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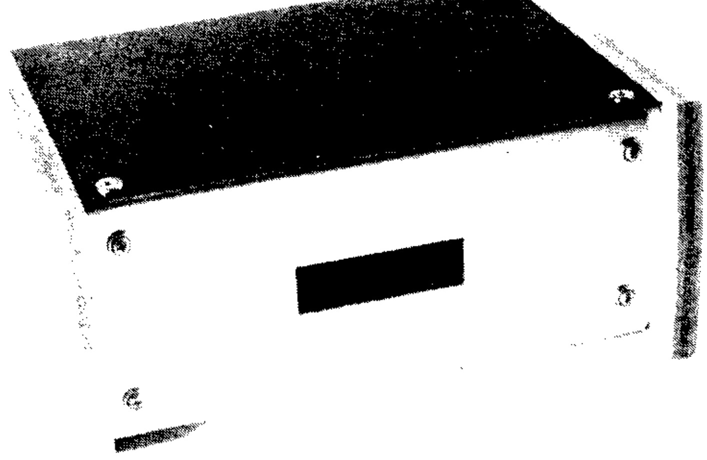


SINGLE CLOCK

By P. R. Arthur

Although it is possible to construct a digital clock using ordinary logic i.c.'s, there is little incentive to do so these days. Special purpose digital clock i.c.'s are currently available at very reasonable prices, and their use greatly simplifies the construction of a digital clock as well as reducing its cost. Admittedly, employing ordinary logic i.c.'s does offer the advantage of giving the constructor a greater understanding of how the finished clock functions, but this will be of minor importance to most readers, and is certainly of little importance here since the main requirement was for a very simple electronic digital clock design.

It was not difficult to select the i.c. which forms the basis of this project, and the AY-5-1224A has been chosen. This device is not one of the most recently introduced clock i.c.'s, but it is nevertheless quite advanced. It is housed in a standard 16 pin d.i.l. package, and it provides all the necessary logic circuitry for a mains operated four digit clock. The clock which is described here is a 12 hour type which is powered from a 50Hz supply. However, it is an easy matter to modify the circuit for 24 hour and/or 60Hz operation, and details of these modifications will be provided. The i.c. is listed by some suppliers, such as Maplin Electronic Supplies, as AY-5-1224 without the suffix "A".

It should perhaps be explained that although this project is relatively easy to construct in comparison with other clock designs, it is not really suitable for the beginner or near-beginner and some experience of etching printed circuit boards is necessary.

An article in the following issue will describe an add-on facility which causes the display to be automatically dimmed under very dark lighting conditions. This reduces glare and is particularly useful if the clock is installed in a bedroom.

OPERATING PRINCIPLE

The greatly simplified block diagram of Fig. 1 illustrates the way in which a clock of this nature operates. The timing control signal is provided by the 50Hz mains supply which is normally accurately maintained at its nominal frequency. The accuracy obtained from the present clock design certainly seems to be better than that provided by most mechanical synchronous clocks. A step-down transformer reduces the mains voltage to a level that is suitable to drive the clock circuit input. This transformer is also used in the power supply section and it provides isolation from the mains supply.

A schmitt trigger appears at the clock input, its function being to provide a 50Hz waveform which has fast leading and trailing edges. The very slow rise and fall time of the mains input is not suitable for directly driving logic circuitry, as malfunctions can occur as the waveform changes slowly from one logic state to the other. The Schmitt trigger incorporates hysteresis, which merely means that the input voltage at which the output goes to logic 1 is higher than that which causes the output to return to the logic 0 state. This helps the Schmitt trigger to operate reliably from the slowly changing input waveform and it also reduces the risk of spurious triggering due to mains noise spikes. (Viewing the mains waveform on an oscilloscope will show that it can be far from a perfect sinewave.)

The output of the Schmitt trigger is fed to a divide-by-300 divider chain, causing the 50Hz input to be reduced to one cycle per minute. A two-digit counter is fed from the divider chain output, but this is not an ordinary 0 to 99 counter. It is designed to automatically reset itself to zero on the following input pulse when a count of 59 has been

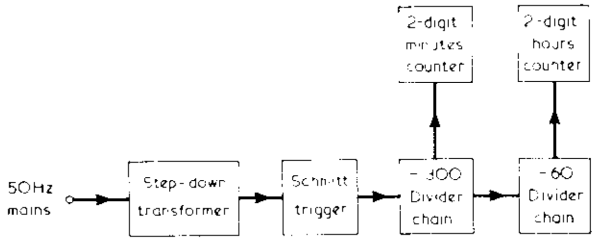


Fig. 1. Simplified block diagram illustrating the stages which allow the 50Hz mains supply to control the minutes and hours display of a digital clock

I.C. DIGITAL

★ Readily available components

★ Attractive design ★ Simple circuit

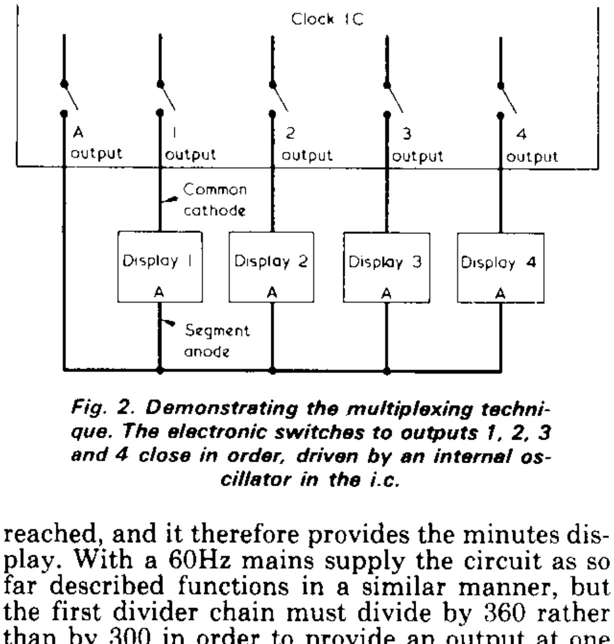


Fig. 2. Demonstrating the multiplexing technique. The electronic switches to outputs 1, 2, 3 and 4 close in order, driven by an internal oscillator in the i.c.

reached, and it therefore provides the minutes display. With a 60Hz mains supply the circuit as so far described functions in a similar manner, but the first divider chain must divide by 360 rather than by 300 in order to provide an output at one cycle per minute.

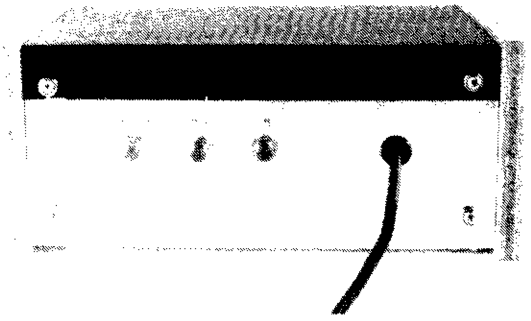
The output from the first divider chain is also applied to a second divider chain, and this time the division is by 60. Thus, an output pulse is produced at intervals of one hour, and this signal is used to feed the two-digit hours counter and display. The signal can also be employed to provide the automatic reset to zero after 12 for a 12 hour clock, or after 24 for a 24 hour clock. Again, this is not a conventional 0 to 99 counter circuit.

MULTIPLEXING

The clock circuitry drives four common cathode l.e.d. displays. Clock i.c.'s are sometimes designed to provide an individual output terminal for each display segment, but this would not be possible here. The AY-5-1224A has only 16 pins, and there are 23 anodes to be driven (5 segments of the left-hand hours display are unused as this display is either blank or indicates the number 1). In consequence, a system known as multiplexing is employed to enable the display to be driven from just 11 i.c. outputs. Apart from reducing the number of pins that the i.c. needs to have, multiplexing also has the advantage of reducing the number of leads which are required to couple the clock circuitry to the display.

Fig. 2 illustrates the way in which multiplexing functions with four common cathode displays. All the A segments in each display are connected together, as are all the B, C, D, E, F and G segments, so that, however many digits there are, there are just seven inputs plus the common cathodes. For the sake of simplicity, only the A segment wiring is shown in Fig. 2. The common cathodes are not simply connected direct to the negative supply rail; instead they are connected to the negative supply rail via switching circuitry inside the i.c. or, to be more precise, via discrete switching transistors which are controlled by outputs of the i.c.

In this example we will assume that the A segments of displays 1 and 3 are to be switched on, and that those of displays 2 and 4 are to be turned off. An internal oscillator of the clock will in turn close the switches at outputs 1 to 4, so that as one switch is closed the previous one is opened. The circuit continually cycles in this manner at high speed, with the switches each being closed for an identical length of time.



On the rear panel are mounted the push-buttons which provide zero reset, minute change and hour change

In order to light up the segments of displays 1 and 3, it is merely necessary to close the switch at the A output each time the switch at either the 1 or the 3 output is closed. Obviously the two A segments will not be powered continuously, but they will be pulsed on and off at a rate controlled by the cycling oscillator. This runs at a relatively high frequency, whereupon persistence of vision causes the segments to appear to be continually lit up. The other segments of each display can be similarly illuminated, the appropriate segment switch being closed at the same time as is the switch coupling to the display common cathode.

THE CIRCUIT

The circuit diagram of the digital clock appears in Fig. 3, and for the sake of clarity the display section is shown in a simplified form with one block representing the four displays. The full display circuit is illustrated in Fig. 4.

With reference to Fig. 3, T1 is the mains step-down transformer and it feeds a full-wave rectifier. C1 provides smoothing of the d.c. output of the rectifier, and this very simple power supply provides more than adequate performance for the present application. The loaded output voltage is about 16 to 17 volts.

The 50Hz input signal for the clock is applied to pin 4 of the i.c., and it is derived from one winding of T1 via a simple RC low pass filter incorporating R1 and C3. The purpose of the filter is to attenuate noise spikes and so reduce the possibility of these causing spurious operation of the input circuitry.

C2 is part of the multiplex cycling oscillator, and its value determines the frequency of oscillation. TR1 to TR4 are used as the multiplex switches between the display cathodes and the negative supply rail. They are fed from the appropriate outputs of the i.c. via current limiting resistors R2 to R5.

Similar discrete transistor segment drive switches are often employed at the segment outputs of the clock i.c., as the segment drive current is limited by the maximum permissible dissipation of the i.c. The AY-5-1224A can, however, drive the segments directly, this being done from the output pins concerned via current limiting resistors R6 to R12. The display section incorporates four high brightness red l.e.d. displays type DL704 with the result that, even though a comparatively small segment current is employed, fully satisfactory results are obtained. The DL704 displays are, incidentally, available from several suppliers including Ambit International.

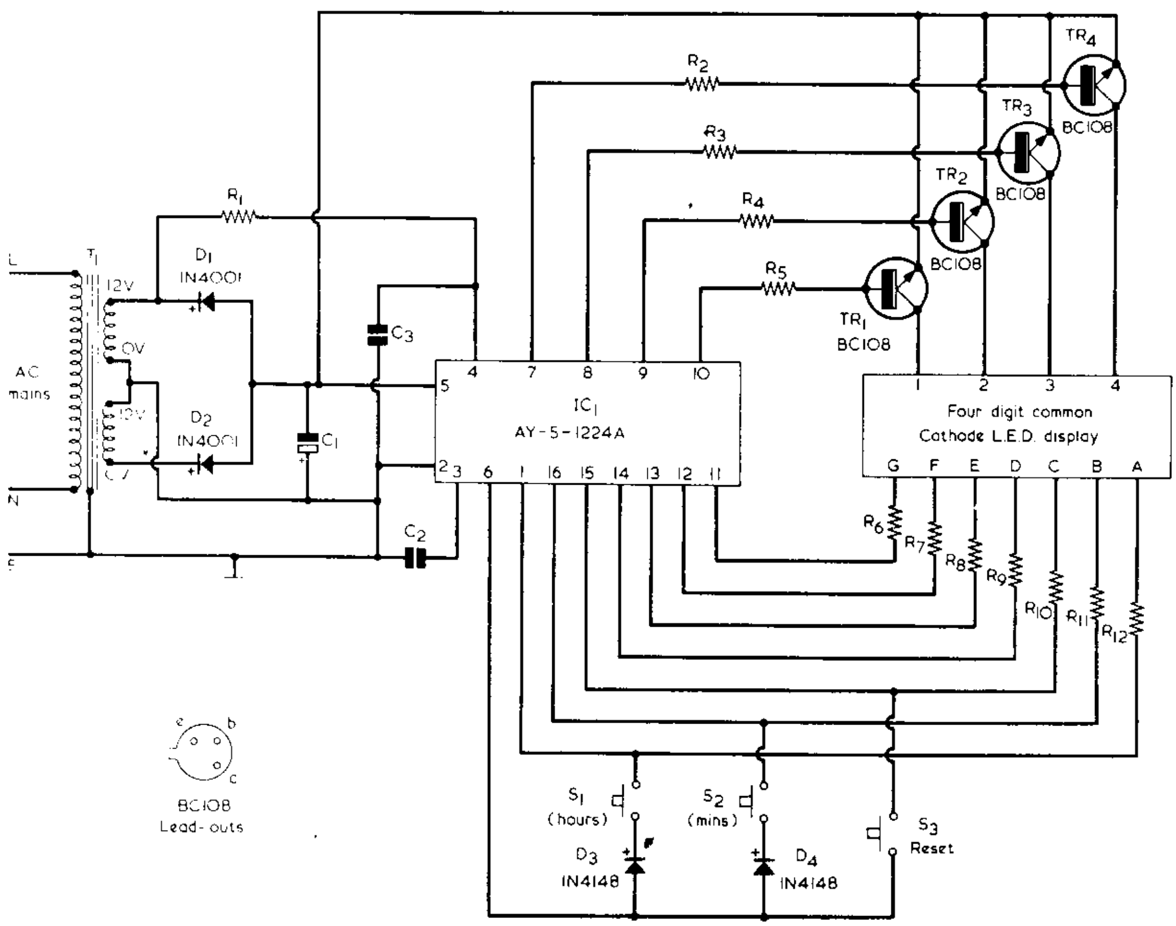


Fig. 3. The circuit of the single i.c. digital clock. For ease of presentation the four DL704 displays are shown as a single display block

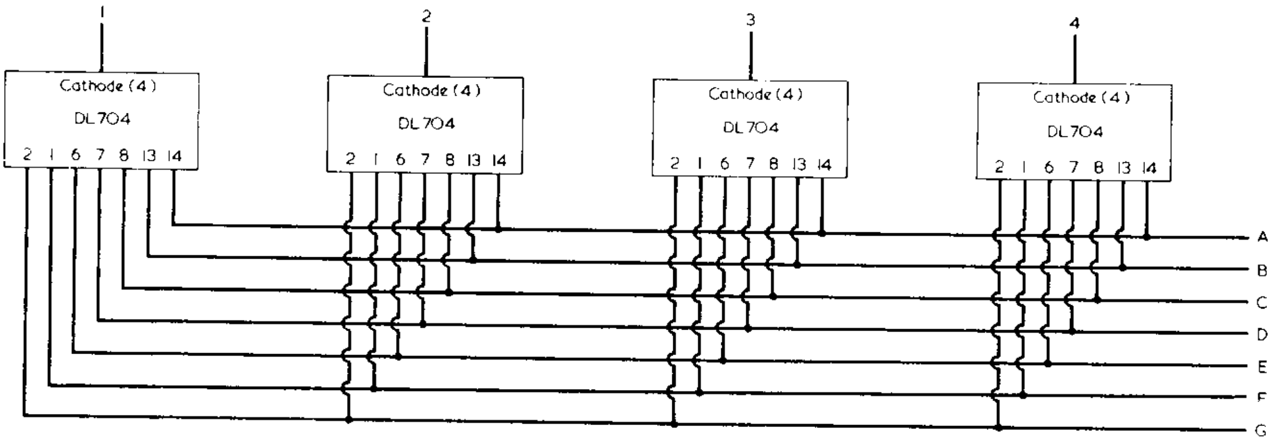


Fig. 4. Detailed circuit illustrating the connections to the DL704 displays. The display pin numbers correspond with the appropriate segments from A to G

COMPONENTS

Resistors
(All $\frac{1}{4}$ watt 5%)
R1 150kΩ
R2 8.2kΩ
R3 8.2kΩ
R4 8.2kΩ
R5 8.2kΩ
R6 2.2kΩ
R7 2.2kΩ
R8 2.2kΩ
R9 2.2kΩ
R10 2.2kΩ
R11 2.2kΩ
R12 2.2kΩ

Capacitors
C1 1,000μF electrolytic, 25V Wkg.
C2 680pF ceramic plate
C3 0.0068μF polystyrene

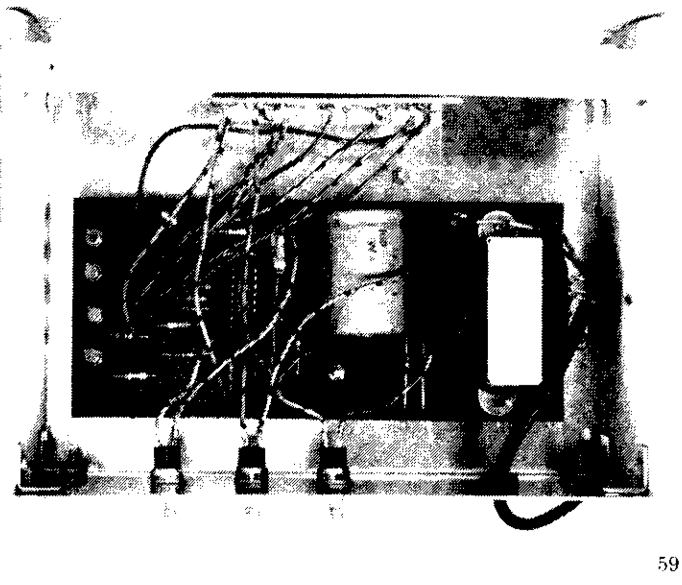
Transformer
T1 miniature mains transformer, secondaries 0-12V 250mA, 0-12V 250mA (see text)

Semiconductors
IC1 AY-5-1224A
TR1 BC108
TR2 BC108
TR3 BC108
TR4 BC108
D1 1N4001
D2 1N4001
D3 1N4148
D4 1N4148

Switches
S1 push-button, press to make
S2 push-button, press to make
S3 push-button, press to make

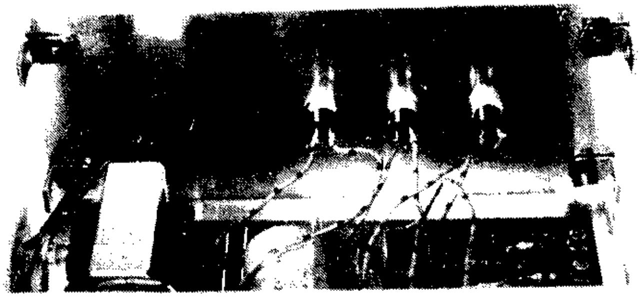
Displays
4-off DL704

Miscellaneous
"Mini-Bec" case, 7 x 5 x 3in. (see text)
Printed board materials
Display filter (see text)
I.C. holder, 16 pin d.i.l.
3-core mains lead
Wire, solder, etc.



Most of the components are assembled on a printed circuit board which is mounted on the bottom of the case

The wiring to the push-button switches on the rear panel



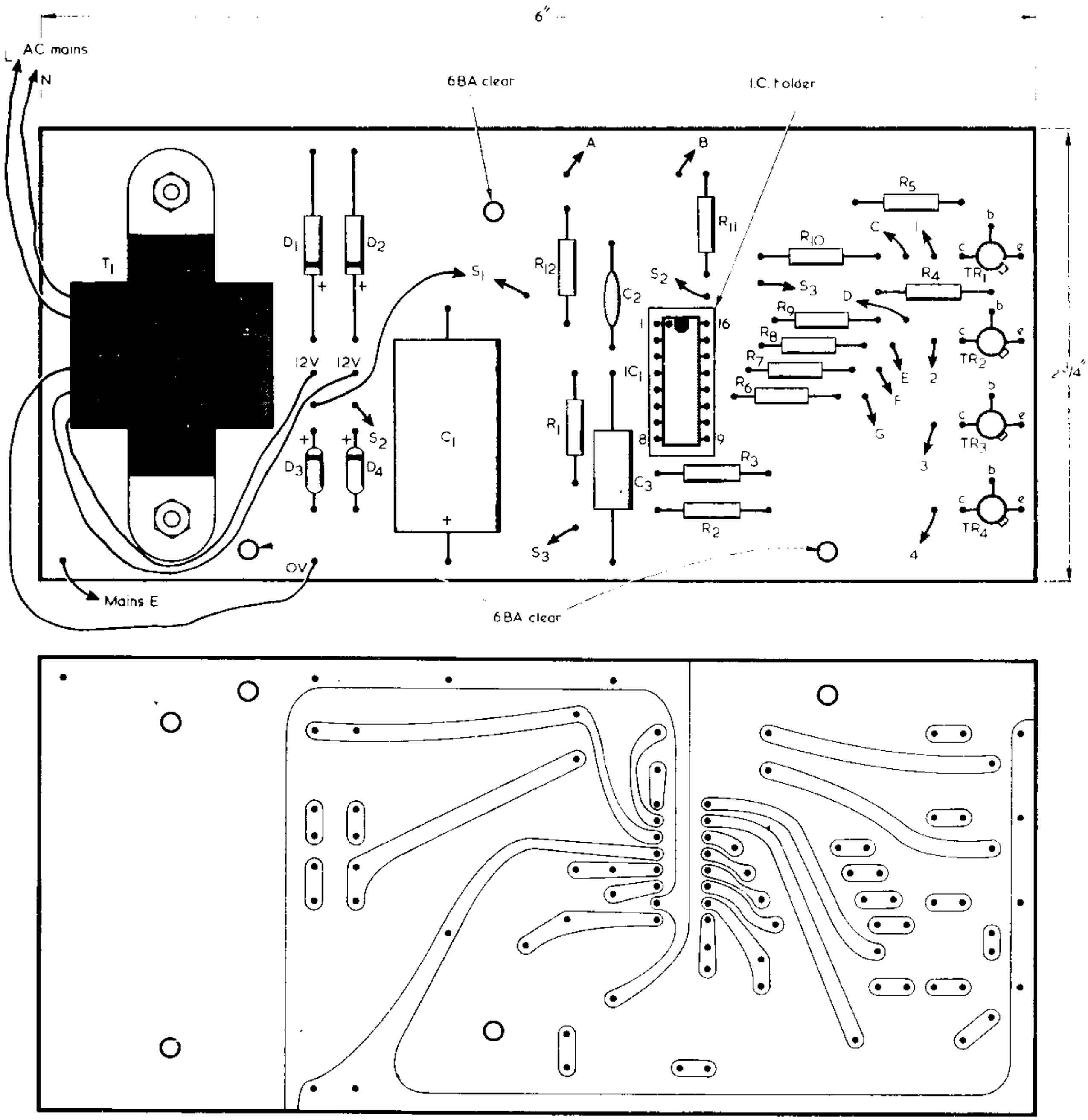


Fig. 5. Component and copper sides of the main printed board. The letter and figure references correspond with the same references in Fig. 6

It is necessary to incorporate some means of setting the clock to the correct time, of course, and closing S1 causes the hours to advance at a rate of one per second. Closing S2 causes the minutes to advance at a rate of one per second and the hours counter to advance at one hour per minute. Depressing S3 sets the counters to zero and, although this is not an essential feature, it can often be useful and save time when readjusting the clock.

CONSTRUCTION

The prototype clock is built in a D.I.Y. "Mini-Bec" case having outside dimensions of about 7 by 5 by 3in. This can be obtained from H.M. Electronics, 275a Fulwood Road, Sheffield, S10 3BD. The case has wooden end cheeks, an aluminium chassis and front panel, and a steel lid with simulated black leathergrain finish. The end cheeks were finished with a satin type varnish, but any other finish may be applied.

The general layout is very simple and straightforward, as can be seen from the photographs. A rectangular aperture measuring about 53 by 17mm. is made at the centre of the front panel for the readout display, and this can be cut out with either a fretsaw or a miniature round file. It is advisable to use some form of display filter in order to provide the unit with a neat finish and to improve the clarity of the display. A piece of red Perspex is employed in the prototype, but any filter intended for use with a red display should be satisfactory. A suitable filter is available, for instance, from Maplin Electronic Suppies. The filter is glued in place behind the aperture with a good general purpose adhesive.

A hole for the 3-core mains lead is drilled towards the right-hand side (as seen from the rear) of the case back, and this hole must be fitted with a grommet. The three push-button switches are mounted in a horizontal row between the centre and the left-hand side of the back, with S1 closest to the mains lead hole, S2 in the middle and S3 at the left. The mains lead should be secured inside the case with a suitable clamp.

PRINTED BOARDS

Apart from the three switches, the remaining components are all mounted on two printed circuit boards. One contains the main circuitry whilst the other is for the display section. Details of the main board are shown in Fig. 5, and the display board is illustrated in Fig. 6. Both diagrams are reproduced actual size so that they can be easily copied.

