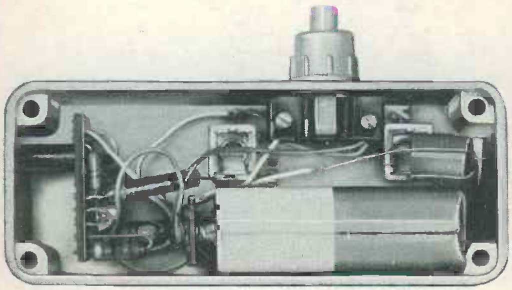
RADIO & ELECTRONICS CONSTRUCTOR

Vol. 26 No. 9 APRIL 1973 20p



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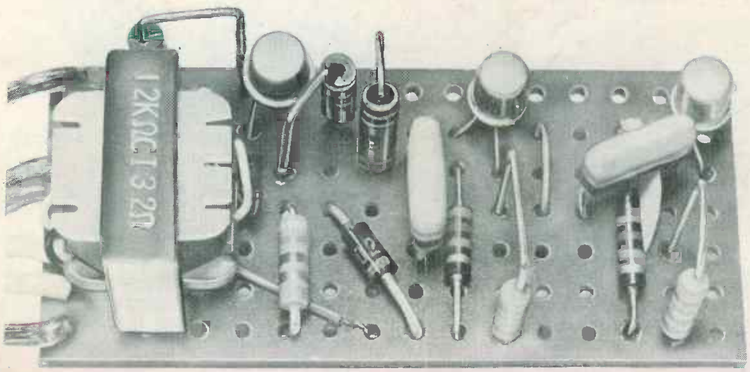

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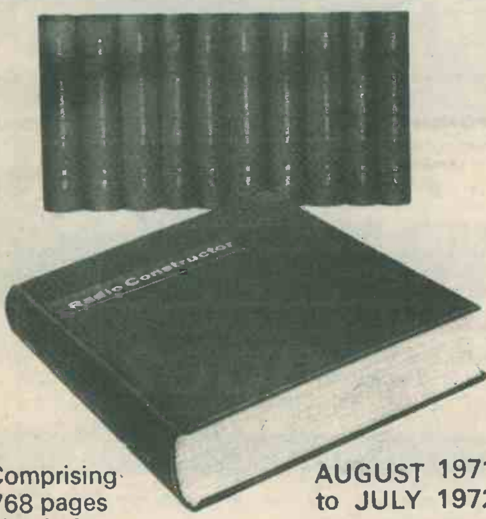

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400	0.06½	0.14½	0.07½	0.22	0.30	0.40½	1.37½
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Cathode cur'nt(mA)	2.3	14	
Numeral h'ght (mm)	16	13	9
Tube height (mm)	47	32	22
Tube diameter (mm)	19	13	12
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SPECIFICATION

Frequency Response 20Hz — 20KHz ± 1dB
Harmonic Distortion better than 0.1%
Inputs: 1. Tape Head 1.25 mV into 50KΩ
2. Radio, Tuner 35 mV into 50KΩ
3. Magnetic P.U. 1.5 mV into 50KΩ
All input voltages are for an output of 250mV. Tape and P.U. inputs equalised to RIAA curve within ± 1dB, from 20Hz to 20KHz.
Base Control ± 15dB @ 20Hz Treble Control ± 15dB @ 20KHz
Filters: Rumble (High Pass) 100Hz
Scratch (Low Pass) 8KHz
Signal/Noise Ratio better than — 65dB
Input overload + 26dB Supply + 35 volts @ 20mA
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Pole	Way	Type	
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6	4	Wafer Rotary	12p each
1	11	Wafer Rotary	
4	3	Wafer Rotary	
3	7	Wafer Rotary	
2	5	Wafer Rotary	
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260	12	
50	50	
100	18	
125	10	
8	50	
12	20	
10	20	
8.2	20	
50	25	
2.5	64	
25	25	

MFD	Volt	
20	12	4p each
500	6	
100	25	
100	6	2p each
6	3	
8	6	
25	6.4	3p
250	18	7p
400	16	6p
400	40	10p
8	500	9p
100	200	10p

CONDENSERS

MFD	Volt	
0.005	500	2p each
0.001	1,250	
3.3PF	500	
500 PF	500	
2,200PF	500	
3,300PF	500	
0.1	350	3p each
0.1	500	
0.25	150	
0.056	5% 350V	
0.061		
0.066		
0.069		
0.075		
0.08		
0.1	1,500	4p each
0.25	350	
0.5	350	5p
0.22	250	5p
0.25	500	5p

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ECL82	44p	PCF82	50p	UY85	42p
ECL86	56p	PCL82	38p	UM84	32p
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1 4	42	BY164	35p

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Amp	Volt		
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BYX49-600	2.5	600	25p
BYX48-300	6	300	27p
BYX48-900	6	900	40p
BYX48-1200	6	1,200	60p
BYX72-300R	10	300	35p
BYX72-500R	10	500	43p
BYX42-300	10	300	40p
BYX42-600	10	600	45p
BYX42-900	10	900	55p
BYX42-1200	10	1,200	75p
BYX46-300*	15	300	2.50
BYX46-400*	15	400	£2.90
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RADIO & ELECTRONICS CONSTRUCTOR

APRIL 1973

Vol. 26 No. 9

Published Monthly (1st of Month)
First Published 1947

Incorporating The Radio Amateur

Editorial and Advertising Offices
57 MAIDA VALE LONDON W9 1SN

Telephone 01-286 6141 *Telegrams* Databux, London

Annual Subscription: £2.70 (U.S.A. and Canada $7.00) including postage. Remittances should be made payable to "Data Publications Ltd". Overseas readers please pay by cheque or International Money Order.

Technical Queries. We regret that we are unable to answer queries other than those arising from articles appearing in this magazine nor can we advise on modifications to equipment described. We regret that such queries cannot be answered over the telephone; they must be submitted in writing and accompanied by a stamped addressed envelope for reply.

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Opinions expressed by contributors are not necessarily those of the Editor or proprietors.

Production.—Web Offset.

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Published in Great Britain by the Proprietors and Publishers, Data Publications Ltd, 57 Maida Vale, London, W9 1SN

The *Radio & Electronics Constructor* is printed by Carlisle Web Offset.

MAY ISSUE WILL BE PUBLISHED ON MAY 1st

AUDIBLE CONTINUITY

A simple item of test equipment which enables continuity checks to be carried out without the necessity of watching a meter.

THE CONTINUITY CHECKER DESCRIBED IN THIS ARTICLE was built up on a piece of Veroboard having a hole spacing of 0.15 in. The piece employed has 7 strips, each with 16 holes, and was, actually, the sample Veroboard which was given away free with the October 1972 issue of *Radio and Electronics Constructor*. A suitable piece can, of course, be cut from a standard Veroboard if the reader does not have the free sample on hand.

An audible continuity tester is an extremely helpful device for such requirements as the identification of tags in a complicated wavechange switch or the tracing out of wiring, since it enables the user to know when electrical continuity between two points is established without having to take his eyes from the connections.

CIRCUIT

The circuit of the continuity tester is given in Fig. 1, and it will be seen that this incorporates a multivibrator. The multivibrator is given in the circuitry immediately around TR1 and TR2 which are both transistors type BC107. The multivibrator runs at around 500Hz, with the collector of TR2 coupling to a 3Ω speaker via C3, R6 and transformer T1. It is necessary to include R6 as, otherwise, the inductance of the transformer primary adversely affects multivibrator operation. The audible level from the speaker is more than adequate for normal workshop use.

No supply is applied to the multivibrator when the two 'Test' terminals are open-circuit. Under these

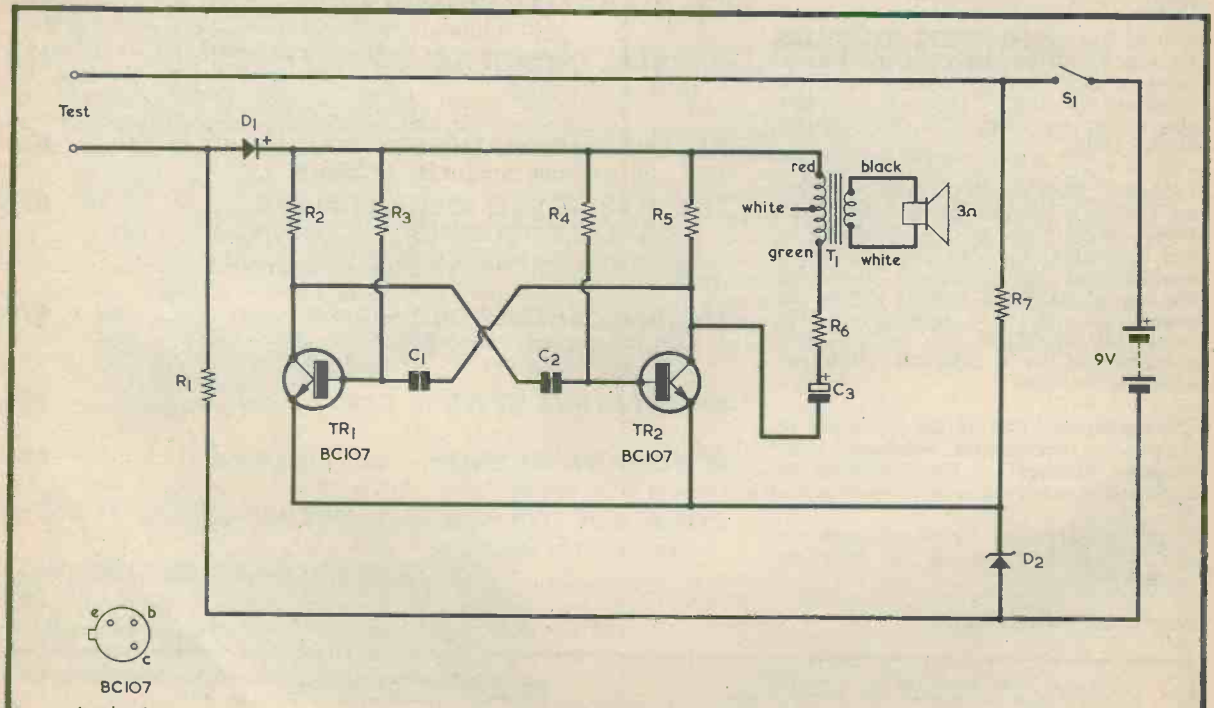
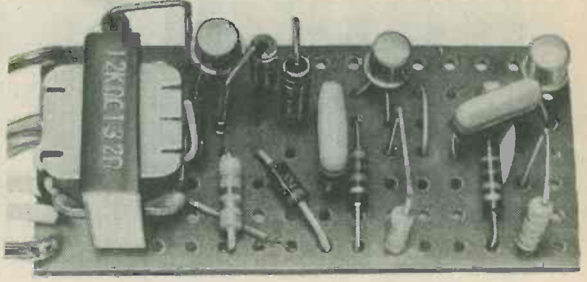


Fig. 1. The circuit of the audible continuity tester

TESTER



By P. T. Jenkins

conditions, the upper end of R1 is at the same potential as the negative line from the 9 volt battery and diode D1 is reverse-biased. At the same time, approximately the nominal zener voltage of 3.9 volts is caused to appear across D2 due to the presence of R7.

When the 'Test' terminals are short-circuited, the positive supply line is applied to the multivibrator via the diode D1 which is now conducting. Also, the voltage across the zener diode remains fixed at approximately 3.9 volts. Since approximately 0.6 volt is dropped across D1, a voltage of 4.5 volts becomes available to operate the multivibrator, which runs and causes the speaker to reproduce the 500Hz tone. Thus, the continuity tester produces an audible tone when the two 'Test' terminals are connected together.

COMPONENTS

Resistors
(All ¼ watt miniature 10%)

R1	470Ω
R2	2.7kΩ
R3	22kΩ
R4	22kΩ
R5	2.7kΩ
R6	470Ω
R7	10kΩ

Capacitors

C1	0.047μF, Mullard Miniature Foil type C280
C2	0.047μF, Mullard Miniature Foil type C280
C3	4μF, 10V Wkg., Mullard miniature electrolytic

Transformer

T1	Output transformer type LT700 (Eagle)

Semiconductors

TR1	BC107
TR2	BC107
D1	1N4001
D2	3.9 volt zener diode, 200-250mW

Switch

S1	S.P.S.T. toggle

Miscellaneous
Veroboard, 0.15in. matrix, 7 strips by 16 holes
3Ω speaker
9 volt battery
2 test sockets and plugs
2 test leads with prods or clips

The reason for including D2 and R1 is to restrict the sensitivity of the continuity tester when the test leads are connected to a circuit possessing resistance. An operating voltage is only applied to the multivibrator when the resistance across the 'Test' terminals is low enough to produce, at the upper end of R1, a sufficiently high voltage for D1 to conduct. In practice, the multivibrator commences to run, producing a very weak tone, when the resistance between the 'Test' terminals is about 350Ω. Lower values of test resistance produce increased volume of the reproduced tone, the latter being at its loudest when the 'Test' terminals are short-circuited.

The current drawn from the 9-volt battery is 0.5mA when the 'Test' terminals are open-circuit, and it rises to 22mA when they are short-circuited.

All the resistors used for making up the tester are ¼ watt miniature types. C1 and C2 are Mullard Miniature Foil type C280 (Home Radio Cat. No. 2EH47) and C3 is a Mullard Miniature electrolytic capacitor (Home Radio Cat. No. 2CH12). Diode D1 can be any silicon diode, and the 1N4001 specified fits comfortably onto the board. Diode D2 can be any 3.9 volt zener diode rated at 200 to 250mW.

CONSTRUCTION

The first procedure in construction consists of cutting the copper strips at the appropriate points. These are shown in Fig. 2, which illustrates the component and copper sides of the completed board. Cut the strips at holes A13, B4, B8, B11, C4, C10, C14, D9, E9 and G10.

Next, take up the output transformer, T1, and carefully file or snip its mounting lugs such that they are capable of being passed through holes G14 and B14. Do not, however, actually fit the transformer yet.

Consulting the upper diagram in Fig. 2, connect the two speaker leads to holes F16 and E16, and the two test leads to holes D16 and C16. Connect a link between holes C15 and A15. This link should consist of thin insulated wire. Shortening as necessary, and whilst the transformer is resting but not mounted on the board, connect the black and white secondary leads of T1 to holes F15 and E15. Then, whilst gently manoeuvring the secondary wires so that they do not become trapped under the transformer, pass the transformer lugs through holes G14 and B14 and solder the lugs at these holes. The transformer need not be pressed tight against the board; its mounting will be quite satis-

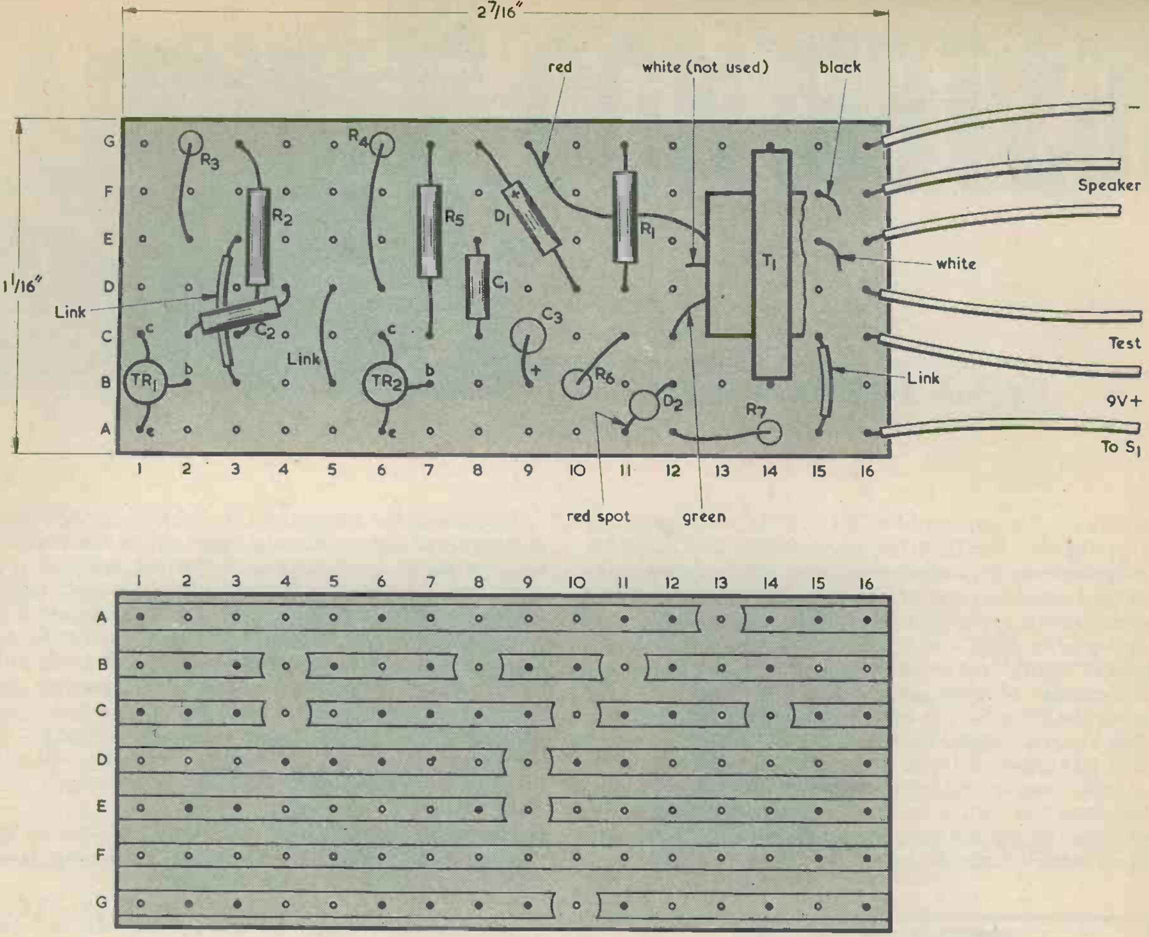


Fig. 2. How the continuity tester is assembled on the Veroboard

factory provided that sufficient of each lug passes through its hole to enable a satisfactory solder joint to be made. The reason for fitting the link and the other wires before mounting the transformer is that this component covers their connection points. The transformer is shown partially cut away in Fig. 2 to enable these connection points to be seen. Whilst dealing with the transformer, a further point is that its two lugs also provide a link via the transformer frame, between holes G14 and B14.

Connect the red primary lead of transformer T1 to hole G9, and the green primary lead to hole C12. The white primary lead is not used; any exposed end it may have should be cut off and the lead coiled up out of the way. It must not be allowed to short-circuit against the transformer frame or any other conductor. All of the transformer leads may, of course, be cut to a suitable length before they are connected into circuit.

Next fit an insulated wire link between holes E3 and B3, positioning this such that free access is available to hole C3. Fit a bare wire link between holes D5 and B5.

Following Fig. 2, fit the following components, which are all mounted horizontally: R2, R5, D1 and R1. The positive end of D1 connects to hole G8. Fit the zener diode, D2, to B12 and A11 with the lead-out which should connect to the positive side of the circuit in which it is used at hole A11. This lead-out is usually identified by a red spot on the outside of the diode case. Next fit capacitors C1 and C2. C2 straddles R2 and the insulated link between holes E3 and B3. Fit C3 vertically, with its positive lead-out at hole B9. Follow this with the fitting of R3, R4, R6 and R7, all of which are mounted vertically.

Fit the two transistors, a negative battery lead to hole G16 and a positive battery lead to hole A16. This last lead connects to the battery via S1.

The continuity tester is now complete and ready for use. If a voltmeter is available, check that approximately the zener voltage appears across D2 when the two test leads are short-circuited. For this test, the voltmeter may, for convenience, be connected between the negative battery lead and strip A1 to A12. If the voltage across the diode is less than 1 volt it has been connected the wrong way round. A zener diode connected wrong way round will also cause the tester to give an output when the 'Test' terminals are connected to values of resistance much higher than 350Ω.

The completed Veroboard assembly, the speaker and the battery can be housed in any conveniently sized plastic or wooden case, this having switch S1 and two test sockets on its front panel. Two flexible test leads terminated in prods or clips are also required, and these are plugged into the test sockets.

■

Two Colour Cathode Ray Tubes

by J. B. Dance, M.Sc.

The presentation of colour pictures for radar displays incurs techniques that are quite different from those used for domestic colour television

THE AMOUNT OF INFORMATION WHICH MUST BE displayed on some types of cathode ray tube screens is now very great. One of the ways in which this increased amount of displayed information can be more quickly evaluated involves the use of cathode ray tubes which can display two or more colours.

PHOSPHOR LAYERS

One might expect such tubes to employ the same type of techniques as those employed in colour television tubes, such as the three gun shadow mask tube. Although these tubes can produce excellent television colour pictures, the resolution provided by the groups of three dots of different phosphors is inadequate for high resolution radar tubes. The latter may be required to have a spot diameter of about 0.3mm. diameter and be capable of displaying information at any or all of about a million points on the tube face.

A high resolution cathode ray tube with a two colour display can be made by employing a layer of one phosphor deposited on the inside of the glass face of the tube with a layer of another type of phosphor deposited on the first phosphor. A thin inert layer which will not emit light is used to separate the two phosphors.

When the accelerating voltage applied to the tube is relatively low, the electron beam is absorbed in the first phosphor it meets. If, however, the accelerating voltage is increased, the electrons will have enough energy to penetrate through the one phosphor and excite the phosphor nearest the glass envelope of the tube.

The use of an inert layer between the phosphors helps to provide greater colour purity by preventing premature excitation of the phosphor nearest the glass by electrons of relatively low energy. The decay times of the two phosphors can be selected to suit the requirements of the particular application concerned.

MODES OF OPERATION

In one type of two colour tube a single electron gun is employed, the energy of the electron beam being changed by varying the potential applied to the final anode of the tubé. The two colours are actually displayed sequentially, but if the tube voltage is switched very rapidly, they appear virtually simultaneously. In some tubes a post deflection acceleration electrode is used and it is then possible to prevent the change of accelerating voltage from affecting the deflection sensitivity and the focusing of the tube.

Another type of tube employs two electron guns. The anodes of such a tube are at the same potential, but one of the cathodes is at a much greater negative potential than the other cathode. Each electron gun then excites its own phosphor.

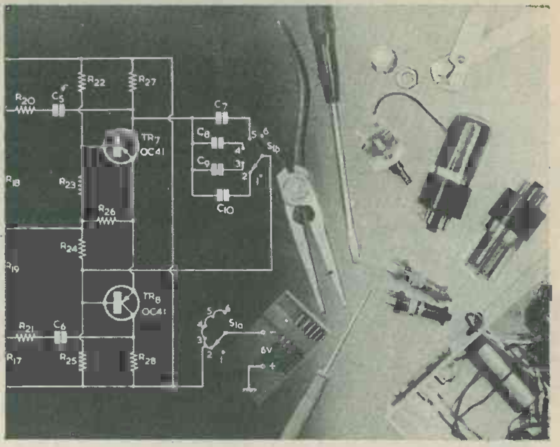
Two colour tubes being developed at present operate at typical accelerating voltages of 8kV and 13kV, but it is possible to generate some intermediate colours by the use of an intermediate accelerating voltage.

APPLICATIONS

It seems likely that two colour tubes will be used in oscilloscope displays, warning systems, computer displays, airline traffic schedule boards, seat reservation displays, etc. Developmental work has been carried out by The M-O Valve Company, London W6 7PE, and a range of tubes is now available.

HIGH INPUT IMPEDANCE AMPLIFIER

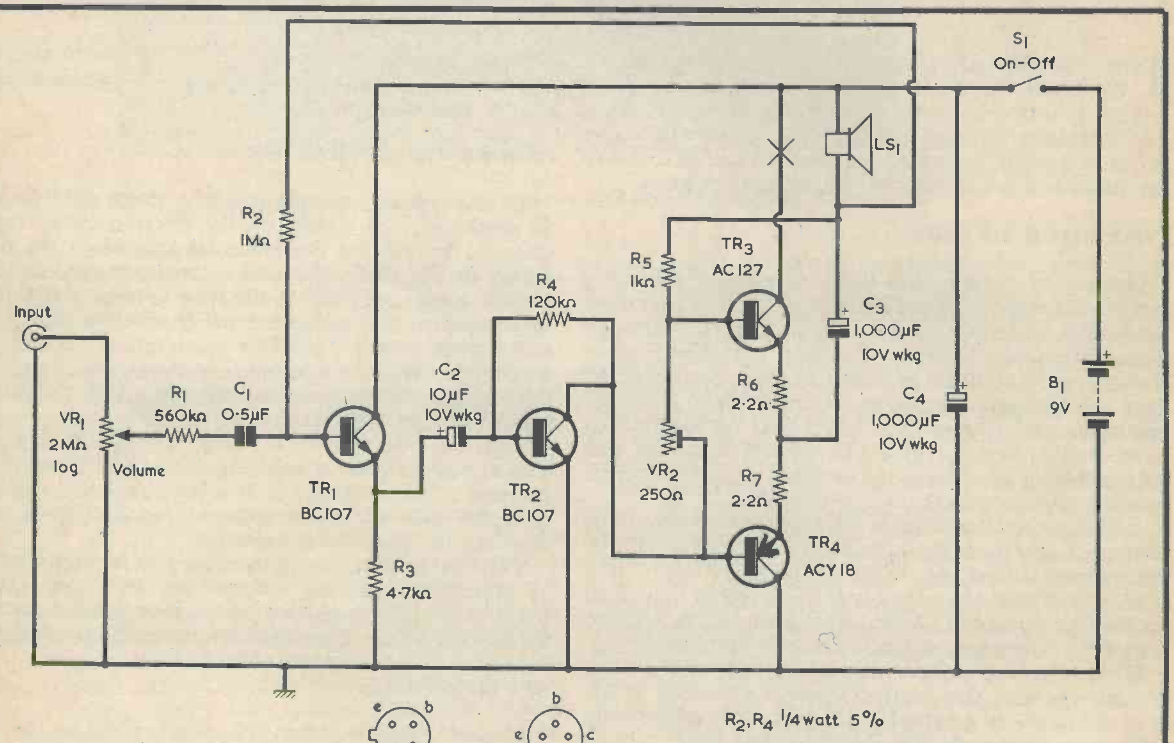
by G. A. FRENCH



THIS MONTH'S ARTICLE IN THE 'Suggested Circuit' series is devoted to a simple a.f. amplifier which may be employed for general purpose work where a high input impedance is required. It is particularly useful for amplifying the output from a ceramic gramophone pick-up, and it can be similarly loaded by other inputs having the same voltage amplitude. With a 25Ω speaker the output power available before the onset of clipping is of the order of 300mW, and the quality of reproduction is comparable with that given by the larger type of transistor battery portable radio. A somewhat unusual bias technique enables feedback to be applied overall without additional components.

