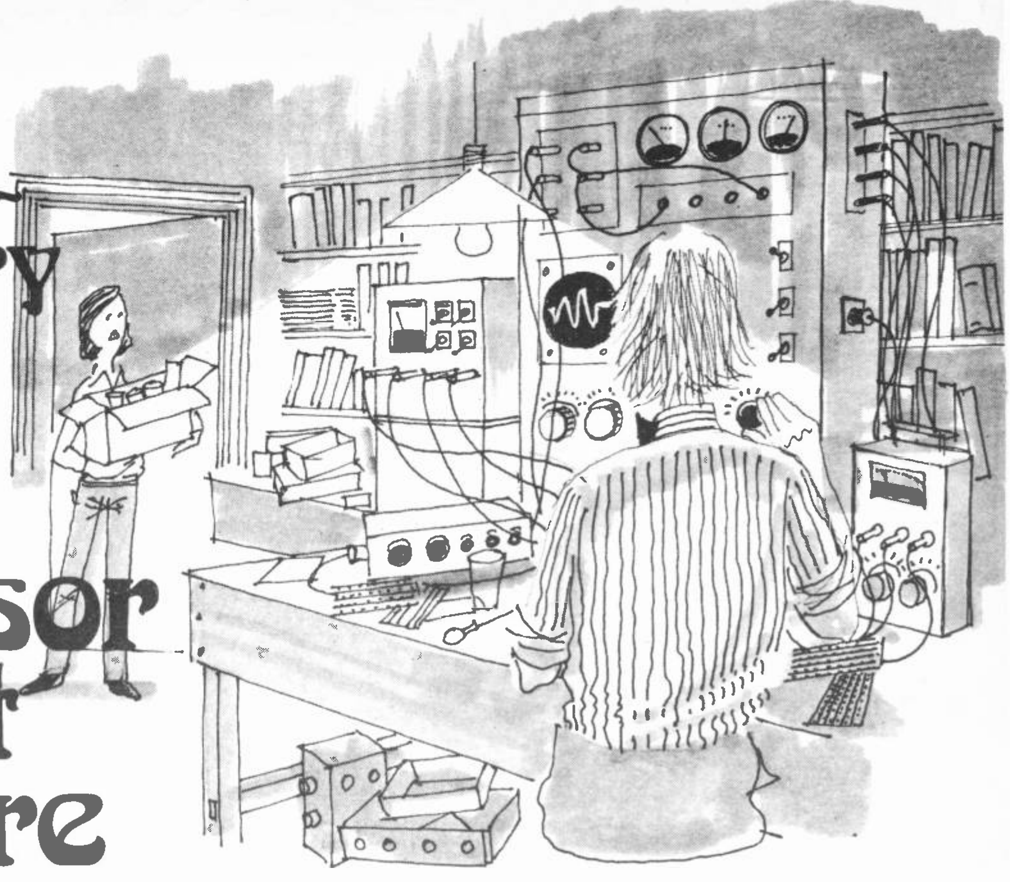
TABLE 1

CAPACITANCE RANGE			EXPRESS IN
1pF	to	999pF	pF
1,000pF	to	99,999pF	pF, nF or μF
100,000pF	to	999,999pF	nF or μF
1,000,000pF	and above		μF