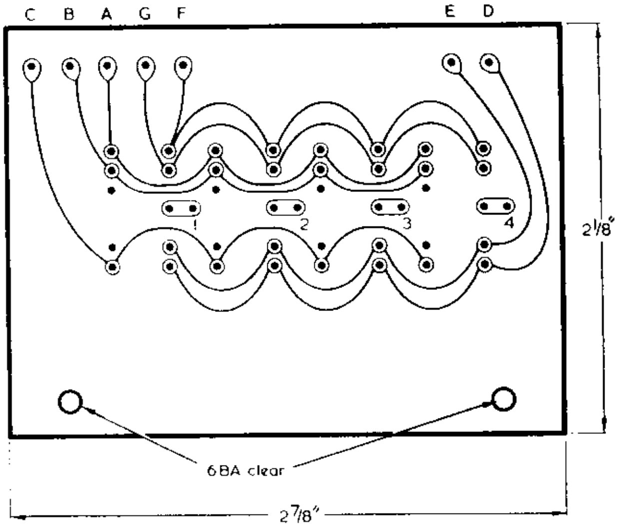
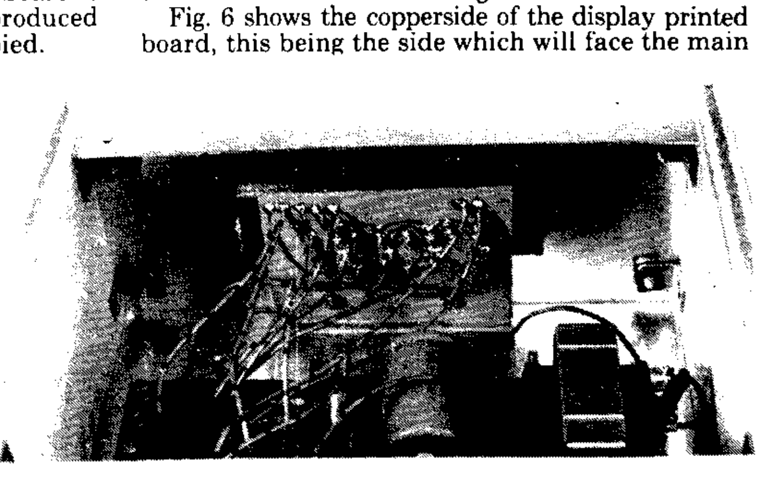


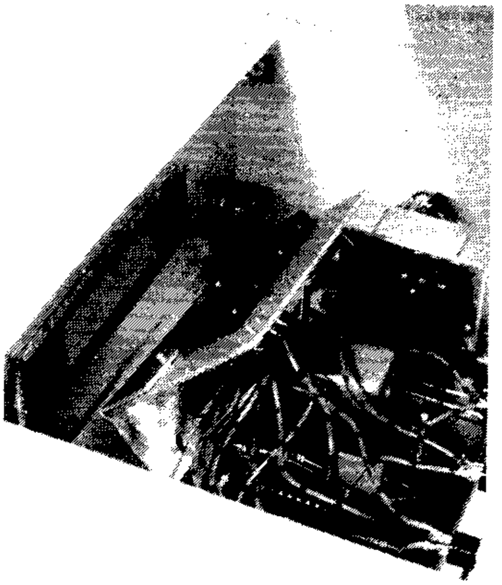
Fig. 6. The copper side of the display board. Connections shown here as lines are, in practice, narrow copper tracks. Like Fig. 5, this is reproduced full size for tracing

The board designs are fairly complex, and an etching pen having a fine nib (such as the DECON-DALO 33 type) is really necessary when constructing these. Using the methods described in the article "Producing Printed Circuit Boards" (*Radio & Electronics Constructor,* March 1977) it is not too difficult to complete both boards. Mains transformer T1 is mounted on the main board by means of two 4BA bolts and nuts. The bolt heads are below the board. The transformer must be a good quality type as it will be left running indefinitely, and some cheap types will overheat if used in this manner. The maximum supply current is about 100mA and so a component having a secondary rating of 250mA, as is specified in the Components List, will be run well within its ratings and will provide trouble-free operation provided it is of reasonable quality. Suitable transformers can be obtained from Maplin Electronic Supplies or Doram Electronics. In the case of the component supplied by the latter, there may be two 115 volt primary windings which must be series connected for use on the normal U.K. mains supply. Both types have two 12 volt secondary windings which must be series connected to provide what is then, in effect, a 12-0-12 volt winding. Secondary connections are as indicated in Fig. 3.

Fig. 6 shows the copperside of the display printed board, this being the side which will face the main



The connections to the display printed board. The copper side of this board is towards the inside of the case



This photograph illustrates the aluminium bracket on which the display board is mounted

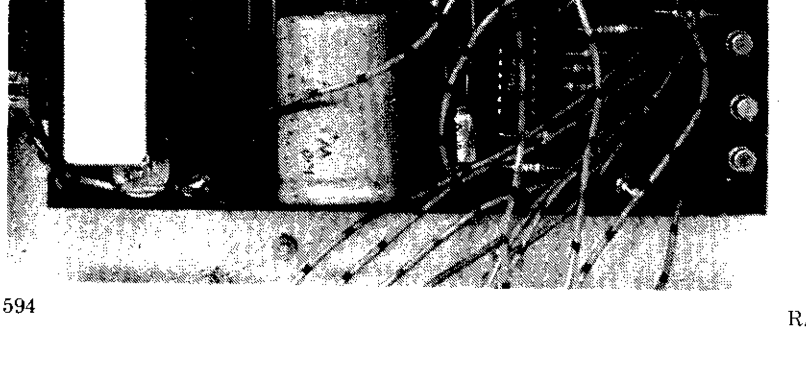
printed board when the display is fitted in place. The display lead-outs pass through the holes and are then soldered to the corresponding copper areas. The only holes which need to be drilled are those for the display lead-outs and the two 6BA mounting bolts. The remaining black points in the diagram merely indicate connecting points which are made on the copper side of the board. Interconnections between segment lead-outs and to the segment connecting points are shown as single lines; in practice they consist of narrow copper tracks a little less than 0.05in. wide.

The display board is mounted on an L-shaped mounting bracket which is constructed from 18 s.w.g aluminium. This raises the lower edge of the board about 6mm. (or as is required) above the base panel of the case in order to bring the display into alignment with the display window. Short 6BA bolts with nuts are used to secure the board to the bracket, and the bracket to the case.

The main printed circuit board is mounted towards the rear of the case by means of three 6BA bolts and nuts. Spacing washers about ½in. long are passed over the mounting bolts to hold the board underside clear of the metal case bottom. The bolt heads are, of course, on the underside of the case. The spacing washer at the hole near transformer T1 must be a metal type as it takes the mains earth connection to the metal chassis. Before the main board is finally mounted, however, the mains earth wire and insulated flexible leads about 100mm. long are sōldered to it, the latter at the points which connect to the display board and the three switches. Then, when the main board has been mounted the wiring can be completed, the insulated leads being cut to length as required and soldered into position. The live and neutral wires of the mains lead can also be connected.

It will be evident from what has already been stated that the leads which connect to the display board are not soldered to this in the usual fashion. They are soldered direct to the copper side of the panel, rather in the same way as connections are made to a "Blob Board".

The unit is then complete and is ready for testing. The mains wiring is accessible before the case lid is secured in position, and so the usual



Detailed view of the component side of the main printed circuit board precautions against shock must be observed. Apart from correctly setting the time using the push-buttons mounted on the rear panel, the finished clock requires no further adjustment.

60Hz/24 HOUR OPERATION

In areas of the world where the mains frequency is 60Hz it is still possible to use the clock as the necessary circuitry is incorporated in the i.c. It is merely necessary to add a 1N4148 diode between pins 6 and 12 of the i.c. as shown in the skeleton circuit diagram of Fig. 7. In practice, probably the easiest way of carrying out this modification would be to simply solder the additional diode in position on the underside of the printed board. Care must be taken to ensure that no accidental short-circuits can result.

If a 24 hour version of the clock is preferred, this can be accomplished by adding a 1N4148 diode between pins 6 and 13 of the i.c. This modification is also shown in Fig. 7. Again, in practice the diode can be soldered into position on the underside of the printed board.

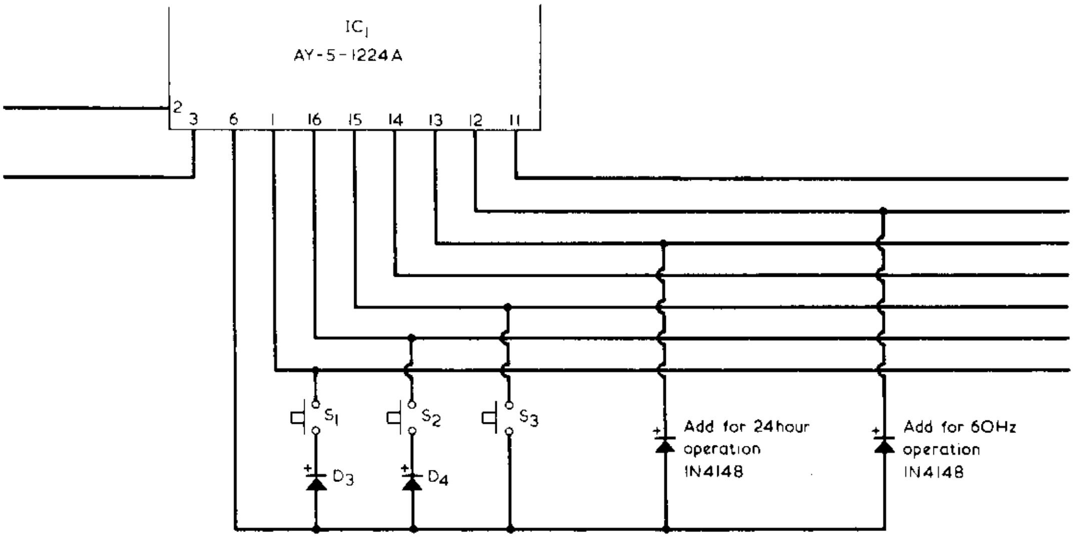


Fig. 7. An additional diode is connected to the circuit if it is desired to have 24 hour operation, or if the clock is to function with a 60Hz mains supply

I.C. HANDLING

The AY-5-1224A i.c. is a PMOS type and can therefore be damaged by static charges. It should be supplied in some form of protective packaging such as conductive foam, and it should not be removed from this packaging until it is time to connect the device into circuit after all wiring has been completed. As indicated in Fig. 5, an i.c. socket is recommended, and it is essential to ensure that the i.c. is plugged into this the right way round. Do not handle the i.c. more than is absolutely necessary.

BRIGHTER DISPLAY

The brightness of the display should be satisfactory for most requirements, although under very bright ambient lighting conditions slightly increasing the brightness will improve legibility. This can be achieved by reducing the values of the current limiting resitors, R6 to R12. These should all have the same value, and it is recommended that they should not be less than 1.8k Ω. With these resistors at the specified value of 2.2kΩ, or reduced to 1.8kΩ, the i.c. will run warm but it should not become hot to the touch.

AUTOMATIC CONTROL

A modification which automatically reduces the brightness of the display under dark ambient conditions will be described in next month's issue.

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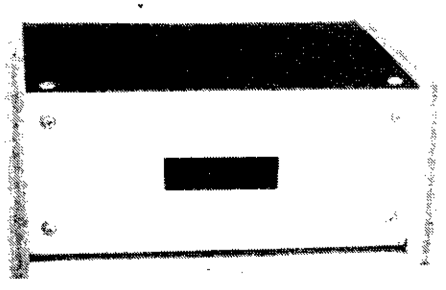


A rectangular aperture on the front panel of the electronic clock provides a window for the digital readout

NEWS . . . AND

PUBLIC VIEWDATA SERVICE — G.P.O.'s 'WORLD FIRST'

A massive £23m has been earmarked by the Post Office to establish the world's first public Viewdata service — enabling people to call up information over their telephone line and have it displayed on their television sets.

The public service will start early in 1979, a year sooner than originally envisaged.

Up to £5m will be spent immediately to set up ten Viewdata centres, located in London and at least two other cities. A further £18m has been made available to extend and develop this revolutionary service during 1979.

Plans now being drawn up are for Viewdata centres in London, Birmingham, Cardiff, Edinburgh, Leeds, Manchester and Norwich.

Viewdata — invented by the British Post Office — is the pace-setting communication system linking the phone to the TV set. It enables people to call up information stored in a computer and display it in words and simple diagrams on their TV screens.

Almost limitless information can be made available, on a wealth of subjects ranging from sports results to stock market prices, and from up-to-the-minute news to welfare services. At the start of public service, the system will have a capacity of a quarter of a million 'pages' of information.

One of Viewdata's chief attractions is that it will make available virtually limitless information on a huge range of subjects — from stock market prices to sports results and from household hints to travel timetables. The information can be called up at the touch of a button and displayed in words or simple diagrams on the TV screen.

Consumer guidance will be available from the Consumers' Association and the Department of Prices and Consumer Protection. There will be rail and air travel information, tourist information, careers guidance, job vacancies and educational opportunities.

Barclaycard and Access are also taking part so that it will eventually be possible to order goods or services, or reserve rail or air seats and pay for them by credit card — all through Viewdata!

To use Viewdata, people at home will need to be on the phone, and to buy or rent a colour TV set that has been specially modified to receive Viewdata. The TV receivers would, in general, be of the more advanced type, with such features as remote picture, volume, and channel control. They are supplied with the push-button units that are used to obtain Viewdata information and they would also enable users to receive teletext, the broadcast information services operated by the British Broadcasting Corporation and the Independent Broadcasting Authority.

For business users, desk-top TV sets are being developed for Viewdata. These may be in black and white or colour. When equipped with typewriter-like keyboards, they would, within the next two years, allow users to send or receive messages as well as display Viewdata information.

There is an annual fee of £250 to provide information for Viewdata, plus a storage charge of £1 per page a year. In addition, the special terminal used to put information into Viewdata costs £400 a year to rent from the Post Office.

It will be interesting to see how soon the viewdata service becomes commonplace.

HOTELS QUIZZED ON ELECTRONIC NEEDS

Hotel managers throughout Britain are being asked their views on the future needs of the industry for the many forms of electronic equipment now becoming increasingly available on the market.

This initiative is being taken by British Relay (Electronics) Ltd which is concerned at the urgent need to plan for the future in the face of the rapid advances now being made in the field of electronics.

The company is mailing a detailed questionnaire to some 2,000 hotels having more than 50 rooms.

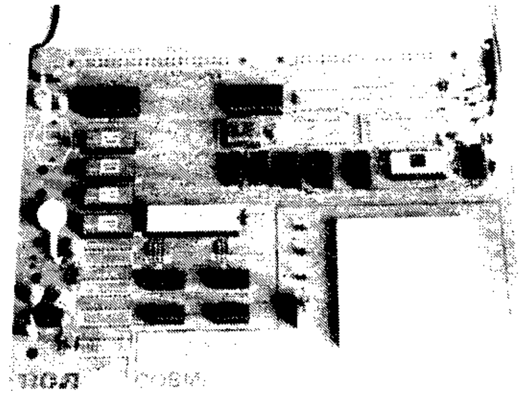
The questionnaire deals with such electronic services as: room status; morning call and message waiting services; the provision of entertainment including television, "in house" movies, pay-TV, and background music; the Viewdata and Teletext information services; the electronic room bar; and conference facilities and simultaneous translation.

The company will make the consolidated findings of the questionnaire available to the hotel industry.

. . . COMMENT

RCA INTRODUCE LOW-COST COMPUTER KIT

A new low-cost do-it-yourself computer kit, the COSMAC VIP (Video Interface Processor) has been launched by RCA Solid State — Europe, Sunbury-on-Thames, Middlesex. The new system, designed to interface with a cathode-ray display or, via a suitable modulator, with a TV receiver, allows the user to assemble a complete microcomputer for creating and playing video games, generating computer graphics and developing microprocessor control functions.



The VIP offers a complete computer system on a printed-circuit card, with a powerful, uncluttered operating system using only 4k bits of read-only memory. Programs can be generated and stored in an audio cassette tape recorder for easy retrieval and use.

The heart of the VIP is RCA's COSMAC CDP1802 microprocessor, incorporating C-MOS circuitry for low power consumption and an 8-bit architecture for ease of application.

GEOSTATIONARY SATELLITE ASSISTS IN STEMMING CONTRABAND DRUGS

General Electronic Company of the U.S.A.'s* researchers have demonstrated that space technology could assist narcotics and immigration agents in stemming the flow of contraband drugs and illegal aliens across remote stretches of the U.S.A.'s borders.

In field tests ranging across the U.S., GE(USA) communications experts have demonstrated that a geostationary space satellite, orbiting at an altitude of 23,000 miles over a fixed spot on the earth's surface, could keep field agents in constant mobile radio contact with a base station — even from isolated points thousands of miles apart.

Until now, conventional mobile radio communications have been limited to line-of-sight transmissions between sender and receiver, a distance of usually no more than 30 miles. And if the terrain is mountainous — as it is, for example, along long reaches of the 1,600-mile U.S.-Mexican border — the message may be blocked.

However, since a geostationary space satellite stays fixed in the sky, it is in line of sight with about 43 percent of the earth's surface. Even though the satellite is thousands of miles away, it can be designed to pick up the relatively weak signal from an agent's mobile radio transmitter, amplify the signal, and relay it back to earth.

* *General Electric company of the USA is not connected with the English company of a similar name.*

TEACHING THE TEACHERS

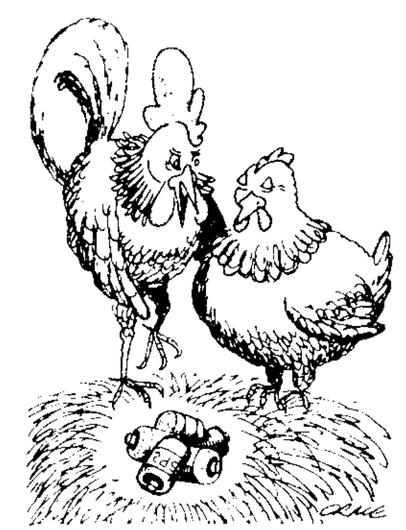
As a magazine for the home electronics enthusiast we feel that the news we give of the wider field of electronics, as given in the foregoing news items, enable the electronics enthusiast to see his hobby in an exciting wider context.

The gap between home electronics projects and the sophisticated projects used by governments and commercial organisations is largely bridged by teachers of electronics, and allied subjects.

We are therefore pleased to give details of the annual electronics summer school for teachers to be held at the University of Essex during the week 10-14 July.

This year, as well as running two established courses in linear circuit design and digital circuit design, a third course in Electronics Systems is being introduced. The new course is closely related to the AEB Electronics Systems 'A' level; the objective being to cover some of the more difficult material on the AEB syllabus as well as discussing the teaching aspects of the 'A' level.

Teachers who require further information on the summer school should contact R. J. Mack at the Department of Electrical Engineering Science, University of Essex, Wivenhoe Park, Colchester.



"I've heard of battery hens but this is ridiculous!"

SUGGESTED CIRCUIT

LOW CURRENT TIMING CIRCUIT

By G. A. French

Some electronic timing circuits are battery operated and are intended to give relatively long timing delays, say from several minutes to half an hour. Typical applications are given by egg timers, reminder timers and guard circuits, which cause an alarm to be given if a timing circuit is not manually reset within a given period of time. Such timing circuits can function quite reliably by taking advantage of the charging of a capacitor, and with modern electrolytic capacitors surprisingly long timing periods are feasible. For example, the time constant of a 4,700μF electrolytic capacitor and a 470kΩ resistor is of the order of 2,400 seconds, or 40 minutes.

Whilst in most conventional battery timing systems it is inevitable that an appreciable current must flow from the battery when the timing period is at an end because some sort of indicator is activated, it is obviously desirable that the current drawn from the battery should be very low during the timing period itself. If the timing system is miniaturised and is supplied, say, by a PP3 9 volt battery, even currents as low as half a milliamp or so become excessive if long and reliable battery life is to be given. The ubiquitous 555 i.c. does not satisfy this current requirement, since it has a typical quiescent current consumption of 6mA at a supply voltage of 9 volts.

This article describes a timing circuit which is particularly suitable for battery operated systems giving long timing periods, the average current consumption during the period being about 0.1mA.

CMOS CIRCUIT

When considering low current consumption circuits one tends to turn to CMOS logic devices which,

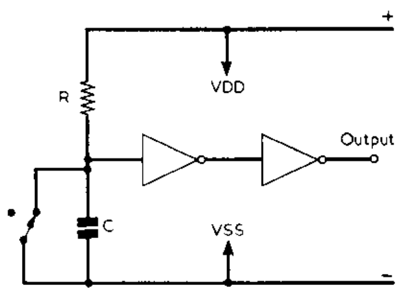


Fig. 1. A simple timing circuit incorporating two CMOS inverters

with their exceptionally high gate input resistances, are particularly attractive for timing applications. A possible timing circuit is shown in Fig.1, in which there are two CMOS logic inverters connected in tandem. The positive supply is applied to the VDD terminal of the i.c. in which the inverters are incorporated, and the negative supply is applied to the VSS terminal.

Before the start of a timing period the switch across capacitor C keeps the capacitor short-circuited, so that it is in the discharged condition. The input of the left-hand inverter is therefore low and its output is high. The output of the right-hand inverter is in consequence low. When the switch is thrown to take the short-circuit off C, this capacitor commences to charge via R. After a period, depending upon the values of C and R, the input voltage to the left-hand inverter reaches transition level and its output, amplified in the inverter, starts to change from the high to the low state. When this output reaches the transition level for the input of the right-hand inverter, the output of the latter starts to go high at a greater rate. Thus the circuit operates as a timing device, the function of the right-hand inverter being to speed up the transition of the output voltage from low to high.

Unfortunately, the current drawn from the supply by the two inverters increases dramatically when their input voltages go central of the fully high and fully low states. Fig. 2. shows typical voltage and current transfer characteristics for a CMOS logic inverter with a 9 volt supply. As will be seen, the current drawn by the inverter increases from a negligibly low level to a maximum of about 2mA as the input voltage approaches and passes through a roughly central voltage.

Fig. 3 illustrates the VDD current characteristic to be expected from the timing circuit of Fig. 1 when it has a 9 volt supply, and this has been checked out by the author in practice. Point O on the horizontal time axis corresponds to the instant when the short-circuit is taken off the timing capacitor and it begins to charge. The current drawn from the 9 volt supply by the two inverters is very nearly zero until point A is reached. The current then rises up to point B, with virtually all the current being drawn by the left-hand inverter. At B the right-hand inverter also commences to draw current from the 9 volt supply, culminating in the peak at point C where current drain (by two inverters now) is of the order of 4mA. The timing period ends approximately at point C, after which the current drawn by the two inverters is of less relative importance since current will also be probably drawn by the timed indicating device.

As can be seen by inspection, the average current drawn in Fig. 3 between points O and B is of the order of three-quarters of a milliamp.

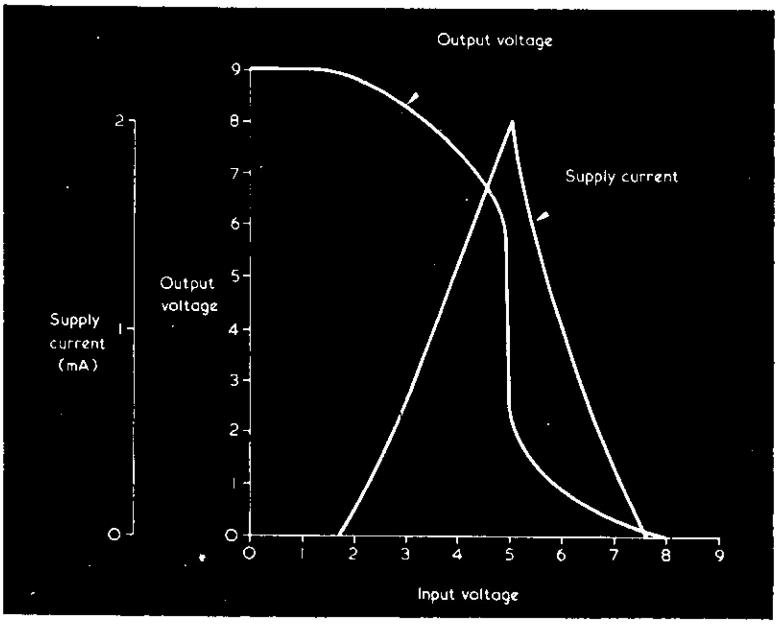


Fig. 2. Typical supply current and voltage transfer characteristics for a CMOS inverter operating from a 9 volt supply

A positive regeneration loop is set up in the circuit as soon as the transistor commences to pass a significant collector current. Increasing positive voltage at the input of the left-hand inverter causes greater current flow in the base of the transistor, whereupon the consequently increased collector current takes the inverter input further positive again. The addition of the transistor and its two resistors considerably increases the rate of change of output from the right-hand inverter at the end of the timing period. Note also that, even if the transistor passes a high collector current, the VDD voltage for the inverters never falls lower than about 0.6 to 0.7 volt below the supply voltage because it is held at this level by the forward biased base-emitter junction of the transistor.

The circuit can be set up so that the transistor turns on at any arbitrarily chosen value, within reason, of VDD current. In the author's circuit it was decided to choose a VDD current of 0.25mA,

LOW CURRENT CIRCUIT

The situation changes considerably if we add a silicon transistor and two resistors, as we do in Fig. 4. The 2.7kΩ resistor and the base-emitter junction of the transistor are now inserted in series with the positive supply to the VDD terminal for the inverters, with the consequence that the VDD current flows through the 2.7kΩ resistor.

After taking the short-circuit off the capacitor this commences to charge, as before. Similarly as before, the VDD current flowing through the 2.7kΩ resistor is initially low, causing only a small voltage to be dropped across it. After a period the VDD current increases in the manner shown in Fig. 3 and, when it ascends to a predetermined level, the voltage across the 2.7kΩ resistor reaches the turn-on base-emitter voltage of the transistor. A further rise in VDD current then results in increased collector current in the transistor, and the latter causes the capacitor to charge very rapidly via the current limiting 1kΩ resistor. As a result, both inverters go quickly through their transition voltage levels, and the capacitor continues to charge rapidly until the current passing through the 2.7Ω resistor falls to a value at which the transistor turns off again.