THE CIRCUIT

The circuit of the amplifier appears in the accompanying diagram, and it will be noted that it employs two silicon transistors in the first stages, these being followed by two germanium transistors in a complementary emitter follower output stage.



The circuit of the amplifier. This can be coupled direct to a ceramic pick-up and it offers an output of 300mW when a 25Ω speaker is used.

The input signal is applied to volume control VR1, whose slider couples to the base of TR1 via R1 and C1. The impedance at TR1 base is such that the input impedance of the amplifier is approximately 700kΩ when VR1 slider is at the top end of its track. The input impedance increases gradually up to 2MΩ as VR1 slider moves down its track towards the minimum volume end. These impedance figures are sufficiently high to enable a ceramic pick-up to be connected directly to the amplifier input.

TR1 functions as an emitter follower and it offers no voltage amplification. Its emitter couples to the base of TR2, which is connected in the common emitter mode. TR2 provides both voltage and current amplification, the latter being sufficient to drive the two output transistors, TR3 and TR4. Apart from a small crossover range for small signal deviation, only TR3 is conductive for positive half-cycles at the collector of TR2 and only TR4 is conductive for negative half-cycles. When conductive, each output transistor operates as an emitter follower and the overall output stage is a conventional Class B complementary design. The collector current for TR2 is obtained via the speaker, R5 and VR2; and a.f. coupling to the speaker is achieved via C3. The two low-value resistors, R6 and R7, are included to prevent thermal runaway in the output transistors.

Finally, S1 is the on-off switch, whilst C4 is a high-value electrolytic capacitor which ensures that a low impedance is still present across the supply rails when the battery ages and its internal resistance increases.

All the transistors except TR2 act as emitter followers, whereupon they may be expected to contribute little distortion to the signal as it is amplified. TR2 is, however, called upon to provide a wide collector voltage swing whilst driving the output transistors, and it cannot do this without contributing a significant degree of distortion. A slight reduction in this distortion is given by returning the bias resistor, R4, to TR2 collector, thereby introducing a small level of negative feedback. But the distortion produced by TR2 is mainly reduced to an acceptable level by coupling TR1 bias resistor, R2, to the lower terminal of the loudspeaker. This overall feedback loop encompasses the whole amplifier including the speaker, and enables the quality of reproduction to be adequate for an inexpensive amplifier of this type.

The values of R2 and R4 are such as to cause the emitter of TR1 and the collector of TR2 to be reasonably close to half supply voltage level for virtually all transistors type BC107, regardless of spread in hFE.

In practice, the collector voltage of TR2 should have a value which causes the junction of R6 and R7 to lie at some 4 to 5 volts positive of the negative supply rail. This means that a peak voltage of at least some 4 volts in either direction is available to drive the speaker before clipping takes place. A peak voltage of 4 corresponds to an r.m.s. voltage of 2.8 with the result that, from V^2/R, an output power of slightly more than 300mW is feasible with a 25Ω speaker.

COMPONENTS AND CONSTRUCTION

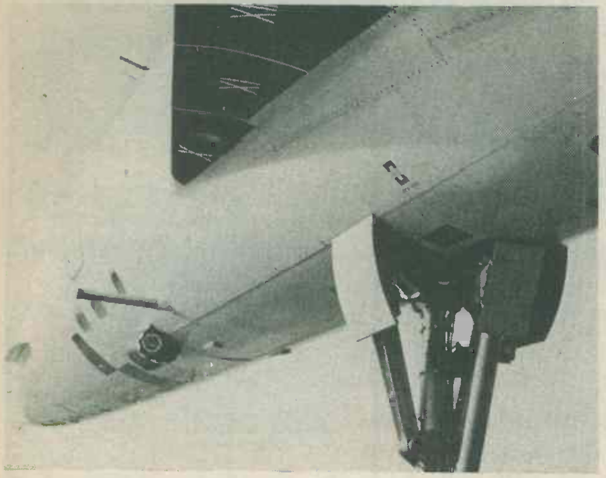
All the components used in the amplifier are readily available. It is important that the transistors employed be those specified. The fixed resistors are as indicated in the diagram. VR1 is a standard panel-mounting potentiometer and it can be ganged with S1, if desired. VR2 may be a skeleton pre-set potentiometer. The electrolytic capacitors can have higher working voltages than those indicated, should components with such working voltages be easier to obtain. The quiescent current drawn by the amplifier is around 10mA, this rising to 50mA or so on volume peaks. A suitable 9 volt battery is the Ever Ready PP9.

Construction should raise no problems and virtually the only layout requirement is that the components in the input circuit, i.e. VR1, R1, C1 and R2, be kept away from those in the output circuit. The input circuit is also very slightly susceptible to hum, but there is no necessity to screen the components concerned if mains leads are not allowed to approach them closely. The complete amplifier can be enclosed in a metal case which is common with the negative supply rail, and this will ensure that all internal components are automatically screened. The coupling from a ceramic pick-up, or similar high impedance source of signal, to the amplifier input socket should be made via a screened lead.

The connection between the collector of TR3 and the positive supply rail should be omitted during initial wiring. The connection is indicated by a cross in the diagram. When the wiring, apart from this connection, has been completed and checked, a current reading meter is inserted between the collector of TR3 and the positive supply rail. VR2 is set so that it inserts minimum resistance into circuit, a 9 volt battery is connected and S1 is switched on. The resistance inserted by VR2 is then slowly increased until the meter indicates about 7mA. The amplifier is next switched off, the meter removed and the collector of TR3 connected permanently to the positive supply rail. It is important to ensure that VR2 is not accidentally set to insert too high a resistance, as the output transistors may then pass excessive current. The amplifier is now set up and complete, and it may be checked out with a ceramic pick-up or similar a.f. signal source. ■

NEWS . . . AND .

COLD WORK FOR CONCORDE CLOSED-CIRCUIT TV CAMERA



Aimed rearwards under the fuselage and port wing of Concorde 002, an all-weather THV-1160 closed-circuit television camera from Bell & Howell provides key pictures of the aeroplane's latest flight-test programme for study by BAC engineers. The camera is visible (left) inside the bubble-type housing

Airborne in temperatures falling to –30°C, a closed-circuit television camera mounted on the outside of Concorde 002 is serving as a flying "eye" for engineers of the British Aircraft Corporation during the current flight-test programme. Giving a rearward view under the port wing, the camera feeds pictures of the complete aerofoil, including the engine intakes, to video recording equipment in the aircraft.

A THV-1160 from Bell & Howell, the camera is an all-weather type with a built-in heating system to combat the extreme cold of high altitudes. Low temperature operation is fundamental to the present tests, which are concerned with the formation and dispersal of ice.

This THV-1160 is a Bell & Howell modified version of a standard monochrome Vidicon camera made by Thomson-CSF Audiovisuel of France. It has been adapted to operate under external sync control and its housing has been pressurised, it is otherwise the normal 1160 camera.

A second closed-circuit camera, a THV-1100, has been installed inside Concorde 002. This supplies a digiclock input for superimposition on the video recordings. The signal is routed, through a Viscount keying system, to the video tape equipment, IVC type 821. Another 821 is on the ground for replaying the recordings.

The IVC 821 was chosen for use in Concorde mainly because it is a full-bandwidth VTR with read-after-write facility for the video track.

PEACE AT A PRICE

PEACE at a price – that's what is offered to parents and neighbours of teenagers who like to play, or learn to play the guitar. An idea which could revolutionize relations between the generations in some households, was described on BBC World Service's *New Ideas.*

The Guitar Set headphone allows the musician to practise on the electric guitar . . . in silence! The sound he produces is transmitted to the pair of headphones he wears which are plugged directly into the guitar itself.

There is no need to feed the sound through a special amplifier; the built-in twin miniaturised amplifiers are powered from a self-contained set of batteries, and you can, of course, control the volume of the headset.

It could prove a useful system for musicians and music schools. The system – the makers say – gives sound reproduction of excellent quality. The Guitar Set sells in Britain at just under £20 – not too bad a price to pay perhaps for peace and quiet?

EMI SUPPLIES NIGERIA WITH TV OUTSIDE BROADCAST VEHICLES

EMI has recently provided two monchrome television outside broadcast vehicles, worth over £155,000, to the Nigerian Broadcasting Corporation for its Channel Ten service based on Lagos. The 18 ft. long vans, complete with mobile power generators, were airfreighted to West Africa in time for the Second All African Games held in Lagos during January.

The photograph below shows a line-up of the vans and their respective EMI '2004' monochrome cameras, cabling, lighting and generator, prior to departure from EMI Sound & Vision Equipment Ltd. at Hayes, Middlesex.

. . . COMMENT

FARADAY LECTURE IN LONDON

The London delivery of "Navigation – land, sea, air and space", the 44th in the series of Faraday Lectures organised by the institution of Electrical Engineers, took place recently at Central Hall Westminster.

Man's navigational instinct is far inferior to that of many animals and he has therefore had, over the ages, first to develop the art and then to apply his scientific and technological skills to devising instruments that enable him to explore his own planet and the universe beyond.

Electrical engineers have played a major part in the development of navigational aids from the time of Michael Faraday in the early 19th century, with his experiments on electromagnetic induction, to the present day and the development of the directional gyroscope which is used by the Lunar Rover for navigating the moon's surface. With increasing numbers of people travelling greater distances on business and pleasure, with the growth of sailing and flying as hobby activities and with manned voyages into space, almost everyone relies to some extent on the electrical engineer who plays his part in designing navigational systems that not only extend the capability of man but also ensure his safety – at an acceptable cost.

"Navigation – land, sea, air and space" was the title of the Faraday Lecture delivered by Dr. Andrew Stratton, Director of the Defence Operational Analysis Establishment, and his Deputy Lecturer, Wing Commander (Retd) E. W. Anderson, Navigational Adviser of Smiths Industries Limited. They told the story of the development of navigation from the days when the stars were our only guide to the sophisticated instruments of today which have helped to make it possible for man to reach the moon.

PACKAGED POWER GOES TO MONTE CARLO RALLY

Driving a Sunbeam Stiletto in this year's Monte Carlo Rally, Andy Michailidis had a significant advantage over his competitors in the event of his car sustaining crash damage. Anywhere along the route between Glasgow and Monte Carlo, Andy was able to use mains-powered tools to effect emergency repairs.

This was made possible by a power unit manufactured by Jermyn Distribution, which provided a 250V, 50Hz, electrical power supply from car batteries. Supplying almost a third of a kilowatt, the unit was used to power an electric drill and a sheet metal cutting machine.

The Rally was Andy Michailidis' eighth international rally and his co-driver, Philip Bond, has driven in two similar events. Both drivers are convinced that the small amount of extra space taken by the Jermyn power supply and the extra weight were a small price to pay for the convenience of their own personal mains power supply.

Jermyn Distribution designed the power supply for domestic use during power cuts.

IN BRIEF

● Microwave 73, the first international conference and exhibition to be devoted to the microwave and allied industries, will be opened by HRH the Duke of Kent.

Microwave 73 will be held in Brighton from 19th to 21st June.

● LST Electronic Components Ltd., of Brentwood, Essex, expect a substantial expansion of their business following the sale of the company's equity to Crellon Holdings Ltd.

Prior to the sale of the equity LST was a privately-owned company founded by Mr. Peter Clarke, who remains Managing Director of LST and Arrow Electronics Ltd.

Mr. Clarke is a radio amateur with the call sign G3LST, hence the name of the company.

● The membership lists of The Radio Amateur Invalid and Bedfast Club show that they had more than 160 licensed members, and more than 240 SWL members at the commencement of this year.

● With the growing importance of the UK offshore oil industry, with its specialised radio communication requirements creating a vast market in its own right, the Marconi International Marine Co. Ltd., a GEC-Marconi Electronics company, has formed an Oil Industry Division under the management of Mr. G. H. W. Johnson.

POWER SUPPLY DESIGN

by A. Foord

How to design stabilized power supplies with the aid of zener diodes, transistors and integrated circuits.

THE POWER SUPPLY IS AN ESSENTIAL PART OF EVERY electronic equipment. In its simplest form it may consist of nothing more than a transformer, rectifier and smoothing circuit, but frequently more elaborate arrangements are needed so that an overall system can meet the stringent performance we expect today. Integrated circuits, for example, may demand well defined power supply levels.

In research and development where time and staff are at a premium it is sometimes more economical to buy complete power supplies than to develop them 'in house', especially if a high performance is required. However in consumer and home constructor applications, where low cost is a prime requirement, power supplies must be designed and constructed to suit the application. An easy and flexible approach is to use readily available components to construct a basic unregulated supply, and then add a suitable voltage regulator to provide the stabilization.

In this article we will consider how modern regulated power supplies are designed using either discrete components or integrated circuit voltage regulators.

BASIC ZENER DIODE SHUNT REGULATOR

The simples method of regulating the output voltage from a basic unregulated supply is by using a series dropping resistor and a shunt zener diode, as in Fig. 1. Here the series resistor R can be assumed to be the sum of the internal source resistance and an external resistor. If the input voltage rises then more current flows through the zener diode and a greater voltage drop is produced across R. The output voltage will always be equal to the zener diode voltage. The basic equation is:

$$Iin = Iz + IL.$$

The maximum power is dissipated in the zener diode when the load current is zero and the input voltage is at maximum. This is given by:

$$Pmax = Vz \times Iz(max)$$

$$\text{where } Iz(max) = \frac{Vin(max) - Vz}{R}$$

This must not exceed the rated power capacity of the diode. When the value for R is determined, the limiting case where Vin is minimal and the load current is maximal must be used. R must be small enough to allow the minimum permissible zener diode current to flow, so that the diode slope resistance is low. (Normally, the minimum permissible zener diode current would be found from manufacturers' data, and it is recommended that diodes are not run below the current at which the nominal characteristics are quoted. If this is not known they should not, as a very rough guide, be run below one-tenth of their maximum permissible dissipation.) Simple equations using Ohm's Law will give the various parameters in the circuit for the maximum and minimum input voltage and load current conditions. Ripple is reduced by a factor which depends on the value of R and the effective impedance of the zener diode (which may be about 3Ω for a diode dissipating 2 watts). One circuit for a 27V supply is shown in Fig. 2.

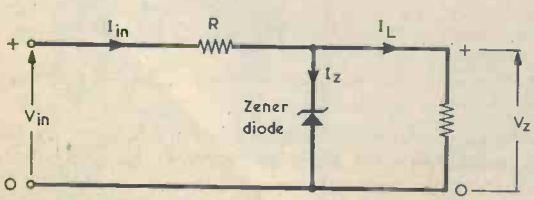


Fig. 1. The simple zener diode shunt regulator

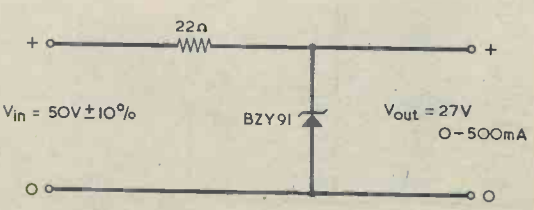


Fig. 2. A practical circuit for a 27 volt supply

The minimum zener diode current is about 100mA and the maximum diode power dissipated is about 34 watts. If the maximum ambient temperature were 65°C a heat sink with a thermal resistance of 1.0°C per watt would be safe. A Mullard type 50D extruded heat sink which was 10cm. long would be correct.

This circuit has the disadvantage that considerable power is dissipated in the zener diode under no-load conditions. Since both high power zener diodes and large heat sinks are difficult to obtain, particularly by home constructors, a zener diode circuit of this nature would only be used to supply small load currents. As small zener diode (400mW or 1.5W) are much more readily available the approaches shown later would be more applicable for the relatively large output current (500mA) illustrated here.

TWO STAGE ZENER DIODE SHUNT REGULATOR

When a particularly stable reference is required, for example in a digital voltmeter, a two stage regulator may be used, as in Fig. 3. This improves the stabilization against input voltage changes although the load and temperature stability is not improved very much. For best results temperature compensated zener diodes can be obtained which consist of a zener diode and a forward biased diode in series, so that the overall combination has a very low temperature coefficient.

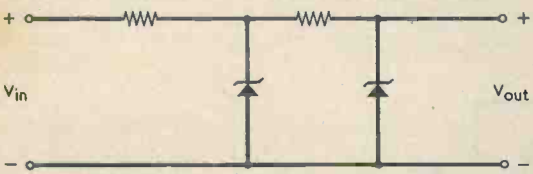


Fig. 3. The basic 2-stage zener diode regulator

SIMPLE SHUNT TRANSISTOR REGULATOR

A simple shunt transistor regulator can be constructed where a low power zener diode is used, see Fig. 4. The transistor can be regarded as an emitter follower and the output voltage will be the sum of the zener voltage and the base to emitter voltage (about 0.7V) of the transistor.

Although highly developed shunt regulators can be constructed, in general it is more efficient if the regulating element (usually a transistor) is in series with the supply.

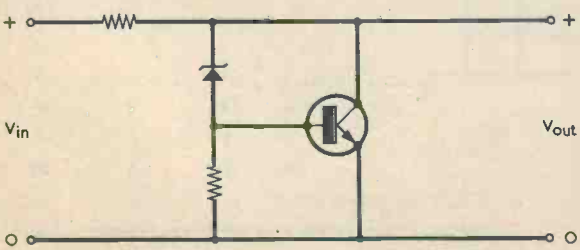


Fig. 4. A simple shunt transistor regulator

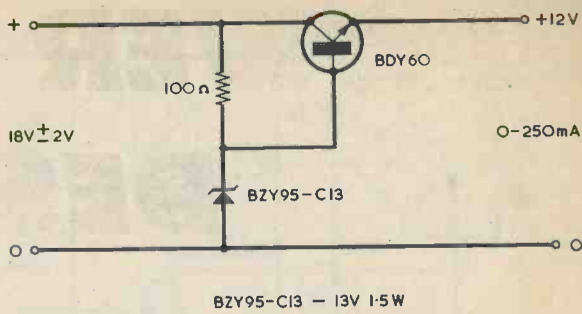


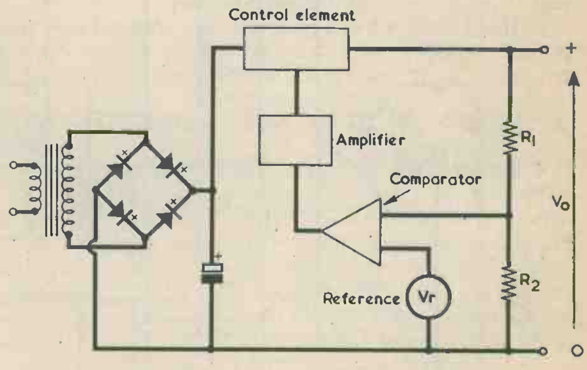
Fig. 5. A simple series regulator for a 12 volt supply

BASIC SERIES REGULATOR

The simplest form of series regulator is shown in Fig. 5. The transistor is used as an emitter follower where the base voltage is maintained constant. Design is straightforward in that the zener diode current must under all conditions be sufficient to maintain the diode at a low impedance. The unregulated supply must be chosen so that there is always a few volts across the transistor, even under maximum load conditions. However, using too high an unregulated supply increases the transistor dissipation without need.

FEEDBACK STABILIZED POWER SUPPLY

The previous regulator circuit can be considered as a device (the transistor) which compares a reference voltage with the output voltage (load current times load resistance) and brings them near to equality. In general terms a feedback stabilized supply will break down into the sections shown in Fig. 6. A reference



$$V_o = V_r \cdot \frac{R_1 + R_2}{R_2}$$

Fig. 6. The basic feedback regulated supply

voltage is compared with the output voltage, any error is amplified and used to control the output level. Depending on the gain round the loop such a circuit can give an excellent performance in terms of ripple and regulation if proper care is taken with the design.

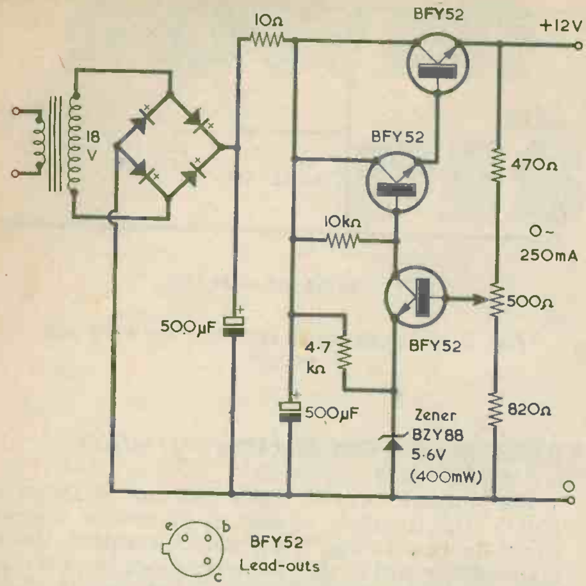


Fig. 7. A feedback regulated supply for 12 volts

A discrete component 12V supply is shown in Fig. 7. The series transistor dissipates up to 4 watts and should be mounted on a heat sink of thermal resistance 10°C per watt. The design is then suitable for ambient temperatures up to 50°C. Output ripple is about 2mV peak to peak and the voltage regulation is 5%.

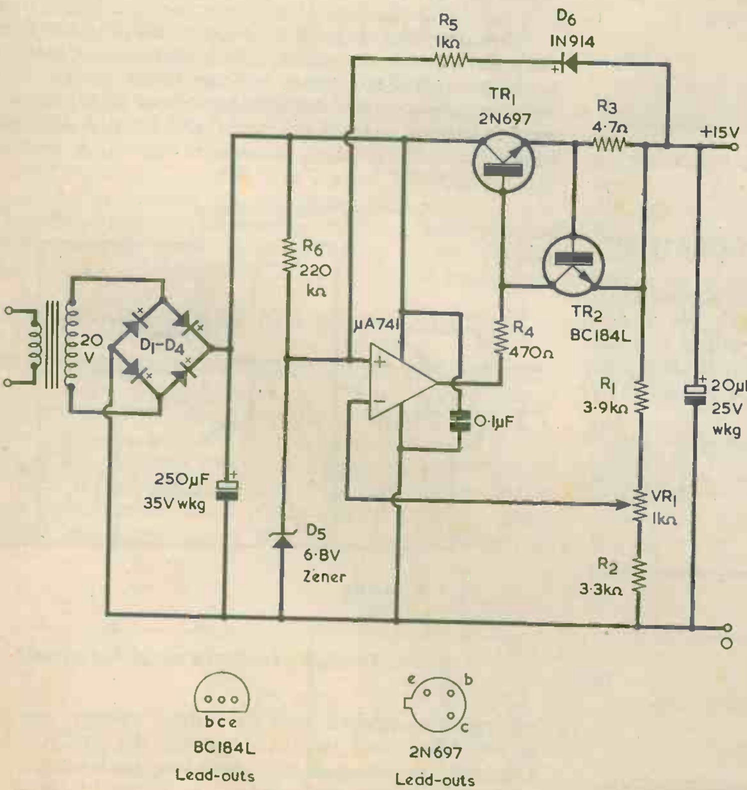
Although more elaborate circuits can be constructed using discrete components it is advantageous to use integrated circuits where an improved performance is required.