ABBREVIATIONS GENERAL LIST

A	ampere (amp)
a.c.	alternating current
a.f.	audio frequency
a.f.c.	automatic frequency control
a.g.c.	automatic gain control
a.m.	amplitude modulation
BA	British Association (nut and bolt sizes)
b.f.o.	beat frequency oscillator
bit	binary digit
C	coulomb
c	centi (÷100)
cm	centimetre
CMOS	complimentary metal oxide silicon
c.r.o.	cathode-ray oscilloscope
c.r.t.	cathode-ray tube
c.w.	continuous wave
d	deci (÷10)
dB	decibel
d.c.	direct current
d.i.l.	dual-in-line
DIN	Deutsche Industrie Nummer
d.p.d.t.	double-pole double-throw
elect.	electrolytic
e.h.t.	extra high tension
e.m.f.	electromotive force
e.m.u.	electromagnetic unit
e.s.u.	electrostatic unit
eV	electron volt
F	farad
f.e.t.	field effect transistor
f.s.d.	full scale deflection
f.m.	frequency modulation
G	giga (x1,000,000,000)
g	gram
H	henry
Hz	hertz (cycles per second)
h.f.	high frequency
h.t.	high tension
i.c.	integrated circuit
i.f.	intermediate frequency
k	kilo (x1,000)
l.e.d.	light emitting diode
l.d.r.	light dependent resistor
l.f.	low frequency
lin.	linear
l.t.	low tension
log.	logarithmic
l.w.	long wave
M	mega (x1,000,000)
m	metre (measurement of length)
m	milli (÷1,000)
mm	millimetre
MOS	metal oxide silicon
m.w.	medium wave
n	nano (÷1,000,000,000)
npn	transistor structure
pnp	transistor structure
op-amp	operational amplifier
p	pico (÷1,000,000,000,000)
p.d.	potential difference
p.i.v.	peak inverse voltage
p-p	peak-to-peak
p.t.f.e.	polytetraflouroethylene
p.v.c.	polyvinyl chloride
r.f.	radio frequency
r.m.s.	root-mean-square
s.p.c.o.	single-pole changeover
s.p.s.t.	single-pole single-throw
s.r.b.p.	synthetic resin bonded paper
s.s.b.	single sideband
s.h.f.	super high frequency
s.w.g.	standard wire gauge
T	tera (x1,000,000,000,000)
t.r.f.	tuned radio frequency
TTL	transistor transistor logic
u.h.f.	ultra high frequency
u.j.t.	unijunction transistor
V	volt
v.c.o.	voltage controlled oscillator
v.h.f.	very high frequency
v.l.f.	very low frequency
W	watt
w.w.	wire wound
X	reactance
Z	impedance
%	per cent
μ	micro (÷1,000,000)
Ω	ohm

The Extraordinary Experiments of Professor Ernest Eversure



by Anthony John Bassett

Bob and the Prof. have been carrying out some experiments with energy beams inside the Prof's giant experimental Space Environment Simulator, a huge and well-equipped vacuum chamber built inside his laboratory by the Prof. and his robots.

Bob has suggested that the Prof. might turn his experimental gravity control down past zero so that they could take off inside the vacuum-chamber and do some of the experiments in a real outer-space environment.

To his surprise the Prof. has suggested an alternative method; an experimental "Replication Beam" apparatus which will cause duplicates of Bob, the Prof. and the Vacuum Chamber to be formed in space! This would leave the originals safely on Earth.

SOLAR POWER

"We will try to beam energy back to Earth using microwaves," he informed Bob. "Many people look on this as a way to provide a channel for delivery of solar energy for use on earth—although it could also be a terrible weapon if the beam were concentrated.

"I want to try an experimental valve microwave generator. By using a special cathode which is both thermo-emissive and photo-emissive it should be possible to obtain a heavy electron-flow at low energy cost simply by focusing sunlight onto this cathode!

"The cathode then does not need to be heated electrically as is usually the case with earthbound valves, and the electrical power we save this way can add considerably to the efficiency of the device."

SPACE EQUIPMENT MAINTENANCE

"I see", said Bob. "Also the equipment will be much more reliable than an electrically heated valve because there is no heater-filament to fail, and because such filaments are quite an expensive part of the valve, it will be cheaper to make such valves.

"Also because the cathodes can be open to space, whenever the electrodes emission becomes lower, space-suited maintenance technicians can visit them and spray fresh electron-emitting surface layers onto them!"

SPACE DUST

"There are a number of possible causes of gradual degradation of an electron emitting surface in outer space", observed the Prof. "Bombardment by cosmic rays, ions and other particles, micrometeorites, space dust and gases. Also the gradual evaporation of the cathode material, which will usually operate at a high temperature.

"Although long experience with electrically heated cathodes in thermionic valves on Earth will provide sufficient knowledge for the initial construction of cathodes for use in space operated valves, a further programme of development on a more long-term basis will doubtless provide even better materials and reduce the requirements for maintenance even further.

"Many people tend to forget that, although solid-state devices will almost certainly dominate space electronics, yet thermionic and photo-emissive electronic devices will still have important functions not to be ignored, and will probably provide interesting and challenging jobs for spacemen of the future."

SPECIAL HOLOGRAPHY

Bob and the Prof. watched as the robots loaded enormous valve parts, grids, anodes, solar reflectors and silicon solar-cell arrays into the vacuum chamber.

"There's no need for us to put our space-suits on," the Prof. informed Bob. "The computer program which controls the replication will ensure that, although space-suits and replicas of people will be formed simultaneously, each of the people represented will actually be inside a space-suit without ever having to get into them down here as well! But we will need another record of you—this time under 'free fall' conditions so that the replica will not suffer a shock of de-gravitation."