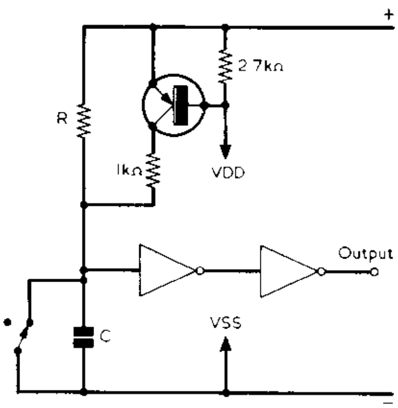


Fig. 4. Adding a silicon transistor to curtail the timing period at a low level of VDD current

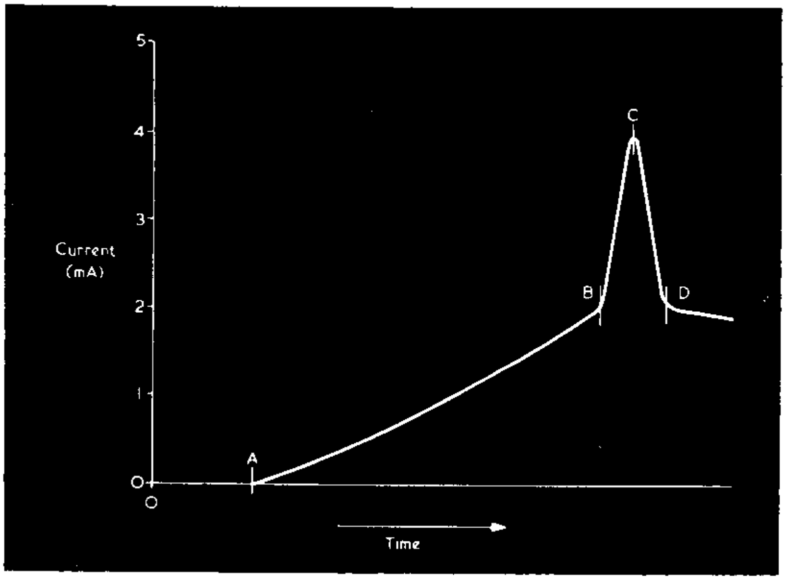


Fig. 3. Current drawn by the circuit of Fig. 1 during and after the timing period

at which the 2.7kΩ resistor gives a calculated voltage drop of 0.67 volt. Some further VDD current must flow in the base-emitter junction of the transistor if the latter is to pass an adequate collector current and it was found that, in practice, the circuit triggered at a VDD current of slightly less than 0.3mA.

The timing period for a given value of C and R with the circuit of Fig. 4 is about half of that given by a circuit of the type shown in Fig. 1. This may represent a slight disadvantage if it necessitates the use of a larger and consequently more expensive capacitor, but the saving in expenditure on batteries should soon counterbalance any initial increase in component costs.

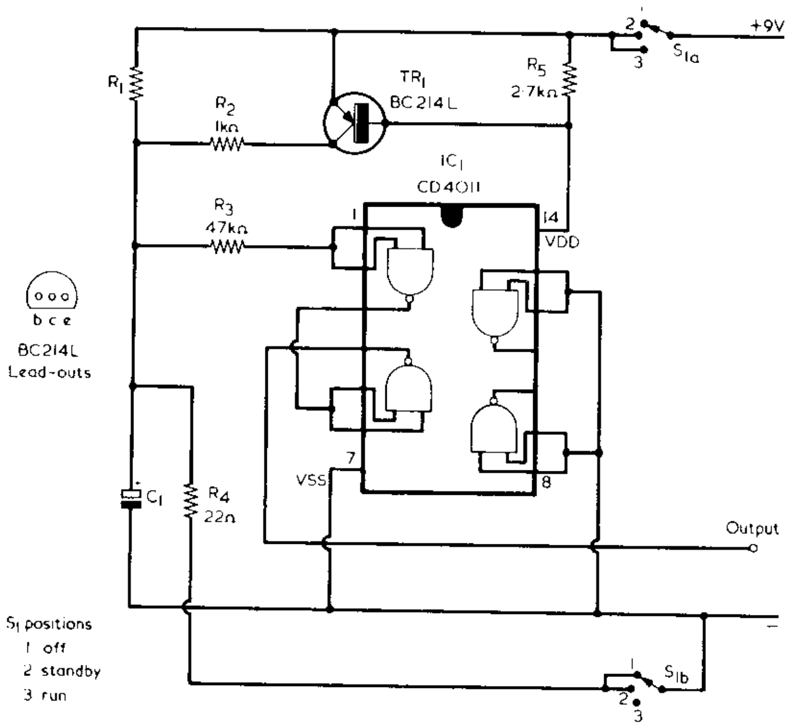


Fig. 5. A practical working version of the timer with two inverters and a transistor. The length of the timing period is controlled by the values of R1 and C1

WORKING CIRCUIT

A working version of the circuit is given in Fig. 5. For convenience the two inverters are NAND gates with their inputs connected together. These have the same transfer and current characteristics which were shown in Fig. 2 for the inverters, and are part of an inexpensive integrated circuit type CD4011. R3 is inserted between the positive terminal of the timing capacitor, C1, and the input of the first inverter. This resistor has no effect on circuit operation and is included merely to limit forward current in the input protection diodes in the i.c. in the event of a fault condition. The inputs of the remaining two NAND gates in the CD4011 are taken to the negative rail and no connections are made to their outputs.

Power supply switching is carried out by the 2-pole 3-way rotary switch S1(a)(b). In the "Off" position S1(a) interrupts the 9 volt supply whilst S1(b) ensures that C1 is maintained discharged via current limiting resistor R4. In the "Standby" position, S1(a) completes the 9 volt positive circuit whilst S1(b) keeps C1 still discharged. C1 is allowed to charge via R1 when S1(a)(b) is set to "Run". Using a 3-way switch in this manner ensures that C1 is always discharged, or very nearly so, when the power is disconnected from the CD4011 by switching S1(a)(b) to "Off".

The current drawn from the 9 volt supply is illustrated by the curve of Fig. 6. C1 commences to charge at point O of the horizontal time axis and continues to do so until the current across R5 of Fig. 5 rises to a little less than 0.3mA. This occurs at point E of Fig. 6. As soon as the transistor starts to pass collector current, the current drawn by the circuit increases rapidly to a peak of about 7mA at point F. This current consists largely of charging current into C1 via R2. The current falls and then rises again to the peak at point G, which is given by the second inverter changing state. After point G the current falls rapidly again to a little less than 0.3mA at point H, and then it very gradually continues to fall as C1 charges further via R1. The length of the period between points E and H depends on the value of C1; when this is 1,000μF the length of the period is of the order of 1 second only. The output from the second inverter changes state at point G.

Working from the curves of Figs. 6 and 3, the average current drawn from the 9 volt supply up to point E is approximately 0.1mA. This can be considered a satisfactory value for a long-period battery operated timing circuit.

Apart from R5, the resistors in Fig. 5 can all be ¼ watt 10%; R5 should be ¼ watt 5%. The switch may be a 4-pole 3-way type with two of the poles unused. The values

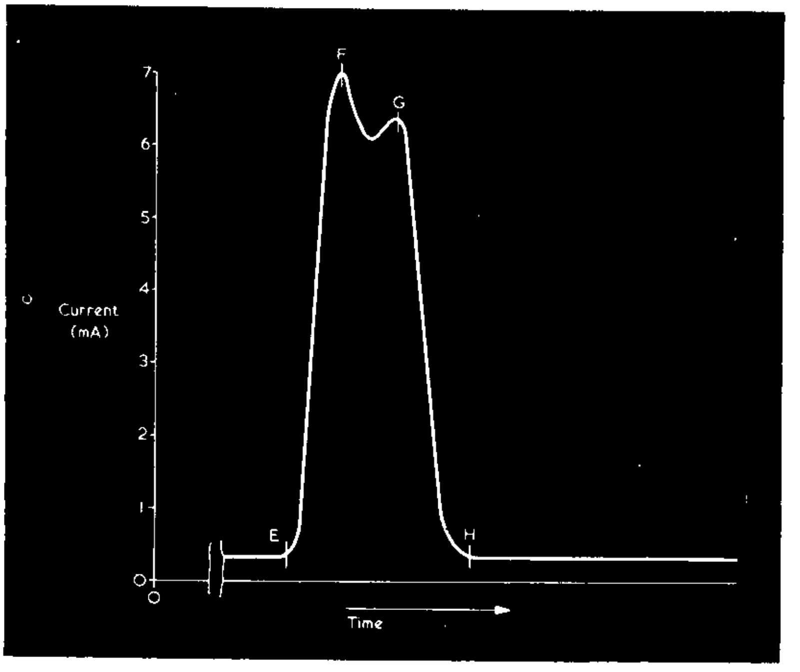


Fig. 6. The circuit of Fig. 5 features low VDD current drain except for a short period at the end of the timing cycle

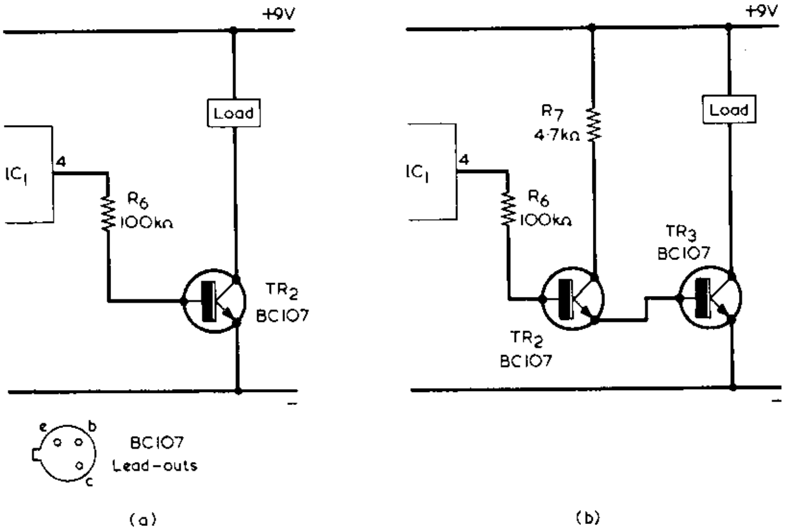


Fig. 7(a). The output of the timer can switch on a load with the aid of an external transistor
(b). Two transistors are required for a heavy load current

of R1 and C1 will depend upon the length of the timing period required and on spread in the characteristics of the i.c. and the transistor, and will need to be determined empirically. Working from results with the prototype circuit the timing period will be about two-fifths of the time constant of these two components.

At the end of the timing period the output of the second inverter, at pin 4 of the CD4011, goes high. The current capability here is rather low and it will be advisable to switch any load, such as a warning indicator, by way of an external transistor. A circuit suitable for load currents up to about 10mA is given in Fig. 7(a). For higher load currents, up to 50mA, it is preferable to add a second transistor, employing the circuit given in Fig. 7(b). Again, the resistors may be ¼ watt 10% types. ■

NEW TOKO I.F. FILTERS

Ambit International, of 2 Gresham Road, Brentwood, Essex, CM14 4HN announce the availability of a new range of Toko i.f. filters for 455 to 470kHz. There are two types in the new series, a four section microminiature ladder filter, type LFY, and a two element mechanical filter, the CFM2. The LFY units are exceptional for their low cost, and the typical shape factor of 6/60dB 2:1 for two units in cascade.

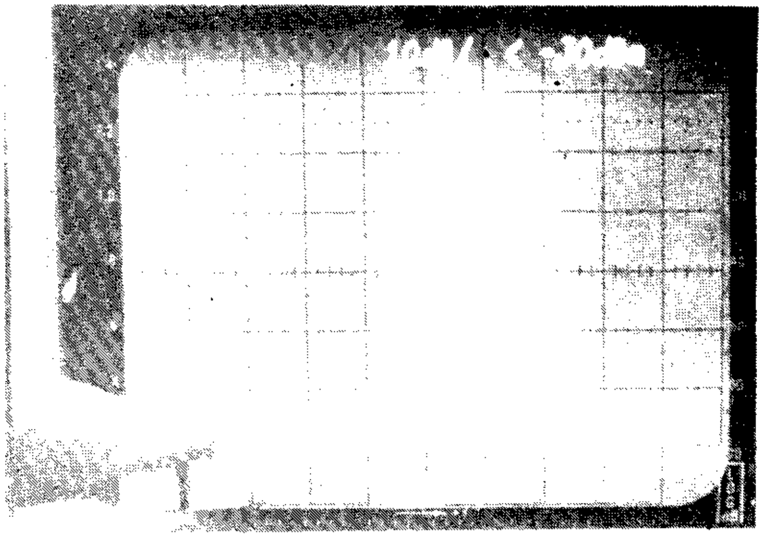
The CFM2 types are the same size as the widely used CFS series of 10.7MHz f.m. ceramic i.f. filters, and can be obtained in a wide variety of bandwidths and centre frequencies. They are particularly well suited to replace the usual capacitor found in many i.f. bandpass filter designs, to improve i.f. shape and to simplify i.f. alignment. As with the LFY series, these filters may be directly cascaded, and can be combined in i.f. designs to provide a variety of i.f. responses for all modes from n.f.b.m. to s.s.b.

The LFY filters have a 6dB bandwidth of plus or minus 3kHz, an insertion loss of 6dB maximum and input and output impedances of 2kΩ. The 40dB bandwidth is plus or minus 9kHz maximum.

One of the features of the CFM2 is its exceptionally small physical size. The filter comprises two ceramic resonator elements with a mechanical coupling in the form of a specially developed alloy. Input impedance is 1kΩ and output impedance is 1.5kΩ. Both the CFM2 and the LFY filters are 3-terminal devices.

Ambit International also announce a new catalogue timed to coincide with the expansion of their stocks of the Toko ranges of coils, i.f. transformers, tunerheads, ceramic and mechanical filters, and this will be provided free of charge to bona fide industrial users. ■

Spectrum analyzer trace illustrating the bandpass of two Toko LFY filters in cascade



3-voltage Battery eliminator

By A. P. Roberts

Easy-to-build unit gives stabilized outputs of 6, 7.5 and 9 volts at currents up to 100mA.

A simple mains operated power supply or battery eliminator having d.c. outputs of 6 volts, 7.5 volts and 9 volts at currents up to about 100mA can be extremely useful when building or servicing small battery powered equipment, and a unit of this type forms the subject of this article. It obviates the need for a supply of batteries to be maintained in the workshop, and with their relatively high price these days the initial cost of the unit can soon be recovered in saved expenditure on batteries. It is also possible to use the eliminator as the normal supply for small battery operated equipment such as transistor radios. Here again the cost of the unit can be quickly recovered, especially if the equipment is used extensively and frequent battery changes would otherwise be required. The eliminator described here is designed to be used as an external unit, and so no major modifications need to be made to the equipment which is supplied. This makes it an easy matter to revert to battery operation if, at some future time, the portability afforded by independence from the mains should be required.

The output voltage is well regulated and drops by only about 60mV between zero output current and full load. The output is also very well smoothed, with the noise on the output being only about 0.5mV at low output currents, rising to about 2mV at full load. Output current limiting is incorporated in the circuit, which also has thermal overload protection in its voltage regulator.

MONOLITHIC REGULATORS

Many readers will be aware of the availability of integrated circuit monolithic voltage regulators, and it is one of these devices which forms the basis of this project. For fairly low current applications such as the present one the smallest types of regulator are almost ideal. These are 3-terminal devices which are contained in TO92 style encapsulations, and in appearance they are indistinguishable from TO92 transistors.

Voltage regulators of this type are employed in the manner shown in Fig. 1(a). For a normal positive type regulator the common terminal is connected to the negative supply rail, the un-

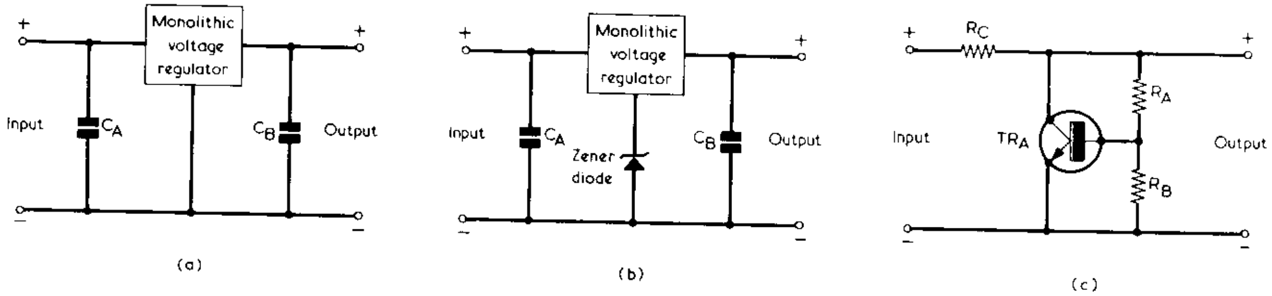


Fig. 1(a). A monolithic voltage regulator can employ the circuit shown here. An unstabilized supply voltage is applied to the input and the regulated voltage appears at the output
(b). The regulated output voltage may be increased by inserting a zener diode in series with the common connection to the regulator
(c). The zener diode may be replaced by an amplified diode. This offers a stabilized voltage which is dependent on the values of RA and RB

On the front panel of the battery eliminator are mounted the two output sockets, the voltage selector switch and the mains on-off switch

regulated supply connects to the input terminal, and the output terminal supplies the regulated output. Capacitors CA and CB are needed to ensure that the circuit has both good stability and transient response.

Virtually all monolithic voltage regulators have some form of output current limiting, and small devices of the type specified for the eliminator have conventional current limiting at a nominal level of 100mA. Most devices of this nature also have thermal overload protection circuitry so that, if the dissipation in the device becomes excessive, a temperature sensing element reduces the output current to a value which produces an acceptable dissipation level. Thus, the devices are not easily damaged in normal use.

When one considers the level of performance and the facilities offered by these regulators, they obviously provide very useful electronic building blocks. Also, they are quite modestly priced. Their one main drawback when used in simple circuits such as that of Fig. 1(a) is that they are only designed to provide a single output voltage, the most common voltages being 5, 12 and 15 volts. Nevertheless, the devices can be easily adapted to produce regulated output voltages which are higher than those for which they are primarily designed. One simple theoretical way of doing this is illustrated in Fig. 1(b). Here a zener diode has been connected in series with the common terminal of the device, and it has the effect of raising the voltage at the common terminal by a level equal to the zener voltage. The zener voltage appears because a small quiescent current flows through the regulator, and this provides the zener diode with the necessary operating current. The output voltage of the regulator is then stabilized at its own fixed level above the potential at the common terminal. In other words, by raising the voltage at the common terminal the output voltage is raised by a similar amount.

Output voltages of 6 volts, 7.5 volts and 9 volts can be provided by a 5 volt regulator if three zener-type devices having voltages of 1, 2.5 and 4 volts respectively are switched into the common terminal circuit. In practice, zener diodes cannot be used at the low voltage of 1 volt, and zener diodes operating at around 2.5 and 4 volts are not very efficient, with the consequence that alternative devices which give the same effect as zener diodes need to be employed instead.

AMPLIFIED DIODE

Low stabilized voltages are usually obtained by means of either forward biased silicon diodes or a high gain silicon diode employed as an "amplified diode", and the latter is the method which is used in the eliminator. The basic idea of an amplified diode is shown in Fig. 1(c).

COMPONENTS

Resistors
(All ¼ watt 5%)
R1 4.7kΩ
R2 1kΩ
R3 1.8kΩ
R4 8.2kΩ

Capacitors
C1 470μF electrolytic, 25V Wkg.
C2 0.1μF type C280 (Mullard)

Transformer
T1 mains transformer, primary 240V, secondary 6-0-6V at 100mA.

Semiconductors
TR1 BC109C
IC1 μA78L05WC
D1-D4 1N4001

Switches
S1 d.p.s.t. rotary mains switch
S2 4-pole 3-way rotary switch.

Sockets
SK1 insulated wander socket, red.
SK2 insulated wander socket, black.

Miscellaneous
Metal case (see text)
Veroboard, 0.15in. matrix.
2 control knobs.
3-core mains lead.
Nuts, bolts, wire, etc.

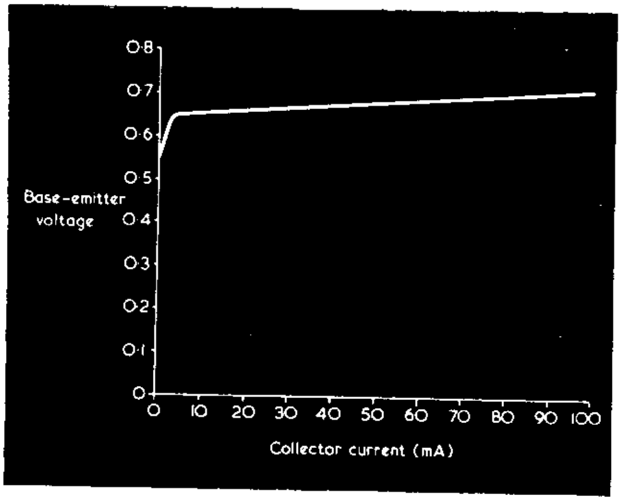
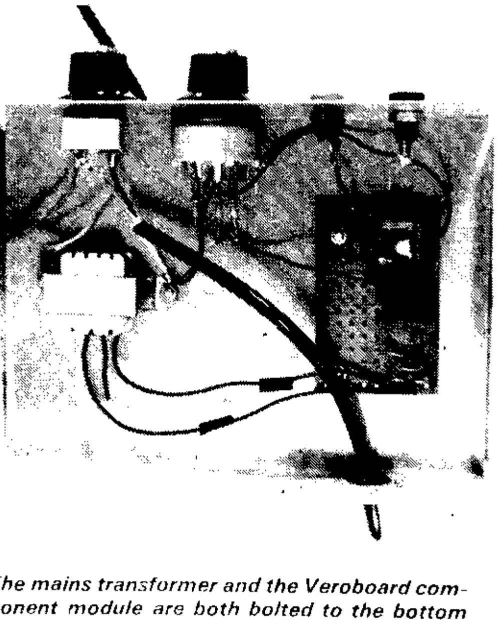


Fig. 2. Typical curve showing the relationship between forward base-emitter voltage and collector current in a silicon transistor

If a graph showing base voltage versus collector current for a high gain silicon transistor were to be drawn the result would be along the lines illustrated in Fig. 2. With base-emitter voltages of up to about 0.6 volt only an extremely small collector current flows. Above about 0.6 volt (the exact figure varies slightly between individual transistors and with changes in temperature) the collector current rises rapidly with very small increases in base-emitter voltage. If in the circuit of Fig. 1(c) the values of RA and RB are equal, about 1.2 volts will be needed at the collector of TRA before this transistor begins to conduct. Raising the input voltage to the circuit well above this level in an attempt to force the collector voltage higher would not be very successful as it would merely result in TRA passing more collector current, with a greater voltage drop across RC. The collector voltage of TRA would rise by only a very small amount.



The mains transformer and the Veroboard component module are both bolted to the bottom of the metal case

When RA and RB are equal, the collector voltage of TRA is therefore stabilized at about 1.2 volts. Other stabilized collector voltages can be obtained, of course, by altering the ratio of RA to RB. Increasing RA with respect to RB will increase the collector voltage and decreasing it will reduce the collector voltage. It is possible to obtain any stabilized collector voltage, within reason, which is higher than the base turn-on voltage of the transistor, but in practice the circuit becomes less effective at higher voltages because the losses in RA and RB become too great in comparison with the gain of the transistor. In the present application the amplified diode circuit works extremely well over the range of stabilized voltages it is called upon to provide.

PRACTICAL CIRCUIT

The complete circuit of the battery eliminator appears in Fig. 3. Transformer T1 steps down the mains voltage to the required level and provides isolation from the mains. S1 is a rotary 2-pole on-off switch. The secondary winding of T1 feeds a bridge rectifier, and the output from this is smoothed by C1. Note that T1 secondary is actually a 6-0-6 volt winding, but the centre-tap is ignored and the secondary is used as a straightforward 12 volt winding.

Apart from providing smoothing, C1 is the equivalent of CA in Fig. 1(a), and C2 is the equivalent of CB. IC1 is the voltage regulator integrated circuit.

TR1 is in the amplified diode circuit, and R1 carries out the same function as did RA in Fig. 1(c). RB is now represented by one of the three switched resistors, R2 to R4. These enable eliminator output voltages of 9, 7.5 and 6 volts respectively to be given, the appropriate resistor being selected by S2.

In the inset for the lead-out layout of IC1, the pins are shown pointing towards the reader. Layout diagrams for the i.c. concerned frequently give a view from above, with the lead-outs pointing away from the reader, and will in consequence differ from the presentation given in Fig. 3. The i.c. is available from Maplin Electronic Supplies.

CONSTRUCTION

The battery eliminator may be housed in any metal case which has adequate room for the component parts, and that employed for the prototype was a cabinet type BV3 which is available from Bi-Pak Semiconductors. This has dimensions of 6 by 4¾ by 1¾in. A smaller case could be employed, if desired. The general layout of the prototype is quite straightforward, as is demonstrated by the photographs. As can be seen, S2 is mounted towards the centre of the front panel, with S1 on its right. Sockets SK1 and SK2 are to the left of S2, and a pleasing appearance is given if the four holes for all these items are on a straight horizontal line.