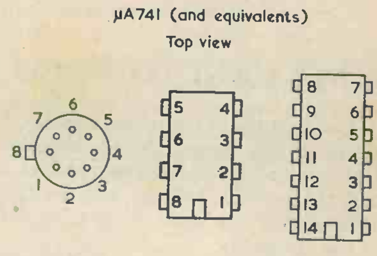
15 VOLT 100mA SUPPLY

The circuit for this supply is shown in Fig. 8. The μA741 is a general purpose operational amplifier and can be used in this type of circuit where a special purpose voltage regulator is not justified. The unregulated d.c. supply is applied through TR1 and the low value resistor R3 to the output. The output voltage is reduced by a potentiometer chain and compared with the reference. Any error is amplified by the μA741 and used to correct the base voltage of TR1. Protection against an excessive load current is provided by R3 and TR2. As the current through R3 increases, TR2 becomes turned on and reduces the base current available to TR1. The supply tends to become a constant current rather than a constant voltage one, and the current is limited to:

$$IL(max) = \frac{0.7}{R3} \text{ amps.}$$

The supply for the zener diode is taken from the output because this improves the performance. With this arrangement there may be a problem about starting





	TO5	8 lead DIL	14 lead DIL
V_{cc} +	7	7	11
V_{cc} −	4	4	6
+ in	3	3	5
− in	2	2	4
out	6	6	10
Offset null 1	1	1	3
Offset null 2	5	5	9

Fig. 8. A +15 volt supply using the μA741 integrated circuit

conditions when the supply is first switched on. The problem is overcome by R6 which supplies a small amount of current to the zener diode until the output is greater than 7 volts, when D6 conducts to provide the usual zener diode current.

The short-circuit current is limited to about 150mA. The hum and noise on the output is 2mV peak-to-peak at the full load current of 100mA. The power dissipated by the 2N697 will depend on the mean value of the unregulated supply under load, but would typically be 1 watt. This is within its rating if its case is kept below 100°C, so a heat sink must be used. Under short circuit conditions it may dissipate 3 watts or more, which is beyond its ratings on an infinite heat sink. The unit can be considered to be protected against a temporary short-circuit only, unless a slightly larger transistor is used.

To power operational amplifiers both positive and negative supplies are required. If identical regulator circuits are used then two separate transformer windings are needed, as in Fig. 9. If complementary regulators can be designed then a single (or centre-tapped) transformer winding can be used, as shown in Fig. 10.

A wide range of equivalents to the μA741 can be used in the circuits of Fig. 8 and Fig. 10. In the 8 lead T05 package, these include L141TI, MC1741CG, TBA221, LM741C, CA3056, SN72741L, μA741C and LIC741C/5. In the 8 lead d.i.l. package, equivalents are 7410PA and SN72741P. Equivalents in the 14 lead d.i.l. package are L141BI, MC1741CP, LM741CN, SN72741N and LIC741C/14. A further equivalent, the 741C, is available from Henry's Radio both in T05 and d.i.l.; whilst the 7410PA is an R.S. Components product. No connections are made to the offset null terminals.

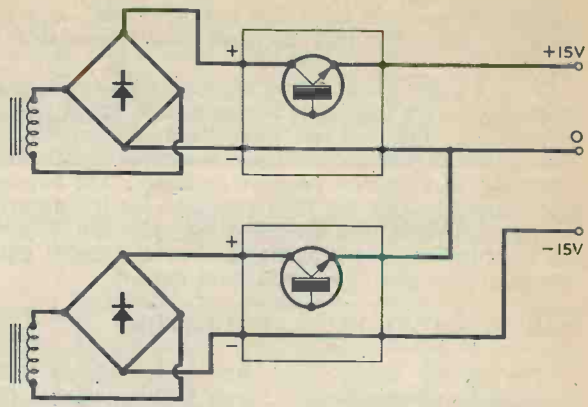


Fig. 9. If identical regulators are used then separate transformer windings are needed for dual supplies

VOLTAGE REGULATOR INTEGRATED CIRCUITS

Since the μA741 can work with a total supply rail of between about 6V and 30V, its use in the manner just described is suitable for power supplies from 6V to 24V or so. If several power supplies are required then it may be worthwhile using an integrated circuit specifically designed for power supply use. Most semiconductor manufacturers make suitable voltage regulators for positive, negative, or more recently, dual positive and negative outputs. The current available depends on the package; in general a current of up to

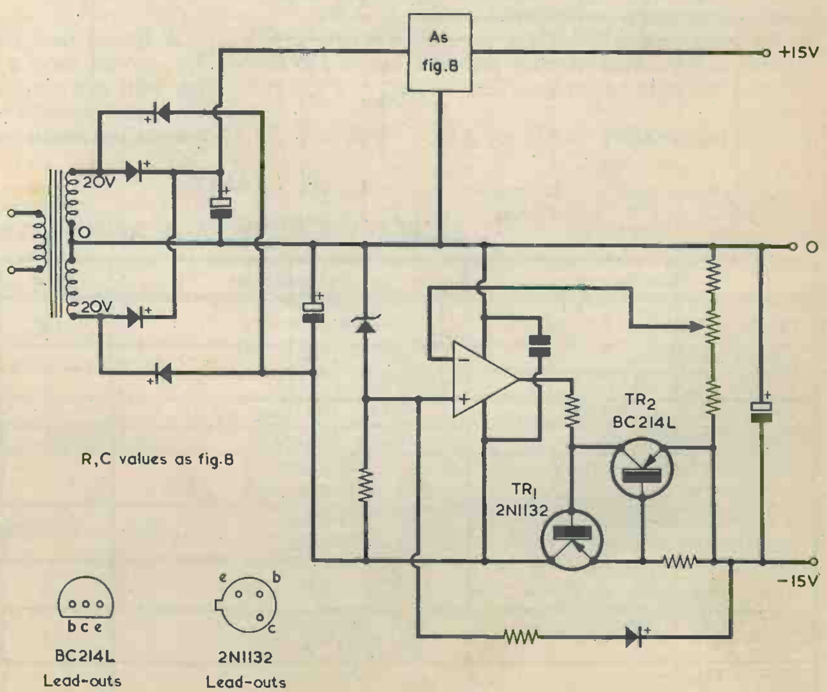


Fig. 10. Where complementary regulators are used two separate transformer windings are avoided

100mA is possible from the package itself, and an external transistor may be used to increase this if required.

Recent developments tend to require fewer external components for frequency compensation, short circuit protection, and voltage adjustment. It would be worthwhile comparing the many available types before deciding on a general purpose regulator. The circuits are designed along the lines indicated for the discrete component regulators and a few examples can be used to illustrate the types available. Manufacturers' data sheets always give full applications data.

THE SG309 VOLTAGE REGULATOR

The SG309 voltage regulator is completely self-contained and produces a 5 volt output suitable for driving logic integrated circuits. It is available in two packages, a T03 version which provides up to 1A and a T05 package which gives up to 200mA, depending on the power dissipated in the package. In large digital systems a 'rough' supply of 10V could be used with local regulation on each individual card. This reduces the problems of short switching spikes remaining on the power supply lines, which produce unpredictable results!

The parameters for the SG309 are shown in the Table, with a typical operating circuit in Fig. 11. It has built-in current limiting and thermal shut-down to protect it against excessive power dissipation, making it essentially destruction proof. The transformer and reservoir capacitor are chosen to keep the rough supply between 7V and 25V from no load to full load.

TYPICAL HEATSINK REQUIREMENTS

Suppose that the mean input voltage is 14V under the full load current, for the T03 version, of 1A.
Voltage dropped across SG309 = 14 – 5 = 9V.
Power dissipated in SG309 = 9 x 1 = 9 watts.
Maximum permitted junction temperature = 125°C.
Thermal resistance from junction to case = 3°C per watt.
∴ base temperature = 125 – 3 x 9 = 98°C.

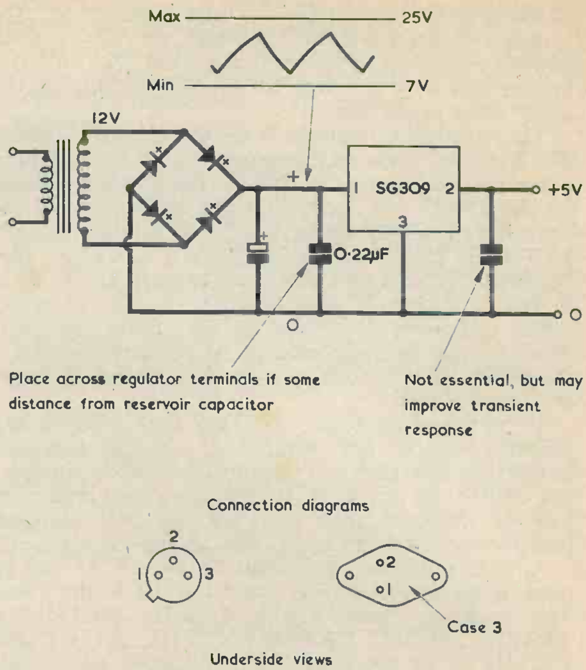


Fig. 11. A 5 volt supply using the SG309

Assuming an ambient temperature of 30°C, then the required heat sink thermal resistance is:

$$\text{Heat sink thermal resistance} = \frac{98 - 30}{9} = 7.6^\circ\text{C per watt}$$

A finned heat sink of dimensions 4in. by 1.5in. by 2in. would have a thermal resistance of about 3.5°C per watt and would provide a good safety margin. If a 9V transformer and suitable capacitor were used to reduce the mean voltage developed across the SG309

TABLE

SG309 5-VOLT VOLTAGE REGULATOR

Parameter	*Conditions*	*Min.*	*Typ.*	*Max.*	*Units*
Output Voltage		4.8	5.0	5.2	V
Line Regulation	Vin 7 – 25V		4	50	mV
Ripple Rejection	10Hz – 10kHz		75		dB
Output Noise Voltage	10Hz – 10kHz		40		μVr.m.s.
Output Impedance	10Hz – 10kHz		0.1		Ω
Thermal Resistance, junction to case	(a) T05 case (b) T03 case		15 3		°C/W °C/W
Thermal Resistance, junction to ambient	(a) T05 case (b) T03 case		150 35		°C/W °C/W
Maximum Junction Temperature				125	°C
Maximum Current	(a) T05 case (b) T03 case			0.2 1.0	A A
Power Dissipation (infinite heat sink)	(a) T05 case (b) T03 case			2 20	W W

then its power dissipation will be reduced. It is useful to note that the case is directly earthed so that in many applications the integrated circuit can be directly bolted to the chassis and a separate heat sink avoided.

The SG309 regulator may be obtained from Rastra Electronics Ltd., 275 King Street, Hammersmith, London, W6 9NF.

R.S. COMPONENTS REGULATORS

Regulators similar to the SG309 are also available in higher voltages. The R.S. Components type MVR series provide 5, 12 or 15V at 600, 500 and 450mA respectively. They are in T03 cans and, when used with the recommended R.S. Components transformers, the output ripple is typically 1mV.

The MVR 5V regulator should be employed with R.S. Components mains transformer type 633, the MVR 12V regulator with the transformer type 632 and the MVR 15V regulator with the transformer type 634. The circuit is the same as for the SG309, with the reservoir capacitor having a value of 10,000µF and the capacitor following the regulator a value of 10µF. The rectifier may be the R.S. Components silicon bridge type REC41A, which is rated at 1.8A with a p.i.v. of 100V.

These regulators, transformer and rectifier may be obtained from suppliers of R.S. Components products, including Chromasonic Electronics, 56 Fortis Green Road, London, N10 3HN or Celectron-E, P.O. Box No. 1, Llantwit Major, Glamorgan, CF6 9YN.

CA3055 VOLTAGE REGULATOR

This R.C.A. voltage regulator is designed to deliver up to 100mA over an adjustable output voltage range of 1.8 to 34 volts. A typical power supply circuit is shown in Fig. 12. Ripple might be less than 0.2mV at a 90mA current load. The regulator has short-circuit protection, a temperature compensated reference voltage, and current limiting. The device can be used for high current regulation, switching regulation, shunt regulation, and positive or negative voltages. The CA3055 is available from A. Marshall and Son Ltd., 28 Cricklewood Broadway, London, NW2.

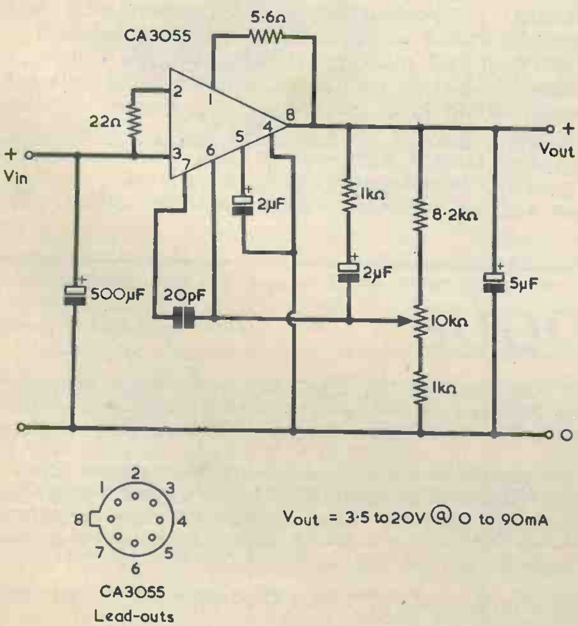


Fig. 12. A low current supply using the CA3055

SG3501 DUAL VOLTAGE REGULATOR

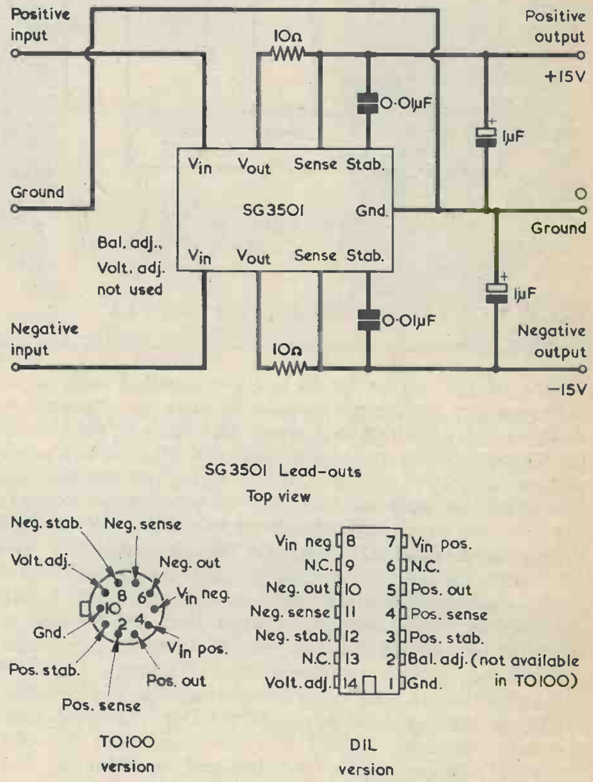


Fig. 13. A low current dual regulator using the SG3501

This is a dual polarity tracking regulator which provides balanced positive and negative output voltages at currents up to 100mA. It is internally set for ± 15 V but a single external adjustment allows both outputs to be varied simultaneously from 8 to 23 V. There is provision for adjustable current limiting and currents over 4 amps can be supplied if external power transistors are added. The minimum input to output differential is 2 volts. The maximum input voltage is 25 V. One circuit for a basic ± 15V, 50mA regulator is shown in Fig. 13 with a high current (4 amps) version in Fig. 14. The two power transistors must be mounted on adequate heat sinks. The types employed may be selected on the basis of current and voltage capability, with low frequency devices preferred to minimise the risk of oscillation.

The SG3501 regulator can be obtained from Rastra Electronics Ltd. at the address given earlier.

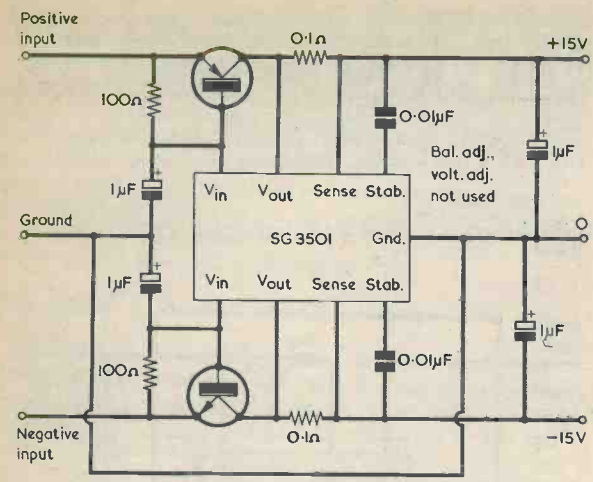


Fig. 14. A high current dual regulator using the SG3501

HIGH VOLTAGE REGULATED SUPPLY USING 741

One of the difficulties in using integrated circuits in high voltage regulated supplies is that the maximum device supply voltage is limited. This may be overcome by the outline arrangement shown in Fig. 15, designed around a μA741 (or one of its equivalents). Diodes D1, D2, D3 supply the amplifier with its correct operating voltages which are referenced to the output, so that output levels of 200V or more can be achieved. D1 maintains the amplifier positive supply terminal at 6V above the output voltage. D2 keeps the inverting input at 10V below the output voltage, and D3 maintains the required 30V across the amplifier supply terminals.

There is always more negative feedback through D2 (which has a low impedance) than there is positive feedback through the potential divider chain, so that the loop remains stable. The division ratio for the potential divider chain is obtained by making the chain's output 10V less than the regulator output voltage.

Short-circuit protection may be added as previously indicated although the series transistor dissipation will be high under short-circuit conditions. In this application and in high current regulators where the series transistor dissipation is excessive under short circuit conditions it is possible to add fold-back current limiting. This reduces the current to a low value as the output voltage falls to zero, and hence avoids dissipation difficulties.

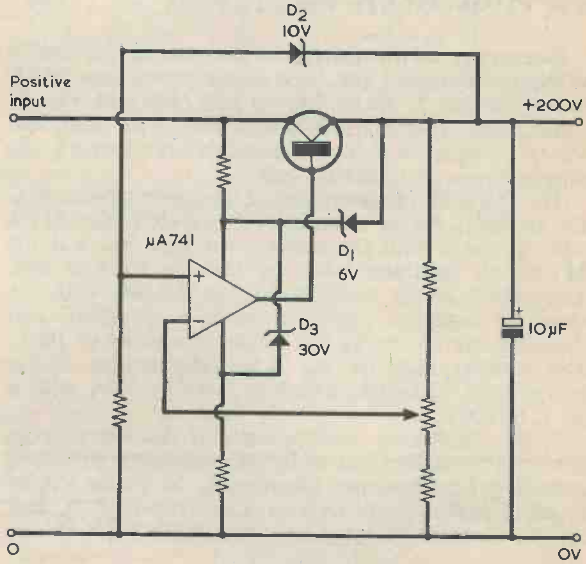


Fig. 15. A high voltage, low current supply using a μA741

CONCLUSION

We have seen how typical voltage regulator integrated circuits can be used on their own or with external components to provide a convenient and straightforward approach to power supply design. The high loop gain made possible by using an integrated circuit enables an overall performance to be achieved which would have meant the use of many discrete components a few years ago. We have not considered constant current regulators or high power switching regulators because such circuits have a rather limited use and are confined to specialised applications. ■

CATALOGUE

Currently available is the latest catalogue of Home Radio (Components) Ltd., 234-240 London Road, Mitcham, CR4 3HD. This is larger than previous Home Radio catalogues, its 250 pages, at 11¾ by 8¼ in., having a 25% greater area. It has a very attractive cover showing Dame Barbara Hepworth's famous sculpture 'Theme on Electronics', commissioned by Mullard Ltd., and reproduced by their kind permission.

The catalogue covers virtually every component likely to be required by the home-constructor and serious experimenter. No less than 6,785 components are listed, and there are 1,750 clear illustrations. The pages are attractively set up and easy to consult, and a browse through the catalogue can be both educational and productive of ideas for future projects. The components appear in general alphabetical order, but there is in any case a comprehensive index which enables any individual part to be located. An invaluable feature is the provision of Catalogue Numbers for the items, thereby eliminating ambiguities when ordering.

A noteworthy and up-to-date feature of the catalogue is the presentation of 'Theme On Electronics', by Barbara Hepworth, on its front cover.

Covering the gamut from aerial attenuators to zener diodes, this helpful catalogue is strongly recommended to anyone interested in the hobby of electronics. Details are given of methods of payment (including Credit Accounts) and of ordering. The catalogue costs 55p plus 20p post and packing, and includes ten free vouchers for 5p each.

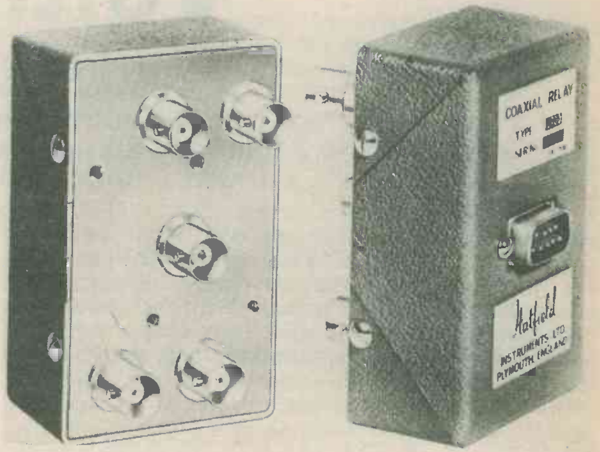
New Products

COAXIAL RELAYS

After extensive life testing Hatfield Instruments announce a range of low-priced 2, 4, and 6-way single-pole relays to enable complex and remote switching functions to be realised in a compact and convenient form. Specification quotes a minimum life expectancy of 1,000,000 operations although prototypes have been tested to over 5,000,000 operations.

The relays have all internal contacts hard gold plated and are available for 12 or 24 volt use. For maximum isolation the unused ways are grounded though non-shorting and terminated types (50 OHM or 75 OHM) are also available. Further developments are in hand to extend the range up to a single-pole 12-way version.

Further details from: Hatfield Instruments Ltd., Burrington Way, Plymouth, Devon PL5 3LZ.



STEREO HEADPHONES FROM MARANTZ

Pyser Britex (Swift) Limited, the sole U.K. distributors for Marantz International audio equipment, have just introduced a new set of stereo headphones to complement the existing range of Marantz products now available in this country.

Designated Model S.D.I., the headphones, pictured here, are finished in 'Marantz Gold' spray with black leather ear cushions and headband. The yokes are fully adjustable and pivoted.

The new headphones, which are available from accredited Marantz stockists, come complete with a 10 ft. spiral lead and are expected to retail at £11.50. ***Specification details*** **– Frequency Response: 20 .HZ–20 KHZ. Impedance: 8 OHM. Input: 1.0 watt per channel. Pyser Britex (Swift) Limited, 2nd Floor, Roussel House, North End Road, Wembley, Middlesex.**

TV PORTABLE FROM ITT

A battery/mains portable television with a performance to match its good looks is ITT's first offering in 1973. It retails at £69.

The screen, housed in a pleasing matt black non-reflective surround, offers a bright, sharp picture using the latest 12" slim-line 110 degree tube.

The brushed aluminium fascia is fitted with sliding volume and brightness controls with calibrated scales and push-button Varicap selections of BBC1, BBC2 and ITV. There is also provision for fourth channel tuning. A separate on/off switch leaves all other controls unaltered in operation.

AFC, contrast and pre-set tuning controls are easily accessible at the back of the set, where the loop aerial connection and external aerial socket are also to be found. The long mains lead stores tidily away on moulded cleats.

The Featherlight Super 12 weighs just over 16 lbs and the special lead supplied allows the use of a 12v car battery or similar power source for location viewing. Use of the battery lead automatically disconnects the mains circuitry.

ITT Consumer Products Ltd., Maidstone Road, Sidcup, Kent DA14 5HT.

High Resistance Voltmeter

by P. James

This easily contructed voltmeter offers three ranges up to 0-20V, and has the especially attractive feature of drawing a very small current from the circuit being checked.

Despite its simplicity, the electronic voltmeter described here offers a surprisingly good performance. Its main advantage is that its input resistance is exceptionally high. With the prototype it was found that there was little, if any, change in reading when a 10MΩ resistor was inserted in series with one of the test leads.

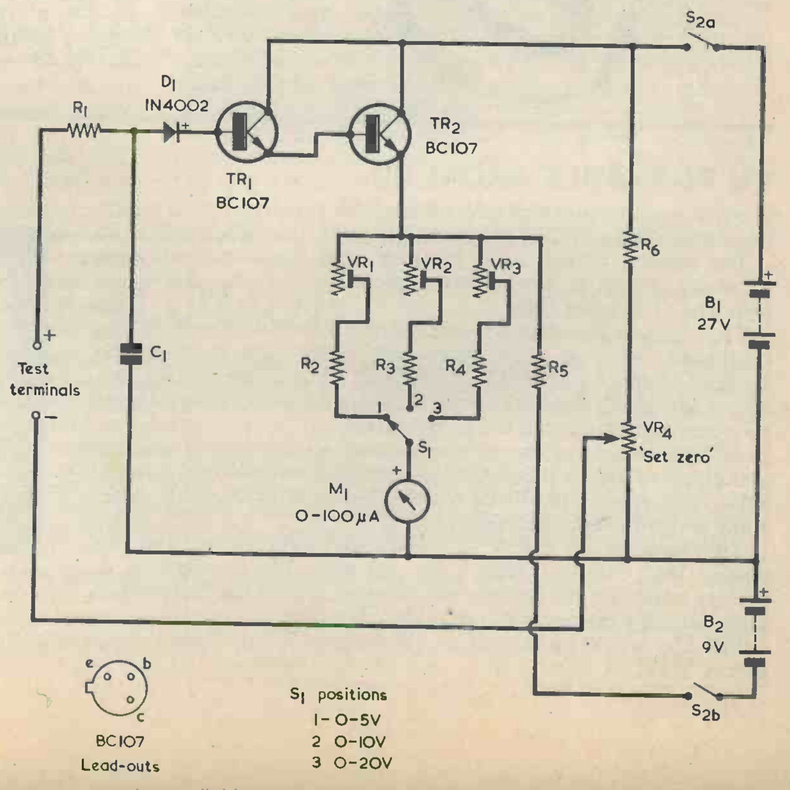
The unit has three ranges, these being 0–5V, 0–10V and 0–20V.