Bob stood once again on the pedestal of the apparatus surrounded by its special sensors. At a signal from the Prof. he jumped up in the air, and at the apex of his leap he experienced once again the strange feeling of being filled for a moment with a flash of shimmering light, and an awareness of his replica shimmering in the storage of the memory of the Prof's strange machine whilst awaiting materialisation from this pre-physical condition.

"The device uses a special form of holography which records the inside details of any object, not just the outside surfaces which ordinary photographic holograms reproduce. Thus every atomic detail is recorded ready for replication! This is one way in which the practice of holography can advance!"

REMOTELY CONTROLLED FURNITURE

When they were ready to begin, the Prof. rustled up a couple of super comfortable motorised armchairs from his stock of radio-controlled mobile furniture, which saved his housekeeper a great deal of work especially during spring-cleaning when the furniture could be moved around effortlessly at the push of a button.

THE PROF TAKES OFF

"Sit down," he invited Bob, and as they relaxed in the chairs, he continued. "We will relax comfortably in these chairs throughout the experiment, and transfer our conscious awareness to the replicas, so that contradictions of awareness are minimised."

The Prof. pushed a few buttons on a control panel near the arm of his chair, then settled back and, breathing slowly and steadily, became deeply relaxed. Bob did likewise and soon his mind seemed to leave his body and go effortlessly up into space, to an orbit near that of the moon. There he gradually became aware of himself in a space-suit, inside a replica of the Prof's experimental Vacuum Chamber Space Environment Simulator.

The Prof. had also arrived inside another space-suit. "Is this really solid?" Bob asked, cautiously tapping one of the work benches in the replica.

"Yes, Bob, we just borrowed a few billions of atoms from the surface of the moon and from some space junk and when we finish the experiment and go back to our own bodies on Earth, they will all be put back neatly with minimum disturbance to the space environment.

"I chose this near-lunar orbit for easy access to these materials, and also to minimise the chances that we would be observed from Earth and cause a distubance again."

At this moment Bob became aware of an insistent bleeping sound. The Prof. pushed a button on one of the computer panels. The bleeping stopped and the Prof. concentrated his attention on the display on the giant computer viewscreen.

A *visitor* "according to my instruments", he informed Bob. "We are to expect a visitor very soon."

"In the Laboratory?" queried Bob.

"No. Here!"

To be continued

Threat to Small Shops

I imagine that what is happening in my neck of the woods is also happening in many other places. I am talking about the continued closure of shops, both big and small. The corner grocery disappeared many moons ago, unable to compete with the supermarkets, but these have been followed by shops of all shapes and sizes and trades.

This in general is caused not by competition, but by inflation. Rents come up for review and usually they have been static for seven years or more, consequently they then double, treble, or even quadruple. The poor old shopkeeper who is only just about holding his own is sunk without trace.

It might be supposed that this increase in rents would to some extent be compensated by the rise in prices over the same period, but I am bound to observe that as far as electronic components go, this has not happened. To quote a few items, resistors, capacitors, transistors and potentiometers have hardly risen at all. The only exception are items which are labour intensive such as variable capacitors, for example.

It was not to be expected that the component supplier would be more likely to escape this calamity than any other retailer. A year ago my friends at Home Radio saw their rent increase two and a half times, and recently I heard that another well known name, J. Bull of Croydon, would be moving for a similar reason. None of this is good news for the constructor, but on the credit side it must be said they are a tough bunch, these component boys and it takes more than a move to make them give up.

I was heartened too, by seeing two names re-appear again after some absence, my old friend Henry French now back in Edgware Road and Doram who are being run by a Dutch company.

The One-line specialist

A long time ago I remember speculating as to whether a man might make a living selling nothing but resistors. Now to my astonishment, I find that not only has one enterprising businessman been doing this for years, but he operates only half a mile from my own business.

Mind you his premises have to be seen to be believed. They consist of a shop with the window painted out, and the first floor. You force yourself through a door impeded by boxes of resistors. These are stacked from floor to ceiling, and the gap between them is so small, you have to turn sideways to get through.

It reminds me of the boot shop in Jerome K. Jerome's "Three Men on the Bummel" which our three heroes visit when trying out the efficacy of a foreign language phrase book. I quote:"It was one of those overfed shops that the moment their shutters are taken down in the morning, disgorge their goods all around them. Boxes of boots stood piled on the pavement or in the gutter opposite. Boots hung in festoons about its doors and windows.