A hole for the 3-core mains lead is required in the rear of the case and this must be fitted with a grommet. A suitable plastic or plastic covered clamp should secure the mains lead on the inside of the case. T1 is positioned to the rear of S1 and is bolted to the bottom of the case by means of two 6BA or 4BA bolts and nuts, as applicable to the particular transformer employed. The nuts are above the case bottom and a solder tag is secured

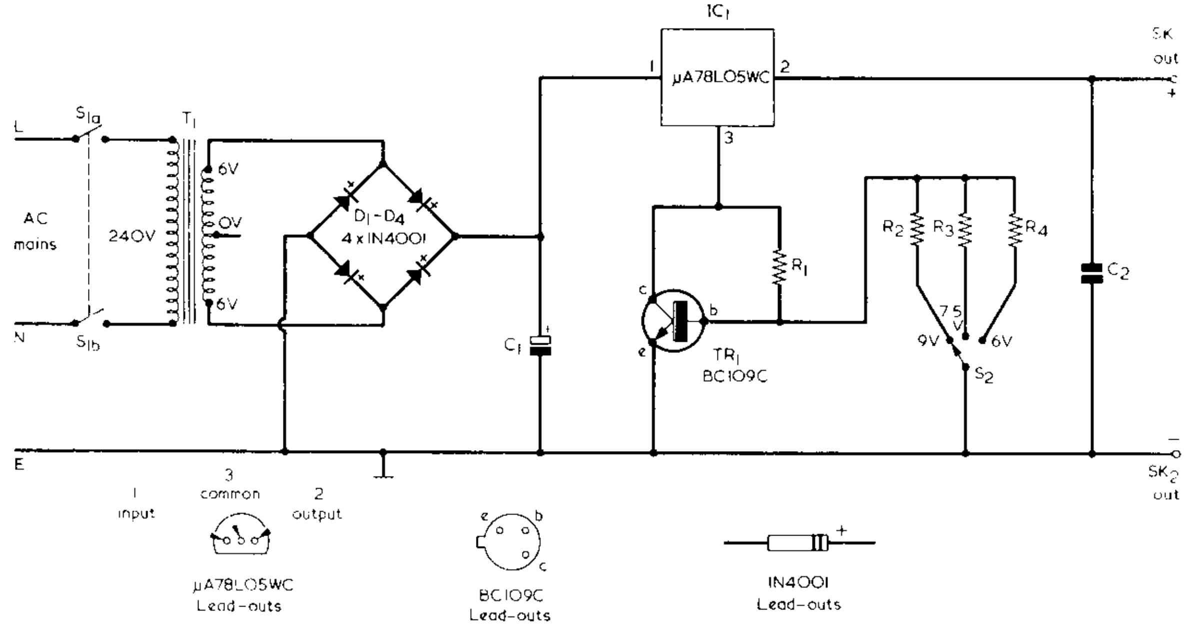


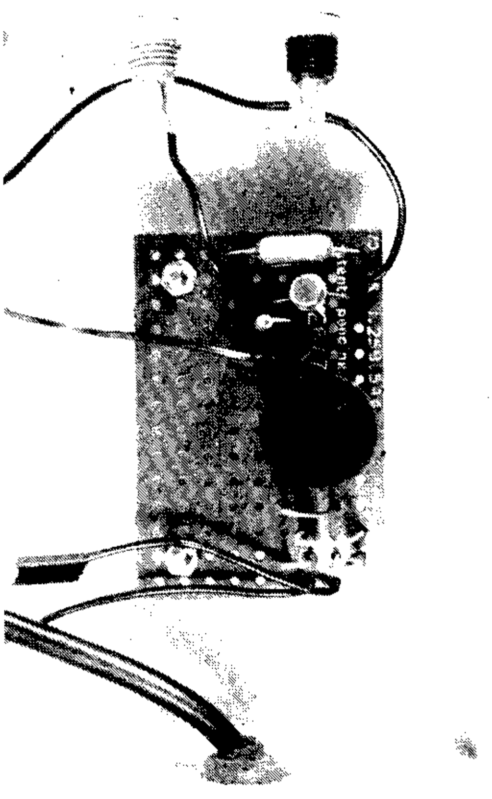
Fig. 3. The circuit of the 3-voltage battery eliminator. No connection is made to the centre-tap of the mains transformer secondary. Output voltages are selected by S2

under one of them, this providing the earth connection to the metal case. The fact that T1 is mounted directly onto a metal surface assists in enabling it to run cool.

Most of the other components are assembled on a 0.15in. matrix Veroboard which has 14 holes by 9 copper strips. When a board of the appropriate size has been cut out, the two 6BA clear mounting holes are drilled out and the single break in the copper strips is made before the various components are soldered into position. Details of the board are provided in Fig. 4. The completed board is wired up to the rest of the unit before it is secured to the bottom of the case, to the rear of SK1 and SK2. It is mounted using two 6BA screws about 1in. long. Metal spacers on the bolts are used to hold the board about ½in. clear of the case bottom surface, so as to prevent short-circuits. Note that the spacers must not be too wide in case they approach strip F of the board too closely.

Before wiring up to S1 it is advisable to check the tags to which connections should be made with the aid of an ohmmeter or continuity tester, since tag positioning with some switches may vary from that shown in Fig. 4. It is similary advisable to locate the inner and corresponding outer tags of S2 as, again, tag positioning may vary. The three resistors, R2, R3 and R4, are soldered directly to the switch tags, as shown. Note that S2 is a 4-pole 3-way rotary switch with 3 of the poles unused.

It should be borne in mind that the wiring to S1 and to the transformer primary is at mains potential and that this wiring is accessible when the cover of the case is removed. In consequence, all precautions against accidental shock must be observed.



The Veroboard layout is neat and uncluttered. The board is mounted by means of two 6BA bolts and nuts with spacing washers

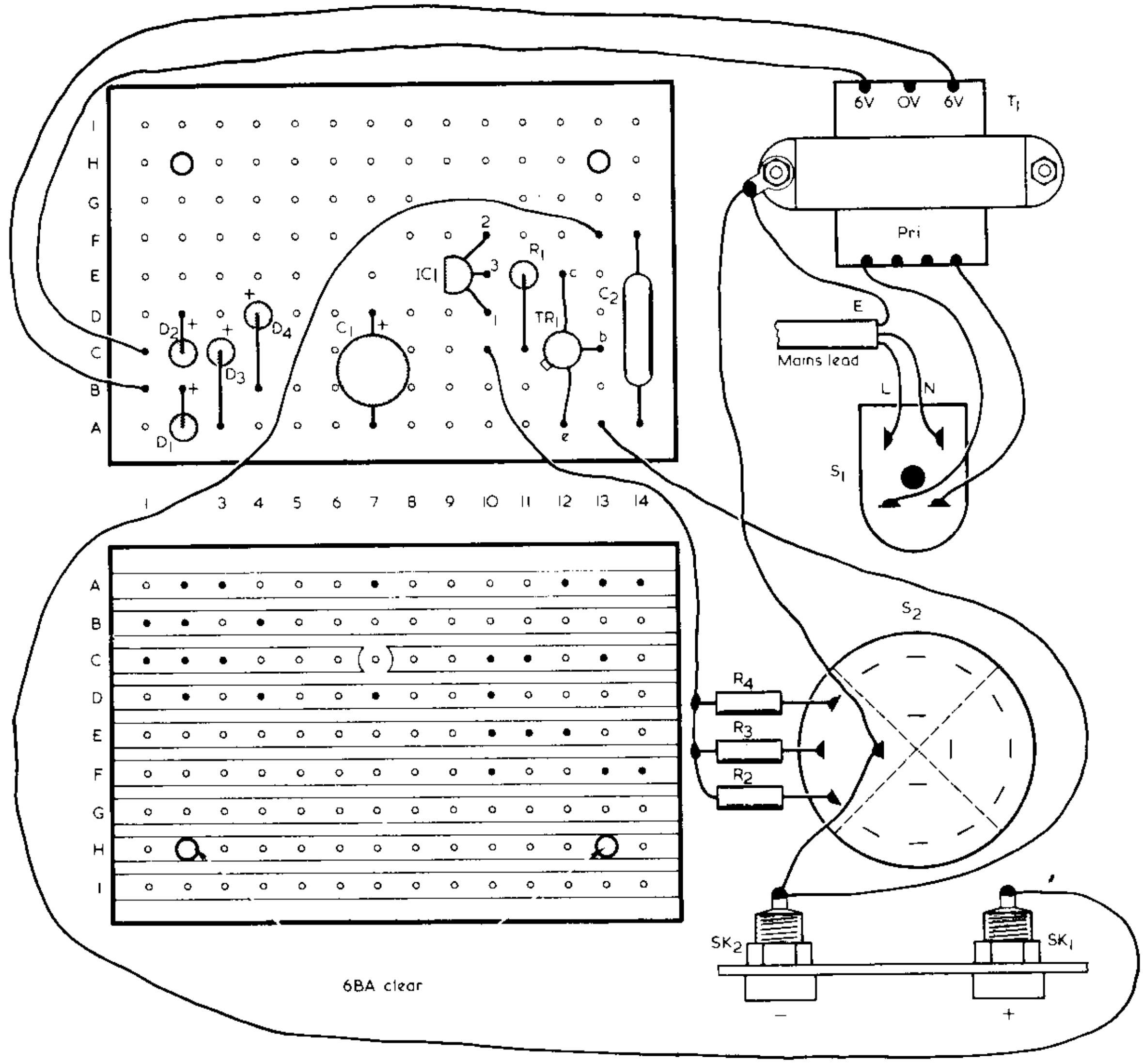
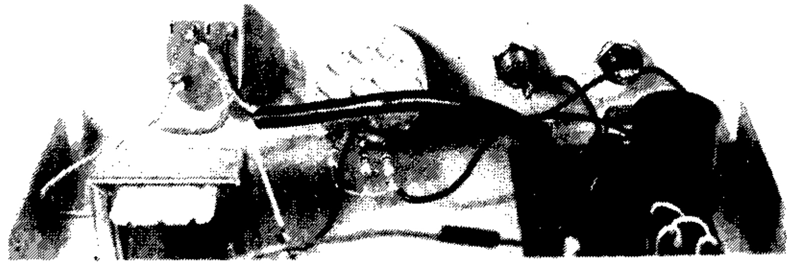


Fig. 4. Layout of components on the Veroboard and the general wiring of the battery eliminator

OPERATION AND USE

The three output voltages are nominal only and, due to spread in the turn-on base-emitter voltage of the transistor and tolerances in the values of the resistors, may be up to 0.5 volt away from the values specified. This is not really of great importance so far as battery operated equipment is concerned. For instance, the actual voltage delivered by a 9 volt battery will usually vary from about 9.6 to 7.5 volts during its working life. Constructors who wish to have the output voltages close to the nominal values may select resistors for R2, R3 and R4 on an experimental basis. Alternatively, the fixed resistors could be replaced by miniature pre-set variable resistors, suitable values being 2.2kΩ for R2, 4.7kΩ for R3 and 10kΩ for R4. However, for nearly all applications it should be more than adequate to simply employ the same resistors as were used in the prototype and accept any small



The wiring to the components mounted on the front panel

discrepancies in the output voltages which may result.

The connection between the battery eliminator and the powered equipment can be made via a twin lead terminated at one end in a red and a black wander plug for insertion in SK1 and SK2. In most cases the other end of the twin lead can be terminated in a battery clip or connectors of the same type as is used in the supplied equipment. Take care to ensure that connections are made with the correct polarity and that the metal parts of the battery clip or connectors cannot short-circuit to any part of the supplied equipment.

If the battery eliminator is to be employed on a semi-permanent basis with the supplied equipment, the latter will require a small notch or hole in its case to provide access for the power lead. No other modification should be necessary. ■

Secondary electron camera tube

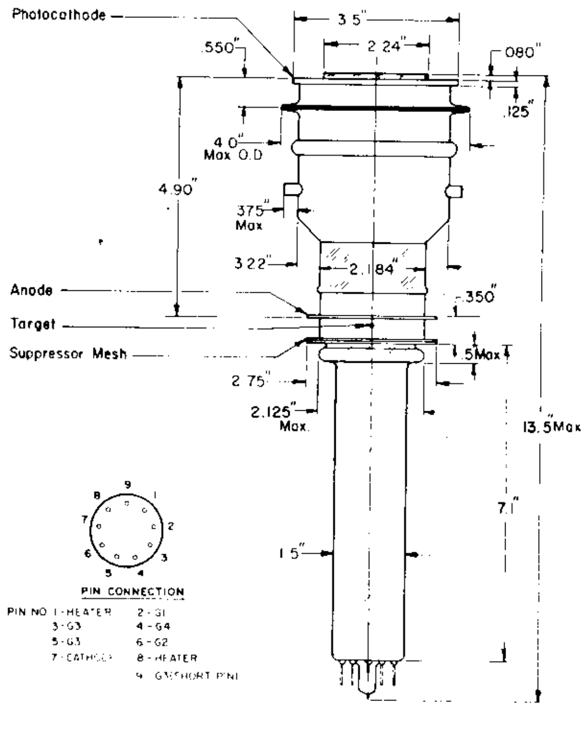
By Michael Lorant

New camera tube takes advantage of secondary emission to provide a very wide range of illumination sensitivities.

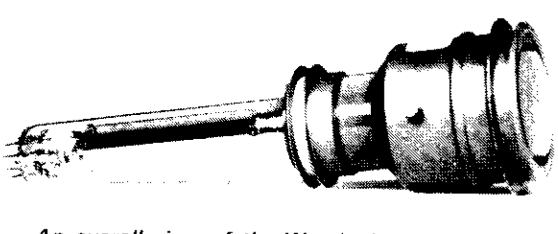
Westinghouse Electric Corporation has introduced a 1.6 in. diagonal image, "Secondary Electron Conduction" (SEC), camera tube. Using magnetic scanning and having an electrostatic image section, this new tube is designated the WX-30654. It has a larger format and provides greater sensitivity, better resolution and a larger signal-to-noise ratio than the company's previous WL-30691 tube, and these improvements are achieved without compromising other performance parameters.

Because of its unique SEC target, the WX-30654 is able to operate over a very wide range of scene illuminations with high sensitivity. Localised regions of a scene which are sufficiently bright to cause saturation do not produce halation or blooming, so that information from surrounding regions is not obscured. The tube performs at slow scanning rates as well as at the normal scanning speed in the U.S. of 30 fields per second.

The electrostatic image section remains in focus for all photocathode voltages. Since the sensitivity of the tube varies with photocathode voltage, this feature provides a convenient means of gain control. There are four grids, connections to these being brought out to pins at the base.

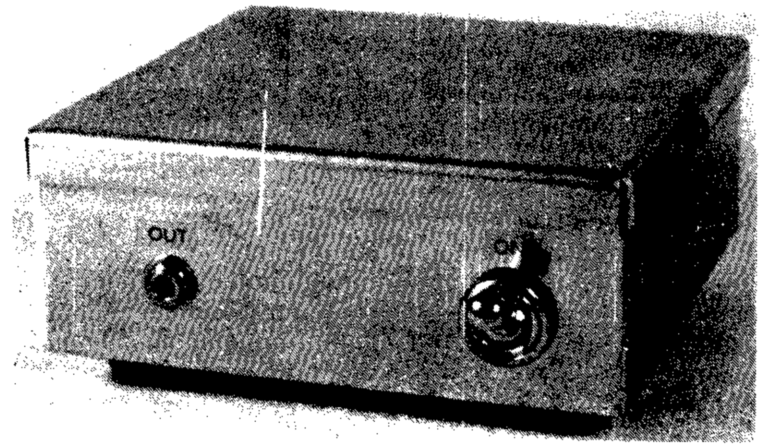


Dimensions of the new camera tube. The pins at the base cater for heater, cathode and four grids. Pin 9 is a short pin for location purposes



An overall view of the Westinghouse Electric WX-30654 SEC camera tube with electrostatic image section

The WX-30654 has been designed for applications where limitations of conventional camera tubes (for example, the persistence and lower sensitivity of the vidicon or the operational complexity and lower dynamic range of the image orthicon) either compromise performance or impose unacceptable systems requirements. ■



TV S
ADA

By R.

A unit which extracts the
direct connection to give im

A u.h.f. television sound channel is theoretically capable of high fidelity performance, but few television sets even come close to such a level of reproduction. This is rather a pity, especially when one considers the number of musical programmes which are transmitted by the various TV stations these days.

It is possible to overcome the shortcomings by feeding the television sound channel to a Hi-Fi system via some form of adaptor, and then turning back the volume control on the TV set to its minimum setting. There are several ways of tapping off the television sound signal, but in most instances it is not possible to use a direct link. This is due to the fact that nearly all TV sets have a chassis which is connected to one side of the mains supply, whilst Hi-Fi systems have an earthed chassis connection. Connecting the two chassis together would be a dangerous undertaking to say the least, and could lead to the possibility of severe shock. Some form of isolating circuit must therefore be used.

The most obvious solution would be to use an a.f. isolating transformer, or a modern equivalent such as a circuit employing an opto-isolator. The drawback to such systems is that they must pick up the sound signal not only after it has been processed by the sound detector in the TV set but probably also by the audio stages as well. Thus, the signal may not be of a very high quality once it reaches the adaptor, which obviates the point of using the adaptor in the first place. Another method is to use a high quality TV sound tuner to provide all the signal processing from aerial to audio output. While this will produce optimum results, it is rather a complex and expensive solution.

The system used in the TV sound adaptor described in this article is in effect a compromise between the two approaches just outlined. The unit consists of a 6.0MHz amplifier and high quality f.m. detector which is fed from a pick-up coil situated inside the TV receiver near the intercarrier sound circuitry. It thus picks up the intercarrier signal, before detection, and processes it to produce an audio output. Provided the television receiver is not badly out of alignment, the intercarrier signal will be at a high quality level, as will then be the audio output from the adaptor.

THE CIRCUIT

Fig. 1 shows the complete circuit diagram of the TV sound adaptor. L1 is the pick-up coil, and this forms a 6.0MHz tuned circuit in conjunction with trimmer capacitor TC1. The latter is adjusted to peak the tuned circuit at the correct frequency. In practice the pick-up coil is connected to the rest of the unit by way of a length of coaxial cable, and the capacitance in this cable also forms part of the tuned circuit.

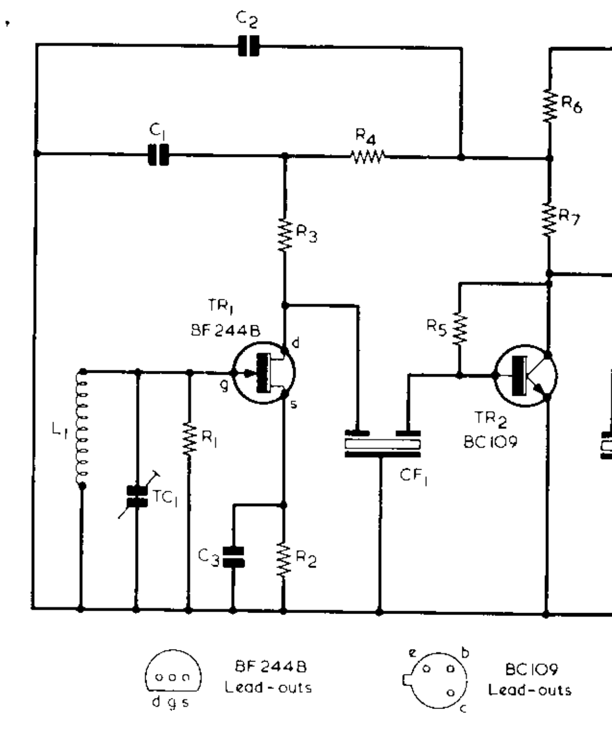


Fig. 1. The circuit of the television sound adapt
carrier signal from the TV set. This is amplified

TV SOUND ADAPTOR

By R. A. Penfold

A unit which extracts the television sound channel without a direct connection to give improved sound reproduction.

THE CIRCUIT

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A common source Jugfet amplifier appears a the input of the adaptor, this being TR1. R1 mair tains the gate at chassis potential if L1 is not plugg ed in, R2 is the source bias resistor and C3 is th source bypass capacitor. The output of th amplifier is developed across drain load resisto R3. This amplifier provides little in the way of volt age gain and is mainly used as a buffer between th pick-up coil and the second 6.0MHz amplifie stage, which incorporates TR2.

TR2 is connected in the common emitter con

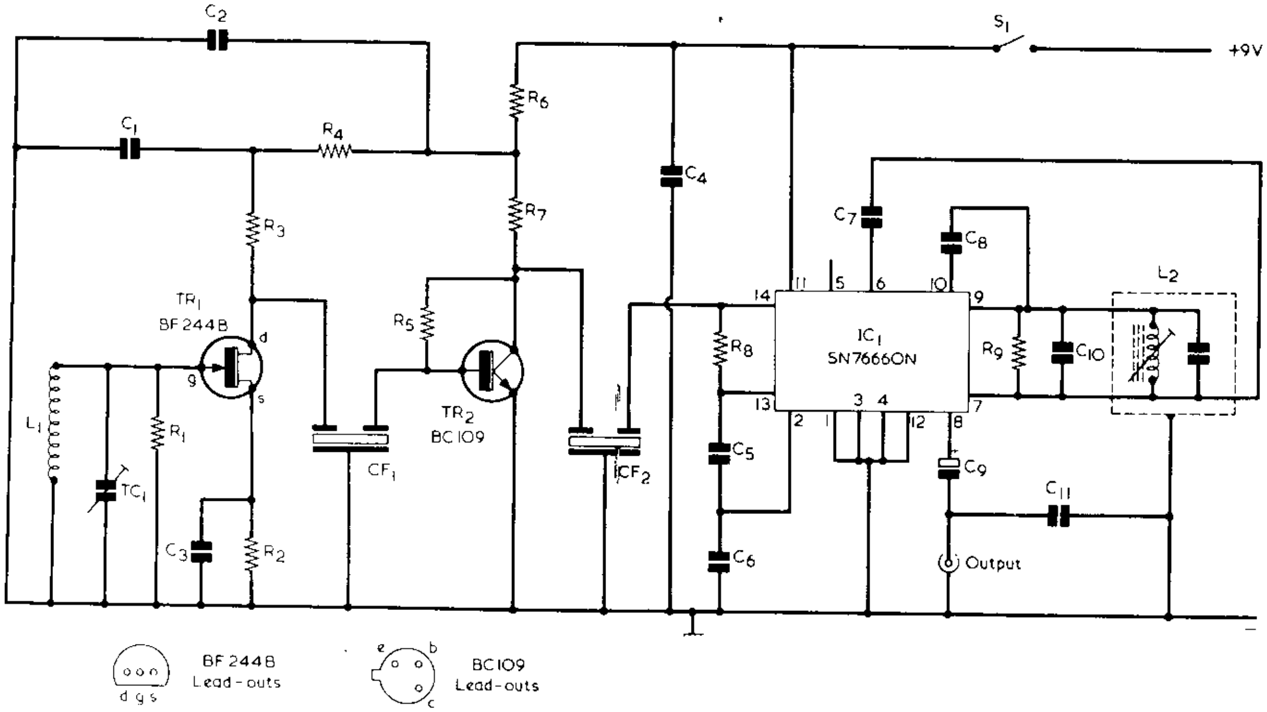


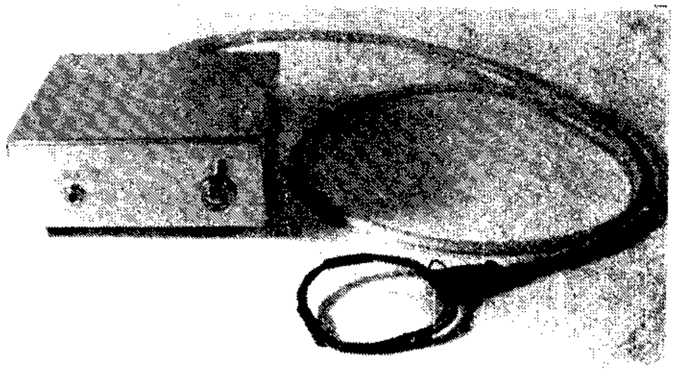
Fig. 1. The circuit of the television sound adaptor. L1 is a pick-up coil which picks up the 6.0MHz intercarrier signal from the TV set. This is amplified by TR1, TR2 and IC1, the last also providing detection

OUND

PTOR

A. Penfold

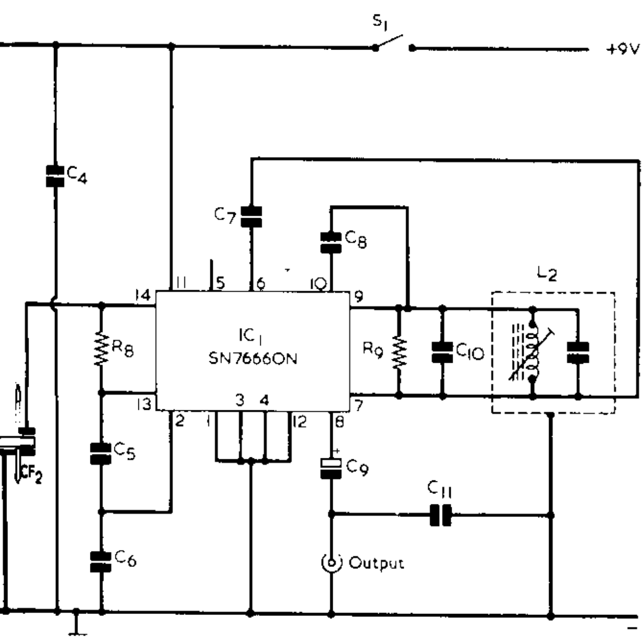
elevision sound channel without a
roved sound reproduction.



The completed adaptor with the pick-up coil plugged in and ready for use

A common source Jugfet amplifier appears at the input of the adaptor, this being TR1. R1 maintains the gate at chassis potential if L1 is not plugged in, R2 is the source bias resistor and C3 is the source bypass capacitor. The output of the amplifier is developed across drain load resistor R3. This amplifier provides little in the way of voltage gain and is mainly used as a buffer between the pick-up coil and the second 6.0MHz amplifier stage, which incorporates TR2.

TR2 is connected in the common emitter con-



r. L1 is a pick-up coil which picks up the 6.0MHz inter- by TR1, TR2 and IC1, the last also providing detection

COMPONENTS

Resistors
(All ¼ watt 5%)

R1 100kΩ
R2 820Ω
R3 330Ω
R4 180Ω
R5 220kΩ
R6 100Ω
R7 330Ω
R8 330Ω
R9 18kΩ

Capacitors

C1 0.1µF plastic foil
C2 0.1µF plastic foil
C3 0.01µF disc ceramic
C4 0.1µF plastic foil
C5 0.1µF disc ceramic
C6 0.1µF disc ceramic
C7 33pF ceramic plate
C8 33pF ceramic plate
C9 10µF electrolytic, 10 V. Wkg.
C10 68pF ceramic plate
C11 0.015µF plastic foil
TCI 10-60pF ceramic trimmer

Inductors

L1 see text
L2 quadrature coil, Toko type KACS K586HM (Ambit International)

Filters

CF1, CF2 6.0MHz ceramic filters type SFE6.0 (Ambit International)

Semiconductors

TR1 BF244B
TR2 BC109
IC1 SN76660N

Switch

S1 s.p.s.t. toggle

Miscellaneous

Aluminium box type AB8
Coaxial socket
3.5mm. jack socket
9 volt battery type PP6 (Every Ready)
Battery connector
Coaxial plug
1 metre coaxial cable
Materials for printed circuit board
4 rubber feet
Wire, bolts, nuts, etc.

figuration with R7 as its collector load resistor and R5 as its base bias resistor. Ceramic filter CF1 provides interstage coupling between TR1 and TR2. Ceramic filters require no alignment, unlike ordinary i.f. transformers, and this greatly simplifies the setting up of the finished adaptor.