THE CIRCUIT

The circuit of the voltmeter appears in the accompanying diagram, and it will be seen that it is powered by the two batteries B1 and B2. B1 offers 27 volts and consists in practice of three 9 volt batteries in series. All four batteries can be small types, such as the PP3 or PP4.

Two flexible leads terminated in test prods are connected to the test terminals. The voltage applied to the positive test terminal is coupled via R1 and D1 to the two transistors, TR1 and TR2. These are silicon n.p.n. transistors type BC107, and are connected together as a compound emitter follower offering a very high level of current gain. The emitter of TR2 couples to meter M1 via whichever of the series resistors, R2 to R4 and VR1 to VR3, is selected by range switch S1. The variable resistors are adjusted such that the meter gives full-scale deflection when the emitter of TR2 is approximately 5 volts above the negative terminal of M1 on Range 1, approximately 10 volts on Range 2 and approximately 20 volts on Range 3. It is of advantage for the three sets of series resistance to be pre-set, as opposed to employing close tolerance components, since they may then be adjusted to take up varying performances in the transistors. The process of adjustment, which is described later, is very simple.

Because of the very high current gain offered by TR1 and TR2, the current drawn from the voltage source being checked is extremely low. Rectifier D1 is incorporated to ensure that high reverse base-emitter voltages cannot be applied to the transistors if the test prods should happen to be connected with incorrect polarity to a circuit being checked. A level of protection is also provided by R1 and C1. The base of TR1 is susceptible to a.c. and r.f. fields and, without R1 and C1 in circuit, there could be high meter readings if the positive test prod were touched by the finger. This effect



The circuit of the high resistance voltmeter. This draws negligible current from the circuit whose voltage is being measured clears when R1 and C1 are in circuit, although it may still be found that small random readings are given when the positive test prod is touched. These do not affect the accuracy of the instrument because the test prods should, of course, be held by their insulated sections when readings are being taken. R1 also provides current limiting.

When a reading is taken, the voltage at the junction of D1 and R1 is about 1.8 volts positive of that at the emitter of TR2. This is because there are three silicon junctions between these two points, each offering a drop of approximately 0.6 volts. It is necessary for the negative test terminal to be at the same potential as the positive terminal when there is zero voltage input, and this is achieved with the aid of VR4, which is set up for a zero reading in M1 with the two test prods short-circuited together. The setting of VR4 holds good for all three ranges, and the potentiometer only requires re-adjustment when battery voltage changes.

Resistor R5 and battery B2 ensure that TR1 and TR2 are still passing current when, with zero voltage input, the voltage at the emitter of TR2 is equal to that on the negative terminal of M1. There is a consequent improvement in linearity of readings at the lower voltages.

The current drawn from the 27 volt battery consists partly of that flowing through meter M1, which varies, according to the voltage being measured, from zero to 100µA, plus slightly more than 100µA passing through R6 and VR4. A current varying from about 40 to 140µA, according to the voltage being measured, is drawn from both batteries via R5. These currents are so low that the working life of the batteries should not be much shorter than their shelf life.

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)

R1	220kΩ
R2	39kΩ
R3	75kΩ
R4	150kΩ
R5	220kΩ
R6	220kΩ
VR1	25kΩ pre-set potentiometer, skeleton
VR2	50kΩ pre-set potentiometer, skeleton
VR3	100kΩ pre-set potentiometer, skeleton
VR4	25kΩ potentiometer, linear

Capacitor

C1	0.02µF plastic foil

Semiconductors

TR1	BC107, Mullard
TR2	BC107, Mullard
D1	IN4002

Switches

S1	Single pole 3-way, rotary
S2(a)(b)	D.P.S.T., toggle

Batteries

B1	27 volt battery (three 9 volt in series)
B2	9 volt battery

Meter

M1	0-100µA meter

Miscellaneous

Test terminals	Battery connectors
Test leads and prods	2 pointer knobs
	Materials for case

CONSTRUCTION

The voltmeter should be assembled in a small insulated case. An insulated case is required because neither of the test terminals is connected directly to a low impedance part of the circuit and a metal case could cause complications so far as earthing is concerned. A case made of plywood would be quite adequate. S1, S2, VR4, the test terminals and the meter should be mounted on the front panel.

After the unit has been assembled the sliders of VR1, VR2 and VR3 should be set to the centres of their tracks and the voltmeter switched on by means of S2(a)(b). Next, the voltmeter is zeroed by connecting the two test prods together and adjusting VR4 for zero reading in M1.

The ranges can next be set up. This process is carried out with the aid of another voltmeter which is connected in parallel with the test terminals of the unit. If a source of continuously variable voltage is available, this may be adjusted to give an output of 5 volts, 10 volts and 20 volts respectively. VR1, VR2 and VR3 are then set up on Ranges 1, 2 and 3 for full-scale readings in M1. In the absence of a variable voltage supply, Range 1 may be set up by connecting both voltmeters to a 4.5 volt battery, Range 2 by connecting to a 9 volt battery and Range 3 by connecting to an 18 volt battery (two 9 volt batteries in series). In this case VR1, VR2 and VR3 are adjusted to give readings in M1 which correspond with those in the second voltmeter.

The results given by the circuit are due to the fact that the transistors specified have, in general, very low leakage currents. In practice, these are lower than the maximum leakage currents specified by the manufacturers and there is a slight risk that some BC107's may not give the same performance as in the author's instrument. The writer has, however, used a number of different BC107's in circuits of this nature and, in every case, these have exhibited the low leakage current exhibited here. Readers constructing the voltmeter must accept the slight possibility (outside the writer's experience) that some devices may exhibit a high leakage current, within specification, whereupon the input resistance of the voltmeter will not be as high as occurs with the prototype.

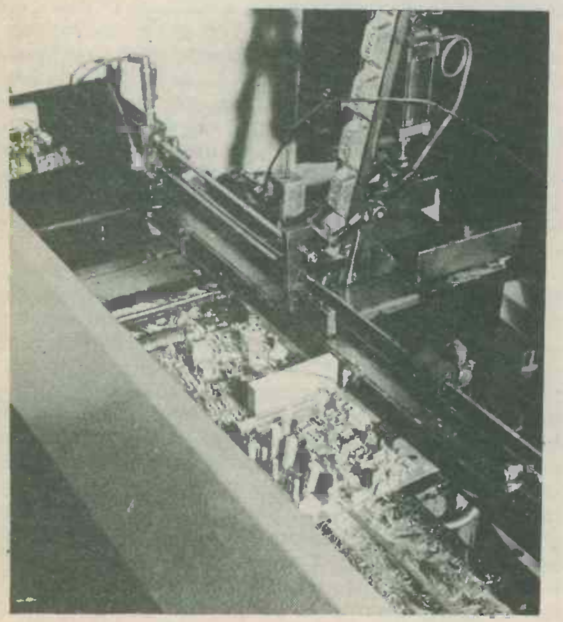
The input resistance may be checked by applying the voltmeter to a source of voltage on any range and noting the reading obtained. A 2MΩ resistor should then be inserted in series with the positive test lead and the voltmeter re-applied to the source of voltage. If there is no change, or negligible change, in voltage reading then the voltmeter can be assumed to have a satisfactorily high input resistance. With the author's model it was, as mentioned earlier, possible to insert a 10MΩ resistor with no significant change in reading. Naturally, it is necessary for C1 to have a high insulation resistance, and this capacitor should be a modern plastic foil component.

The voltmeter may give random readings when the test terminals are open-circuit. These are mainly due to the small amount of leakage current still existing in TR1, and they are not in evidence when the test prods are connected to the circuit whose voltage is to be measured. ■

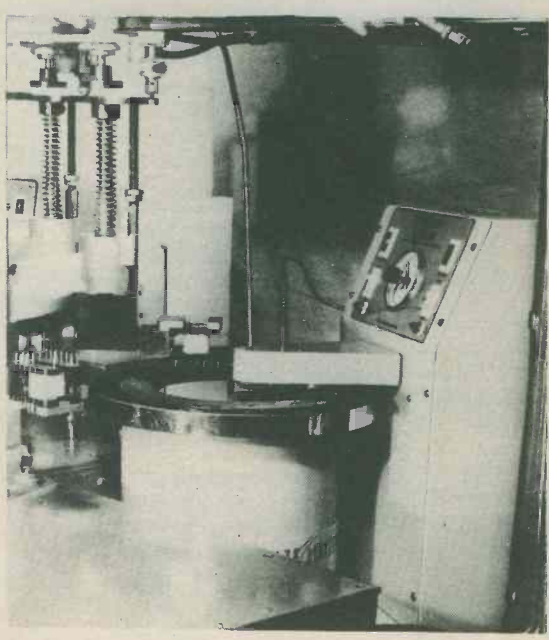
TIN IN THE ELECTRONICS INDUSTRY

THE PRODUCTS OF THE ELECTRONICS INDUSTRY, BE they transistor radios, TV sets or communications apparatus or computers or a myriad other items of complex gadgetry, are now accepted as facts of modern living. The growth of the industry has been, and continues to be, phenomenal. Furthermore, with growth has come a spread in the range of products, which now embraces both low cost, mass-produced portable equipment and highly specialised and expensive communications and control systems.

One thing common to all types of apparatus is the use of tin or its alloys as an essential material of construction. The more important uses of tin in electronics are as solder alloys and for coatings. However, tin alloys or chemical compounds of tin contribute to many new and interesting devices.



Printed circuit assemblies being soldered on a wave soldering machine at a modern factory. Courtesy: British Radio Corporation, Enfield, Middlesex.



Part of the Soldip machine for mechanised soldering, showing the solder pot with movable arm for removing surface dross. Courtesy: Solbraze Ltd., Erith, Kent.

SOLDERING

Soldering with tin-rich, low-melting alloys provides the fastest and most reliable method of making electrical connections and the soldered joint is the essential basis of virtually every electronic circuit.

For specialised operations, a wide range of individual forms of solder alloys has become available within recent years. Pre-forms – small or miniature shapes made from solder and often with self-contained flux – can be produced to almost any specification and are particularly useful in certain applications, e.g. for soldering multi-layer printed circuit boards or for joining semiconductors.

Perfect solder joints in vertical wire terminations. Results such as this can be readily achieved with modern printed circuit mass soldering techniques. Courtesy: Tin Research Institute.

Solder alloys are also available in paste or cream form, which again usually incorporate a flux. These preparations find use in many mechanised soldering processes.

Automated production lines enable hundreds of electrical connections to be soldered within the space of a few seconds and the combination of printed circuit technology and mechanised soldering methods produces efficient and reliable results.

TIN AND ALLOY COATINGS

Reliability is further ensured by correct preparation of surfaces prior to soldering. Here again, coatings of tin or high-tin alloys are the best and most widely used means of retaining solderability in storage.

Modern developments in coating technology have led to a wide variety of coatings being available. Tin or tin-lead alloys may be electroplated as matte or as bright coatings and today the large-scale manufacturer may employ continuous plating production lines for the manufacture of printed circuits. For many applications hot dip or flow-melted coatings may be desirable. The low melting point and good alloying properties of tin and its alloys enable hot dip coatings to be readily applied to a variety of substrate metals.

LESSER-KNOWN USES OF TIN

Alloys of niobium and tin are in the class of materials known as superconductors, that is, at very low temperatures their electrical resistance falls to an infinitesimally small value. Such superconductors can be used to make high field magnets and a potentially important material of construction for high power electrical transmission cables. Experimental and prototype power systems are already in operation.

Tin-tellurium alloys have been developed for laser beam operated detectors for monitoring atmospheric pollution. In another sphere, tin oxide/glass combinations are widely used to make precision electrical resistors, whilst a small but interesting application for organotin compounds in electronics lies in the manufacture of liquid scintillators used as counting devices for radio isotope work. ■

The information in this article supplied by courtesy of the Tin Research Institute.

CRYS

MICROPHONE

By R. A.F

CRYSTAL MICROPHONES ARE VERY POPULAR AMONG amateur users, as they are generally inexpensive but nevertheless give a fairly high quality output. Unfortunately, they have the disadvantage that they are only really suitable for use with amplifiers which have a high input resistance if a wide frequency response is to be obtained.

HIGH IMPEDANCE

This high input resistance is required because of the series self-capacitance of the microphone, which may be of the order of 1,000 to 2,000pF. At a first approximation, a crystal microphone may be regarded as a voltage generator in series with this self-capacitance, as illustrated in Fig. 1. If the load resistor, which represents the input resistance of the amplifier to which the microphone connects, has a low value, then the reactance of the self-capacitance can become greater than this value at the lower audio frequencies. The result is that much of a low frequency voltage is developed across the series capacitance rather than across the load resistor, and low frequency voltages are not in consequence applied to the amplifier at their full amplitude. Thus, coupling a crystal microphone to an amplifier whose input resistance is too low results in a loss of bass response. Normally, a crystal microphone should couple to an input resistance of the order of 1MΩ or more.

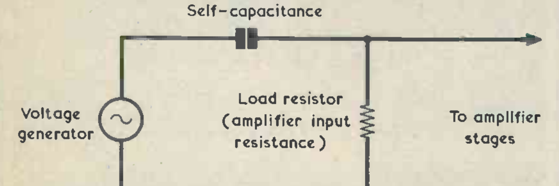


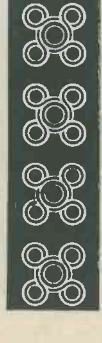
Fig. 1 A crystal microphone may be looked upon as a voltage generator in series with its own self-capacitance

Cover Feature -2

SELF-CONTAINED UNIT

The unit to be described here is completely self-contained and the parts are fitted in a case measuring only $3\frac{3}{8}$ by $1\frac{1}{2}$ by $1\frac{7}{32}$ in. It matches the high impedance of a crystal microphone into the low resistance input of a transistor power amplifier.

The complete circuit of the impedance matching pre-amplifier is given in Fig. 2. This uses a general purpose



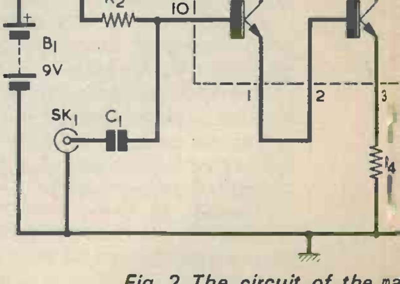
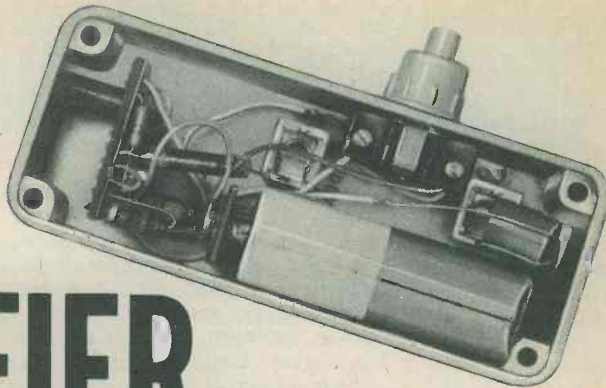


Fig. 2 The circuit of the ma... internal circuitry of the ... the ...

STAL

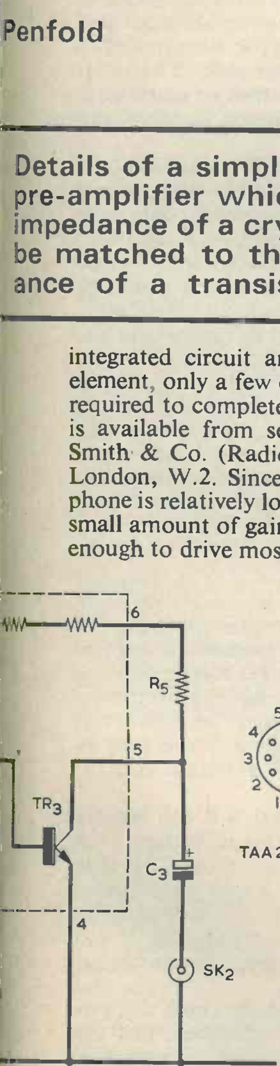
PRE-AMPLIFIER



Penfold

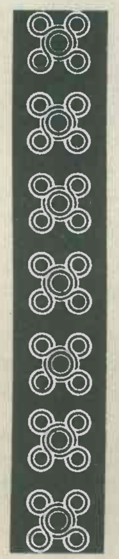
Details of a simple integrated circuit pre-amplifier which enables the high impedance of a crystal microphone to be matched to the low input resistance of a transistor a.f. amplifier.

integrated circuit amplifier type TAA293 as a basic element, only a few external discrete components being required to complete the circuit. The i.c. type TAA293 is available from several suppliers, including G. W. Smith & Co. (Radio) Ltd., 11–12 Paddington Green, London, W.2. Since the output from a crystal microphone is relatively low, the pre-amplifier also provides a small amount of gain to boost the signal to a level high enough to drive most amplifiers.



tching pre-amplifier. The integrated circuit is inside broken line

TAA 293 base



COMPONENTS

Resistors
(All miniature ¼ or ⅛ watt, 10%)

R1	8.2MΩ
R2	8.2MΩ
R3	3.3kΩ
R4	560Ω
R5	3.3kΩ

Capacitors
(All miniature types)

C1	0.22μF.
C2	10μF electrolytic, 10 V.Wkg.
C3	10μF electrolytic, 10 V.Wkg.

Integrated Circuit
I.C. type TAA293

Switch
S1 s.p.s.t. switch (see text)

Battery
B1 9 volt battery type PP3 (Ever Ready)

Sockets

SK1	3.5mm. jack socket
SK2	3.5mm. jack socket

Miscellaneous
Verobard, 0.1in. matrix, 10 strips by 9 holes
Diecast box type 7969P (Eddystone)
Battery clips
Wire, etc.

The circuit of the unit is quite straightforward. The area inside the broken line in Fig. 2 represents the internal circuitry of the i.c., the discrete components being those outside this area. The input transistors (TR1 and TR2) are connected in a configuration similar to that of a Darlington pair, giving a very high current gain. The 560Ω resistor R4, in the emitter circuit of TR2, produces a large amount of voltage negative feedback which gives the circuit its very high input impedance. Resistors R1 and R2 bias the two input transistors. Due to their high values they have little shunting effect on the input impedance. Two resistors connected in series are used since a single resistor of sufficient resistance is not generally available.

TR3 is operated as a common emitter voltage amplifier, taking its bias current and input signal from the collector of TR2. The two internal resistors between terminals 6 and 9 together with the discrete 3.3kΩ resistor, R5, form the collector load for TR3. The output is taken from the collector of TR3 via C3. R3 reduces the 9 volt supply to a level of around 4 volts whilst C2 provides a bypass capacitance. C1 is the input coupling capacitor. The total current consumption is approximately 1.5mA only.

The maximum recommended supply voltage for the TAA293 in a circuit configuration such as that of Fig. 2 is 7 volts. As is explained later, the unit is initially checked with a 6 volt supply to ensure that wiring errors do not cause an excessive voltage to be applied. When this test is completed, the 9 volt supply is finally connected up.

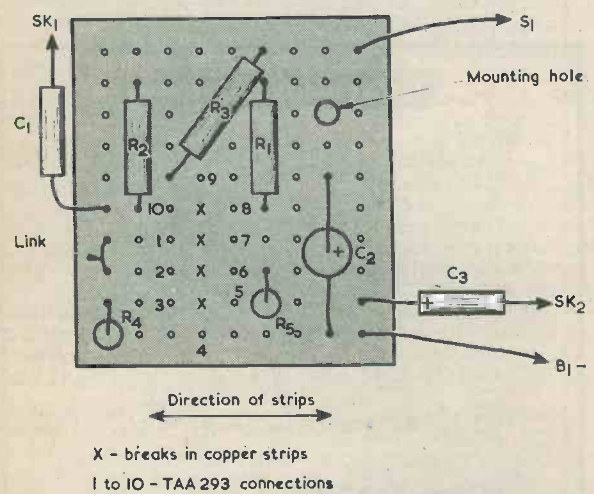


Fig. 3 Layout of parts on the Veroboard. This view is of the component side of the board, with the copper strips underneath

ASSEMBLY

Most of the components are mounted on a piece of 0.1in. matrix Veroboard having 10 copper strips by 9 holes. The layout of the board, as seen from the components side, is shown in Fig. 3. It is necessary to cut the board from a larger piece, and then cut the copper strips on the reverse side of the board as indicated. The board is then ready for the components to be mounted.

The link wire should be connected first as this is somewhat awkward to connect if left until the end, and is easily forgotten altogether.

To minimise the risk of damaging the i.c. due to overheating, this should be the last component to be mounted. Great care must be taken when soldering it into circuit. Only one lead-out of capacitors C1 and C3 is connected to the board. The remaining lead-outs connect to the input and output jack sockets.

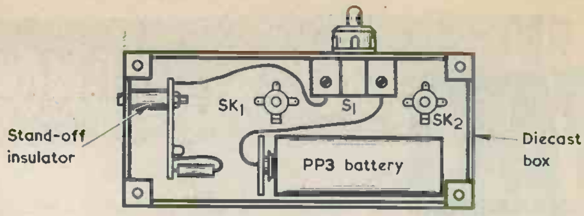


Fig. 4 The layout inside the diecast box

It is not necessary for the input and output wiring inside the metal case to be screened, as these are screened by the metal case. This arrangement has been found to be perfectly stable in practice. All external input and output connecting leads must of course be screened to prevent stray pick-up of mains hum, etc. The outer braiding of the external input and output screened leads connects to the metal case of the unit via the sleeves of the input and output jack plugs.

An Eddystone diecast box type 7969P is used to house the pre-amplifier. This box is available from Home Radio under Cat. No. E7969. The general layout inside the box is shown in Fig. 4. The on-off switch used with the prototype is a push-on type obtained from Woolworth's stores, but a miniature slide switch would be equally suitable although less easy to fit.

The component board is mounted by means of a ¾in. 8BA bolt and nut. A stand-off insulator, cut from a piece of narrow-bore Paxolin tubing, or similar, is employed to space the copper strips on the underside of the board clear of the inside surface of the box. The earth connection to the diecast box is made at the tag of socket SK1 which couples to the jackplug sleeve. The dimensions of the box are such that the battery is held in place when the lid is screwed on.

CASE FINISH

The exterior finish of the case is rather rough and it will require cleaning. A Brillo pad is excellent for this purpose. The case may be painted, or it can be polished to give a very attractive finish, as was the prototype.

As a finishing touch, legends may be positioned alongside the input and output sockets. These may be obtained from Panel-Signs Set No. 3, available from the publishers of this journal.

When the unit has been completed, a 6 volt battery should be temporarily connected to the battery clips and the unit switched on. The voltage across C2 is then measured. If this is of the order of 2 to 3 volts then it may be assumed that the integrated circuit is drawing an adequate current through R3. The temporary 6 volt supply is then removed and the correct 9 volt battery connected up.

Finally, should there be instability when the pre-amplifier is connected to the main amplifier, this will probably be due to the wide bandwidth of the integrated circuit. The cure is to connect a low-value capacitor of 100 to 1,000pF between leads 3 and 5 of the integrated circuit. This capacitor must be a miniature type as there is very little space to accommodate it inside the case. ■

RECENT PUBLICATIONS

TRANSISTORIZED RADIO CONTROL FOR MODELS. By D. W. Aldridge.
164 pages, $5\frac{1}{2} \times 8\frac{1}{2}$ in. Published by W. Foulsham & Co., Ltd. Price £2.50.

This book is intended for the constructor who prefers to assemble his own radio control equipment rather than purchase it ready made. As the author rightly points out, there is more pleasure to be obtained from operating home-built gear than in using commercially available 'black boxes'. The systems described in *Transistorized Radio Control for Models* are mainly intended for model boat control and, as such, do not have to be extremely small in size or light in weight. The basic principles are still, of course, capable of miniaturisation. The major types of model control up to, but not including, the more advanced levels of multi-proportional control are covered. The author considers that advanced multi-proportional control, with its attendant complicated test equipment, is best left to specialist manufacturers.

The book commences by giving a general explanation of radio control systems, then carries on to steering systems, receivers and transmitters. The construction of a wavemeter, transmitter and superhet receiver are next dealt with, after which steering systems employing mark-space control, simple proportional and progressive techniques are described. Included in the remainder of the book are chapters describing a four channel pulse system, the tuned reed system, tuned chokes and a proportional circuit which permits the use of tone controls for secondary channels and which was specially devised by the author.

The book is written in down-to-earth style by a model enthusiast for other enthusiasts, and offers sensible advice which can be followed by anyone who can wield a soldering iron and has sufficient knowledge of electricity and electronics to understand the principles involved in simple radio control systems.