"Its sunblind was as some grimy vine, bearing bunches of black and brown boots. Inside the shop was a bower of boots. The man when we entered was opening a new crate full of boots. George took a sentence at random from the phrase book. It was not a happy selection. It was a speech that would have been superfluous to any boot maker. Under the present circumstances, threatened and stifled as we were on every side by boots, it possessed the dignity of positive imbecility. It ran, 'One has told me that you have boots for sale' ".

One of these days when I am feeling extra brave, I shall knock on Mr. . . . . . .'s door and when he has squeezed himself past all the boxes and levered the door open, I will say, "One has told me you have resistors for sale".

Marshall's

A. Marshall (London) Ltd., Kingsgate House,
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Industrial Sales: 01-328 1009
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See catalogue for details.
Comprehensive range Siemens Layer Polyester Caps: .001 to 3.3mF
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See catalogue for details.
Large range of Mullard/Siemens Electrolytic Axial/Radial
Capacitance values 1.0mF to 10,000mF
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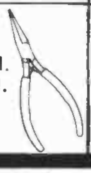

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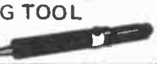

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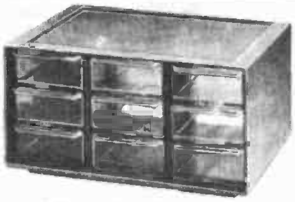

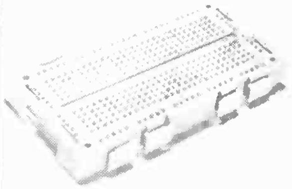

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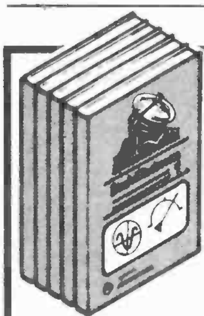

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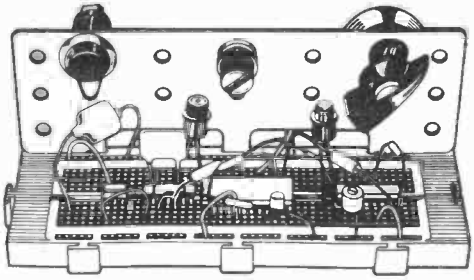

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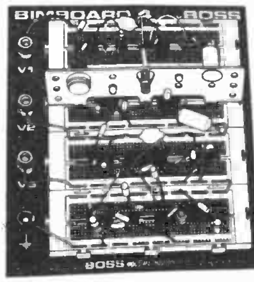

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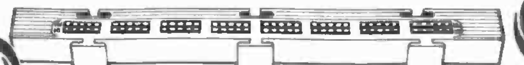

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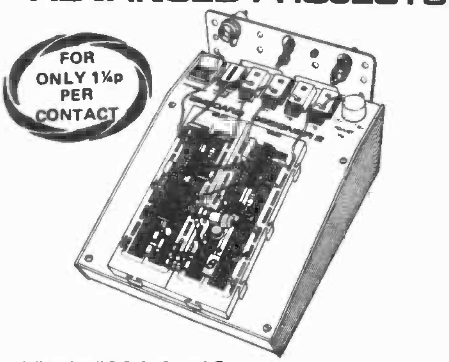

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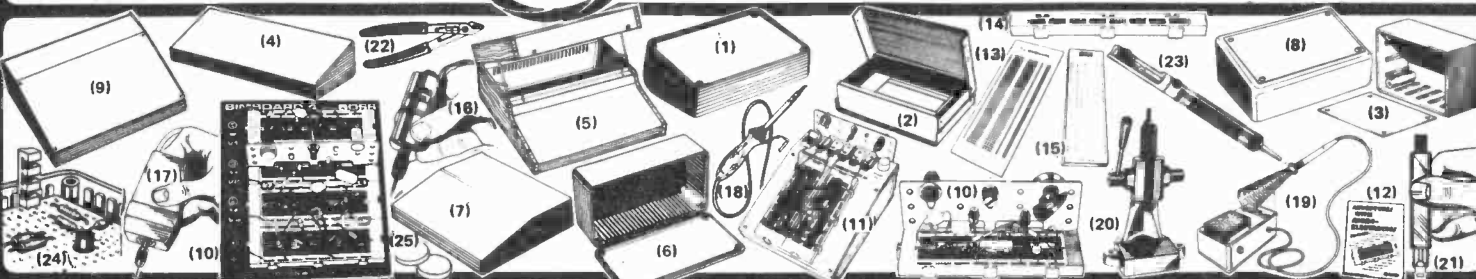