A second ceramic filter couples TR2 to IC1, which provides most of the voltage gain in the circuit. At 6.0MHz this is typically of the order of 60dB. R8 is a bias resistor and it also sets the input impedance of the i.c. at the required level.

As well as incorporating a high gain amplifier, IC1 also contains a high quality quadrature detector. L2 is the detector coil, this component being primarily intended for use with 10.7MHz quadrature demodulators. C10 shunts the internal capacitor of the coil unit and reduces the operating frequency to the required figure of 6.0MHz.

The audio output is obtained from pin 8 of the i.c., and C9 provides d.c. blocking here. C11 gives de-emphasis, which is merely a degree of treble cut. This compensates for a similar amount of treble boost or pre-emphasis applied to the audio signal at the transmitter. The result is an overall flat frequency response together with a somewhat improved signal-to-noise ratio. The audio output level is above 250mV r.m.s.

The supply needs to be well decoupled due to the fairly high gain and operating frequency of the adaptor. This decoupling is provided by R4, R6, C1, C2 and C4. S1 is the on-off switch. The current consumption of the adaptor is typically about 17mA. Power is obtained from a PP6 battery, which has a reasonably long working life.

COMPONENTS

Three of the components used in this project are of a rather specialised nature and are not widely available. These are the two ceramic filters and the quadrature coil, all of which can be obtained from Ambit International, 2 Gresham Road, Brentwood, Essex, CM14 4HN. The i.c. is available from several component suppliers, including Ambit International.

The trimmer capacitor, TC1, used in the prototype is a 10-60pF ceramic component Type A, which can be obtained from Doram Electronics Ltd., P.O. Box TR8, Wellington Road Industrial Estate, Wellington Bridge, Leeds, LS12 2UF. However, any small trimmer having a similar capacitance swing should be equally suitable. The BF244B transistor specified for TR1 and the aluminium box type AB8 in which the adaptor is housed are available from several suppliers, including Electrovalue Ltd., 28 St. Judes Road, Englefield Green, Egham, Surrey, TW20 0HB.

CONSTRUCTION

Most of the components are mounted on a printed circuit board, which is illustrated full size in Fig. 2. The board is made up in the usual way, but note that the two holes for the mounting lugs of L2 must be somewhat larger than the other holes. Dimensions here are best taken from the coil unit itself. The project is housed in an aluminium box which measures about 102 by 102 by 38mm. (4 by 4 by 1½in.) and the general layout can be seen in the accompanying photographs.

The two ceramic filters are symmetrical devices with identical input and output impedances, and tests carried out by the author indicate that they may be connected either way round with, of course, the centre lead-out connecting to chassis.

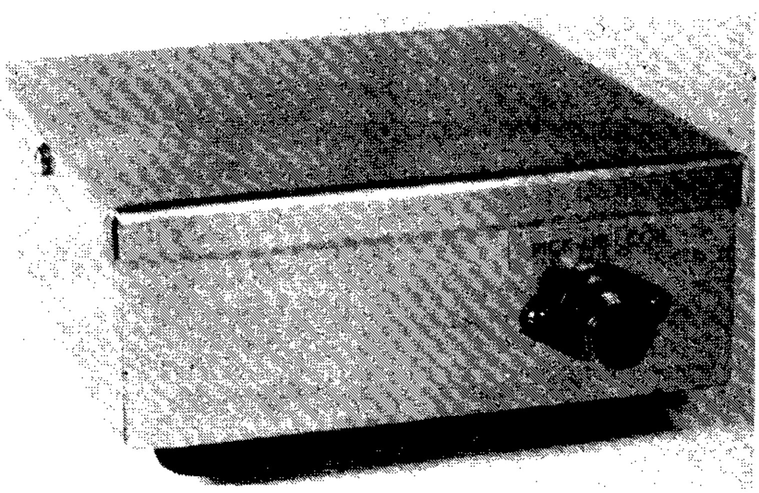
The input socket is a standard panel-mounting coaxial type, and a solder tag is secured inside the case under one of its 6BA mounting nuts. TC1 is soldered directly across the centre contact of the socket and this solder tag. The solder tag also provides a connection for the negative battery lead. A single wire connects the centre contact of the coaxial socket to the appropriate point of the board. Another single lead connects to the output socket, a 3.5mm. jack type of open construction which allows its bush contact to be automatically connected to the metal case when it is fitted in place.

The printed circuit board is mounted using a couple of 6BA bolts about 1in. long, and metal spacers are used over these bolts to hold the board a little way clear of the metal case. The chassis connection to both the input and output sockets is completed by way of these spacers.

Finally, four rubber feet are bolted or glued to the bottom of the box.

PICK-UP COIL

The pick-up coil consists of 8 turns of thin multi-strand p.v.c. covered connecting wire, and it has a



The coaxial input socket is on the rear panel of the box

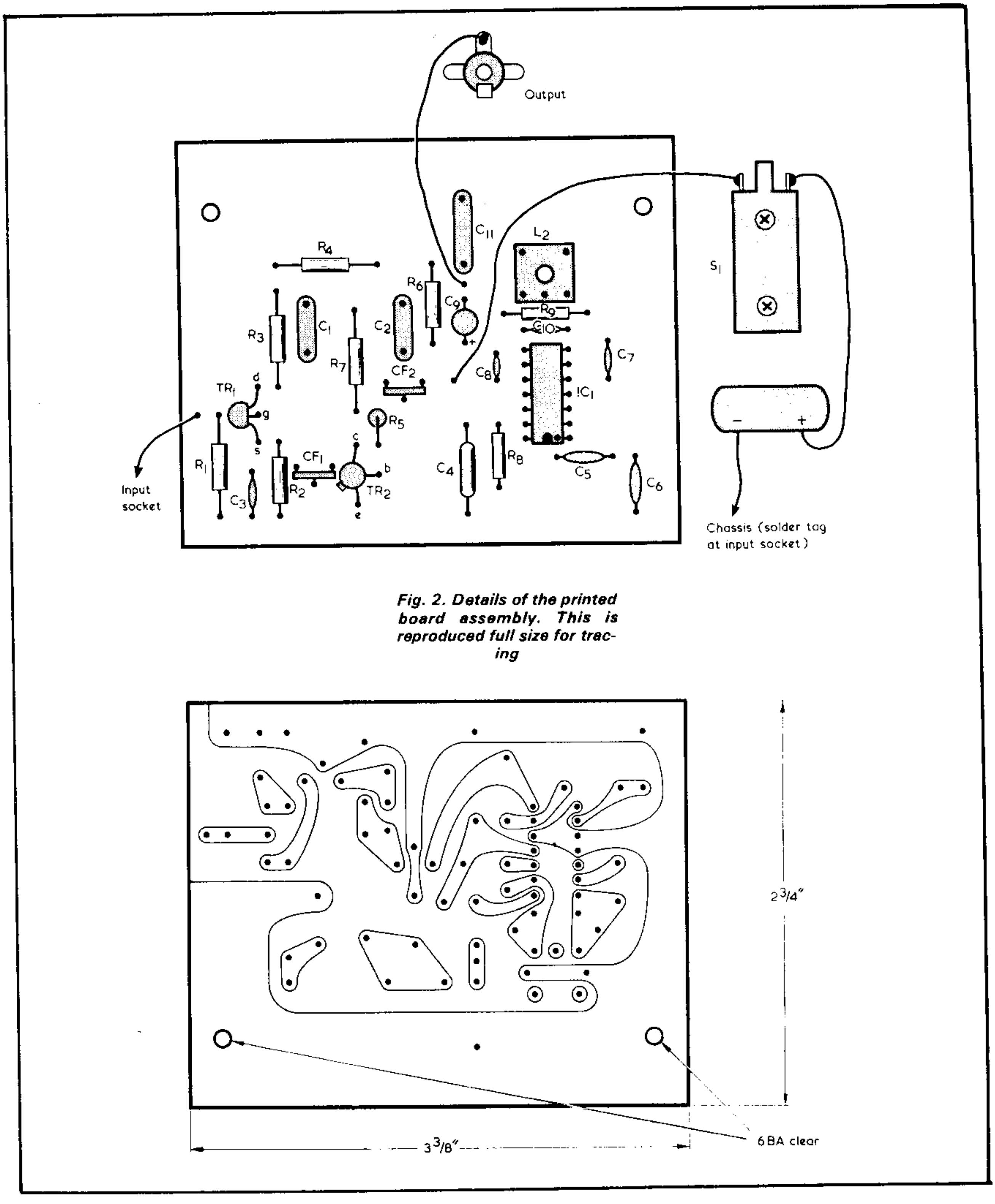
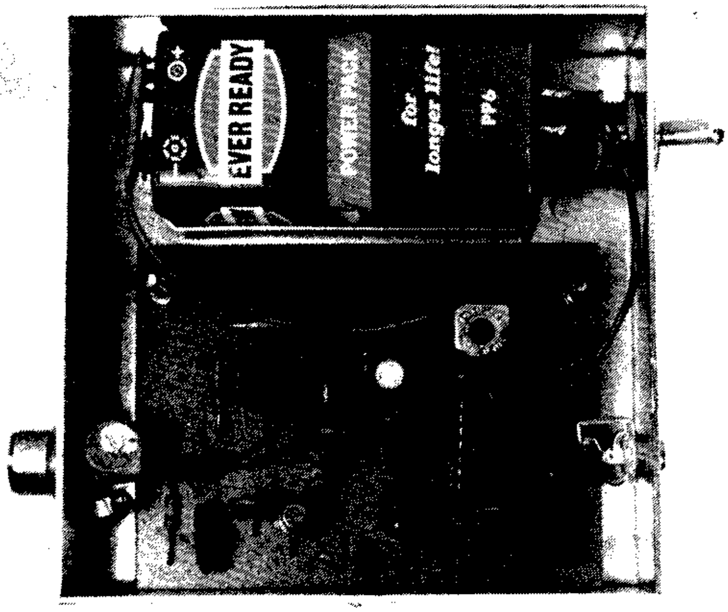


Fig. 2. Details of the printed board assembly. This is reproduced full size for tracing

diameter of 2in. Four bands of insulating tape are used to prevent the coil from unwinding and make it self-supporting. The coil is connected to the adaptor by a lead which consists of a 1 metre length of standard TV coaxial cable terminated in a coaxial plug. The soldered connections which join the coil to the coaxial cable must be very well covered with several layers of insulating tape. The coil will eventually fit inside the TV set cabinet, and it is absolutely essential that there is no risk of any direct connection between the coil and any part of the TV receiver occurring.

If the television set and the Hi-Fi amplifier are some distance apart, do not use a longer length of coaxial cable to enable the adaptor to be situated near the amplifier, as this would make it impossible to peak the pick-up coil properly. The adaptor should be placed near the TV set and a long output lead used instead. The output lead must be a screened type.



General layout of components

ADJUSTMENT

Assuming that no suitable test gear is available, the easiest way of adjusting the unit is to first connect everything up and switch on all the equipment. By placing the pick-up coil near the intercarrier circuits of the television set it should be possible to pick up the sound channel, although perhaps not very well at this stage. TCI is then peaked for best results, which correspond to minimum background noise. After this, the core of L2 is adjusted for maximum audio output. Use a proper trimming tool when adjusting L2, as there is otherwise a risk of damaging the core. Finally, move L1 away from the television intercarrier circuits to a point where only a rather poor signal is received, and then peak TC1 for minimum background noise once again.

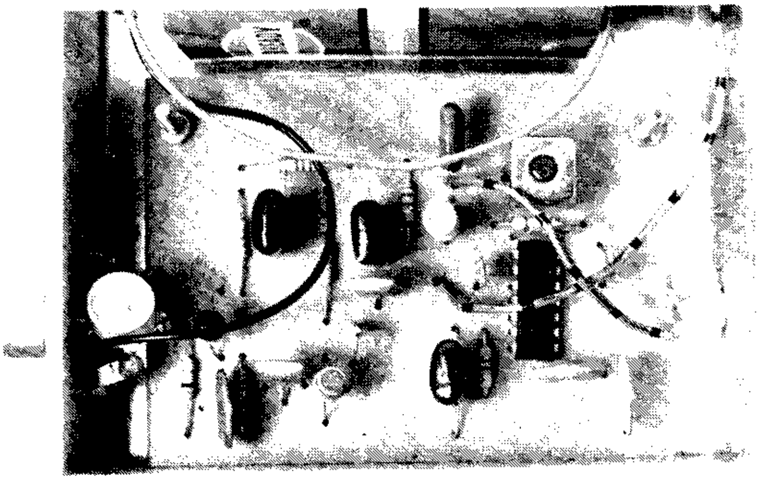
In use the pick-up coil is placed in the position which gives the most noise-free signal and its exact positioning will probably not be too critical, this being especially true if the TV set is a valve type. These normally provide quite a large amount of intercarrier radiation. It may be necessary to make a small entry hole in the rear of the set for the coaxial lead, but it is more than likely that some suitable access point will already be available.

It may be possible to obtain satisfactory results with the coil completely outside the TV set case, but this is only likely if the TV intercarrier circuits happened to be close to the set back. The necessity of positioning the pick-up coil fairly close to the TV intercarrier circuits is not primarily due to there being a lack of suitable 6.0MHz signal strength several inches away. Instead, it is due to the fact that the 6.0MHz frequency coincides with the 49 metre short wave broadcast band, which normally provides very strong signals after dark. It is in consequence necessary to have a fairly tight coupling to the TV intercarrier signal so that this is sufficiently strong to swamp out the broadcast signals.

All precautions against shock must be fully observed when working with the television receiver. If the pick-up coil does have to be positioned inside the TV receiver, *do not touch anything inside the set while it is plugged in to the mains supply.* Doing so could result in a severe or dangerous electric shock being obtained. It is advisable to wear rubber gloves when positioning the pick-up coil.

Finally, it should be pointed out that the unit is only suitable for use with u.h.f. 625 line TV sets, as the necessary 6.0MHz intercarrier signal is only present with this type of receiver. ■

Nearly all the parts are wired up on a single printed board module



RECENT PUBLICATIONS

THE BANG & OLUFSEN BOOK OF HI-FI. By Dan Everard. 134 pages, 180 x 110mm. (7 x 4¼in.) Published by Woodhead-Faulkner (Publishers) Ltd. Price £1.25.

Although the publication of this book has been sponsored by Bang & Olufsen, this well-known manufacturer of high fidelity equipment has in no way influenced the content of its text. The book is simply a well-written introduction to high fidelity, having a general approach with no bias whatsoever towards the products of any one company.

In his preface the author states that he has been approached over the years by non-technical people seeking advice on quality audio equipment, and has found that their unwitting purchase of incorrect items has proved to be costly in terms of expenditure. He felt that "someone ought to write a book" on the subject, and the publication under review is the result.

The book explains in simple terms how the various sections of a hi-fi installation work in conjunction with each other. Dealt with in detail are the overall system, records and record players, radio tuners, amplifiers, loudspeakers and tape recorders. The book then proceeds to the setting up and maintenance of high fidelity equipment, carrying on to chapters describing the nature of sound and recording techniques. There is finally a 21 page glossary of the terms encountered in audio sound recording and reproduction.

110 INTEGRATED CIRCUIT PROJECTS FOR THE HOME CONSTRUCTOR. By R. M. Marston. 127 pages, 215 x 130mm. (8½ x 5in.) Published by The Butterworth Group. Price £2.95.

This is a completely rewritten second edition and follows the successful first edition which was published under the same title. The integrated circuits dealt with in the present volume are amongst the latest available.

The book is divided into five chapters, each of which describes projects incorporating a particular integrated circuit. The first chapter deals with 741 op-amp projects, these including amplifiers, voltage followers, phase splitters, filters, square wave and Wien bridge generators, and instruments for the measurement of current, voltage and resistance. Chapter 2 is centred on the 555 timer i.c., and again there is a wide range of applications, including three imaginative circuits which are capable of reproducing the sound of the British two-tone police siren, the "wailing" American police siren and the "Red Alert" alarm heard in the ***Star Trek*** TV series.

The third chapter is devoted to projects built around the XR-2206 function generator. This is a very versatile i.c. which, with little external circuitry, can produce sine, square, triangle, ramp and pulse waveforms at frequencies from considerably less than 1Hz to several hundred kHz. The output frequency, which is RC controlled, can be modulated in amplitude or frequency, and can also be subjected to phase or frequency shift keying. The chapter gives circuits which take advantage of all these capabilities. In the fourth chapter we find 2 watt audio amplifier circuits incorporating the LM380, and in the fifth chapter power supply projects employing the 723 voltage regulator i.c.

MODEL ENGINEERING. By Martin Evans. 224 pages, 245 x 190mm. (9½ x 7½in.) Published by Pitman Publishing Ltd. Price £7.95

There is an artistic and almost creative gratification in the building of a working model of machinery. This is given not only by the exercise of skill in dealing with the materials employed but also by the dimensional accuracy with which the work must be made, the fact that the model is intended to function and, finally, the overall ***appearance*** of the completed model. In this hard cover book, Martin Evans successfully captures all these facets of the world of model engineering.

Dealing first with the text, the volume covers the entire field of practical model construction, giving full details of all the tools required from the humble hammer to the screw-cutting centre lathe. Also given is very helpful and down-to-earth advice on the home workshop, together with descriptions of the materials incorporated in working models and the joining of metals.

And that is just the text. Accompanying the words are an exceptionally large number of clear and attractive photographs of actual models, including steam locomotives, traction engines, internal combustion engines, clocks and scientific instruments.

The experienced will find this book a continuing pleasure to browse through, and the newcomer will find it an excellent source of information on successful model building. It is certainly a delight to review a work which is so exceptionally well set up both in its pictorial and in its textual subject-matter.

SHORT WAVE NEWS
FOR DX LISTENERS

By Frank A. Baldwin

Times = GMT *Frequencies* = kHz

As most of this article is devoted to the HF bands (see Around the Dial), some LF loggings are presented here; we commence with —

● SWAZILAND
TWR Mpangela on **4760** at 0403, religious service, hymns in Afrikaans.

● AFGHANISTAN
Kabul on **3390** at 0146, religious chants in the Home Service 1, scheduled from 0130 to 0330 for this transmission.

● PAKISTAN
Islamabad on a measured **5061** at 0125, religious chants and programme.

● CONGO
Pointe Noir on a measured **4843** at 1938, classical piano solo, OM announcer in French.

● COLOMBIA
Radio Bucaramanga on **4845** at 0330, OM with identification in Spanish, LA pops.

● BRAZIL
Radio Olinda, Pernambuco, on **3285** at 0137, OM with an excited sports commentary in Portuguese.

● CAMEROON Radio Bertoua on **4750** at 1828, YL with English programme followed by that in French at 1830.

● PERU
Radio Quillabamba on **5025** at 0133, local pops on records, OM in Spanish.

CURRENT SCHEDULES

● SPAIN
"Radio Exterior de Espana", Madrid, presents a service in English to Europe (not Sundays) from 2030 to 2230 on **7155** and **9505**.

● PAKISTAN
"Radio Pakistan", Karachi, has an External Service in which a newscast in English read at slow speed is directed to Europe from 1100 to 1115 on **15115** and on **17665.** A programme in Urdu for the U.K. is from 0830 to 1100 on the same frequencies. From 1915 to 2115 a transmission in Urdu and from 2115 to 2145 in Sylheti for the U.K. may be heard on **4718, 6235** and on **7095.**

● TURKEY
"The Voice of Turkey", Ankara, operates an External Service in which an English programme for Europe, North Africa and North America can be heard on **7170** and on **9515.**

● AUSTRIA
"Radio Austria", Vienna, radiates programmes in English for Europe from 0830 to 0900 on **6155, 15105, 15410** and on **17815;** from 1230 to 1300 on **6155, 9770, 11790** and on **17710;** from 1830 to 1900 on **6155, 9725, 15335** and on **17770.**

● LEBANON
"Radio Lebanon", Beirut, has an English programme for Africa from 1830 to 1900 on **11755** and for North America from 0230 to 0300 on **9680.**

● PORTUGAL
"Radiodifussao Portuguesa", Lisbon, offers a programme in English for Europe from 2030 to 2100 (Sundays 2030 to 2050) on **6025** and on **9740.**

VATICAN CITY
"Vatican Radio", Vatican, beams programmes in English to the U.K. and Eire from 1345 to 1400 on **6190, 7250, 9645** and on **11740;** from 2030 to 2045 on **6190, 7250** and on **9645.**

● HUNGARY

"Radio Budapest" schedules programmes in English to Europe from 1200 to 1220 (not Saturdays or Sundays) on **6040, 7155, 9585, 11910, 15160, 17785** and on **21525**; from 2100 to 2130 on **6060, 6110, 7200, 9655, 11910, 15225** and on **17780** daily. A programme for Dxers is to be heard on Tuesdays and Fridays in English from 1515 to 1530 on **5980, 7215, 9585, 11910** and on **15160.**

● BULGARIA

"Radio Sofia" directs programmes in English to the U.K. and Eire from 1930 to 2000 on **6070** and on **7270** and from 2130 to 2200 on **5915** and on **7115.**

● IRAQ

"Radio Baghdad" lists a programme in English for Europe from 2130 to 2230 on **9745.**

● POLAND

"Radio Warsaw" broadcasts programmes in English to Europe from 0630 to 0700 on **6135, 7270** and on **9675**; from 1200 to 1230 on **6095** and **7285**; from 1600 to 1630 on **6135** and 9540; from 1830 to 1900 on **6095** and **7285;** from 2030 to2100 on **6095** and **7285** and from 2230 to 2300 on **5995, 7125** and on **7270.**

● MONGOLIA

Ulan Bator transmits programmes in English to South East Asia and the Far East from 1220 to 1250 (not Sundays) on **6385** and on **12070** and from 1715 to 1745 (not Sundays) to the same target areas on **7262** and on **9575.**

AROUND THE DIAL

In which are reported some of the interesting stations logged recently, the first being–

● CLANDESTINE

"Voice of Arab Syria" on **6060** at 1819, OM with exhortation in Arabic. The schedule is from 1800 to 1900 during Winter & Spring and from 1700 to 1800 in Summer. Broadcasts are anti-Syrian regime and the identification in Arabic is "Sawt Suriya al-Arabiya."

"Voice of Lebanon" on **6550** at 1946, OM in Arabic interspersed with short excerpts of local-type music. This pro-Phalangist transmitter identifies as "Huna Sawt Lebnan, Sawt al-Hurriyah wa al-Karamah" ("This is the Voice of Lebanon, the Voice of Freedom and Dignity"). The schedule of this transmission is from 1900 to 2105.

"Popular Front for the Liberation of Oman" on **9650** at 2008, OM with world news in Arabic, political harangue 2015 to 2020 with many mentions of Oman, local-type music. The schedule would appear to be from 2000 to 2025.

● SWEDEN

Stockholm on **11950** at 2036, OM in Swedish in the Domestic Service 1st Programme radiated in the USB mode to embassies, firms, ships and Swedes abroad, this transmission being from 1800 to 2130.

Stockholm on **21690** at 1237, OM with world news in English in a programme for Africa, the Far East and North America scheduled from 1230 to 1300. Also in parallel on **9745** and **15305.**

● U.S.A.

WYFR Okeechobee, Florida, on **11780** at 2048, OM with a religious programme in English.

● JAPAN

Tokio on **15325** at 0800, OM with identification in English and a newscast. Listen for the programme in French then musical box interval signal prior to 0800.

●AUSTRALIA

Melbourne on **11770** at 1840, OM with the English programme to Europe (General Service) scheduled from 1800 to 1900.

Melbourne on **9580** at 2000, identification and YL with world news in English in a General Service transmission scheduled from 2000 to 2030.

Lyndhurst on **11870** at 1840, YL with a pop song in English transmitted in USB mode.

● PHILIPPINES

Radio Veritas, Manila, on **11955** at 1410, YL with a talk about the Moslem faith and a forthcoming flower festival on Mindanao, a large island south and part of the Philippines, in the English programme scheduled from 1400 to 1500. Listen for the identification and various addresses for station reports at 1400.

INDONESIA

Jakarta on **11790** at 0830, "Voice of Indonesia" identification then YL with world news in English and a programme intended for South East Asia and the Pacific, scheduled from 0800 to 0900.

● GUAM

KTWR Agana on **11730** at 1100, musical chimes, identification in English, organ music and hymns. This one may be heard after the VOA transmitter closes at 1059 on this channel. Also on **9670** at 1359, musical chimes, identification and a newscast in English.

● CHINA

Radio Peking on **6550** at 1605, Chinese music, YL with song in Chinese in the English programme for East and South Africa, scheduled from 1600 to 1700. Radiated in the suppressed carrier LSB mode.

● TAIWAN

Taipeh ("The Voice of Free China") on **11915** at 0855, five chimes interval signal, choral anthem, OM in the Amoy programme to South East Asia, scheduled from 0900 to 1000.

● EGYPT

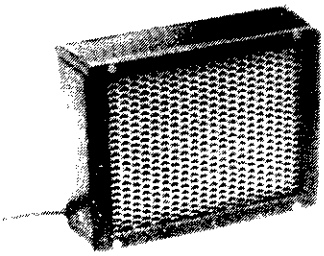
Cairo on **6230** at 0217, YL with a newscast in English in the North American Service, scheduled from 0200 to 0330.

● IRAQ

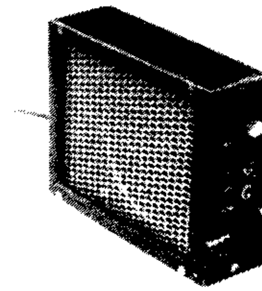
Radio Baghdad on **9745** at 2149, Arabic-type music, YL with announcements then a talk about Babylon and recent 'finds' in the area. All in the English programme scheduled from 2130 to 2230 on this channel.