TELEVISION INTERFERENCE MANUAL. By B. Priestley, G3JGO.
100 pages, 148 x 210mm. ($5\frac{3}{4} \times 8\frac{1}{4}$in.) with spiral binding. Published by Radio Society of Great Britain. Price 80p.

The amateur transmitting enthusiast who lives in a crowded urban area has many difficulties, not least of which is that of TV interference. Anyone who has had experience with transmitter operation can readily visualise the situation in which breakthrough occurs on a nearby receiver which has, to all intents and purposes, an otherwise impeccable performance. Apart from input overloading by the transmitted signal, any non-linear item including even a corroded solder joint in the receiver or its aerial system can result in cross-modulation and consequent breakthrough. Interference may also, of course, be caused by out-of-band spurious radiations from the transmitter.

The problems of the amateur are further increased by the social difficulties arising from TV interference. The owner of a £300 colour set is not likely to respond kindly to the suggestion that it may be his receiver which is at fault and not the transmitter. Even if the transmitter is blameless, a layman can hardly be expected to accept this fact if, so far as he can see, his set is obviously working correctly when the transmitter is off the air.

Television Interference Manual sets out to advise the amateur on ways of preventing TV interference, dealing with the subject both from the engineering and the social points of view. Much of the book is devoted to methods of producing a clean transmission and it is pointed out that this must be achieved before attempting to solve the problem at the receiver. Also included is a chapter on breakthrough in hi-fi systems, and one of the appendices gives details on Post Office interference investigation methods.

The author is a specialist in the field of TVI, and the book will be a valuable addition to the library of the amateur transmitter. It can, if desired, be obtained by mail order direct from RSGB Publications, 35 Doughty Street, London, WC1N 2AE, in which case the post paid price is 90p.

ABC'S OF INDUSTRIAL ELECTRONICS. By J. A. Wilson.
102 pages, 135 x 215mm. ($5\frac{1}{4} \times 8\frac{1}{2}$in.). Published by W. Foulsham & Co. Ltd. Price £1.50.

This work is in the Foulsham-Sams Technical Book series, and consists of an American text with an introductory chapter for English readers. It deals with the electronic systems which are encountered in industry and in manufacturing processes.

The first chapter of the book discusses the transducers used in industrial electronics systems, switching components and the types of amplifiers employed; and this is followed by two chapters devoted to power supplies and amplifier control systems. The fourth chapter gives an introduction to counting systems and logic circuits, this being succeeded by a chapter which discusses the logic circuits employed in industrial control. The final chapter deals with numerical control systems.

The book covers a very wide range, from fluidics to t.t.l. circuits, and probably because of this does not discuss any particular subject in great depth. It offers a useful introduction to the techniques used in industrial control systems and enables the basic principles of these techniques to be understood.

THE 'HYBRIDYNE' MEDIUM WAVE PORTABLE RECEIVER

by
Sir Douglas Hall, K.C.M.G., M.A. (Oxon)

Despite the fact that this medium wave portable employs a t.r.f. circuit it provides comprehensive automatic gain control. Incorporated in the receiver are three transistors and one DL96 valve.

SOME, IF ASKED TO NAME THREE circuit devices which they considered to be obsolescent, might mention the valve, the frame aerial, and the use of reaction. The author's comment would be that despite the obvious advantages of the transistor, the valve is still superior in some respects; that a frame aerial with, say 10 in. sides, though bulky, can be very much more sensitive than any normal ferrite rod; and that no-one seems to think that Q multiplication circuits are old-fashioned, though Q multiplication is only a modern name for reaction.

The useful combination of the very high thermal stability of the valve and the high mutual conductance of the transistor has been used to obtain amplified a.g.c. in three previous designs, these being two car radios and a mains transportable.* The present design makes use of the same basic principles in a battery operated design, but an important new feature is incorporated by means of which the a.g.c. loop now includes a reaction circuit. Previously, although reaction was used, this was unaffected by the a.g.c. circuit. The result with the new circuit is not only amplified a.g.c. but a circuit which changes an inherently unstable condition to sensitive stability as soon as a station of reasonable signal strength is tuned in. In other words, the receiver may be set to an oscillating condition and then any fairly powerful signals can be tuned in without touching the reaction control except, perhaps, between widely separated parts of the tuning scale. Weak stations can still be brought in by critical reaction adjustment in the usual way. It may be found that with a really powerful local station, oscillation can not be produced even with reaction set to maximum.

THE CIRCUIT

The circuit is shown in Fig. 1. L2 is a medium wave frame aerial with a 10 in. side, and the signal is applied from the tuned circuit given by L2 and VC3 to the base of TR1, a high amplification p.n.p. transistor connected as a common emitter amplifier. A suitable tapping is taken from L2 for the base of TR1, and in addition C2, which is bypassed by R1 for d.c., provides a further capacitive tap. It is permissible, though not really necessary to experiment with the value of C2. If it is too large there will be a lack of selectivity and 'rough' control of reaction. If too small there will be loss of sensitivity. L1, with VC1 and VC2 in parallel, offers a high impedance collector load for TR1 which will accordingly give large voltage amplification. VC2 and VC3 are the two sections of a 2-gang tuning capacitor. VC1 is a trimmer across the tuned circuit which has the lower stray capacitances. L1, it should be mentioned, is a Denco miniature dual-purpose valve-usage aerial input coil. Only its tuned winding is in circuit and its coupling winding is ignored.

The amplified signal at the collector of TR1 is then applied to V1. Because of C5 and R4, and the small positive bias at the grid, V1 acts as a leaky-grid detector. The grid is about 1.5V positive of the negative rail because of the silicon diodes D2 and D3, and this bias is held constant notwithstanding the condition of the battery. Similarly, the screen-grid potential is held steady at about 6V positive because of the zener diode D1, in conjunction with D2 and D3. Anode voltage will fall with an ageing battery but a characteristic of the pentode valve is its high output impedance, as a consequence of which anode current remains steady despite falling anode potential. This is provided, of course, that signal grid potential and screen-grid potential remain constant.

The two diodes, D2 and D3, can be any silicon diodes or small silicon rectifiers, such as the 1N4002.

R6 acts as an r.f. load and allows reaction to be applied to the base of TR1 via C7 and VR2. Note that reaction is given over both stages. The phase at the anode of V1 is the same as that at the base of TR1, so no coupling coil is necessary and the base tap can be employed.

The reaction control VR2, has a log track and is connected so that reaction increases as it is turned anti-clockwise. This provides very smooth control.

L3 is the large winding of a microphone or crystal pickup transformer.

*Sir Douglas Hall, 'Design of Universal Car Radio', *The Radio Constructor*, April 1969; 'The "Droitwich" Car Radio', *The Radio Constructor*, November 1971; 'Hybrid Transportable Receiver', *The Radio Constructor*, November 1969.

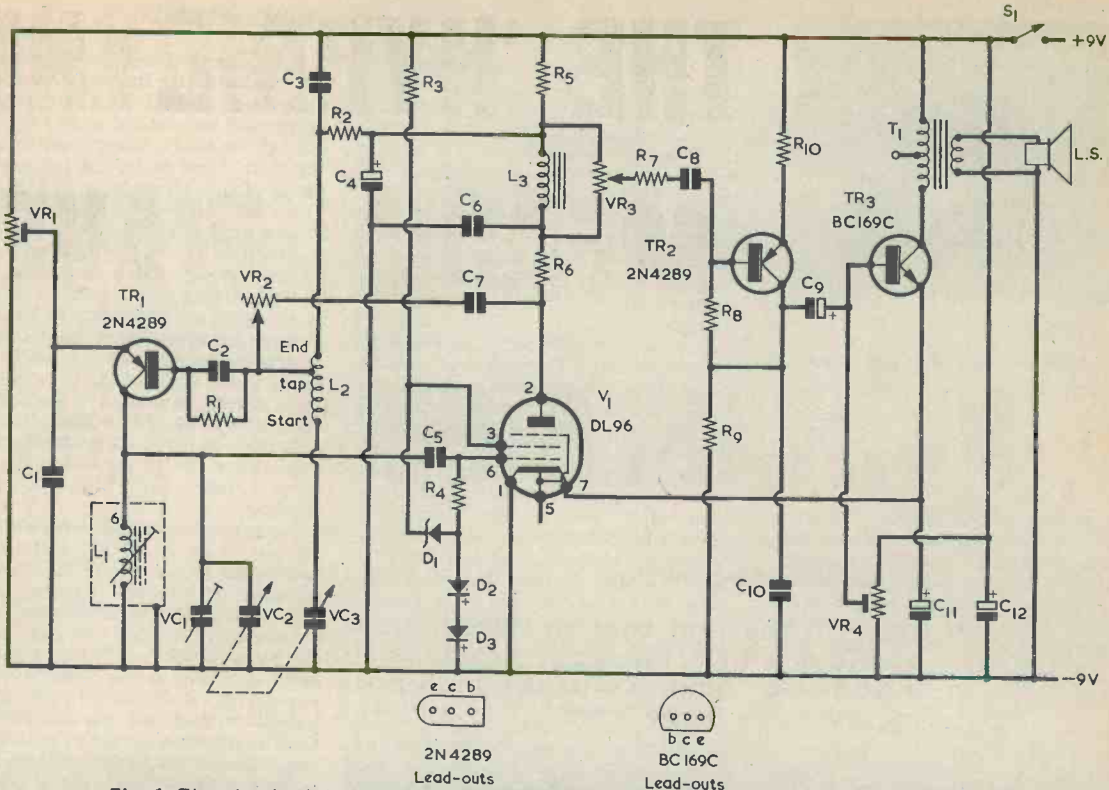


Fig. 1. The circuit of the medium wave portable receiver. The inductor L2 is a frame aerial

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1	10kΩ
R2	10kΩ
R3	1.5kΩ
R4	3.9MΩ
R5	18kΩ
R6	3.3kΩ
R7	47kΩ
R8	2.2MΩ
R9	1kΩ
R10	1kΩ
VR1	25kΩ pre-set potentiometer, skeleton
VR2	500kΩ potentiometer, log track
VR3	1MΩ potentiometer, log track, with S1
VR4	25kΩ pre-set potentiometer, skeleton

Capacitors

C1	0.1μF paper or plastic foil
C2	100pF silvered mica or ceramic
C3	0.1μF paper or plastic foil
C4	1μF electrolytic, 10 V.Wkg.
C5	180pF silvered mica or ceramic
C6	1,000pF silvered mica or ceramic
C7	180pF silvered mica or ceramic
C8	0.1μF paper or plastic foil
C9	8μF electrolytic, 4 V.Wkg.
C10	0.22μF paper or plastic foil
C11	400μF electrolytic, 4 V.Wkg.
C12	1,000μF electrolytic, 10 V.Wkg.
VC1	40pF trimmer, mica
VC2-3	365+365pF 2-gang variable capacitor type 0 (Jackson Bros)

Inductors

L1	Denco Miniature Dual Purpose coil, valve usage, Blue, Range 2
L2	Frame aerial, see text
L3	Microphone transformer (only primary used) type TT53 (Repanco)
T1	Output transformer type T/T7 (R.S. Components)

Semiconductors

TR1	2N4289
TR2	2N4289
TR3	BC169C
D1	Zener diode, 4.7V 200-250mW
D2	Silicon diode
D3	Silicon diode

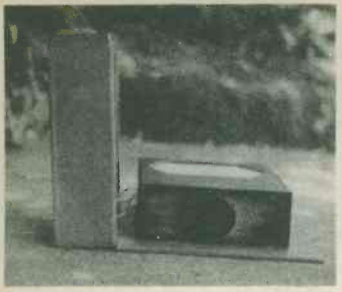
Valve
V1 DL96

Switch
S1 S.P.S.T. (part of VR3)

Speaker
3Ω speaker, 8 in. by 5 in.

Batteries
2-off 4.5 volt batteries type 126 (Ever Ready)

Miscellaneous
18-way R.S. Components standard size groupboard (Home Radio Cat. No. BTS10)
Epicyclic drive type 4511 (Jakcson Bros)
Clip for coil can
32 s.w.g. enamelled wire
B7G Valveholder
Plywood
Hardboard
Fablon or Contact
Speaker fabric
Nuts, bolts, etc.



The receiver is operated with the case opened and the frame aerial vertical

(No connections are made to the other winding.) With the small current passing through L3 it offers an inductance of the order of 200H. This enables V1 to give good voltage amplification notwithstanding the very low direct voltages available for its screen-grid and anode. R5 is a decoupling resistor used in conjunction with C4. Because of V1's function as a leaky-grid detector, the current passed by the valve will drop with the receipt of a signal and, consequently, the voltage drop across R5 will fall. R5 is connected via decoupling components R2 and C3 back to the base of TR1 which thereby receives bias which varies according to the amplitude of the signal being received. The pre-set potentiometer VR1 is adjusted so that, with no signal being detected by V1, a collector current of 150μA passes through TR1. A potentiometer is used here rather than a simple series resistor in the emitter circuit since it helps to reduce variations in the emitter potential for changes in the base voltage. A series resistor would give d.c. negative feedback and would reduce the effect of the a.g.c. In practice, even a small signal detected by V1 will cause sufficient change in TR1 bias to result in a significant drop in collector current. A large signal will almost cut TR1 off. Not only does good a.g.c. result but the effect of the reaction is also automatically varied, and this helps additionally in keeping the signal strength steady.

An audio signal appears across L3. VR3 acts as a volume control, and the signal from its slider is fed through the stopper resistor R7 and the capacitor C8 to TR2. TR2 is a p.n.p. common emitter amplifier with 100% voltage feedback at the emitter, and it matches the high output impedance of V1 to the much lower input impedance of the output transistor TR3. This arrangement is used in preference to an emitter follower as the presence of a resistor in the collector lead enables a simple form of negative feedback of d.c. to be used in providing base bias through R8. Also, a p.n.p. device is used rather than n.p.n. as the latter would mean that the surge through C9, on switching on, could cause a large current to flow momentarily through TR3. As will be explained later, it is this current which also flows through the filament of V1 which could consequently be damaged. In theory, TR2 *can* be dispensed with, the secondary of the microphone transformer being used to provide correct matching for TR3. But this involves a drop of 25 times in voltage gain which cannot conveniently be tolerated. TR2, though offering no voltage amplification in itself, yet prevents a fall of amplification by 25 times from taking place. To all intents and purposes the stage may therefore be credited with an effective gain in the present circuit of 25 times.

TR3 is straightforward common emitter output transistor with base bias set by VR4 so that it passes a current of 25mA. The filament of V1 is used as an emitter resistor for TR3 so that the normal drawback encountered with the use of a battery valve – the need for a separate filament battery – is avoided. The voltage across the filament can drop appreciably, with an ageing battery, without the anode current of V1 being affected.

The output transformer chosen gives exactly the right ratio for maximum undistorted output for the conditions prevailing, but the Repanco TT56 is a near-equivalent and could be used instead, if desired. The R.S. Components transformer specified may be obtained from Chromasonic Electronics, 56 Fortis Green Road, London, N10 3HN.

FRAME AERIAL

It is suggested that the frame aerial be made first. Its construction is illustrated in Fig. 2. Two pieces of hardboard are cut out as in Fig. 2 (a), a small hack-saw being used to make the slots. Next to be cut out are two pieces of ¼ in. plywood, as in Fig. 2 (b). These are screwed or pinned together to take up the form shown in Fig. 2 (c). A length of 32 s.w.g. enamelled wire is passed through the hole for the start of the winding and is held in position by wedging a match-stick in the hole. 21 turns are wound on, either clockwise or anti-clockwise, with 3 turns to each set of slots. The end of the winding is then passed through the appropriate hole, and is locked in position there. A tapping is made by soldering about 8 in. of fine flex to the end of the 18th turn, 3 turns from the end of the winding.

Next, two pieces of ¼ in plywood are cut out 11 in. by 3⅛ in., and another two pieces 10½ in. by 3⅛ in. These are screwed or pinned together as in Fig. 3 (a) and a hardboard back measuring 11 in. by 11 in. pinned into place behind them. The frame aerial is fitted centrally in this assembly, as in Fig. 3 (a), and secured with screws passed through the hardboard back. Only two screws should be used at this stage in case the aerial winding needs to be modified. Next, cut a piece of hardboard to the dimensions shown in Fig. 3 (b) and fit two small hinges to it, as illustrated. Screw the hardboard frame to the front of the assembly of Fig. 3 (a), again using only two screws at this stage.

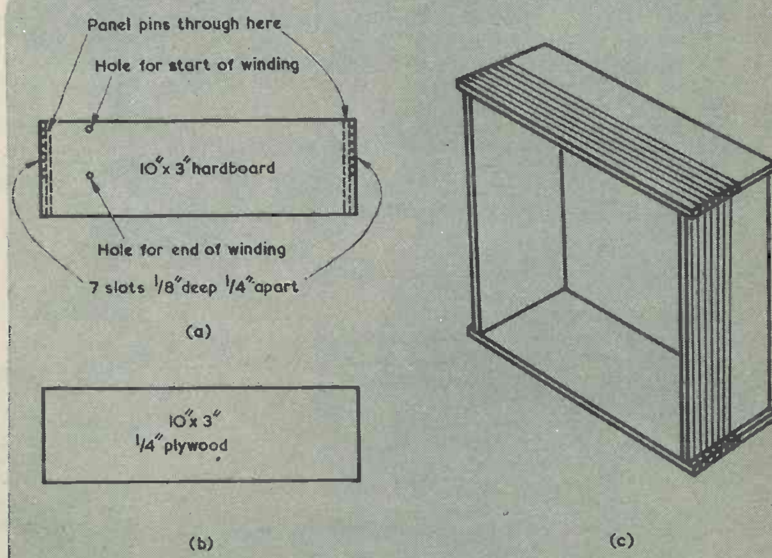


Fig. 2 (a) The upper and lower sections of the frame aerial assembly
(b) The two sides of the assembly
(c) How the aerial appears after winding

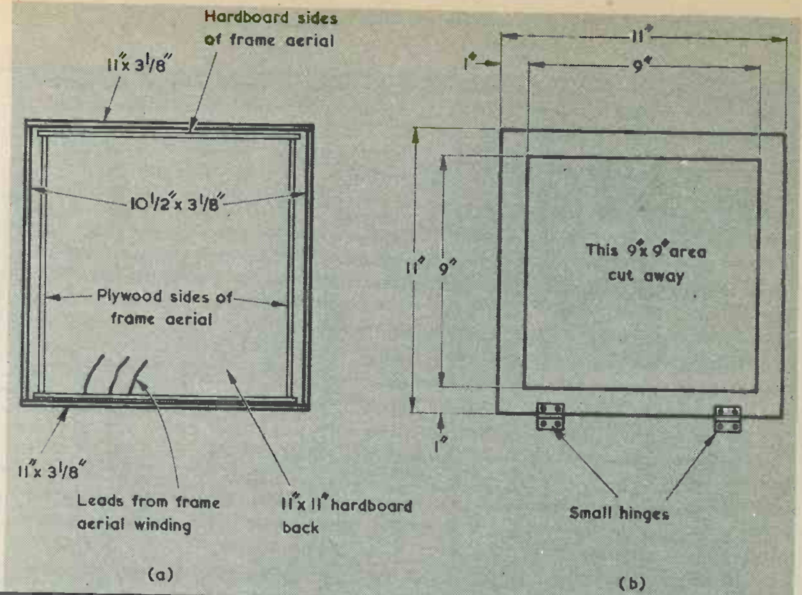


Fig. 3 (a) The aerial is fitted inside an 11 by 11 in. frame
(b) Front cover for the assembly of (a)

RECEIVER ASSEMBLY

Next turn to Fig. 4 (a). Cut two pieces of plywood and two pieces of hardboard as shown and screw or pin them together to make a 4-sided frame without top or bottom. The bottoms of the pieces are all at the same level so that, at the top, sides B and C project higher than sides A and D by $\frac{1}{8}$ in. The hardboard control panel shown in Fig. 4 (d) will later be positioned behind side A, and this side has a cut-out to allow access to the controls. The shape of the cut-out is evident from Fig. 4 (a) and the photograph showing the controls.

Cut a piece of plywood 11 in. by 11 in. Cover this with Fablon or Contact. Similarly cover the frame of Fig. 4 (a) with Fablon or Contact. Do not cover the frame aerial assembly at this stage. Temporarily attach the hinges, already screwed to the frame aerial assembly, to the 11 in. square plywood, as shown. It is now necessary to screw the frame of Fig. 4 (a) to the 11 in. square section, so as to take up the position shown in Fig. 4 (b). This must be done so that the 11 in. square section, acting as a lid, can be closed onto the frame aerial assembly, with the 4-sided frame of Fig. 4 (a) settling neatly inside with room available for knobs protruding slightly at side A. This means that the frame of Fig. 4 (a) must be fixed to the lid slightly off centre, as shown in Fig. 4 (b). Side D comes close up against the inside of the frame aerial assembly when the lid is closed. One way to achieve the correct position is to apply transparent plastic cement to the bottom edges of the Fig. 4 (a) assembly, and allow this to become tacky. Then the assembly can be held lightly, but free to be moved slightly as may prove necessary, until it is ascertained that the lid can be closed correctly. When the correct position has been found the cement

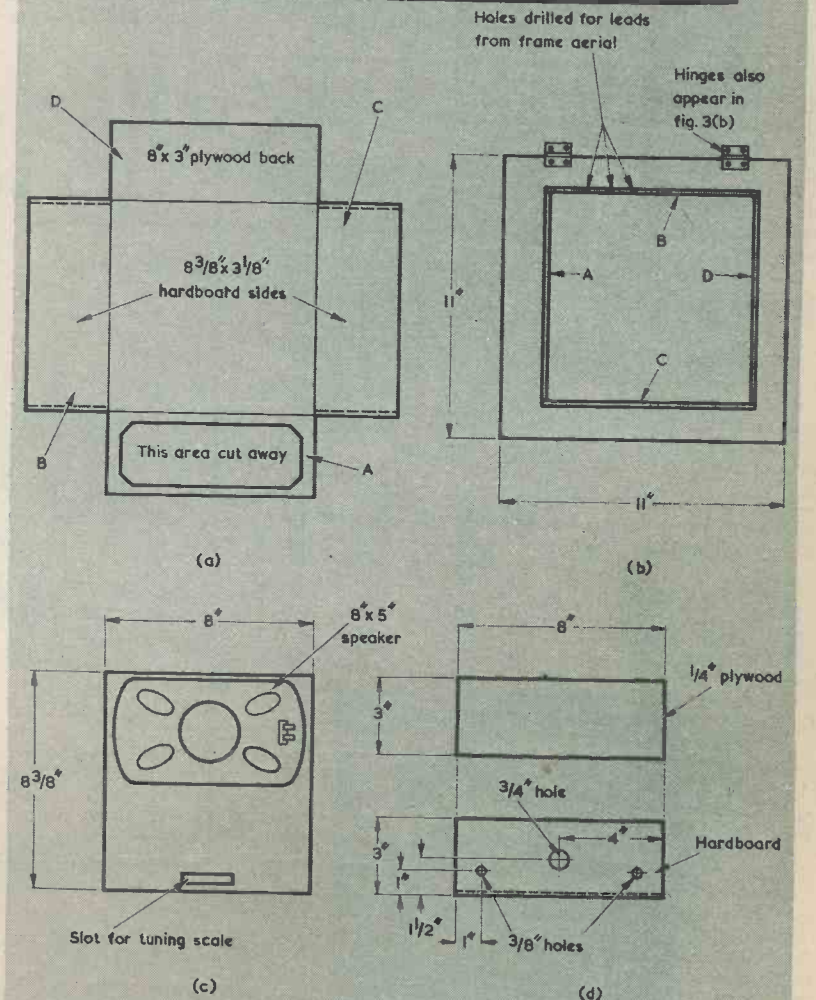


Fig. 4 (a) The four sides of the receiver chassis housing
(b) Fitting the housing to the receiver lid
(c) The top panel, on which the speaker is mounted
(d) The receiver 'chassis' comprises a plywood baseboard and a hardboard control panel

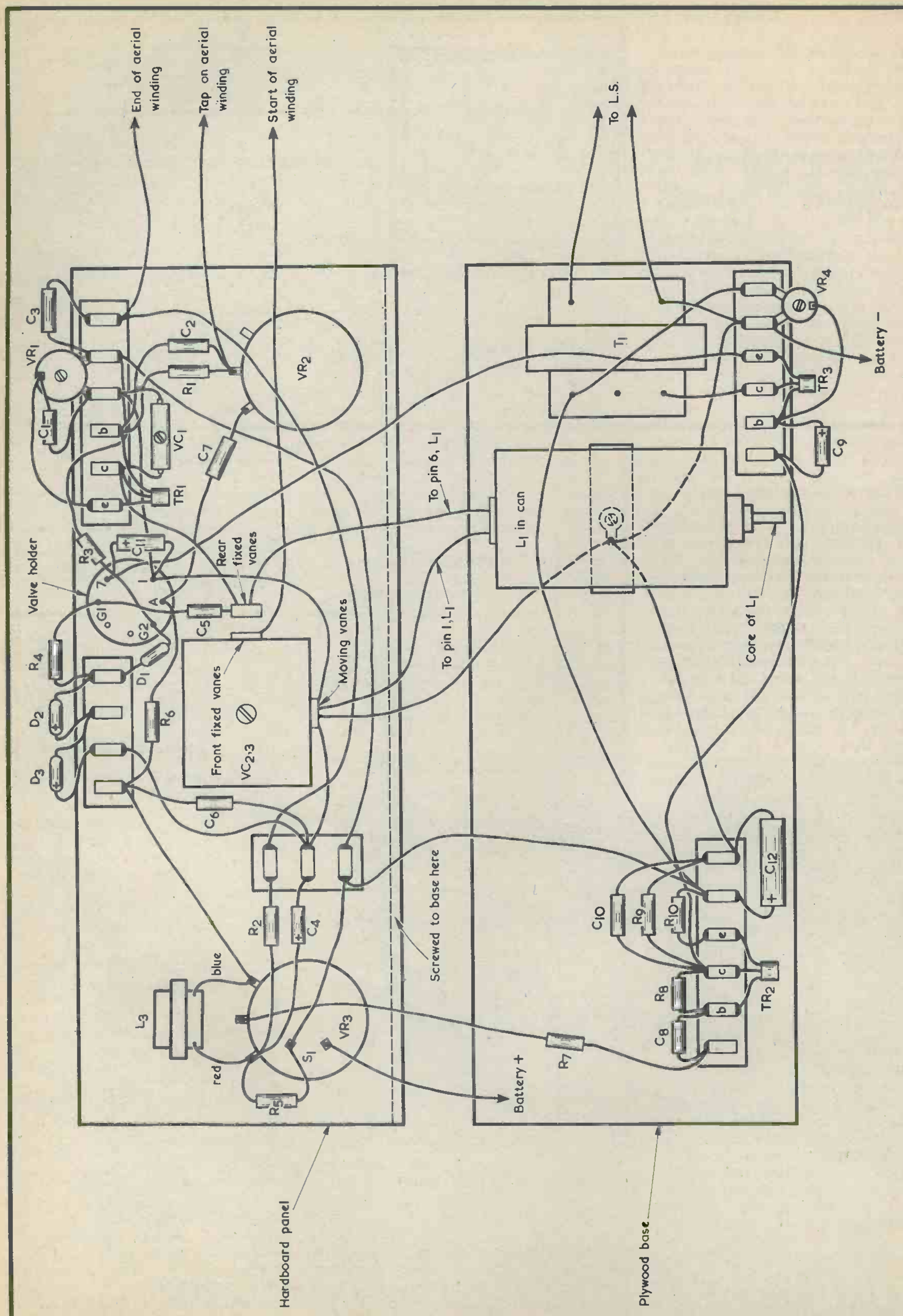


Fig. 5. Components and wiring on the control panel and baseboard

can be left to dry and then small screws can be passed through the lid into the Fig. 4 (a) assembly to give extra strength.