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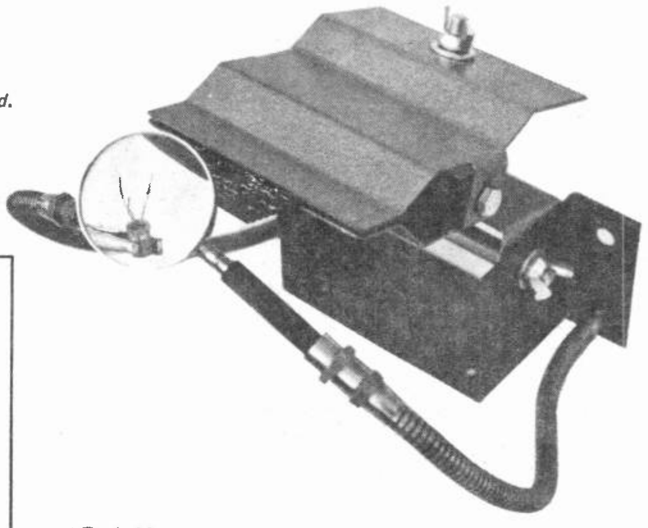

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79	1·0	3·93	1·10
3	2·0	6·35	1·10
20	3·0	6·82	1·31
21	4·0	8·79	1·31
51	5·0	10·86	1·52
117	6·0	12·29	1·67
88	8·0	16·45	1·89
89	10·0	18·98	1·89
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103	1·0	4·57	1·10
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105	3·0	9·42	1·57
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150	100	8·38	1·31
151	200	12·28	1·31
152	250	14·61	1·73
153	350	18·07	2·12
154	500	22·52	2·47
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1000	30·67	2·65	84W
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71	2	1	3·88	0·90
18	4	2	4·46	1·10
85	0·5	2·5	8·18	1·10
70	6	3	6·99	1·10
108	8	4	8·16	1·31
72	10	5	8·93	1·31
116	12	6	9·89	1·52
17	16	8	11·79	1·37
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207	500, 500	0-8-9, 0-8-9	3·05	·85
208	1A, 1A	0-8-9, 0-8-9	3·88	·90
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Size 9¼" x 8¾" x 4" approx.
NOTE: for use with 4 to 8 ohms speakers. p&p £2.55 £13.95
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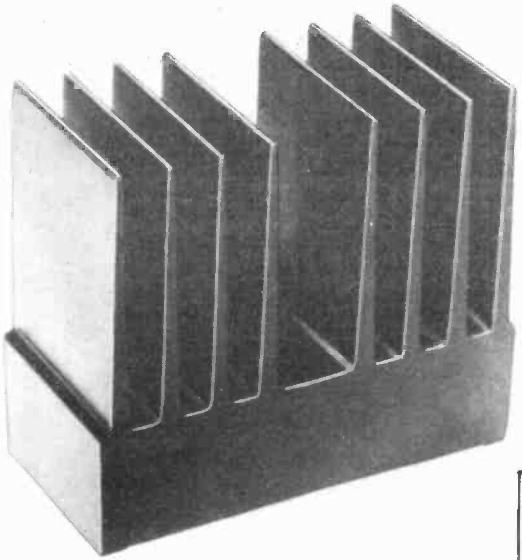

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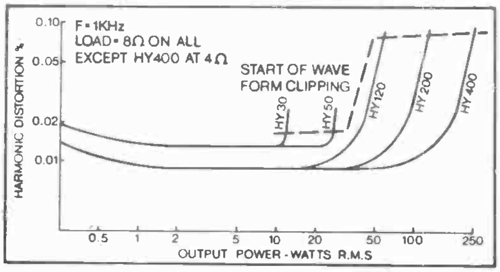

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Input impedance - all models 100K Ω
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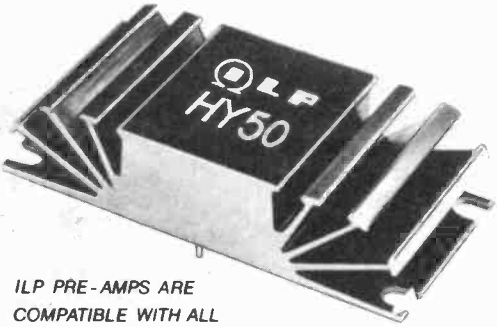

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