NOW HEAR THIS

SRS (Stichting Radio Omroep Suriname) Paramaribo, Surinam on **4850** at 0144, Glen Miller records, OM announcer in Dutch.



THE "MAINS MICRO-AMP"



By Sir Douglas Hall, K.C.M.G.

Part 2 (Conclusion)

Concluding details on this unusual amplifier project.

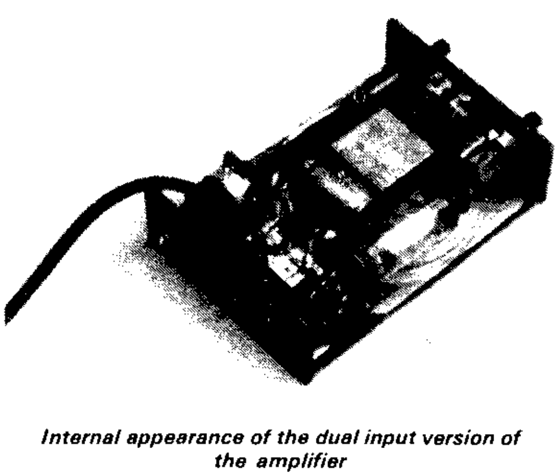
In last month's issue the circuit of the "Micro-Amp" amplifier was described, as also were the first constructional steps. We proceed next to the wiring.

WIRING UP

The wiring for the single input version of the amplifier is shown in Fig.4(a). The wiring of the double input version is the same apart from the components on the panel shown in Fig.2(c), which was published last month. Also, VR1 requires a modification before wiring commences with the dual input version of the amplifier, and this will be described shortly.

At this stage the section of Fig.2(a) will now be assembled to that of Fig.2(b), this being desirable to ensure that the parts fit together correctly. It is, however, necessary to remove the Fig.2(a) section whilst wiring is being carried out, as this eases the process. The wiring is then completed as in Fig.4(a).

In this diagram, both VR2/S1 and the valveholder have been turned through 90 degrees to illustrate the connections more clearly. Pin 4 of the valveholder, which corresponds to an "NC" pin of the valve, is used as an anchor tag. Confirm, with the aid of an ohmeter or continuity tester, the tags of S1 which correspond to the two switch poles before wiring in the mains lead. This is because the tag positioning may vary with some switches, with the result that the mains input could be short-circuited when the switch is closed. Similarly confirm the mains transformer tags against the maker's information to ensure that connections here are correct. Note that the mains transformer clamp is earthed by way of the solder tag under one of its securing nuts. When the 120Ω speaker is used, a wire passes from this solder tag to the speaker frame tag. The mains lead is secured inside the case by a small plastic or plastic-covered clamp fixed by a 6BA bolt and nut at hole T of the section of Fig.2(a). This clamp is not shown in Fig.4(a). The 3-core mains lead should be correctly terminated in a 3-way fused mains plug.

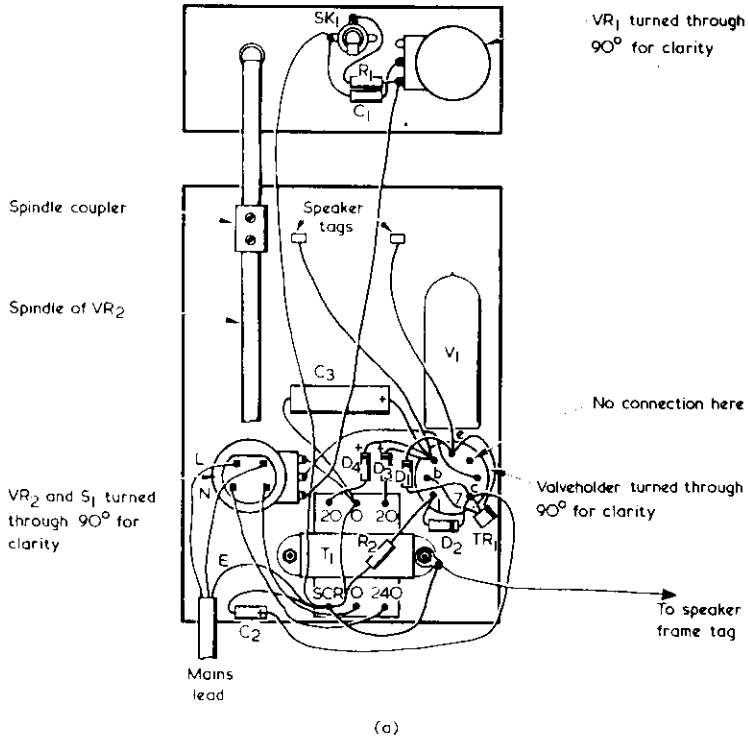


Internal appearance of the dual input version of the amplifier

DUAL INPUT VERSION

If the dual input version is to be made, a different assembly is needed on the panel of Fig.2(c).

The type P20 potentiometer recommended for VR1 has a plastic extension of the spindle passing through a central hole in the rear. This extension should be filed flat. A piece of thin tinplate is then cut out with scissors as illustrated in Fig.5(a), and this is bent along the dotted lines to form a clamp for transformer T2. This clamp is then soldered to the case of VR1 in the manner shown in Fig.5(b). The orientation of the transformer with respect to



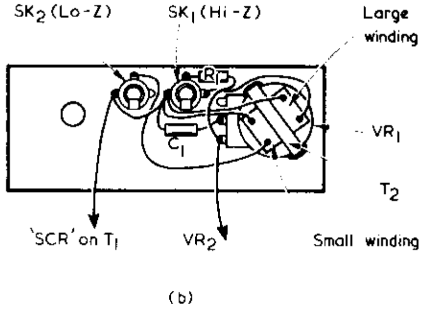
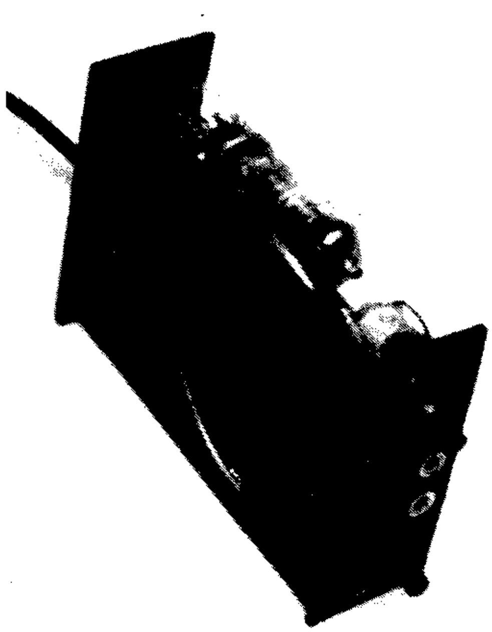


Fig.4(a). Wiring up the amplifier. The connections around SK1 are for the single input version.
(b). If the dual input version is being built, two input sockets are fitted and are wired as shown here

the potentiometer tags can be seen in Fig.4(b).

The second jack socket is then fitted and wiring is carried out as illustrated in Fig.4(b). The "large" and "small" windings indicated in Fig.4(b) are those which have high and low resistances respectively.



Three-quarter view. Here the two input jack sockets of the dual input version may be seen on the control panel

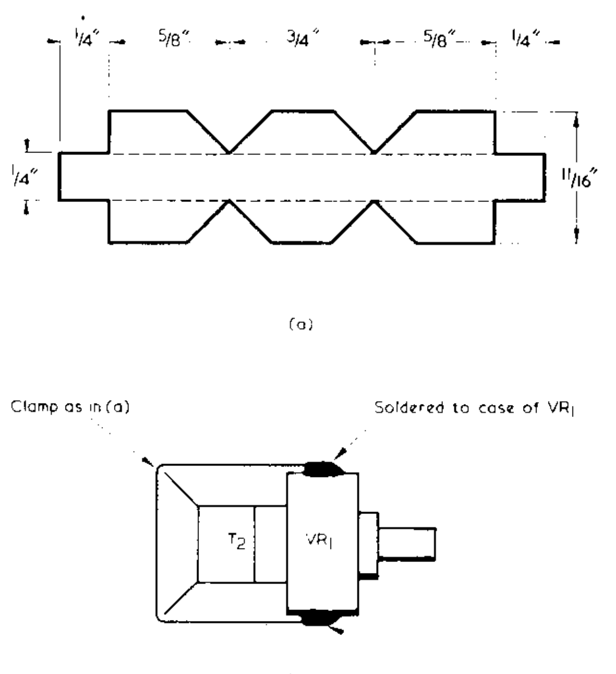


Fig.5(a) A piece of tinplate is cut out to form a mounting clamp for T2
(b). After bending, the ends of the clamp are soldered to the body of VR1

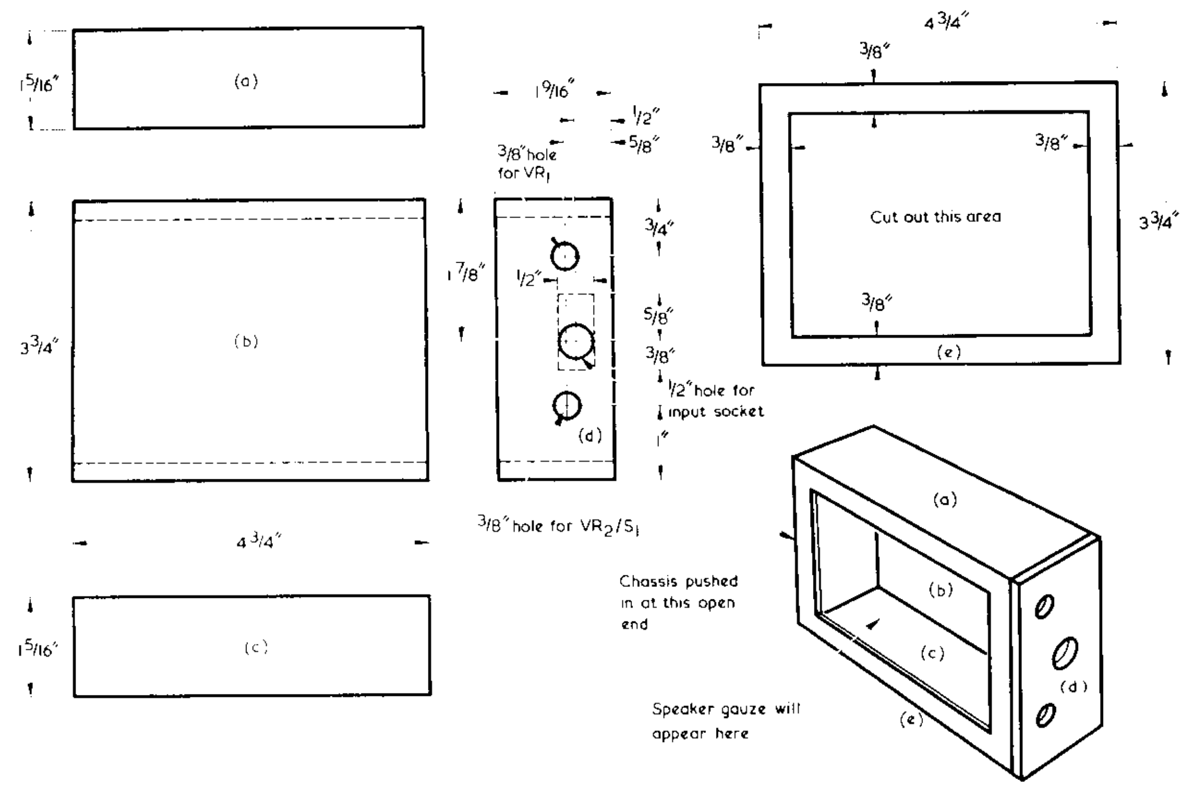


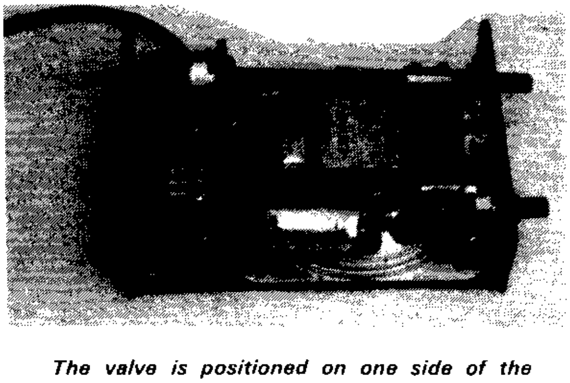
Fig.6 A case may be made up in the manner shown here with items (a) to (e) inclusive. The finished assembly appears as in (f). Dimensions are for guidance only

TESTING

After completion in either single or dual input form, the amplifier is ready to be tried out. No setting up adjustments are required and it is simply necessary to plug in the valve, connect up to the mains and switch on. It should be remembered that at this stage the amplifier is not fitted in a case and that connections carrying dangerous mains voltages are accessible. All precautions against shock must be observed.

The high impedance input can be coupled to a crystal cartridge of the type described in Part 1, or to a tuner unit having a medium or high impedance output. The connection should be via screened cable with the braiding connected to the amplifier earth, i.e. to its negative supply rail. This will mean that any tuner unit used will automatically be connected to earth via the braiding, a fact which may modify tuner operation should this be a simple t.r.f. design.

Low impedance inputs can similarly be applied to the low impedance jack socket. A ZN414 receiver will match into the low impedance input nicely, though it may not fully load the amplifier. Where it is necessary to fit a d.c. blocking capacitor between the output of the tuner and the low impedance input, an electrolytic capacitor of around 100μF will be satisfactory. It should be connected with a polarity suitable for the particular d.c. conditions existing.



The valve is positioned on one side of the speaker magnet with the extended spindle of VR2/S1 on the other side

CASE

A case is necessary, and this may be made up as shown in Fig.6. The sections of Figs.6 (b), (d) and (e) are made of ⅛in. s.r.b.p., whilst those of Figs.6 (a) and (c) are ¼in. plywood. The latter pieces can be covered with Fablon, or painted to match the s.r.b.p. sections. The assembly is held together with small thin woodscrews which pass, through holes in the s.r.b.p. pieces, into the edges of the plywood. There should be room for a piece of metal speaker gauze to be placed in front of the "chassis" before it is slipped into the case. The "chassis" is held in place by the two knobs on the potentiometer spindles. More secure methods may readily be devised, if preferred.

The dimensions shown in Fig.6 are intended for guidance only, as they assume that the receiver has been made exactly to size, and they offer no clearances. The actual case should be made to suit the "chassis" as built. At least some of the dimensions in Fig.6 will need revision to allow this to be done and to enable the "chassis" to be a comfortable sliding fit.

(Concluded)

A DEMONSTRATION CONTROL SERVO

By E. A. Parr and J. Ash

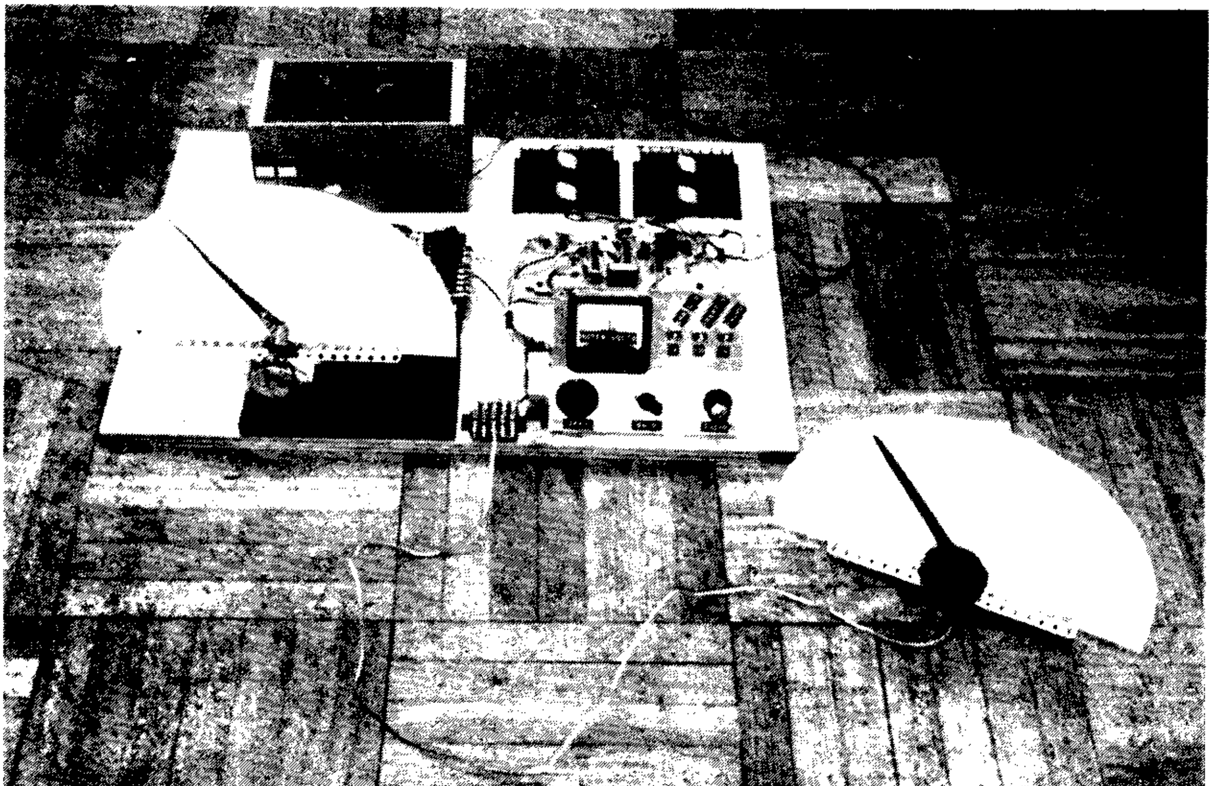
A comprehensive demonstration system incorporating controllable options for servo gain, inertia, tacho and tacho gain.

This unit was designed as a visual aid for a lecture on elementary servo systems and position controls. It contains the majority of features found in an industrial servo system (such as error limit and tacho feedback) and it can be made to demonstrate the idiosyncrasies of a real life system (such as hunting, sluggishness and general instability).

GENERAL PRINCIPLES

The requirements of a simple position control are shown in Fig. 1. We have two dials: the "user" turns one to a desired angle and the "black box" turns the other to the same angle.

The first building block we need is some device



The complete servo system. The transmitter pointer and dial are in the separate unit coupled by a length of wire to the main receiver section

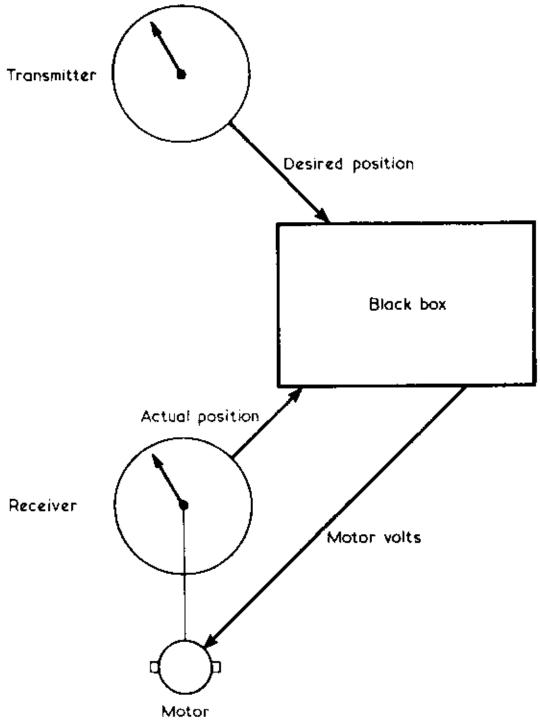


Fig. 1. Block diagram illustrating a simple position control system

to measure the position of the hand-turned dial (called the "transmitter" in the jargon) and the motor-turned dial (called the "receiver"). There are many forms this position, measuring device (or p.m.d.) can take; common ones are synchros, shaft encoders and the homely potentiometer. Our simple servo uses a potentiometer. If the potentiometer is connected with its track across a ± 12 volt supply, the voltage on the wiper will be dependent on the shaft angle and, moreover, should be reasonably linear.

We thus have two voltages, one representing our desired position and one our actual position. A subtraction will give us a voltage which represents the error in position and the sign will tell us which direction the error is in (i.e. more left or right).

A very simple servo system could then be built along the lines of Fig. 2. The voltage error signals are fed to two comparators which operate two relays: drive left and drive right. The resistor chain at the comparator inputs provides a dead band so that at the homed position the left and right relays are not continually chattering. This type of servo is called a "bang bang" system. It should be noted that R1 and R2 are large compared with RV1 and RV2 to minimise loading. R3 and R4 set the dead band.

This simple servo has one very serious shortcoming. The motor drives the pointer at a constant speed until shortly before the desired position (the start of the dead band). If the speed is too high the dial will pass through the dead band and out the other side. The dial will then hunt back and forth about the desired position. Obviously this can be prevented only by having a wide dead band (poor accuracy) or a slow speed (poor response).

PROPORTIONAL SERVO SYSTEM

Instinctively we want the motor to go fast when we are a long way from the correct position and to slow down as we come near the correct position. This can be done by making the motor volts proportional to the error voltage. A servo along these lines is shown in Fig. 3.

The substraction of the two position signals is carried out by IC1. This is, you will say, an adder, but the two p.m.d.'s are arranged so that the ± 12 volts are reversed on the receiver potentiometer. This means that if the transmitter is sitting at say +3 volts, the receiver should be at −3 volts and the sum (error) is 0. The error signal then feeds a power amplifier to drive the motor.

The power amplifier consists of the three amplifiers, IC3 to IC5, and the four emitter followers, TR1 to TR4. The amplifiers operate as simple inverters with unity gain to give a push-pull output across the motor. Note that the feedback on IC3 and IC5 is taken from the transistor emitters to compensate for the 0.8 volt base-emitter voltage. (The PNP3055 specified for TR3 and TR4 is a p.n.p. power transistor having virtually the same characteristics as the 2N3055. It is available from R.S. Components Ltd., and readers who do not have access to this company will have to order the transistor through a retailer. — Editor).

The gain of the system is set by VR1, which determines the relationship between motor volts and error volts (i.e. position error). The setting of the gain is important. If it is too low we have a sluggish drive that does not reach position. If it is too high we will have instability again.

A simple servo like this will work, but its performance is limited by the gain that can be used before instability sets in. The standard way to overcome this is to measure the motor speed, compare it with the desired speed (i.e. the error voltage

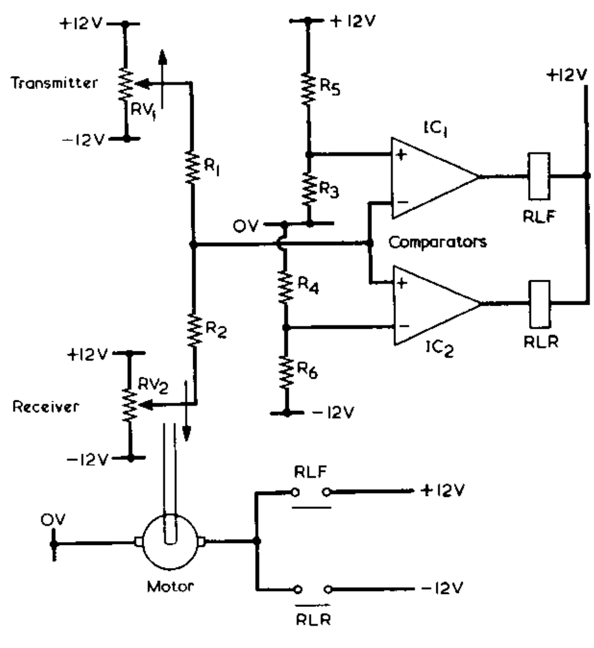


Fig. 2. A "bang bang" servo system. The arrows alongside the potentiometers indicate clockwise rotation

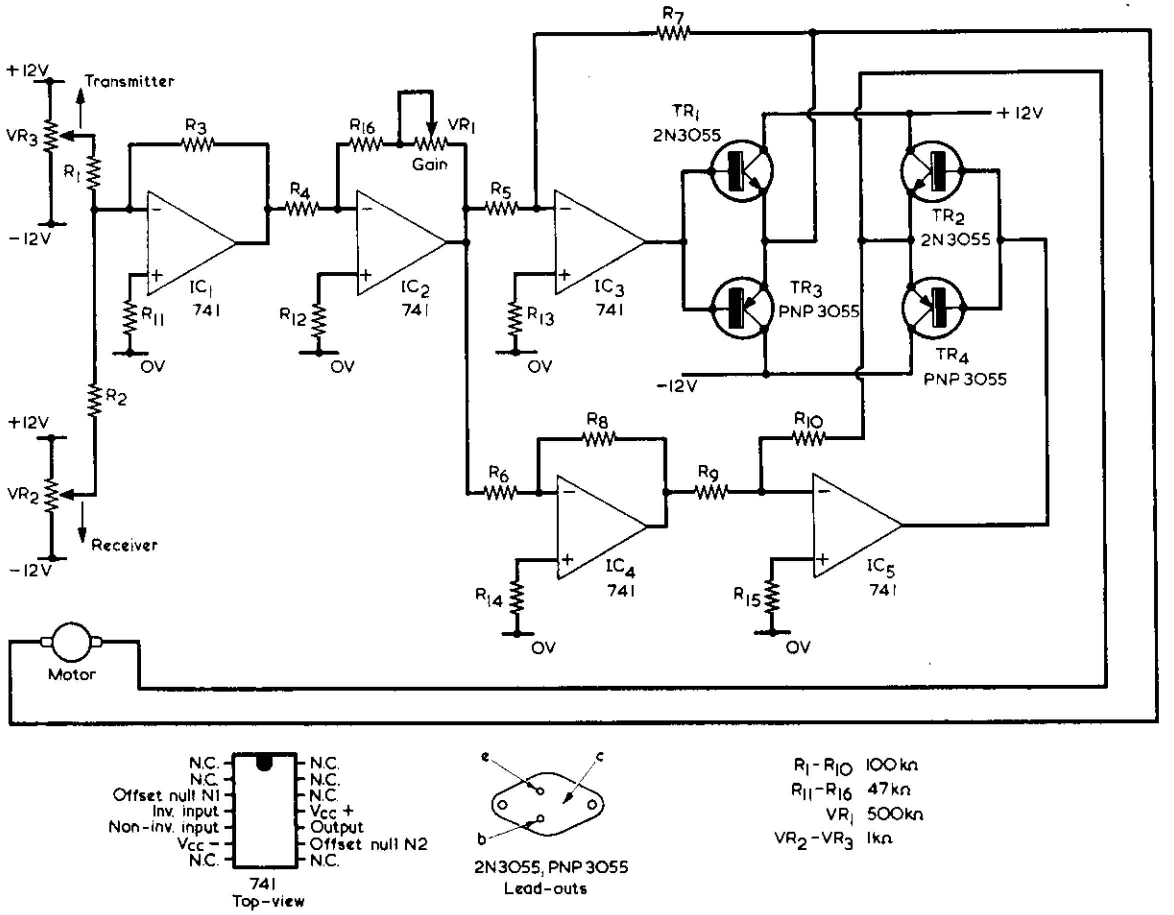


Fig. 3. A proportional servo system. (No connections are made to the offset null pins of the 741's)

COMPONENTS

Resistors
(All fixed values ½ watt 5% unless otherwise stated)
R1 68kΩ
R2-R4 100kΩ
R5 10kΩ
R6-R17 100kΩ
R18-R24 47kΩ
R25-R27 10kΩ
R28, R29 5.6kΩ
R30, R31 100Ω, 2 watts
VR1 500kΩ potentiometer, wire-wound or cermet
VR2 500kΩ pre-set potentiometer, wire-wound or cermet
VR3 500kΩ potentiomer, wire-wound or cermet
VR4-VR6 1kΩ potentiometer, wire-wound
VR7 100kΩ pre-set potentiometer, wire-wound or cermet

Capacitors
C1 0.1μF polyester
C2-C4 10μF polyester or polycarbonate
C5 0.01μF polyester

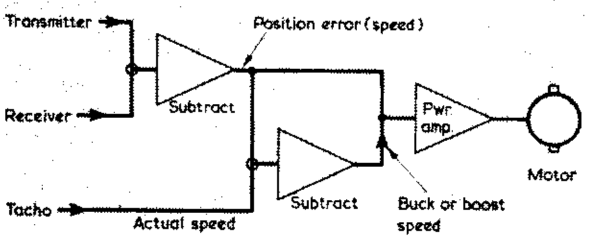
Semiconductors
IC1-IC8 741
TR1, TR2 2N3055
TR3, TR4 PNP3055
ZD1, ZD2 zener diode, 5.6V 400mW
D1, D2 see text

Switches
S1, S2 s.p.s.t., toggle
S3 s.p.d.t., toggle
LS1, LS2 miniature s.p.d.t. microswitch (see text)

Meter
M1 15-0-15V, centre-zero

Miscellaneous
Drive motor (see text)
Tacho generator (see text)
Heat sinks
Hardware for dials, gear train, etc.