Next cut a piece of hardboard as in Fig. 4 (c). Cut out a suitable aperture for the 8 in. by 5in. speaker, which may be mounted over a piece of gauze. At this stage do not cut out the slot for the tuning scale and do not cover with Fablon or Contact.

Cut and drill a piece of hardboard as in Fig. 4 (d) and also cut a piece of plywood as shown. These will form the panel and baseboard respectively for the receiver 'chassis'.

Mount components as shown in Fig. 5. The tuning capacitor, VC2-3, is mounted on a small plywood sub-panel, as indicated in Fig. 6, this being held away from the main panel by two 1½ in. 4BA bolts fitted with 3 nuts each. The epicyclic ball drive is mounted on the inside of the main panel at its exact centre, where the ⅜ in. hole has been cut out. The end of the tuning capacitor spindle is fitted inside the ball drive and the nuts on the 4BA bolts adjusted and tightened so that the whole assembly is held solid.

L1 is fixed by means of its plastic nut through a hole drilled in the centre of the can in which the coil is supplied. A second hole is drilled through the centre of the bottom of the can, and two different coloured leads, soldered to pins 1 and 6 respectively of the coil, pass through this hole. A rubber grommet should be fitted at the hole. The lid is then screwed onto the can and the whole is held in a clip which is screwed to the baseboard, with a solder tag acting as a washer for the screw. The two transformers, L3 and T1, may be cemented into position, or tin plate clamps may be made with feet and holes for screws. It will be seen that there are 5 sets of tagstrips, three of them 6-way, one 4-way and one 3-way. These are all cut from an R.S. Components standard size 18-way tag board. The tag strips on the panel are fixed with 8BA countersunk bolts and nuts. Countersunk wood screws are used to fix the tag strips to the plywood base.

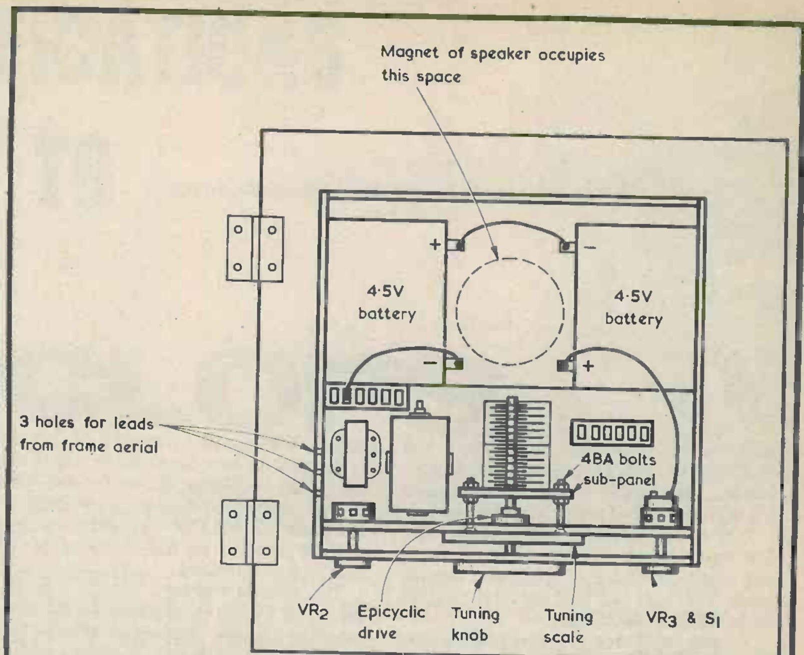


Fig. 6. View looking into the receiver housing. This illustrates the sub-panel on which VC2-3 is fitted

In Fig. 5 the valveholder is shown turned through 90° for clarity. In fact it is fitted with a bracket and held so that pins 1 and 7 are furthest from the panel, and the valve lies over the tag strip on which TR1 is mounted. The bracket should be high enough to allow good clearance for components mounted on this tag strip.

All wiring with the exception of the connections to the frame aerial and speaker and the wires between the panel and the baseboard of Fig. 5 should now be carried out. The panel may then be screwed to the baseboard and the connecting leads between them soldered in. These look long in Fig. 5 but are, in fact, quite short when the two parts have been secured together. The lead from L1 to the frame of VC2-3 should be connected temporarily only at this stage, as the connection is opened later during the setting up operation.

Now, cover the front panel of the chassis with Fablon or Contact, then cut a plywood wheel, 2⅞ in. in diameter, and with a ½ in. hole at its centre. Fix with adhesive a ¼ in. wide strip of white cardboard round its periphery. This functions as a tuning scale. Push-fit this wheel over the slow-moving wider section of the ball drive, if necessary winding on a turn or two of Sellotape to make a tight fit. Place the complete chassis assembly in the box, as in Fig. 6, leaving just enough space between the front of the panel

The inside of the receiver housing with the speaker panel removed

When the case is closed the receiver can be easily carried around

and the inside of side A to allow the tuning scale wheel to turn freely. Secure the chassis to the 11 in. square lid with the aid of small wood screws.

Place the speaker panel over the box containing the chassis and mark the position of the slot for the tuning scale. Cut this out and cover the panel with Fablon or Contact.

Attach, anchoring in any convenient manner, lengths of about 8 in. of fine flex to the start and end leads of the frame aerial. Pass these, and the tap lead, through the three holes in the box shown in Fig. 6 and connect to the appropriate points on the chassis as indicated in Fig. 5. Connect up the two batteries as shown, and connect the speaker, using leads which are long enough to enable the speaker panel to be placed clear of the box when setting up and, later, when changing batteries.

Fit the knobs. These should be shallow types or they will foul the inside of the frame aerial seembly when the case is closed.

SETTING UP

Adjust VR1 fully clockwise with its slider up against the track end connected to C3, and VR4 with its slider up against the track end connected to battery negative. This is also fully clockwise as shown in Fig. 5. Set the core of L1 with about ¼ in. protruding and have VC1 at minimum capacitance. Turn VR2 and VR3 fully clockwise.

The receiver is at its best on the floor or ground. This brings out the bass nicely. So place it on the ground for setting up. Clip a voltmeter across pins 1 and 7 of the valveholder with negative at pin 1, switch on and adjust VR4 until a reading of 3 volts is given *with new batteries in use*. Take care not to allow the slider of VR4 to pass too high a positive voltage to the base of TR3 or excessive voltage will be applied to the filament of V1 and it may burn out.

Disconnect the lead from L1 to the frame of VC2-3 and connect a current-reading meter between these two points. Adjust VR1 to give a reading of 150μA. Reconnect the lead to VC2-3.

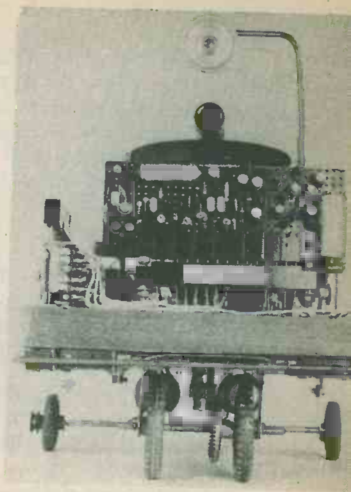
Now find a station near 200 metres and peak it by adjusting VC1. VR2 should be turned anti-clockwise to increase sensitivity. Then find a station around 450 metres and peak it by adjusting to core of L1. Repeat this operation two or three times to find the best compromise settings. If the core of L1 is too far out, or VC1 is at too low a capacitance, there may be instability. There will be no uncontrollable instability when the circuits are correctly trimmed, but as trimming becomes more accurate it will be found necessary to turn VR2 further clockwise to prevent oscillation. If it appears that with the core of L1 fully into the coil the latter still does not have sufficient inductance for correct tracking, remove one turn from the start end of the frame aerial. If the core cannot be screwed far enough out, add one turn. Neither of these modifications are at all likely to prove necessary. When listening to a fading station reaction should be adjusted to the critical point during a trough in the signal. If it is so adjusted during a peak, there will be oscillation during troughs.

As soon as trimming has been satisfactorily carried out the frame aerial assembly can be properly screwed together and covered with Fablon or Contact. The inside of this assembly should be lined with thin cardboard panels covered with Fablon or Contact. This material will also hold the leads from the aerial firmly to the inside of the frame.

The scale on the wheel can be calibrated and the case fitted with a handle together with a catch to keep the lid shut during transit. It is obvious that the receiver must be open in use and that the lid is then horizontal. In fact it then becomes a base, with the frame assembly standing up and being orientated according to the position of the station. The unencumbered frame aerial provides good pickup and a very clear, hiss-free signal. The total current consumption of the receiver is 27 to 28mA from the 9 volt battery.

A large number of stations on wavelengths between 190 and 600 metres will be received, at good quality and volume. This new circuit is very free from vices. The only characteristic of the receiver which could possibly be so defined is a tendency for hand-capacitance effects on weak stations around 200 metres. These effects can be reduced by using a large diameter knob for tuning, enabling right hand finger tip control to keep the hand away from 'live' components behind the left hand side of the receiver panel. The effects are also reduced by using the receiver on the floor or ground. In any case, the matter is of little importance as most signals worth listening to will operate the a.g.c. circuit whereupon any hand-capacitance effects disappear with the reduction in reaction amplification. ■

MODIFICATIONS TO CYCLOPS



Part 1

by L. C. Galitz

Cyclops, or Cybernetically Controlled Light Oriented and Powered System, was featured in our issues for July to December 1972. The present 2-part series describes modifications which may be carried out to enable him to exhibit further reactions to his environment.

Regular readers will have followed the series on Cyclops which appeared in the last July to December issues inclusive. (These back-issues may be obtained by post from Data Publications, Ltd. at 20p plus 6p post each, or at £1.20 plus 21p post for the set of six.)

When we left Cyclops he was free to roam about his environment without offering anything in return for this privilege. Details will now be given of how to make him work for his living and, also, to see what happens when we try to make him work too hard.

CONDITIONED REFLEX

With the conditioned reflex unit on Board 2, we can present to the two inputs and the two outputs any combination of meaningful senses and responses, and the board, as a central core, will be ready to build up a conditioned reflex.

As the cost of building several conditioned reflex units is prohibitive, the next best solution is to have switching on the inputs and outputs of the conditioned reflex unit, and thus enable Cyclops to demonstrate several different versions of conditioned response, using only one conditioned reflex unit.

The first response that can be added is to attempt to make Cyclops work for a living. In the preceding series we saw that the basis of training animals in a circus is to reward it with food upon performing a trick successfully, and this can be extended to Cyclops.

Suppose we put a weight on Cyclops, back. Being a rather lazy animal, we might expect him to go into a tantrum and shake it off. However, we wish to train Cyclops to carry the weight, and so we must give him some sort of reward, and a good reward would be food. With Cyclops light is food, because it is assumed that light, by way of solar cells, can be converted to electricity, which is Cyclops' staple diet.

Thus if, every time we place a weight on his back, we shine light in his eye it would not seem unreasonable if Cyclops decided that it would be a good idea to put up with the weight.

It should now become obvious that if we present the output of some load sensing mechanism to the Sn input, and the output from RLC to the Ss input, and then if we connect the En output to the obstacle avoiding mechanism, we have satisfied the conditions outlined above. On receipt of Sn, a load, the conditioned reflex unit will evoke En, (in other words, the obstacle avoiding mechanism) and Cyclops will try to shake the load off his back. However, if Sn is coupled with Ss (in other words, light) after a while, instead of Sn evoking En, it will evoke Es. However, nothing is connected to Es and thus, after conditioning, the placing of a load on Cyclops' back will have no effect at all, and he will carry the load.

ANXIETY NEUROSIS

Cyclops is, after all, only a bundle of electronics, and if we try and ask too much of him, and tease him, it would not be surprising to find him behaving neurotically. Suppose that every time he tried to move off someone applied a magnet such that he had to stop for a while. Then, as he moved off after a short pause of 'playing dead' suppose he once more received a magnetic stimulus such that again he had to stop. After a while, the very act of moving off would mean the application of a magnet, and so Cyclops would stop in anticipation of this. However, when he tried to move off once more the very act of starting would trigger the conditioned reflex again, and he would have to stop. Thus Cyclops would move around in short jerks – a sad state indeed – until the conditioned reflex unit forget the association between starting to move and magnets. Naturally, if the conditioned response were continually reinforced, Cyclops would continue nervously twitching and never recover from his attack of neurotic depression.

The way this state of affairs may be simulated is by connecting to the Sn input some device which senses when Cyclops just starts moving, and by connecting the magnetic sensor to th Ss input. One could then connect RLB to Es output, and the conditions just outlined would then evoke a fit of neurotic depression.

THE CIRCUIT

Before considering the conditioned reflex input switching, there are a number of modifications to be carried out first which do not alter the mode of operation at present, but are essential for correct operation later on.

Previously, only RLB was connected to En output, and it was convenient to connect the En output gate to the Sn monostable to provide the delay required for RLB operation. Now, however, other circuits are connected to En output which do not need the delay. Thus, the En output must be converted such that there is no delay and a delay circuit incorporated at the relay itself, seeing that other circuits, whose outputs are non-delayed, are also required to operate RLB.

In order to detect when the motors start operating, the voltages on both of the coils of RLB are monitored. Rather than use RLC contacts which, being connected directly to the motors, are rather noisy, a similar circuit monitors the voltage on RLC coil. These two circuits, plus the RLB delay circuit, are all mounted on a third piece of Veroboard, and the circuit of this third board is given in Fig. 1.

Dealing with the RLB delay circuit first, when D12 receives a negative pulse (from TR31 in Fig. 27 – Part 5 of the previous series) C14 charges by way of R53, and the voltage across it rises almost instantaneously to the full pulse potential. The voltage across C14 is monitored by TR34 whose output passes directly to a Schmitt trigger. If the voltage across C14 exceeds a certain amount the Schmitt trigger fires, and the voltage at TR36 collector rises to nearly the negative rail potential. This turns TR37 on, which operates RLB. As C14 discharges, eventually a point will be reached where the Schmitt trigger switches off, and RLB de-energises. There are, of course, simpler ways of arranging a delay circuit, but in order to simplify the circuit to be described in the next paragraph, the voltage across RLB coil must either be high or low, rather than a smoothly varying one as would be obtained if the Schmitt trigger were omitted. The delay circuit would still work, but the following circuit would not.

It would no doubt be simpler just to employ a relay across the drive motor to detect whether the motors were running, but a neater approach, which eliminates further moving parts, is to use solid-state electronics to detect whether RLB is energised or not.

To do this, R60 connects to one coil and R61 connects to the other of the coils of RLB. R62 causes a potential divider to be set up, and the junction of this potential divider is connected to the base of TR38, which is wired in the common emitter mode to give high voltage gain. TR39 inverts the output from TR38. When any of the coils are energised TR38 switches on, thus switching off TR39, whose collector consequently goes negative by virtue of the resistor going up to the negative rail in the input circuitry of the conditioned reflex unit (R37 in Fig. 27). When both of the coils are de-energised, and the motors start, the collector of TR39 goes positive, which is the effect desired, so that the monostable in the input circuitry of the conditioned reflex unit is triggered.

A similar circuit monitors the voltage on the basic reflex coil of RLC only, for reasons to be explained in a moment. This time, when the coil operates TR33 turns on causing the collector to go positive, which is the effect

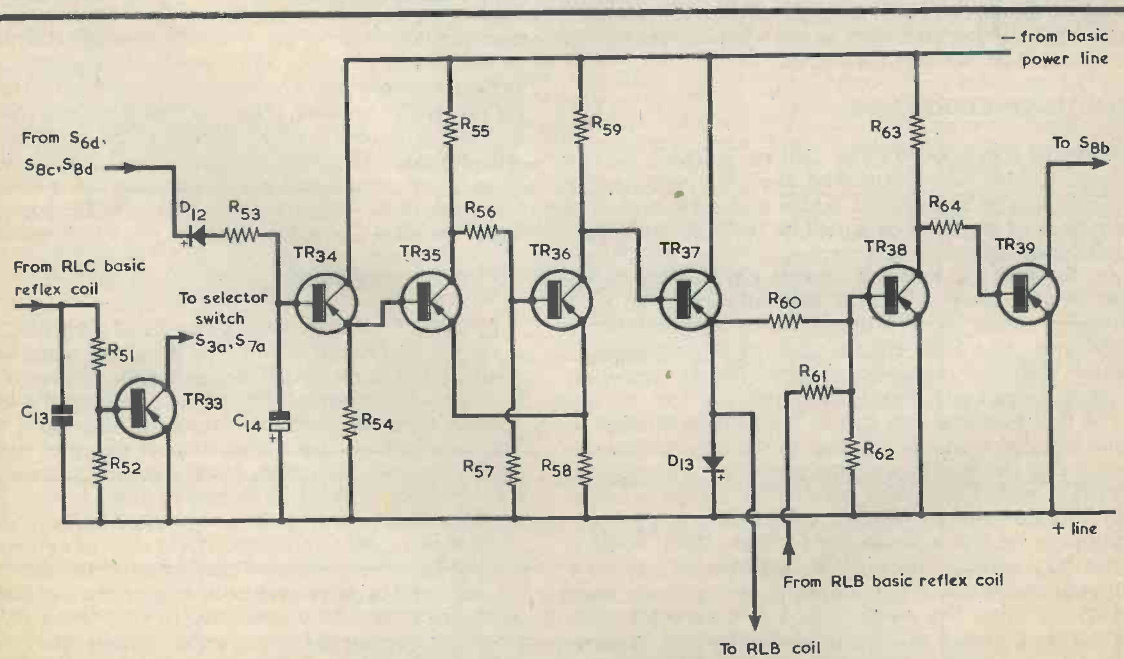


Fig. 1. The circuitry installed on the added component board

desired in this case. (TR33 couples via the switching circuits to pin 3 of Board 2.) C13 eliminates any noise on the input.

The inhibit Ss gate in the original design was included to prevent automatic reinforcement of conditioning when it was not required, because in certain cases, such as conditioning to light, the operation of Es automatically evoked Ss. The discerning reader will now notice that the circuit which detects the operation of RLC is connected to the coil operated by the basic reflex circuitry and, therefore, when the conditioned reflex circuitry operates RLC, no pulse is automatically fed back to Ss.

We similarly do not want automatic reinforcement of either of the two new conditioned reflexes, as neither are defensive, but seeing that there is nothing connected to Es in the weight training mode, and seeing that operation of RLB does not operate the reed switch in the anxiety neurosis mode, the inhibit Ss gate can now be totally dispensed with.

The Ss input circuitry is now changed to that shown in Fig. 2. Resistor R23 and capacitor C6 provide the circuitry required to trigger the monostable. The circuitry around TR15 and TR16 will be explained later.

Now that the delay for RLB has been dealt with by circuitry on the new board, the input of the En output gate that originally went to TR21 collector to provide the delay, now goes to Sn directly. However, in order for the gate to function correctly, the base of TR27 must be taken negative to cut TR27 off when Sn operates. When Sn operates it goes positive, and thus an inverter in the form of TR32, R49 and R50, is interposed between Sn input and the En output gate.

LOAD SENSING

There are several ways of arranging a mechanism such that, when a load is placed on Cyclops' back, the output goes positive. The easiest is to have a large hinged plate upon which loads can be carried, with the hinge operating a microswitch, and this is the method employed. One terminal of the microswitch is connected to the positive supply line, whilst the other terminal connects to the conditioned reflex input selector switch.

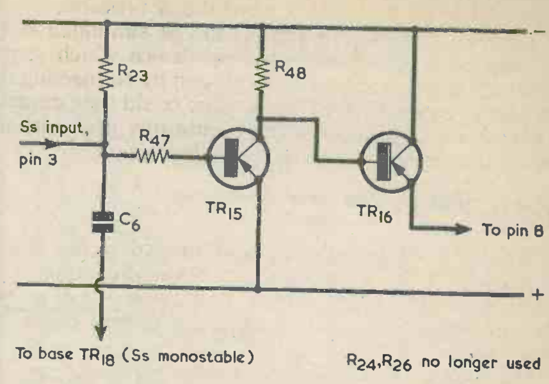


Fig. 2. The modified Ss input circuit

SELECTOR SWITCH

The conditioned reflex switching is carried out by an added 3-button interlocking push button unit, each switch having 4 changeover contacts. The inputs and outputs now provided are listed in Table I. The first button selects the old S3, so that the original two conditioned reflexes may be selected. The second button connects up the inputs and outputs in such a way that Cyclops is ready to learn how to carry loads. The third button connects the conditioned reflex unit so that Cyclops is susceptible to nervous breakdowns.

There are a number of extra components in the modifications whose functions have not yet been explained.

Table 1
Conditioned Reflex Connections

Reflex	*Ss*	*Sn*	*Es*	*En*
Touch	RLA2	Magnet Sensor, X2	RLA Delay Circuit. Pin 6, Board 1	RLB delay circuit. D12–Connection 1, Board 3
Light	RLC Sensor. TR33–Connection 5, Board 3	Magnet Sensor, X2	RLC Coil	RLB delay circuit. D12–Connection 1, Board 3
Weight	RLC Sensor. TR33–Connection 5, Board 3	Load Sensor, S9	—	RLA delay circuit. Pin 6, Board 1
Anxiety	Magnet Sensor, X2	RLB Sensor. TR39–Connection 7, Board 3	RLB delay circuit. D12–Connection 1, Board 3	—

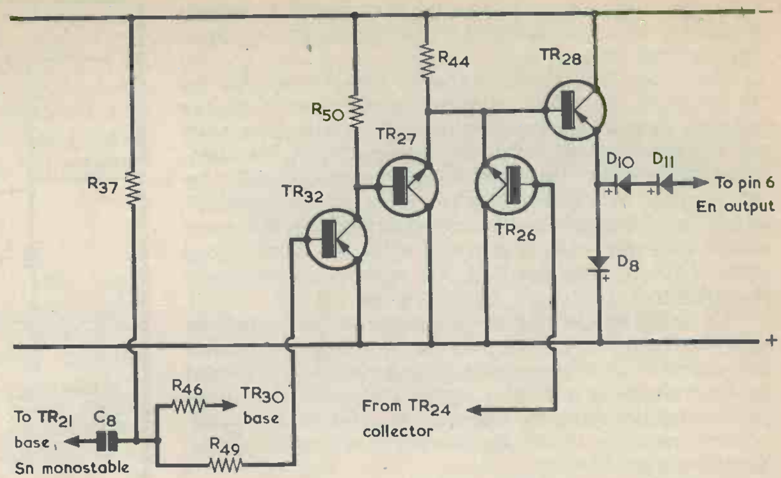


Fig. 3. The new En output circuit

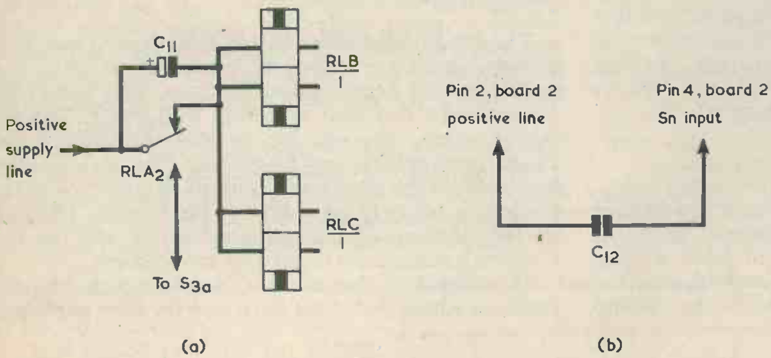


Fig. 4. (a). Suppression capacitor C11 is fitted as shown here (b). Adding suppression capacitor C12

Two of these, C11 and C12, are shown in Fig. 4.

Even though the potential dividers eliminate spurious triggering of the monostables, pulses appear when RLA2 disconnects the common connection of all the coils from the positive line. The other ends of the coils tend to jump from 0.5 volt to 1.5 volt in nearly all cases. C11, connected across RLA2 contacts, eliminates the sharp pulse completely. C12 similarly reduces noise on the Sn input, being wired between pins 2 and 4 of the socket for Board 2.

When conditioning to touch or light is selected, the reed switch connects to Sn whilst D12 connects to En, so that detection of a magnetic field causes the robot to stop. However, when anxiety neurosis conditioning is selected, the reed switch is connected to Ss input and D12 is connected to Es. Unfortunately, no provision has been made to cause Es to be evoked by Ss and so, in this special case where existing circuitry does not do this, an extra circuit has to be brought in. Whenever Ss input goes positive, TR15 turns off allowing TR16 to switch on. When the selector switch is in the anxiety conditioning position, the emitter of TR16 connects to D12, and thus the reed switch which is connected to Ss input under these circumstances operates the RLB delay circuit.

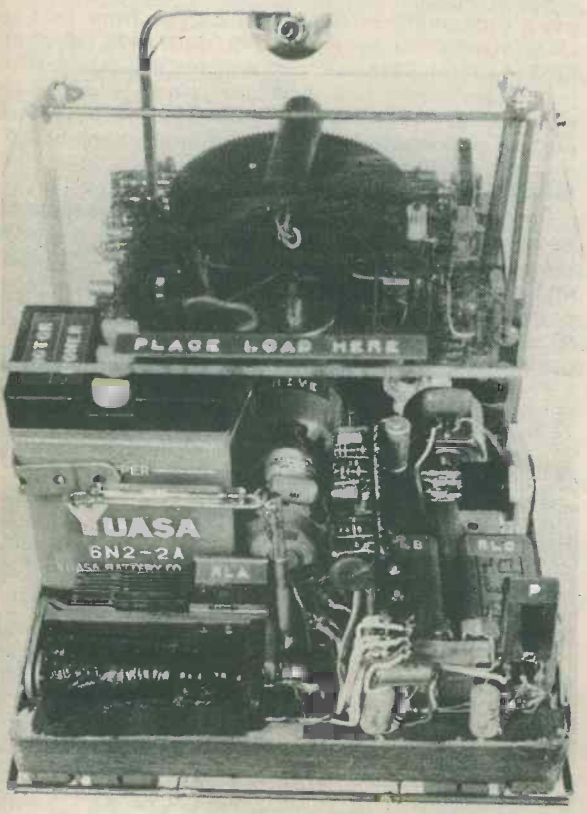
There are two extra diodes, D10 and D11, connected in series with the En output. It was found that the voltage on the En output was too high when Cyclops was in the unconditioned state, preventing release of RLA when En reverted to the off state. Similarly, the voltage was high enough when Cyclops was in the conditioned state to cause RLB to operate when Sn was given, even though the voltage on the output rose to only 1.5V instead of the usual 5V. Rather than include extra components in the gate to keep the voltage down, two silicon diodes were used to drop the output by about 1.35V. This was found to be sufficient to prevent an output appearing when it was not supposed to, whilst not being too high to prevent the gate operating when it was meant to.

COMPONENTS

The additional parts required are listed in the accompanying Components List. Some of the components, including in particular those under 'Miscellaneous', will be referred to in detail when the constructional information is given in next month's issue. The Veroboard and Perspex parts should not be obtained until further comments in the next article have been read.

The selector switch, S6-S8, is a miniature 3-button type, each button controlling a 4-pole changeover switch, and is such that depression of one button releases another that is already depressed. It was obtained from G. W. Smith & Co. (Radio) Ltd., 3 Lisle Street, London, W.C.2.

S9 is the load microswitch and this has to be quite sensitive, so that the lightest of loads causes it to operate. The microswitch specified meets this requirement.



Cyclops, from behind, after the modifications. Board 3, with C11 below, is in the foreground with S5, in its new position, at the right. At the top is the Perspex load-carrying plate, with the Perspex brackets at left and right. The bracket on the right carries the microswitch, S9. The load-carrying plate tension spring is to the left of the microswitch actuating rod

COMPONENTS

Resistors

(All ½ watt 10%)

R23	(new value) 2.2kΩ
R47	27kΩ
R48	5.6kΩ
R49	56kΩ
R50	2.2kΩ
R51	27kΩ
R52	2.2kΩ
R53	10kΩ (see text)
R54	12kΩ
R55	4.7kΩ
R56	22kΩ
R57	10kΩ
R58	470Ω
R59	4.7kΩ
R60	22kΩ
R61	22kΩ
R62	2.2kΩ
R63	6.8kΩ
R64	15kΩ

Capacitors

C11	125μF electrolytic, 10 V.Wkg.
C12	0.1μF
C13	0.05μF
C14	100μF electrolytic, 6 V.Wkg.

Semiconductors

TR32-TR39	Any p.n.p. transistors of medium gain, i.e. greater than 60
D10-D13	Any silicon diodes

Switches

S6-S8	Three push-button unit, each section with 4-pole changeover contacts (see text)
S9	Sensitive microswitch, e.g. Bulgin S530 (Home Radio Cat. No. WS104)

Miscellaneous

Veroboard, 0.15 in. matrix, 2⅜ in. × 1 in. (6 strips × 18 holes – see text)
8-way plug and socket (optional – see text)
1-off piece ⅛ in. Perspex, 6⅝ in. × 6½ in.
2-off pieces ⅛ in. Perspex, 6¼ in. × ⅝ in.
2-off Meccano angle brackets, part 12
1-off Meccano screwed rod, 2 in., part 81
1-off Meccano rod 8 in., part 13a
1-off Meccano rod 5 in., part 15
2-off Meccano rods 1½ in., part 18a
1-off Meccano tension spring 2 in., part 43
3-off Meccano bolts
6-off Meccano nuts

In the prototype, Board 3 was mounted on a miniature 8-way plug, with a corresponding socket on the chassis. However, the board is quite small and connections could be soldered direct to it if preferred.

All the diodes are silicon, and the transistors are as specified in the Components List.

(*To be continued*)

SHORT WAVE NEWS
FOR DX LISTENERS

By Frank A. Baldwin

Times=GMT *Frequencies*=kHz

We commence this month with a report on the reception of signals from Radio Hanoi, North Vietnam, on a measured frequency of **4892** (61.32 metres) on several occasions around the 2230 mark, at which time announcements and identification in Vietnamese are made. This transmission is part of the service to South Vietnam and also the domestic programme.

The domestic/S. Vietnam programme is radiated at various time periods from 0920 through to 0530 on **3365** (89.15m), **4715** (63.62m), **6380** (47.02m), **7740** (38.75m), **10015** (29.95m) and on **10095** (29.71m).

The service for S. Vietnam only is as follows – **4892** (measured but listed **4895**) (61.32m) from 1557 to 1858 and from 2129 to 2400; **7105** (42.22m) from 0925 to 1858 and from 2129 to 0530 and on **10050** (29.85m) from 0925 to 1555 and from 0100 to 0530.

The External service (Main Network) radiates a thirty minute programme in English on **10040** (29.88m) and **15105** (19.86m) at 0100, 0200, 1000, 1300 and at 2230.

The Second Network, to Indochina, on **7080** (42.37m) and **7800** (38.46m) radiates a half-hour programme in English from 1000 and from 1300.

Note: all the channels listed above are subject to some 10kHz variation (i.e. plus or minus 5kHz).

CURRENT SCHEDULES

●EGYPT

The Arab Republic of Egypt broadcasts to the non-Arab world in various languages throughout the day, that for the English transmission to Europe is on **9805** (30.59m) from 2145 to 2300 with the newscast at 2200. A broadcast in English is made from 1315 to 1430 on **17920** (16.74m) directed to South and Southeast Asia. From 1730 to 1845 on **17655** (16.99m) to East, Central and South Africa and from 2030 to 2200 on **17725** (16.92m) to West Africa. A further programme in English is directed to North America from 0200 to 0330 on **9475** (31.66m).

Programmes for the Arab world are radiated from Cairo throughout most of the day, listen for instance from 1630 to 1635 on **15475** (19.38m) or **17745** (16.90m) for a news summary in Arabic in the "Voice of the Arabs" service, or from 2030 to 2045 on **7050** (42.55m) or on **9850** (30.45m).

The Palestine service can be heard when signing-on at 1400, in Arabic, on **15475** (19.38m), **17625** (17.02m) and on **17745** (16.90m).

The Arab Maghrib service is on the air from 2130 to 2135 on **7050** and on **9850**.

The "Sudan Corner" programme from sign-on at 1200 through to 1625 on **9475** (31.66m) and on **11915** (25.17m).

The "Voice of the Palestine Revolution" operates from 1730 to 1930 on **9755** (30.75m). Another interesting transmission on this latter channel is that of the "Holy Qur'an Station", consisting of readings from the Holy Qur'an, from 0400 to 0900, 1200 to 1730 and from 1930 to 2100. (Qur'an, westernised incorrectly to Koran)

●ALBANIA

Radio Tirana broadcasts in English to Europe as follows – from 0630 to 0700 on **7065** (42.46m) and on **9500** (31.57m); from 1630 to 1700 on **7065** and on **9480** (31.64m); from 1830 to 1900 from 2030 to 2100 and from 2200 to 2230 on the two latter channels.

●GERMANY (EAST)

Radio Berlin International, "The Voice of the GDR", has a programme in English to Europe from 1815 to 1900 on **6080** (49.34m), **6115** (49.05m), **6125** (48.97m), **7185** (41.75m), **7215** (41.58m) and on **7300** (41.09m).

In English to the U.K. and Eire from 2130 to 2215 on all the above channels plus **9730** (30.83m) and from 2245 to 2330 on all the foregoing channels except **7215**.

●BULGARIA

Radio Sofia radiates programmes in English directed to the U.K. and Eire from 1930 to 2000 on **6070** (49.42m) and on **9700** (30.92m). Also from 2130 to 2200 on the same two channels.

●VATICAN CITY

Vatican Radio broadcasts in English to the U.K. and Eire from 1500 to 1515 on **9645** (31.10m), **11740** (25.55m) and on **15120** (19.84m); from 2045 to 2100 on **7250** (41.37m); **9645** and on **11740**.

●KOREA (NORTH)

Radio Pyongyang does not currently operate a service in English to Europe or the U.K. but does radiate in English to Africa, the Near and Middle East, from 1800 to 2000 on **3560** (84.26m) **6580** (45.59m) and on **9515** (31.52m).

●KOREA (SOUTH)

Seoul, the "Voice of Free Korea", directs a programme to Europe in English from 0630 to 0700 on **15335** (19.56m).

●ROUMANIA

Radio Bucharest has an English service to Europe from 1300 to 1330 on **11940** (25.12m), **15250** (19.67m) and on **17710** (16.93m). From 1930 to 2030 on **7195** (41.69m) and on **9570** (31.34m) and from 2100 to 2130 on **6150** (48.78m) and **7225** (41.52).

●POLAND

Radio Warsaw operates an English service to Europe as follows – from 0630 to 0700 on **7285** (41.18m), **9540** (31.44m) and on **9675** (31.00m); from 1200 to 1300 on **7285** and **9540**; from 1600 to 1630 on **6035** (49.71m), **7125** (42.10m), **7285** and **9540**; from 1830 to 1900 on **6035, 7125, 7285** and **9540**; from 2030 to 2100 on **6035** and **9540** and from 2230 to 2300 on **5995** (50.04m), **6135**, **7285** and on **9540**.

●KUWAIT

Radio Kuwait has a service in English for listeners in Europe, India, Pakistan and Sri Lanka from 0430 to 0700 on **15345** (19.55m) and from 1630 to 1900 on **15345** and on **9520** (31.51m).

●JORDAN

The Hashemite Kingdom of Jordan has a Foreign Language service from Amman, the English periods of which are – from 1100 to 1130 on **7155** (41.92m) and from 1630 to 1730 on **9560** (31.38m).

●AUSTRALIA

Radio Australia, Melbourne, operates a transmission directed to the U.K. and Europe in English from 0645 to 0745 on **11765** (25.49m) and from 0700 to 0745 on **9570** (31.34m).

●FINLAND

The FBC from Helsinki has an English schedule for Europe as follows – from 1400 to 1430 on **9550** (31.41m), **11755** (25.52m), **15185** (19.75m) and on **21605** (13.88m); from 1800 to 1830 on **9550, 11755, 15185** (not Tuesdays) and on **21605**; from 2030 to 2100 on **9550** and **11755**.

●SYRIA

Damascus has an English programme for Europe from 2030 to 2200 on **15165** (19.78m).

●IRAQ

Radio Baghdad has an English transmission directed to Europe from 1930 to 2020 on **9745** (30.78m).

The Home Service "Voice of the Masses" operates almost throughout the day and night, part of this schedule can be heard (in Arabic) from 1800 to 2305 on **7225** (41.52m) and from 1900 to 2305 on **3960** (75.75m).

The "Voice of Palestine, Voice of the Palestine Revolution", the programme of the Palestine Liberation Organisation, can be heard from 1630 to 1730 on **3960**.

AROUND THE DIAL

Radio Iran is currently using the additional channel of **15137** (19.81m) in parallel with the usual **15085** (19.88m) for the Domestic service from 0720 to 1430.

We have logged Radio Tehran on the unlisted channel of **9620** (31.18m) with the programme in English from 2000 to 2030, the frequency was not amongst those announced.

●AUSTRALIA

Radio Australia can often be logged during the afternoons, we heard them at 1620 on **7145** (41.98m) with identification in English and light music, also in parallel on **7235** (41.46m). This is part of the service to South and Southeast Asia which is as follows – from 1400 to 1500 on **9570** (31.34m) and on **11790** (25.44m); from 1430 to 1500 on **11765** (25.49m); from 1500 to 1730 on **5975** (50.20m), **6160** (48.70m), **7145, 7235, 9550** (31.41m), **11765** (25.49m), **11945** (25.11m) and from 1515 to 1730 on **9680** (30.99m).

●CUBA

Havana may be heard, with identification both in Arabic and French, at 1659 on **17735** (16.91m).

●PAKISTAN

Radio Pakistan has been entered into our log at 1330 on **21590** (13.89m) when we heard identification and a news comment in English.

Also heard on **9470** (31.67m) at 2023 with programme of local music and songs and on **7340** (40.87m) at 2030 with the news in English for the U.K.

Another channel on which Pakistan has been logged is that of **3940** (76.14m) at 1619 with a talk in English on Pakistan affairs. This is the Rawalpindi transmitter.

●CANADA

Radio Canada may be heard at 1900 on **11860** (25.29m) when a programme in English and Canadian news is radiated.

●ITALY

RAI Rome has an English programme, with the news at 1930, on **9710** (30.89m).

●BULGARIA

Radio Sofia can be heard on **9700** (30.92m) at 1930 with both the world and local news in English.

●SOUTH AFRICA

RSA has a newscast in English at 1900 on **15175** (19.76m). Johannesburg can also be heard with Interval signal and identification in English at 0757 on **21545** (13.92m).

●ECUADOR

HCJB Quito, may be logged at 1230 on **21460** (13.97m) at which time we heard the English programme preceded by identification, three short and one long 'pip' and time-check.

●MOZAMBIQUE

Radio Clube de Mozambique is listed on **4855** (61.79m). We logged them recently on a measured **4854.5** at 2000 when three chimes and station identification in Portuguese were heard. This is part of the Portuguese service, evening schedule of which is from 1530 to 2210.

R.C. Mozambique can also be heard on **4925** (60.91m) around 2000, we logged them at 2011 when a talk in Afrikaans was heard. This is the English/Afrikaans service, evening schedule from 1500 to 2200.

●ANGOLA

CR6RZ Emisor Official, Luanda, operates from 1700 to 2400 on **4820** (62.24m) we logged them at 2247 when a programme of Portuguese music and songs was being radiated.

CR6RG Radio Commercial de Angola, Sa da Bandeira, can often be heard around 2030 on **4795** (62.56m).

●SAO TOME

Radio Clube de Sao Tome operates on **4807** (62.40m) and can be heard around 1950 or so, usually with songs in Portuguese and local music. A mystery about this one is that it is apt to vanish from the scene for whole periods of time but the writer offers the tip – try on Friday evenings.

●CONGO

An interesting Dx station, recently logged for the first time, is that of a regional transmitter at Pointe Noire on a measured **4843** (61.94m) when a programme in French was heard. This transmitter relays Brazzaville from 0500 to 2000, we logged it at 1935.

In your workshop

In this episode, Smithy the Serviceman concludes the discussion on tape recorders which he started last month, and devotes his time to enlightening Dick on the subject of the magnetic tape transfer characteristic. He also, incidentally, demonstrates some surprising vagaries in his approach to matters of dress.

"NOW, WHAT ON EARTH HAS happened to them?"

Smithy set down his tin mug of tea and glanced over at his assistant. Dick was searching diligently over the surface of his bench, which was in its usual cluttered condition.

"What have you lost?"

"Some crocodile clips," replied Dick. "I had four nice and shiny new crocodile clips on my bench yesterday which I was going to fit on some of my test gear leads when I had the time. But I can't find them anywhere now."

Smithy absorbed this information.

"Whilst," he commented, "I applaud your diligence in looking for those crocodile clips during lunch-break, I'd much prefer it if you'd sit down quietly instead. You're getting on my nerves. clattering things about on your bench all the time."

BIAS CURRENT

"As you like," replied Dick unexpectedly. "If I sit down will you do me a favour?"

"That depends."

"Will you," asked Dick, "continue the discussion we started during our last gen-session? If you remember, you promised to explain why an a.c. bias signal is applied to the record head of a tape recorder during recording."

"Did I?" queried Smithy absently. "Ah yes I remember, now that you mention it. Well, for the sake of peace and quiet, I'll give you the gen you want. So fill up my mug again, then come on over to my bench."

Eagerly, Dick rose and took Smithy's mug to the tea pot situated near the Workshop sink. He soon returned with the mug, its precious cargo steaming cheerfully.

"Before we get on to technical matters," said Smithy as he took the mug, "there's something I've been meaning to tell you all morning. And that is that I don't think those trousers of yours are at all the sort of thing to wear in a reputable establishment such as this."

Dick looked down at his widely flared nether garments.

"What's wrong with them?"

"Anybody who wears trousers like that," pronounced Smithy firmly, "should be scrubbing decks, not fixing radios and TV's."

But Dick was more interested in tape recording than in standards of dress.

"Let's get on," he said keenly, "with this a.c. bias thing."

"Oh, all right," said Smithy resignedly, as he pulled his note-pad towards him. "I must, however, warn you that the particular subject we're going to deal with is a wee bit sticky in places so I'll need your full attention."

He fell silent for a moment, as he collected his thoughts.

"Now, at our last gen-sesh," he resumed, "we considered the function of the erase oscillator in a tape recorder. This oscillator produces a sine wave, which has to be kept as pure as possible, at a frequency of 40kHz or more. The sine wave is fed to the erase head. The recording tape passes the erase head first and then carries on to the record head which, in the usual low-cost type of domestic tape recorder, operates as a playback head also when the recorder is switched over to that function."

"That's right," put in Dick. "When the recorder is switched to record, the erase head wipes the tape clean of any previous signal it might have had on it, whereupon it's all ready to have a new signal applied to it at the record head." (Fig. 1).

"Correct," said Smithy. "Also, a small proportion of the erase alternating current is fed to the record head as bias."

"And that," chimed in Dick, "is where I got lost last time! I just don't get this business of an alternating bias current at all."

"Fair enough," commented Smithy. "Well now, if you're going to find out why we need an a.c. bias current you have first got to understand what happens when the tape is magnetised by the signal which is being recorded. And before you can understand *that*, you've got to take in a bit of basic magnetic theory."

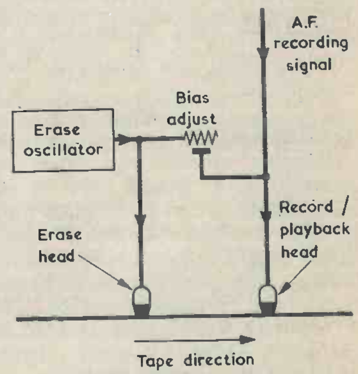


Fig. 1. When a tape recorder is switched to record, the full output of the erase oscillator is fed to the erase head and a small amount, as bias, to the record/playback head, the latter now functioning as a record head

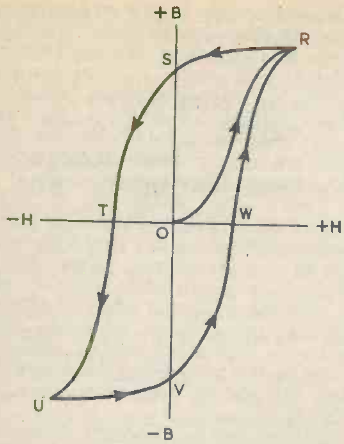


Fig. 2. The familiar BH hysteresis loop for successive cycles of magnetisation of a magnetic material. The dimensions and shape of the curve vary for different materials

Smithy pulled a ball-point pen from the cluster in his top pocket and proceeded to sketch out a diagram. (Fig. 2).

"What's that?" he asked.

"I suppose," said Dick thoughtfully, as he examined the diagram, "that it's a curve of some sort. It seems to have a familiar look about it."

"Can you remember it appearing in any basic iron-cored transformer theory you've encountered in the past?"

Dick looked more closely at the curve.

"Why, that's it!" he exclaimed suddenly. "It's an electromagnetic hysterical loop!"

Smithy turned a long-suffering glance towards the ceiling.

"If," he remarked in a hollow tone, "the future of our Electronic Age has to depend on the likes of you, Heaven rest the next few generations. It's not a 'hysterical' loop, you great big hairy steaming nit, it's a *hysteresis* loop. The word 'hysteresis' applies to any effect where, if you apply a force to a quantity, then reverse the force and bring it back to its starting point, the quantity does not revert to its old state. You have a hysteresis effect here, as I'll show you."

"What," interrupted Dick, "do the letters H and B stand for? You've shown the horizontal line as H and the vertical line as B."

"I have, indeed," agreed Smithy. "But before we get on to those letters I must next tell you that this loop shows what happens when a magnetic material undergoes a number of cycles of magnetising force. This state of affairs occurs in particular in an iron-cored transformer, where the magnetic material is the iron core of the transformer and the magnetising force is provided by passing on alternating electric current through the primary of that transformer; and that is why you encounter the curve when you're doing basic transformer theory. However, the loop applies also to any other instance where a magnetic material undergoes a changing magnetising force. And now for those two letters. The letter H stands for magnetising force and the letter B stands for the magnetic flux density which the magnetising force causes to appear in the magnetic material."

"Flux density," repeated Dick musingly, "Is that the same as magnetic field strength?"

"It is," confirmed Smithy. "But it's a little more correct, technically, to refer to it as 'flux density'. Let's start, now, by saying that our magnetic material is completely demagnetised and that we have zero magnetising force. This situation is represented at the point O, where the B and H axes intersect. We next begin to increase the magnetising force with a polarity which corresponds with its going to the right towards +H. This causes the flux density to increase also, and the latter rises from the zero point O towards the height corresponding to point R. We are approaching saturation in the piece of magnetic material at point R, and there is no real advantage to be gained in taking the magnetising force beyond this level."

"The flux density," commented Dick, "hasn't gone up in a very linear manner, has it?"

"It hasn't," agreed Smithy. "The rise in flux density from O to R is slow at first, then it speeds up to a maximum in the central part of the line. After that, it slows down again. The only nearly linear section of the OR line is the part in the middle. We shall now press on to the next operation, which consists of reducing magnetising force back to zero again. This does not, however, cause the flux density to reduce to zero also. Instead, the flux density merely goes down a little bit, falling only to point S on the B axis. This effect is the result of the residual magnetism which is left in the magnetic material, and the flux density of this residual magnetism is equal to the height of point S above point O. This height also represents the 'remanence value' of the magnetisation."

COERCIVITY

"How," asked Dick, "do you get the residual magnetism down to zero?"