Fig. 4. Block diagram showing a servo system with tacho feedback



after the gain is set) and either add or subtract to the motor volts if there is an error. The block diagram of this system is shown in Fig. 4.

Suppose we are approaching the correct position at high speed with positive motor volts, and we overshoot. The speed reference calls for small negative motor volts (because the error is small) but the tacho sees a large speed error because the motor is travelling fast in the wrong direction. The speed error signal adds to the small speed reference to give large negative volts to stop the motor quickly. This technique is called tacho feedback.

Servo mechanisms can be a very mathematical subject, but it is hoped that the circuits developed along the above lines will give an intuitive feel for the basic principles. It is years, anyway, since either author did a Nyquist diagram.

PRACTICAL CONSTRUCTION

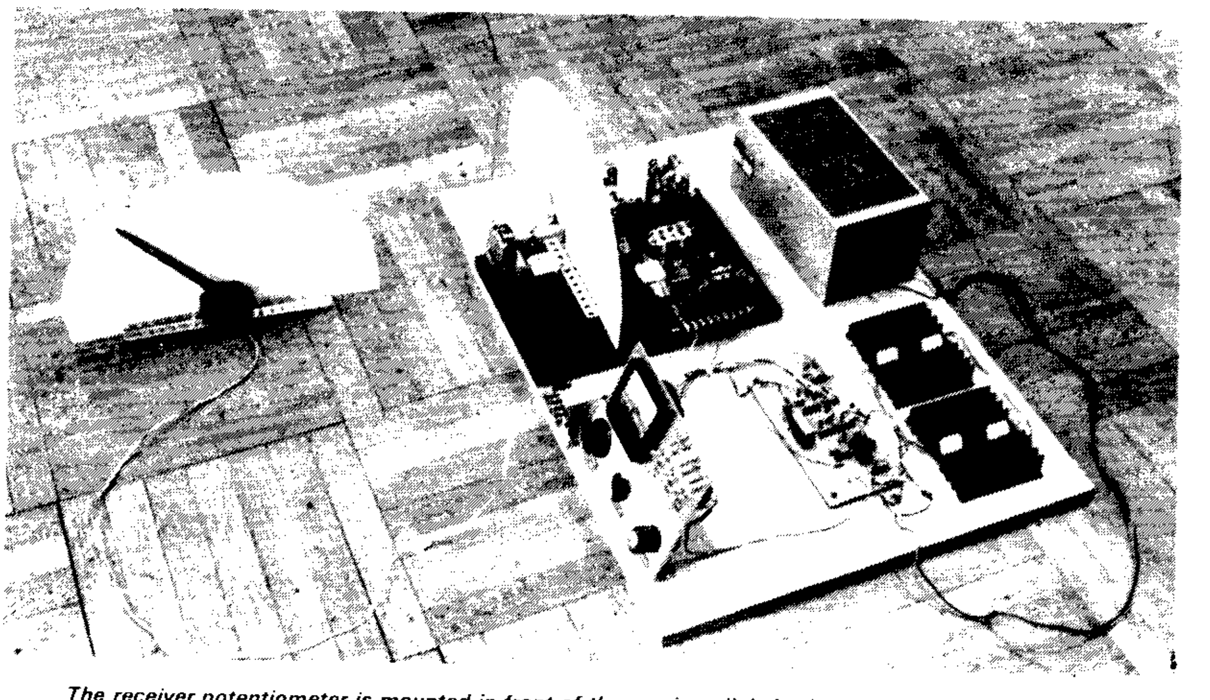
There is much mechanical as well as electrical work in building the demonstration servo, and most people will probably use what they have in their "come in handy" box. The mechanical notes are therefore a guide, not a shopping list.

The prototype used a slot car motor for the main drive motor. It was found by trial and error that a gearbox ratio of about 1,000 to 1 was needed. We were fortunate in that we were able to obtain two 30 to 1 gearboxes from some scrap industrial position controls, but the initial layout used simple Meccano gearboxes.

The tacho was a small Ripmax motor used as a generator. The type is not very important and a motor from a Matchbox car game was used originally, this being changed to the Ripmax model because the latter was easier to mount. The tacho is coupled to the motor shaft by a piece of flexible rubber tubing and gives about 4 volts when the slot car motor is rotating at top speed. Fig. 6 shows the basic mechanical layout.

The mechanical construction should be made as free as possible, and where misalignment can occur flexible couplings should be used. An excellent universal joint can be made with windscreen washer jet tubing.

The two p.m.d.'s were ordinary 1kΩ wire-wound potentiometers. To allow for misalignment, only 180 degrees of the 270 degree movement was used, and a zeroing control added in the form of a third potentiometer.



The receiver potentiometer is mounted in front of the receiver dial. At the rear of the receiver board is the power supply, with the output transistor heat sinks to its right. The positions of other parts of the receiver section are described in the text

CIRCUIT DESCRIPTION

The final circuit is shown in Fig. 5. The circuit is somewhat pedantic and uses far more op-amps than are strictly necessary. The circuit was designed, though, to separate out each stage. In a real servo system the error amplifier and gain stage, for example, would be all one stage. The separation of stages does, however, make the system easy to explain and demonstrate.

The error subtraction is done by IC1. As before, the voltages are inverted on the two potentiometers so that their sum is zero. The zero potentiometer is used to compensate for any initial error in setting the physical position of the potentiometers and pointers.

The gain is set by IC2 in the range 1 to 50. This was found adequate for our system and covered the whole range from very sluggish to downright unstable.

IC3 allows the mechanical inertia to be increased electronically by delaying the speed reference. This was added because the low inertia of our system meant that the oscillations obtained with the high gain were too rapid to observe easily. The pseudo inertia gives an oscillation of about 1 second period.

In the absence of tacho feedback, the speed reference is simply applied to IC4, IC7 and IC8 to drive the motor in push-pull as before.

The tacho signal is amplified by IC5 with gain set by VR2. The gain is set such that, with the motor running at top speed off load, the voltage out of IC5 is equal in magnitude but opposite in sign to the voltage out of IC2, the speed reference. The voltage out of IC6 will then be a speed error signal (suitably amplified) which is added into IC4 and IC7 to buck or boost the speed reference.

Note that the error signal is derived from IC2 speed reference, not IC3. The tacho feedback will thus correct for the electronic inertia introduced by IC3.

The motor used is a 12 volt type, but under long movements it could be fed with 20 volts. The motor voltage signal is limited to 12 volts by ZD1 and ZD2. These limit the output of IC2 to ±6 volts, and hence the motor volts to ±12 volts (it is driven in push-pull, remember). This clamping of the error signal is called "error limiting".

The error limit, tacho and electronic inertia are all switchable for demonstration.

Limit switches LS1 and LS2 are overtravel limits to prevent damage to the pointer in the event of zero mis-setting, or wild oscillations. These switches were R.S. Components type 337-879 miniature s.p.d.t. microswitches with the operating lever terminated in a roller, and operate off the receiver pointer. The normally closed contacts are used, stopping the drive when the pointer hits the switch. (The switches were added after the photographs were taken.) The diodes D1 and D2 allow the motor to drive out of limit in the safe direction. They are silicon rectifiers with forward current ratings suitable for the motor.

The 10μF capacitors C2, C3 and C4 are polyester or polycarbonate and *not* electrolytic. (A 10μF polycarbonate capacitor is listed by Home Radio). Difficulty may be experienced in obtaining the 500kΩ wire-wound or cermet potentiometers required for VR1 to VR3. Carbon potentiometers can be used, but it is slightly bad practice to use carbon potentiometers in a feedback loop.

The circuit operates with long leads and a straggly layout. To prevent it taking off in wild oscillations at high frequencies, the response of amplifiers with long leads attached is slugged by capacitors in the feedback.

The ±12 volt supply is derived from a single 24 volt supply. This is split into ±12 volts by the two resistors R30 and R31. In choosing a suitable supply the motor current should be taken into account; ours takes about 1 amp.

CONSTRUCTION

The original circuit was built on R.S. Components i.c. stripboard, but the layout is not critical and other methods of assembly could be used. As can be seen from the photographs, the controls and motor voltmeter were mounted on a front panel of the receiver section. The variable controls on this panel are "Zero" (VR5), "Gain" (VR1) and "Tacho" (VR3). The three switches are "Error Limit" (S1), "Inertia" (S2) and "Tacho" (S3).

Behind the front panel is the circuit board and behind this the four output transistors. These are mounted on heat sinks to protect them should the motor stall.

To the left of the front panel on the main receiver board is the receiver dial and pointer, with the receiver potentiometer in front of the pointer. Directly behind the receiver dial and pointer is the gearbox, this being coupled by a rubber band drive to the motor, which is on the right. Also on the right, and coupled to the motor, is the tacho generator. All these parts are mounted on their own chassis which in turn is mounted on the main receiver board. Connection to the electronics is made by way of plugs and sockets. Behind the receiver dial, motor and tacho chassis is a metal case containing the power supply.

The transmitter, with its own dial, adjusting knob and potentiometer, is constructed on a free chassis and connected to the receiver by about 3 metres of cable.

SETTING UP

Commissioning of the system should be done in the following manner.

1. Disconnect the motor electrically and set the gain for maximum. Set both dials by hand to 90 degrees. Connect a meter to the output of IC2 and adjust the zero control for zero. Set the dials by hand to 0 degrees. Adjust the span control for zero. Check again with both dials at 180 degrees. Note that the span control is a pre-set, whereas the zero control is user accessible. If a zero is not obtainable at 0 degrees and 180 degrees check the wiring to the potentiometers.

2. Have error limit, inertia and tacho out. Set gain to mid-point. Set both dials to 90 degrees and observe motor volts. Move the transmitter dial either side of 90 degrees. The motor volts should rise and fall in each direction (positive and negative) from zero.

3. Connect the motor electrically but not mechanically. Repeat Step 2 and observe that the motor drives and reverses correctly. Set both dials to 90 degrees and mechanically connect the motor. Have a hand poised over the On-Off switch in case of a runaway. Move the transmitter dial by 45 degrees. The receiver dial should follow in the

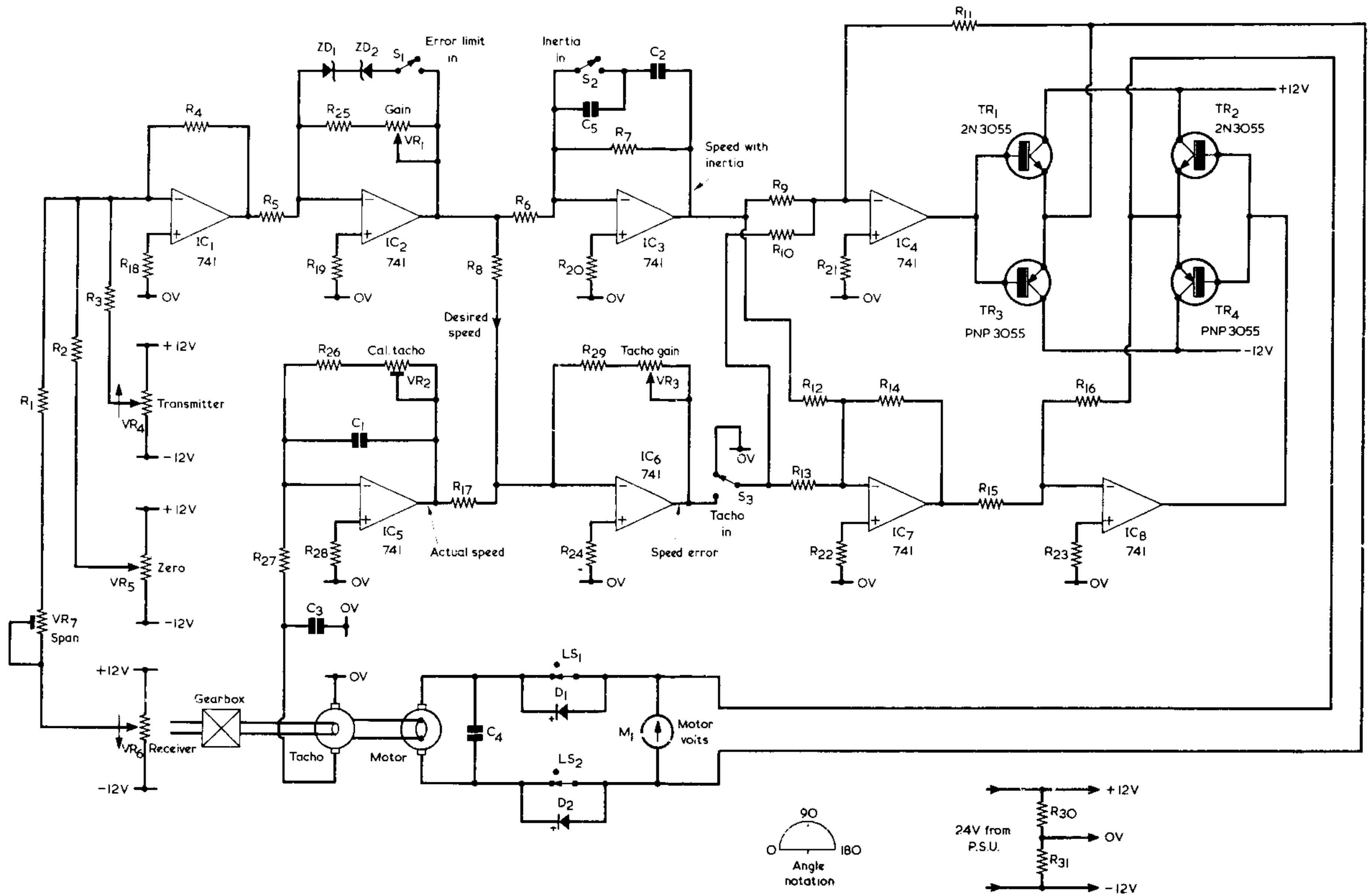


Fig. 5. The final circuit of the demonstration position control servo. In the practical version the diodes D1 and D2 may need to be reversed in polarity to allow the motor to drive in the safe direction out of the range limits

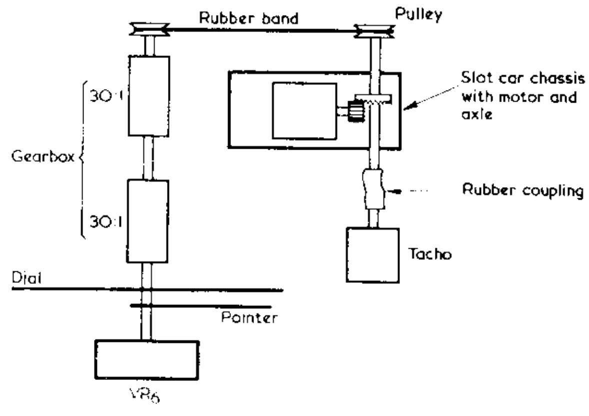


Fig. 6. The mechanical layout of the motor, tacho and drive to the receiver pointer

same direction (do not worry about oscillation about the final position). If the dial moves the wrong way reverse the motor connections.

4. With the motor connected the correct way, disconnect it mechanically again. Move either dial until the motor is running at top speed, and check that the voltages out of IC5 and IC2 are of opposite polarities. If they are not, reverse the tacho connections. If they are of opposite polarity, turn the tacho gain (VR3) to maximum, observe the output of IC6 and set VR2 to give zero. Note that VR2 is not user accessible.

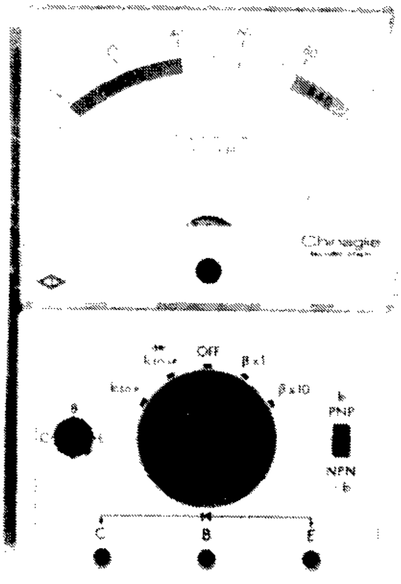
5. We now check that the tacho works. With the motor still mechanically disconnected, set either dial so that the motor is running at about one-third speed. With the tacho switched out, apply light finger pressure to the motor shaft to slow it down, observe the motor volts and switch the tacho in. The motor volts should rise to compensate for the load and the motor speed up again. This may take some experimentation with the tacho gain potentiometer to find the correct setting. Move either dial with the tacho in and out and compare the slow running characteristics of the motor. It should be far better with the tacho than without. If there is a tendency for the motor to "cog" (i.e. for the motor to hunt by speeding up and slowing down quickly of its own accord) the tacho gain is too high and should be reduced. Do not confuse this with oscillations occurring because the position control gain is too high; cogging will occur with the motor mechanically disconnected.

6. Mechanically reconnect the motor and check that the error limit keeps the motor volts to around 12 volts, and that the inertia gives a sluggish drive, prone to overshoot and oscillate. The inertia should be corrected by the tacho feedback. The overtravel limits and diodes D1 and D2 should be checked. The diode directions, i.e. polarities, are best found by trial and error.

The servo system is now set up and ready for use. The zero, loop gain and tacho gain adjustments can be altered for demonstration. ■

Trade News

PANTEC TRANSISTOR TESTER



Precision Instrument Laboratories, following their recent appointment as main agents for the Pantec range of Portable Test Instruments, have released details of the new range of Pantec multimeters etc, specifically designed to meet the requirements of "Electronic Engineers".

The Pantec transistor and diode tester provides simple and wide range measurement of gain and leakage both for p-n-p and n-p-n devices.

Price £26.50 plus carriage and VAT. For further information contact: Precision Instrument Laboratories, 212 Ilderton Road, London, SE15 1NT.

EMI WIN BBC ANTENNA EQUIPMENT CONTRACT

EMI Sound & Vision Equipment, a division of EMI Industrial Electronics Limited, has won a contract worth £438,000 from the British Broadcasting Corporation for the design, supply and installation of antenna tuning equipment. Three of the Corporation's high power M.F. transmitting stations are covered by the contract.

The new tuning networks are required to operate with a variety of new and existing mast radiators and main feeders at the BBC's transmitter sites at Burghead in Morayshire, Westerglen in Stirlingshire and Brookmans Park in Hertfordshire. A large scale re-engineering programme at these and other BBC stations has been implemented so that the Corporation can accommodate the changes which will result from a major reallocation of frequencies in the M.F. and L.F. bands scheduled for Europe later this year.

In your work-shop

STEREO AMPLIFIER REPAIR

A Tale of Two Electrolytics

"Ah, this will make a pleasant little job to finish off the day!"

Beaming, the Serviceman gazed down at the small stereo record player and its two speakers which he had just carried over from the "For Repair" rack. As he fitted the 2-way DIN speaker plugs into their sockets at the rear of the player he heard his assistant walk towards the complementary "Repaired" rack.

"Have you finished that TV then?" called out Smithy over his shoulder.

"Yep," responded Dick dejectedly as he deposited a monochrome television receiver on the rack.

Smithy glanced at his watch.

"There's only half an hour to go," he remarked, "If you like you can spend it helping me with this record player."

"As you like," replied Dick listlessly.

STEREO PLAYER

A dispirited Dick carried his stool over to Smithy's side and flopped down on it. Smithy had already picked out the service sheet for the record player and had it open at the circuit diagram. (Fig. 1.)

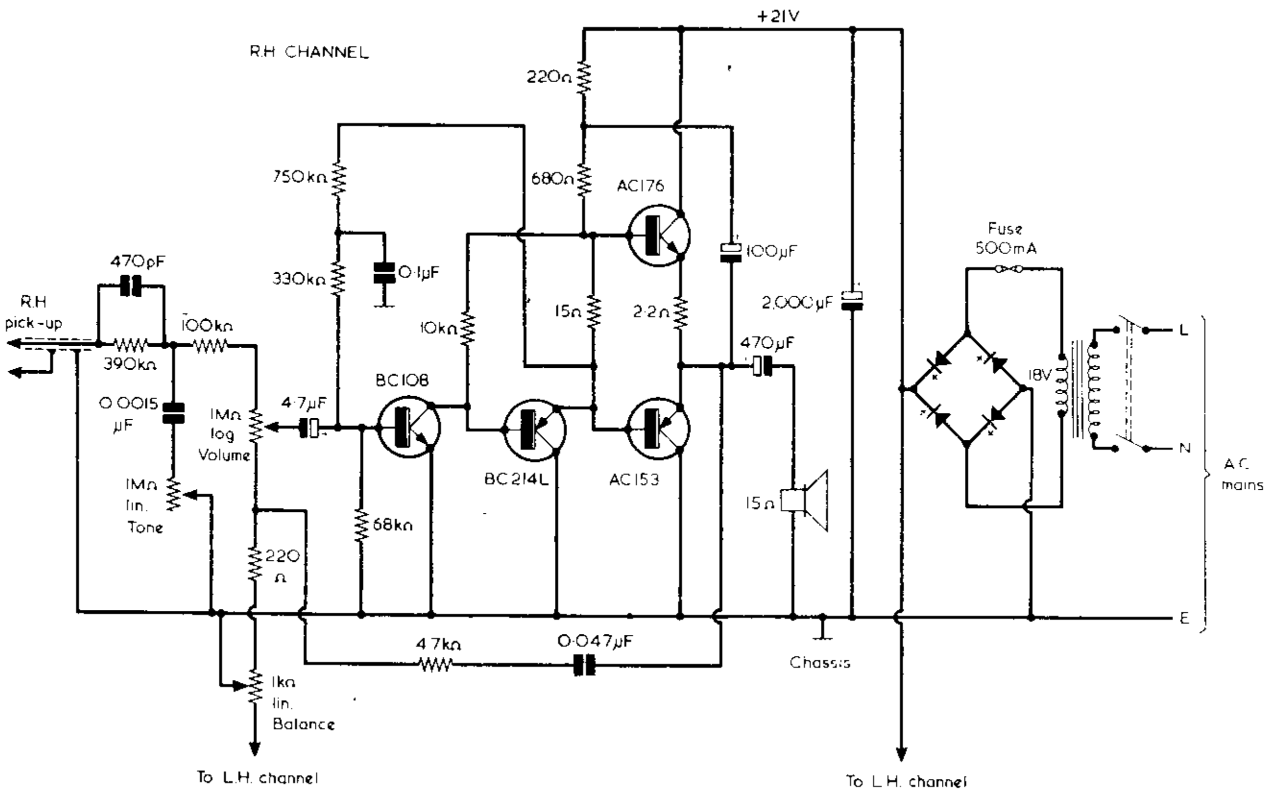


Fig. 1. One channel of an inexpensive stereo record player. The tone and volume controls of the left hand channel are ganged with the similar controls in the right hand channel. Component values are representative of commercial practice

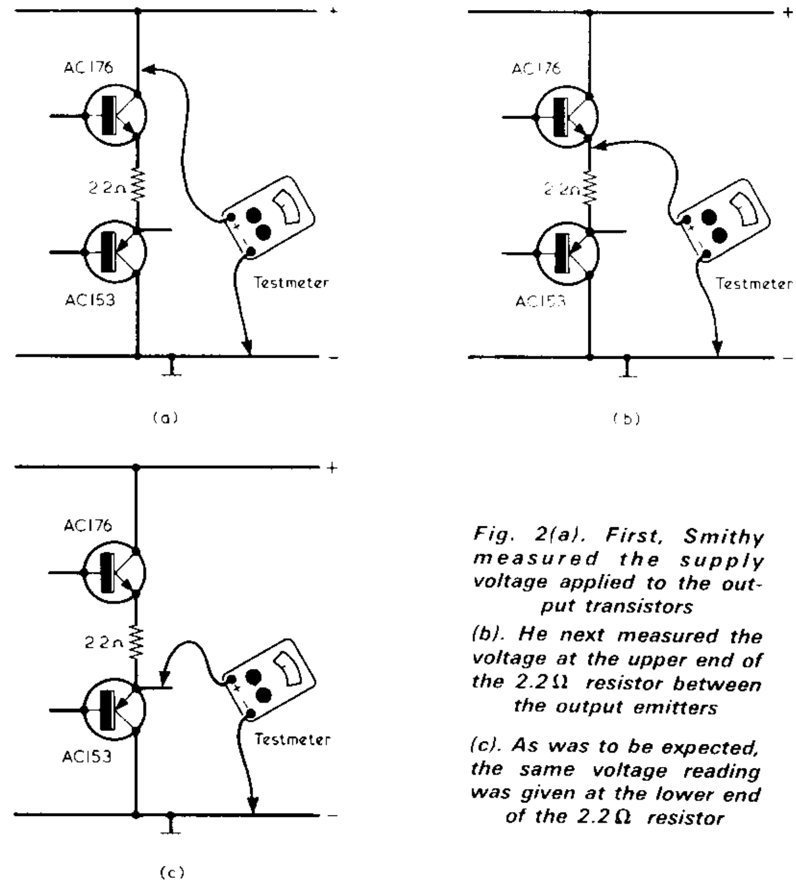


Fig. 2(a). First, Smithy measured the supply voltage applied to the output transistors

(b). He next measured the voltage at the upper end of the 2.2Ω resistor between the output emitters

(c). As was to be expected, the same voltage reading was given at the lower end of the 2.2Ω resistor

"There doesn't appear to be anything very complicated there," commented Dick in a despondent tone as he glanced at the circuit. "What's supposed to be the snag?"

Smithy glanced at a small ticket attached to the record player.

"According to this," he remarked, "there's distortion in the right hand channel."

"Fair enough," responded Dick.

He gave voice to a heavy sigh.

Smithy glanced at him sharply then plugged the record player into the mains. After this he switched it on and reached up to the shelf over his bench for an l.p. test record. The changer mechanism caused the record to clatter down onto the rotating turntable and the pick-up stylus to descend into the outside lead-in groove. There was a slight hiss from the speakers, after which both channels were reproduced at a comfortable volume level without any noticeable distortion on either.

Experimentally, Smithy reduced the volume. As he did so a noticeable and increasing distortion became evident in the right hand channel, and the sound from its speaker disappeared almostly completely when there was still a small volume level audible from the left hand channel speaker. Smithy rotated the balance control to favour the right hand channel, whereupon its volume level, still distorted, increased by a small amount.

"Well," he remarked contentedly, as he operated the changer lever to return the pick-up to its rest and then switched off the amplifier, "there's nothing very mysterious about the symptoms here. Righty-ho, Dick, perhaps you'd like to get the printed board out."

"Huh!" grumbled Dick as he moved towards the record player and picked up a screwdriver from Smithy's bench. "I thought you'd get me over to do the donkey-work."

"Here, what's getting into you these days?" queried Smithy irritably. "For the last few weeks you've been getting more and more miserable all the time. You're positively insufferable this afternoon."

"It's my luck," complained Dick, removing the bottom cover of the record player amplifier. "There's nobody, *nobody*, who could have luck which is as bad as mine."

"I hadn't noticed," stated Smithy. "Incidentally, isn't it your birthday in a few days' time? That should be something to look forward to."

"It's on the seventh of April, if you must know."

By now, Dick had removed the knobs from the volume, balance and tone controls.

"Ah yes," commented Smithy knowledgeably. "That makes you an Aries, doesn't it?"

"I'll say it does," said Dick unhappily. "And, what's more, I'm dreading my birthday. When is your birthday?"

"First of September," responded Smithy promptly. "I'm a Virgo."

"Then you're the one who's getting all the good luck whilst I'm the one who's getting all the bad luck. Oh well, let's get on with this printed board."

The pair fell silent for some moments as Dick struggled with the board. Eventually, he was able to lay it out on the bench, coupled to the pick-up by way of a stereo screened lead, and to the speaker sockets by 2-way flexible leads. The three controls were secured to the board and Dick refitted their knobs.

VOLTAGE CHECKS

"Shall we try the record again?" asked Dick.

"Not for the moment," responded Smithy. "I think I'll do a few d.c. voltage checks first."

He switched on the amplifier, turning the combined volume control and on-off switch to a central volume setting, pulled his testmeter towards him and set it to a voltage range. He clipped its negative lead to the record player chassis, then, after consulting the service sheet, located the output stage of the offending right hand channel amplifier.

"First check," he called out, "is to measure the supply voltage. Tell me what the meter reads."

He applied the positive test prod to the collector of the AC176. (Fig. 2(a).)

"About 21 volts," said Dick.

Smithy applied the meter to the emitter of the AC176. (Fig. 2(b).)

"And now?"

"10 volts."

"Good," remarked Smithy. "That means that the output emitters are sitting at about half the supply voltage. The 2.2Ω resistor between them is almost certain to be all right, but I'll just confirm it by measuring the voltage on the emitter of the AC153. What's the meter say now, Dick?"

Smithy touched the test prod against the AC153 emitter. (Fig. 2(c).)

"10 volts again."

"Right," commented Smithy. "Since the distortion only appears at low volume levels, let's see if the output emitter voltage varies if I adjust the volume control."

Slowly, Smithy rotated the volume control knob anti-clockwise.

"The voltage is still steady at 10 volts," announced Dick. "Wait a minute, though, it's started to go up! Blimey, it's going up all the time; it's right up to 20 volts now!"

"And that," said Smithy, taking his hand off the volume control knob and removing the positive testmeter lead from the printed board, "is the output emitter voltage given when the volume control is at the minimum volume position. I hardly need to tell you what

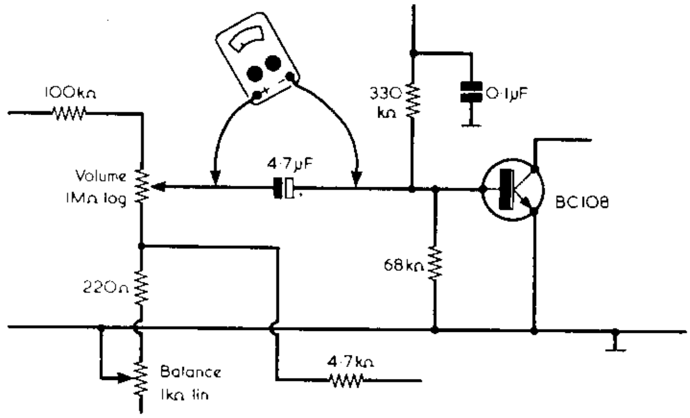


Fig. 3. Checking the electrolytic capacitor coupling the volume control slider to the base of the BC108

component will be the most obvious cause of this snag, do I?"

"Don't you? I'm darned if I can see it."

"Look at the circuit and think about it. The slider of the volume control pot has no d.c. connection to the following stages in the amplifier, and yet it is altering the d.c. conditions in those stages. How can this happen when the only connection is via an electrolytic capacitor?"

"Do you mean the 4.7μF one between the pot slider and the base of the BC108?"

"I do."

"Oh," said Dick, his interest rising despite his gloom. "Perhaps it's gone short-circuit or low resistance, then."

"Exactly. Such a fault is the most probable because it's obvious that a short here would provide the unwanted d.c. connection. If the electrolytic *is* short-circuited, taking the volume control slider down to the minimum volume end of its track will cause the base-emitter voltage of the BC108 to fall below the 0.6 volt level which is needed to turn a silicon transistor on. So the BC108 will cut off. And that's exactly what is happening here."

Smithy switched off the record player, selecting a resistance range on his testmeter and adjusted its set-zero control. He then applied the test prods to the 4.7μF electrolytic capacitor. The meter indicated a very definite short-circuit. (Fig. 3.)

"What did I tell you?" said Smithy triumphantly. "A dead short, no less! Perhaps you'd like to fit a new capacitor, Dick."

"Oh, all right," responded Dick grumpily, as he walked towards the spares cupboard.

"Ye gods," snorted Smithy, "don't say you're still all cheesed off. What on earth is it that's getting you down?"

"If you must know," said Dick reluctantly, "it's the *District Clarion and Weekly Advertiser.*"

A grin passed fleetingly over Smithy's face. The *District Clarion and Weekly Advertiser* was a local journal of struggling circulation, erratic make-up and idiosyncratic coverage which subsisted mainly on neighbourhood club news together with photographs of weddings and other local events (credited, unpaid, to the photographers concerned) occasional poems (anonymous and similarly unpaid) and a remarkably varied selection of small advertisements for second-hand household goods.

"Ah yes," stated Smithy. "A very fine progressive publication, I didn't know you read it."

"My old maid aunt, Ineffible Eff, takes it. I used to quite enjoy glancing through it until they started this new astrology feature of theirs a couple of months ago. It's written by someone called Gipsy Esmeralda."

"Well?"

"Do you know, Smithy, that astrology column is sending me screaming up the wall! Every week, she prophesies middle of the road stuff for all the signs of the Zodiac except for Aries and Virgo. She gives marvellous forecasts for Virgo, and she foretells nothing but misery and disaster for Aries. And this is going on continually week after week. I tell you, it's driving me crazy!"

"You shouldn't let a thing like that get you down," advised Smithy. "Anyway, have you got that replacement 4.7uF electrolytic yet?"

EMITTER FOLLOWERS

Grimly, Dick tore his thoughts away from his forebodings for the future and concentrated on the immediate present.

"I've got it here now," he replied, handing the component to the Serviceman. "Incidentally, *you* seem to be trafficking in the occult today, too. What led you from the output emitter voltage going high to that 4.7μF electrolytic?"

"Just examine the circuit," said Smithy in reply. "There's only one amplifying device, so far as signal voltage is concerned, in the whole amplifier and that's the BC108. The three transistors which follow it are all emitter followers. This means that the voltage at the output emitters will be the same, give or take a fraction of a volt dropped in the base-emitter junctions, as that at the BC108 collector." (Fig. 4.)

"Yes?"

"So," continued Smithy, "if the BC108 cuts off its collector goes fully positive via the resistors which couple it to the positive rail. Now, the business of the BC108 is to hold the output emitters at a central voltage under quiescent conditions and it is assisted in doing this by the d.c. negative feedback resistors."

"Which ones are they?"

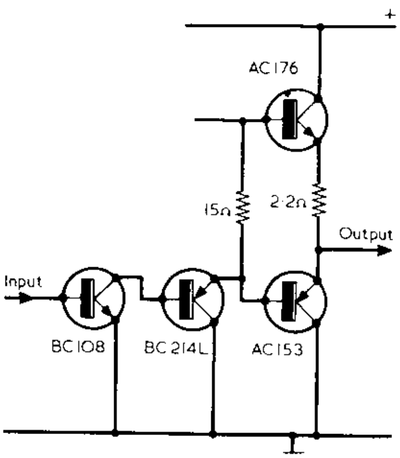


Fig. 4. The only voltage amplification in the amplifier is given by the BC108. The three transistors which follow are all emitter followers

"They're the 750kΩ and 330kΩ resistors from the emitter of the BC214L back to the base of the BC108. In company with the 68kΩ resistor from the BC108 base to chassis they keep that base at about 0.6 volt above chassis level."

Smithy traced out the circuit path with his finger. (Fig. 5).

"Hang on a minute," said Dick excitedly, "Am I correct in saying that if the upper end of the 750kΩ resistor is at 10 volts positive the base of the BC108 is about 0.6 volt positive of chassis?"

"You are. If you work out the voltages from the resistor values you'll find that that is the case."

"Right," said Dick decisively. "What happens after you switch on the amplifier, then, is that the emitters of the BC214L and the two

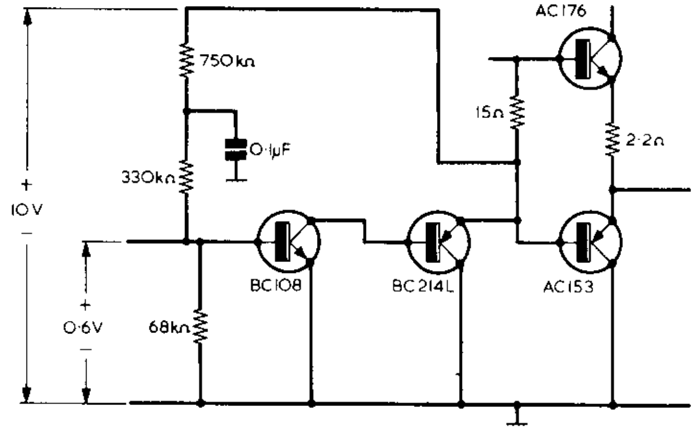


Fig. 5. The d.c. feedback loop consists of a potential divider given by the three resistors from the BC214L emitter to chassis. Their values cause about 0.6 volt to appear at the BC108 base when the BC214L emitter is at 10 volts

output transistors all start to go positive. When they reach 10 volts or so the base of the BC108 has risen to 0.6 volt above chassis, whereupon it starts to conduct and prevents the emitters from going any more positive."

"You've got it exactly. The 0.1µF capacitor between the junction of the 750kΩ and 330kΩ resistors and chassis is an a.f. bypass capacitor, and it kills any a.f. that would otherwise be fed back to the BC108, making the feedback loop purely d.c. only. And, of course, the shorted 4.7µF capacitor you've just replaced caused the BC108 base to go well below the 0.6 volt level at low volume control settings."

"So that's the d.c. feedback loop," commented Dick musingly. "Now, when a signal is applied to the base of the BC108 its collector will go positive and negative of the centre voltage as it follows the signal, and so also will the emitters of the emitter followers after it. Hallo, there's another feedback loop. It's the one from the output emitters via the 0.04µF capacitor and the 4.7kΩ resistor to the bottom of the volume control track." (Fig. 6.)

"That's the a.f. negative feedback circuit," stated Smithy. "Now, how about wiring in that new electrolytic?"

ANOTHER FAULT

"All right, said Dick brightly, as he seated himself in front of the amplifier printed board.

"Thank goodness you've started to cheer up a bit," commented Smithy. "You were beginning to get right up my nose with all that stuff about bad luck and Gipsy Esmeralda."

Dick's hand, reaching for the

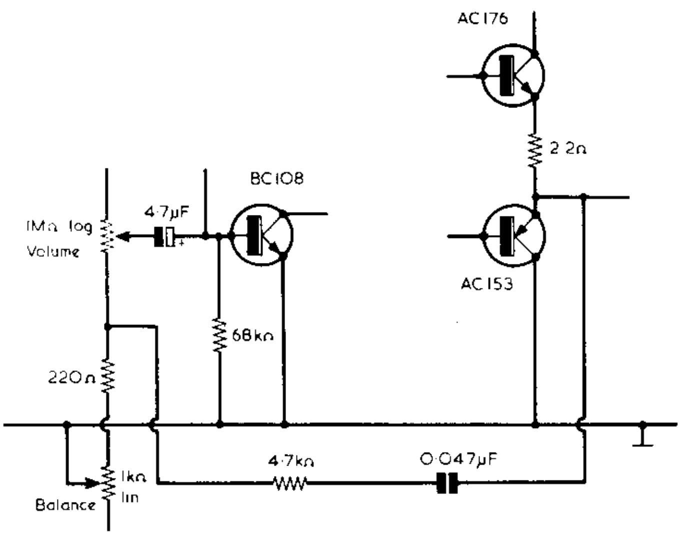


Fig. 6. A.C. negative feedback is provided via the 0.04µF capacitor and the 4.7kΩ resistor

soldering iron, faltered.

"Dash it all, Smithy," he complained, "what did you have to remind me of her again for? It's nothing short of traumatic picking up a paper each week and finding that you're booked for every calamity that's going. I'm dreading the latest issue."

"Why's that?"

"Well, you know that after the ordinary horoscopes she has a special section on birthdays during the following week, where she says what's going to happen in the twelve months to come. My birthday is next week, as you know, and I'm terrified of what she's put in the *Advertiser* for *my* next year."

Dick moaned unhappily.

"I suppose there's nothing else for me to do but soldier on," he stated morosely.

"An excellent sentiment," said Smithy approvingly. "In fact, if you get a move on putting in that new capacitor we should be able to get this record player finished before we pack up tonight."

Glumly, Dick busied himself with Smithy's soldering iron and snips, and it was not long before the new capacitor was installed. As Dick returned the soldering iron to its rest, Smithy leaned over and switched on the amplifier. He quickly checked the voltage between the output emitters and chassis, to find that this was now a steady 10 volts at all settings of the volume control. Putting his testmeter to one side he started the record again. This time the right hand channel produced an output which matched that of the left hand channel when the volume control was taken from its zero setting to about a quarter of its full output.

"That's cleared up the distortion fault," said Smithy triumphantly. "I must confess I'm quite satisfied with this record player now. Let's just turn the wick up a bit more before we finally declare it officially repaired."

He advanced the volume control further until the Workshop was filled with the sound from the two speakers. As he listened his expression changed from one of pleasure to one of exasperation. This time, whilst the left hand channel was happily handling high level signals, the right hand channel was quite clearly overloading.

"Blast it," snorted Smithy irately, as he turned back the volume control. "There's another fault here. We're getting distortion on the right hand channel at high volume levels now!"

"That's because," remarked Dick darkly, "you asked me to help you on this job. What's happened is that my bad luck has spread out onto this amplifier."

"Nonsense," retorted Smithy. "This second lot of distortion isn't by any means as noticeable as the one we've just cured and I would guess that the chap who owns this record player only plays it at fairly low levels anyway. It's almost certainly the first distortion snag which caused him to bring it in for service. Oh well, we'd better see what's causing this second fault."

"How do you intend to do that, Smithy?"

"I'm going to follow a hunch," replied Smithy. "I'm going to measure the voltage on the output emitters all over again, but this time with a signal from the pick-up going through. I'll start off by checking the output emitter voltage for the left hand channel."

"But the left hand channel isn't faulty!"

"I know it isn't. But one of the little benefits which are given by carrying out voltage checks in stereo amplifiers which have only one channel bad is that you can first see what the correct voltages should be with the *good* channel. Right, keep an eye on the meter, Dick."

The record was still playing as Smithy applied the positive prod of his meter to the output emitters of the left hand channel.

"The meter," pronounced Dick, "is reading about 10 volts again."

Smithy advanced the volume to its maximum level.

"It's still reading about 10 volts," called out Dick above the music from the speakers, "although the voltage is jogging a wee bit on loud passages. Nevertheless the general value is still around 10 volts."

"Right," said Smithy. He reduced the volume level once more, and applied the test prod to the output emitters of the right hand channel.

"It's 10 volts again," stated Dick.

Smithy advanced the volume to maximum.

"There's quite a noticeable difference on this channel," sang out Dick. "The meter needle goes *down* on loud passages, and it then hovers around the 6 or 7 volt mark. It's still sitting at 10 volts during the quiet bits, though."

BOOTSTRAP CAPACITOR

With a satisfied grunt, Smithy turned back the volume control.

"Those readings are quite informative," he remarked. "What they tell us are the *average* voltages on those output emitters. If the two output transistors are handling positive and negative signal half-cycles at equal level the meter reading should stay steady at 10 volts. The fact that it wobbles around a little with the left hand channel means that the channel is clipping a bit at high signal levels. But with the right hand channel the meter reading changes by a much greater amount. Since the average voltage drops, it follows that the output stage is giving less amplification to positive half-cycles than it is to negative half-cycles."

"What could cause that, Smithy?"

"Off-hand, several things. But since we found that the first snag was due to an electrolytic I'm going to chance my arm and see if the second snag is also due to an electrolytic. See if you can find me a 100µF electrolytic, Dick. Any working voltage above 15 volts or so will do."

Dick soon found a suitable component and handed it to Smithy. By now the record was nearing its end and Smithy recycled the changer so that the pick-up was once more at the start of the disc.

"You hold the test prod against

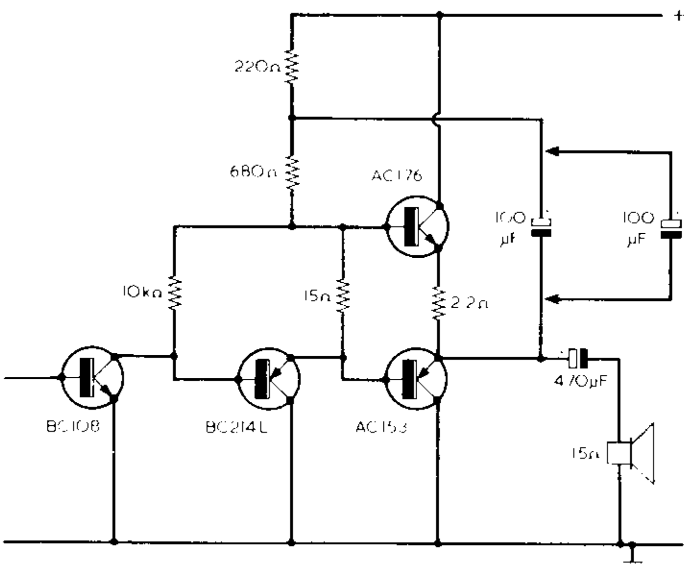


Fig. 7. Smithy experimentally bridged the 100µF capacitor in the amplifier by another of the same value. This capacitor provides the bootstrap coupling to the top of the 680Ω resistor, causing this to go positive as the signal output voltage goes positive

the right-hand output emitters on this occasion," he said. "I'm going to try a little experiment."

Once again, he turned the volume to full as Dick held the testmeter lead in position. After bending the 100μF capacitor leads to give a suitable spacing, he applied them across the lead-outs of the 100μF capacitor on the board which linked the output emitters to the junction of the 220Ω and 680Ω resistors. (Fig. 7.)

At once the overloading in the right hand channel ceased, and the two speakers both handled high amplitude signals at the same quality level.

"That's it!" shouted Dick. "The meter needle's now gone back to 10 volts all the time, with only a little waggle on the loud bits. Just like the left hand channel."

Pleased, Smithy took away the 100μF capacitor and turned back the volume control of the record-player.

"And that's our second snag located," he grinned. "The first one was a short-circuit 4.7μF electrolytic and the second one was an open-circuit 100μF electrolytic."

"But I don't understand it," wailed Dick. "How could that open-circuit 100μF capacitor cause positive half-cycles to be handled at reduced level by the output transistor?"

"Because," stated Smithy, "it's a bootstrap capacitor. It provides the bootstrap coupling back to the 680Ω load resistor for the BC214L emitter and the AC176 base."

"I still don't get it."

"Look," said Smithy. "On positive-going half-cycles the output emitter follower which is doing all the work is the AC176, right?"

"Well, yes."

"Then, if the 100μF bootstrap capacitor is open-circuit the base current from the AC176 has to flow from the positive rail through the 220Ω and 680Ω resistors. Okay?"

"Yes," repeated Dick guardedly.

"So, for high positive signal excursions which would normally take the AC176 base nearly up to the positive rail, the current available for that base through these two resistors is not high enough to enable it to go as positive as it should. That's why the output stage wasn't handling the positive signal half-cycles as well as it handled the negative ones. When we have a serviceable 100μF bootstrap capacitor, though, the upper end of the 680Ω resistor is caused to go positive, even above the level of the positive supply rail, on positive signal half-cycles. This means that there's always plenty of positive voltage available at the upper end of the 680 Ω resistor to give the required base current for the AC176."

Gosh, I can see it now! The AC176 emitter provides enough positive voltage via the 100μF capacitor to supply its own base through the 680Ω resistor."

"That's exactly right," confirmed Smithy. "Well, I see it's past packing-up time so I'll leave it to you to decide whether you put in a new 100μF capacitor now or leave it until tomorrow."

DICK'S FUTURE

"I'll do it now," said Dick hastily. "Anything to put off the evil hour."

"What evil hour?"

"I'm due to go to Auntie Eff's after this, and when I get there the latest issue of the *District Clarion and Advertiser* will be waiting lurking for me."

"It so happens," remarked Smithy in an off-hand tone, "that I've already picked up my copy of the latest *Advertiser* so I can save you the waiting."

He reached to a drawer in his bench, pulled out a newspaper and turned the pages.

"Here we are," he remarked cheerfully to his apprehensive assistant. "This is the astrology feature. What day did you say your birthday was on?"

"April the seventh," groaned Dick.

"Right," said Smithy. "Gipsy Esmeralda says: 'For those born on the seventh of April the next twelve months will be bleak indeed.' "

Feverishly, Dick snatched the paper from him.

" 'Be warned'," he read in a trembling voice, " 'that business ventures will inevitably end in bankruptcy, matters of the heart in betrayal, journeys in unfulfilment and ambitions in total failure.' Ye gods, how bad can things get?"

"Is that all?"

"There's more. 'Beware of legal entanglements. On the bright side is the fact that you may well see April the seventh for 1979 but, regrettably, with a personality so degraded that former friends and acquaintances will shun you.' "

Smithy's stricken assistant reeled back against his stool.

"It could be worse," said Smithy soothingly. "I forgot to put in the bit about your expenditure going up several hundred per cent."

"*You* forgot?"

"A creative geyser like me," stated Smithy, as he stood up and started walking hastily towards the Workshop door, "needs an outlet other than servicing sets and things. Even though I haven't been paid for it, I've enjoyed writing that Gipsy Esmeralda column over the last few months!"

With which words the erstwhile Gipsy Esmeralda retreated rapidly through the door, thereby delaying any retaliatory action from his furious assistant until the following morning.

After all, a day is a long time in astrology. ■