"By increasing the magnetising force in the opposite direction. Which means, in our diagram, by taking the magnetising force from the zero point O to the left, towards the −H end of the H axis. If we do this we will eventually reach the point T, at which point flux density is again zero. But, as you can see, we've had to use quite a lot of magnetising force in the −H direction to achieve this. For the record, the length of the line OT on the horizontal axis is a measure of the coercive force applied, or of the coercivity of the magnetic material."

"Okeydoke," said Dick brightly. "So far as I can see from the loop, if we continue to increase magnetising force in the −H direction by the same amount as we did in the +H direction, we will eventually arrive at point U, which is dead opposite the first peak at point R."

"That's right," stated Smithy. "Should we next start changing H in the right-hand direction so that it first decreases to zero and then increases on the +H side, we finally come back again to point R. In doing so, the loop passes through points V and W in turn, and the curve U, V, W, R has the same shape as the curve R, S, T, U."

"Well, all that seems reasonable enough," remarked Dick cheerfully. "When we start with a demagnetised piece of magnetic material and pass it through a number of cycles of magnetising force starting from zero, the graph for magnetising force and flux density initially traces out the line OR. After that, successive cycles of magnetisation take the relationship around the outside loop."

"You've got it," confirmed Smithy. "Now, it so happens that for our present discussion, where we're talking about the magnetisation of moving tape, we're only interested in the part of the curve which goes from O to R and then drops down again to S."

Smithy tore the top sheet from his note-pad and, in so doing, glanced down at the side of his bench.

"Darn it, Dick," he expostulated, "those trousers of yours really *are* too bad. I honestly think I'll have to tell you not to wear them in here again."

"Don't say you're still on about them," protested Dick aggrievedly. "What you don't seem to know is that these trousers of mine have been greatly admired by my friends. I decided to start wearing them in here today to brighten the place up a bit."

"Do they," asked Smithy querulously, "have to be such a *bright* scarlet?"

"If," Dick stated loftily, "you followed fashion a bit more closely you'd know that these trousers represent the very latest in current trends."

"To my mind," retorted Smithy crossly, "they just look common."

Dick's face approached the colour of his trousers at this superlative epithet.

"At any event," he replied furiously, "I don't go around with half a dozen pens poking out of my breast pocket. Blimey, mate, the top front left of your jacket looks like the diapason pipes of the organ at Canterbury Cathedral."

"A man in my position," snorted Smithy, highly offended by this sudden attack, "*always* has a lot of pens in his breast pocket. It's expected of him."

"Also," said Dick cuttingly, "I don't wear braces."

Smithy's jacket was already unbuttoned and, with a contemptuous flourish, Dick flicked it open to reveal the accessories in question.

"Well, really," spluttered the affronted Serviceman, "this is tantamount to bodily assault."

But Dick had spotted something at the end of one of the braces supports.

"Ye gods," he gasped. "What's this?"

"Get your hands off me," said Smithy hastily, as Dick peered more closely, "and don't go poking your nose into things that don't concern you."

"I *thought*," chuckled Dick, "that one of those braces buttons looked a little funny. It is, too. It isn't a button at all – it's an 0.1μF disc ceramic!"

"I'm having trouble with the dry cleaners," explained Smithy, patently embarrassed by Dick's discovery. "They've mislaid my other working suit and I had to dig out this old one. The trousers had a braces button missing and so I made do with that capacitor as an alternative."

He stopped for a moment, and his old authority gradually returned.

"It makes a jolly good button, too," he stated aggressively. "You just push the two lead-outs through the fabric at two points that are slightly spaced apart, then twist the wires together on the inside. The braces loop then goes over the body of the capacitor."

"Blow me," said Dick, continuing his examination of Smithy's garments, "there's something else here, too."

He turned one of Smithy's jacket flaps over.

"I must," he remarked unbelievingly, "have seen everything now. One of your jacket buttons is held on with a bit of black enamelled wire twisted round a 2BA washer at the back of the material. Dash it all, Smithy, can't you sew a button on properly?"

Smithy pushed his assistant's hands away from him and rose in dignity.

"I am a service engineer," he stated pompously, 'and not a seamstress; and I use the products appropriate to my calling. Now, if you've quite finished messing around with my clothing I'd be obliged if you'd go and get me another mug of tea."

As his grinning assistant walked over to the Workshop sink, the ruffled Smithy carefully preened himself and settled his clothes properly once more. Dick returned with the mug. This act of obedience to Smithy's command restored the Workshop to its proper condition, with Smithy in his rightful place as Service Manager, and Dick in the more lowly niche of Staff.

TRANSFER CHARACTERISTIC

Smithy took a sip from the mug and marshalled his scattered wits.

"Let's see," he said, "if I can recall what it was we were talking about a few minutes ago. Ah yes, I remember now. I'd explained the BH hysteresis loop to you and I then said that, so far as magnetic tape is concerned, the only part of the loop we're interested in is the bit where the magnetising force goes up to maximum in one direction and then returns to zero again."

"Why is that?" asked Dick, as his mind once more concentrated on technical matters. "What about the remainder of the outside of the hysteresis loop?"

"We can forget about that," replied Smithy, "by making the assumption, which is certainly true for the lower audio recording frequencies, that the magnetisation of the tape only follows the first section of the loop. The subsequent parts of the loop are not applied to the tape because it has by then left the record head gap where the magnetising force appears. Let's see what happens to a particle in the magnetic coating of the tape at the moment of passing the record head gap. This particle is raised to a flux density which is proportional to the record current flowing in the record head winding, after which it leaves the head and is subjected to no further magnetising force. The flux density in the tape then drops to the residual, or remanence, value."

"Oh, I see," said Dick quickly. "Each particle in the tape is taken up to a value on the OR line in the hysteresis loop, after which it drops to the corresponding remanence value."

"That's it," confirmed Smithy, picking up his pen and drawing some further sketches. "Let's next look at a few of the remanence values we're likely to get on the tape. I'll start off by drawing an initial curve in which the magnetising force takes the flux density as high along the OR curve as it did in the hysteresis loop diagram, then I'll add its drop to remanence level. Here you are."

Dick looked at Smithy's diagram. (Fig. 3(a)).

"Well, that," he remarked, "is perfectly clear. It's the same as we had in the overall hysteresis curve when we went from point O to point R and then back again to point S."

Smithy sketched out three further diagrams. (Figs. 3(b), (c) and (d)).

"And here," he remarked, "are three more examples. In the first of these the magnetising force takes the

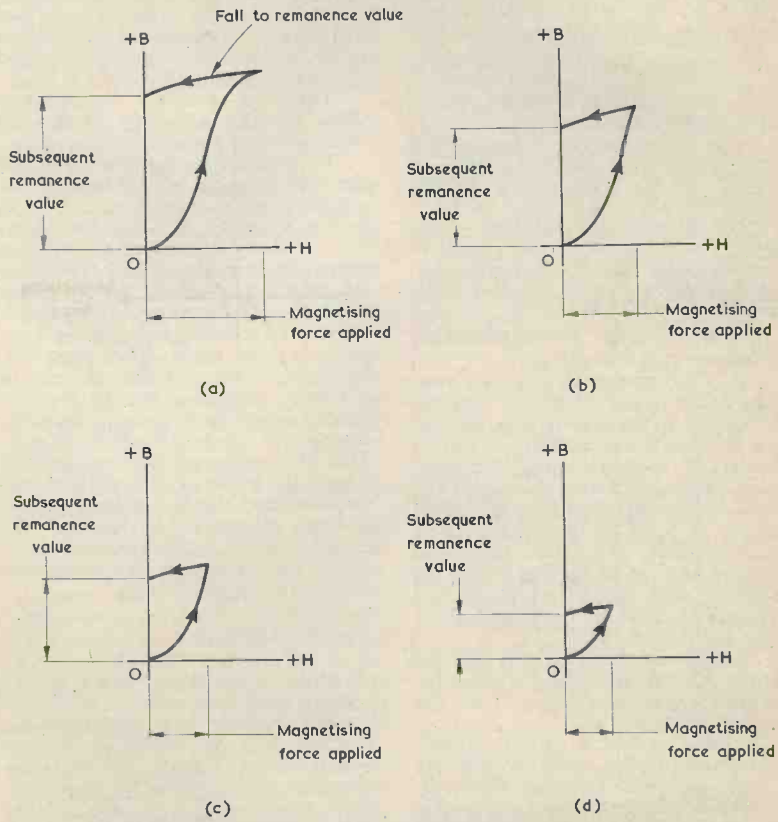


Fig. 3 (a) Subsequent remanence value in recording tape for the magnetising force shown
(b) (c) (d) The remanence values given by progressively reducing magnetising forces

flux density about three-quarters of the way up the original OR curve, the second takes it about half-way up and the third about a quarter of the way up. In each case there's a subsequent drop to remanence value. Do you notice anything about these drops to remanence value?"

Dick examined the diagrams critically.

"I can't see anything in particular," he remarked. "Apart from the pretty obvious fact that the amount of drop to remanence in each instance is approximately proportional to the height of the curve before the drop commences."

"That," said Smithy, pleased, "is just what I wanted you to say. Since the falls to remanence value are proportional to the peak flux density in each case it follows that, if we were to draw a curve showing final tape remanence value against magnetising force, this curve would have just about the same shape as did our original OR curve. If we used the same flux density units on the vertical axis as in the previous case, the only difference would be that the new curve would be smaller in height."

Smithy drew the curve in question. (Fig. 4(a)).

"There you are," he remarked. "That's the curve showing tape remanence value against magnetising force. But this curve shows only half of the complete picture because, with an alternating signal current applied to the record head, there will be magnetisation with opposite polarity as well. This will produce remanence values of flux density in the bottom left-hand quadrant of our diagram in exactly the same way as in the top right-hand quadrant, and we obtain a bottom left-hand curve which is a mirror image of the top right-hand curve. I'll sketch it out now."

Smithy added the second part of the curve. (Fig. 4(d).)

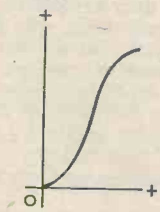
"Phew," said Dick. "We seem to have covered a lot of ground just to arrive at this curve."

"There *have* been a few things to consider," conceded Smithy. "But it was necessary to start off with the original hysteresis loop, pick the initial magnetisation section out of this, then make the hop from the flux density produced by the magnetising force to the remanence value which is left when the magnetising force is removed. Now this final curve I've drawn is a very important one because it represents the transfer characteristic of the tape. If defines the flux density which is left on the tape, and which will later activate the playback head, for the varying magnetising forces which are produced by the record head as the tape passes it."

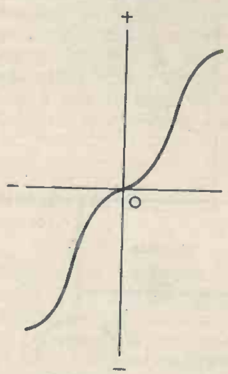
"I see," commented Dick. "I assume that the magnetising force applied to the tape is proportional to the recording signal amplitude at the record head."

"It's proportional," said Smithy, "to the amplitude of the recording signal *current* flowing in the head winding. It's necessary here to think in terms of the signal current only in the head winding, and not in terms of the signal voltage across the winding or the power dissipated in it.'

"Thinking in terms of current only seems sensible enough to me," stated Dick, critically. "For instance, when we talk of the magnetising force given by, say, a solenoid coil we normally refer to this as so many amp-turns, the amp bit being the current in the coil and the turns bit being the number of turns the coil has."



(a)



(b)

Fig. 4 (a) The curve showing tape remanence value against magnetising force is similar to the curve OR of Fig. 2

(b) To accommodate magnetising forces of both polarity, the curve of (a) is repeated in the opposite quadrant. The complete curve shown here is the transfer characteristic for the tape

D.C. BIAS

"That's the idea," affirmed Smithy. "Coming back to the tape recorder head, the recording signal is normally fed to this by what is called a 'constant current' circuit. A circuit of this nature is required because, since the record head is essentially an inductive component, it offers an impedance which increases with the recording signal frequency. With the earlier valve recorders it was a simple process to provide a 'constant current' arrangement, as all that had to be done was to supply the record head from a voltage amplifier anode by way of a fixed resistor whose value was much higher than the impedance of the head at the highest frequency to be recorded. The valve anode then worked into a load whose total impedance only altered by a small amount over the whole audio frequency range, whereupon the current in the record head winding was, near enough, proportional to voltage amplitude at the anode for all audio frequencies." (Fig. 5(a)).

"What about present-day transistor recorders?"

"Well," said Smithy. "You can't get as high a voltage swing at the collector of a transistor as you can at the anode of a valve because the supply voltage is much lower. The series resistor idea is still common in transistor recorders, nevertheless, but the lower voltage available means that the head impedance and resistor values are a lot smaller. A scheme you'll encounter in some transistor recorders employs a step-up transformer at the stage which feeds the record head. This steps up the audio voltage available, whereupon the fixed series resistor arrangement becomes comparable with that in a valve recorder." (Fig. 5(b)).

Smithy took a further draught from his mug.

"However, we're digressing a bit here," he continued, "as our main interest at the moment is in the a.c. bias that's applied to the record head."

"That transfer characteristic you drew just now," said Dick, returning to Smithy's sketch, "doesn't look very linear to me."

"It's anything but," agreed Smithy, as he tore the next sheet from his pad and proceeded to draw a further diagram. "The worst bit is in the middle, on either side of the zero point. If we apply a sine wave current to the record head it will appear, as remanent magnetisation on the tape, in extremely distorted form."

Smithy completed the diagram, then showed it to Dick. (Fig. 6(a)).

"As you can see," he went on, "the non-linear part of the characteristic causes the centre of the sine wave on the tape to be all squashed up. If the sine wave has a large amplitude, its peaks also get compressed."

"The two central bits of the characteristic above and below the zero line look fairly linear," commented Dick. "Couldn't you apply the sine wave to one of them?"

"You could," said Smithy, busy again with his pen. "And a suitable way of doing this would be by feeding a direct current to the record head in addition to the audio current. This is known as d.c. bias, incidentally, and it shifts the sine wave over to one side." (Fig. 6(b)).

Dick looked with interest at the latest diagram Smithy had drawn out.

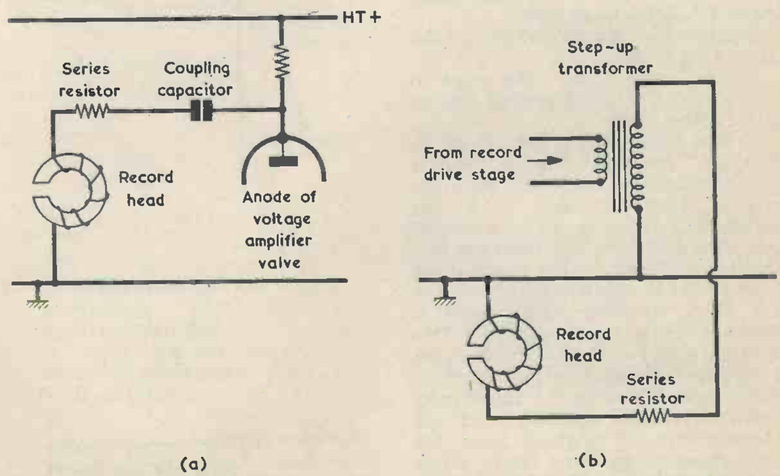


Fig. 5 (a) A 'constant current' record head drive circuit can be easily provided in a valve tape recorder
(b) Some transistor recorders have a step-up transformer to provide a high voltage swing for a 'constant current' circuit. The transformer, via suitable taps, may also drive the speaker when the recorder is switched to playback

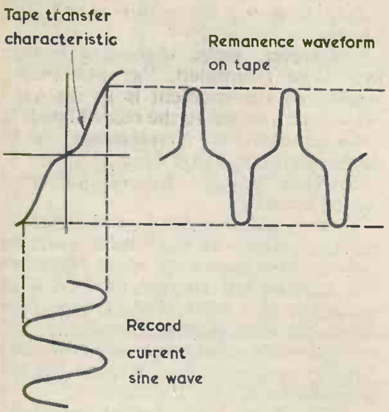


Fig. 6 (a) If a sine wave current is applied graphically to the tape transfer characteristic, the corresponding tape remanence waveform can be drawn on the right. In this instance the remanence waveform is heavily distorted

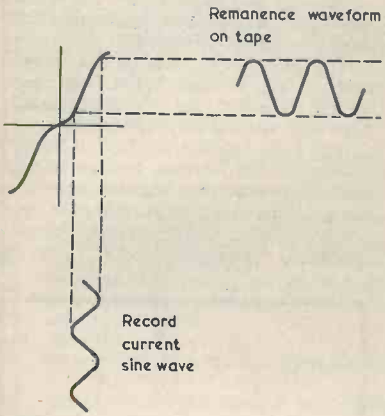


Fig. 6 (b) D.C. bias shifts the record current sine wave to a linear section of the transfer characteristic. Provided the record current amplitude is reasonably low the remanence waveform does not have excessive distortion

"That looks fairly practicable," he remarked. "Provided the sine wave amplitude isn't too large, the waveform on the tape should be reasonably free from distortion."

"True enough," said Smithy. "But in practice the d.c. bias approach doesn't work very well. The main difficulty is that the tape becomes continually magnetised and this results in noise. D.C. bias was used in early experimental recorders, but it was soon abandoned when the a.c. bias approach was discovered. The a.c. bias current, which as we have already mentioned is of the order of 40kHz or more, is given an amplitude which causes its peaks to be at the centres of the two linear sections of the transfer characteristic. Like this."

Smithy scribbled out a further sketch. (Fig. 7(a)).

"If now," he continued, "we add an audio sine wave current at the record head, the bias peaks are deflected to the left and right in our diagram in sympathy with the sine wave. The resulting remanent magnetisation on the tape consists of a series of peaks which are produced by way of the two linear sections of the transfer characteristic. The average remanent value between these two sets of peaks then takes up a form which is a virtually distortion-free version of the recording sine wave current. Here's what happens."

Smithy quickly drew out yet a further diagram. (Fig. 7(b)).

"Blimey," remarked Dick, impressed. "The a.c. bias current certainly overcomes the non-linearity in the transfer characteristic of the tape. Why, even a tiny little signal amplitude will still be effectively applied to the linear sections of the characteristic."

"It will."

"Hang on a minute," said Dick. "You haven't drawn any bias cycles in the right-hand remanence waveform. What's happened to them?"

"They disappear after the tape leaves

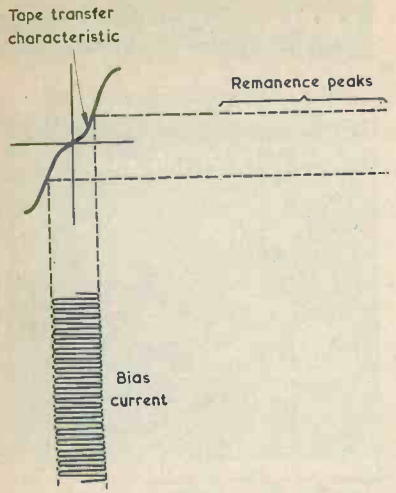


Fig. 7 (a) A high frequency current applied to the tape transfer characteristic

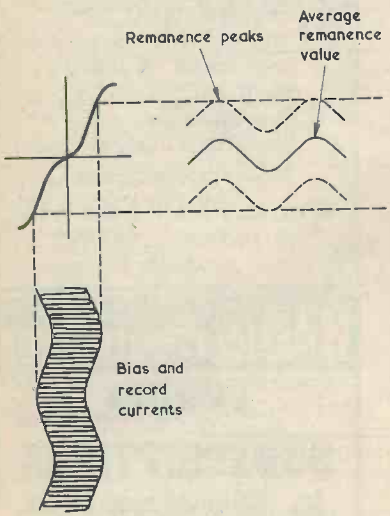


Fig. 7 (b) When an a.f. sine wave is added to the bias current the average remanence value on the tape is similarly a sine wave. In practice, the bias frequency will be higher than indicated here, and the peaks closer together

the record head," explained Smithy. "Audio recording tape has a self-demagnetising effect at very high frequencies and so it cannot retain the bias cycles."

"Stap me," remarked Dick. "Why, this is really fascinating. What the a.c. bias does is to put the recording signal on to the linear sections of the transfer characteristic whilst the tape is actually passing the record head. After that, it quietly fades away from the scene."

"Precisely," concurred Smithy, pushing his note-pad away from him with a purposeful gesture. "And that finally explains why a.c. bias allows low-distortion recordings to be obtained on magnetic tape."

He rose and drained his mug, then glanced down irritably at his assistant.

"And I wish," he added severely, temporarily forgetting his own sartorial shortcomings "that those horrible pants of yours would quietly fade away from the scene as well. They're *most* unsuitable."

"At least," retorted Dick, irritated by Smithy's insistence on the unsatisfactory nature of his trousers, "they *are* proper clothes and not just bits and pieces held together with wire and components like you wear. Hello, I've just noticed something else."

Dick peered down at Smithy's smartly polished brown shoes.

"What have you seen now?"

"It's those shoes of yours," breathed Dick incredulously. "They aren't tied up with laces at all. They're tied up with lengths of brown p.v.c. wire!"

MYSTERY SOLVED

"What's wrong with that? Why buy shoe laces when there's a cheaper alternative available?"

"Do you know, Smithy," commented Dick, "you're just a walking electronic store-room. When you get undressed at night, you must need a box spanner and a soldering iron to get everything undone."

Smithy made no reply and glowered at his assistant.

"Oh, well," stated that worthy airily, "since we've finished talking about tape recorders, there seems to be nothing left for me to do but to resume my hunt for those four crocodile clips of mine."

"I'll return them to you," remarked Smithy unguardedly, "when I get my trousers back from the cleaners."

"You'll do *what?*" stuttered Dick. "Don't tell me that you're wearing crocodile clips as well."

An embarrassed expression crossed over Smithy's face.

"It so happened," he explained reluctantly, "that the zip fastener on my trousers broke yesterday afternoon just before I was leaving the Workshop. I've now got the two flaps joined together by those crocodile clips equi-spaced on the inside!"

And even Smithy, student of human character that he was, had to confess himself completely dumbfounded as his assistant broke into a full minute of uncontrollable and hysteresis – sorry, hysterical – laughter. ■

Yell out to dad something's wrong with the TV and watch his face when he comes through the door!

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(Continued on page 599)

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(Continued from page 597)

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RESONANT FREQUENCIES I

The Table gives calculated resonant frequencies, in MHz, for tuned circuits having inductances from 0.1 to 20µH and capacitances of 5pF, 20pF, 80pF and 320pF. Thus, 10µH and 20pF are resonant at 11.2MHz.

Inductance (µH)	5pF	20pF	80pF	320pF	Inductance (µH)	5pF	20pF	80pF	320pF
0.1	225	112	56.2	28.1	6.0	29.1	14.5	7.27	3.64
0.2	159	79.5	39.7	19.9	7.0	26.9	13.4	6.72	3.36
0.4	112	56.2	28.1	14.0	8.0	25.2	12.6	6.30	3.15
0.7	85.1	42.5	21.3	10.6	9.0	23.7	11.9	5.93	2.97
1.0	71.2	35.6	17.8	8.90	10	22.5	11.2	5.62	2.81
1.3	62.5	31.2	15.6	7.81	11	21.5	10.7	5.37	2.69
1.7	54.6	27.3	13.6	6.82	12	20.5	10.3	5.01	2.56
2.0	50.4	25.2	12.6	6.30	13	19.7	9.85	4.92	2.46
2.5	45.0	22.5	11.2	5.62	14	19.0	9.52	4.76	2.38
3.0	41.1	20.5	10.3	5.14	15	18.4	9.20	4.60	2.30
3.5	38.1	19.0	9.52	4.76	16	17.8	8.90	4.45	2.22
4.0	35.6	17.8	8.90	4.45	17	17.3	8.65	4.32	2.16
4.5	33.6	16.8	8.40	4.20	18	16.8	8.40	4.20	2.10
5.0	31.8	15.9	7.95	3.97	19	16.3	8.15	4.07	2.04
5.5	30.4	15.2	7.60	3.80	20	15.9	7.95	3.97	1.99

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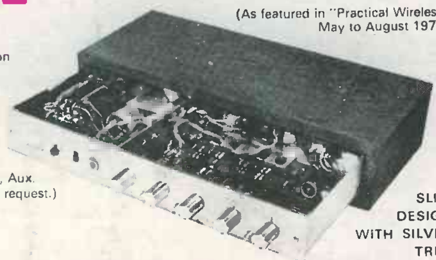

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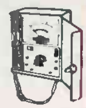

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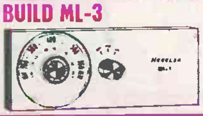

Uses Mullard Module. Slow motion tuning. Built in battery. Ferrite aerial. Overall size 7" x 2¾" x 3⅞". TOTAL COST TO BUILD £4.85. Post 15p. All parts sold separately – Leaflet No. 6.

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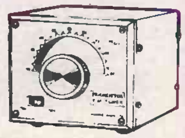

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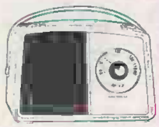

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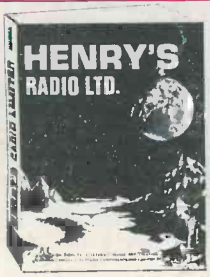

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