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Vol 19 No 12

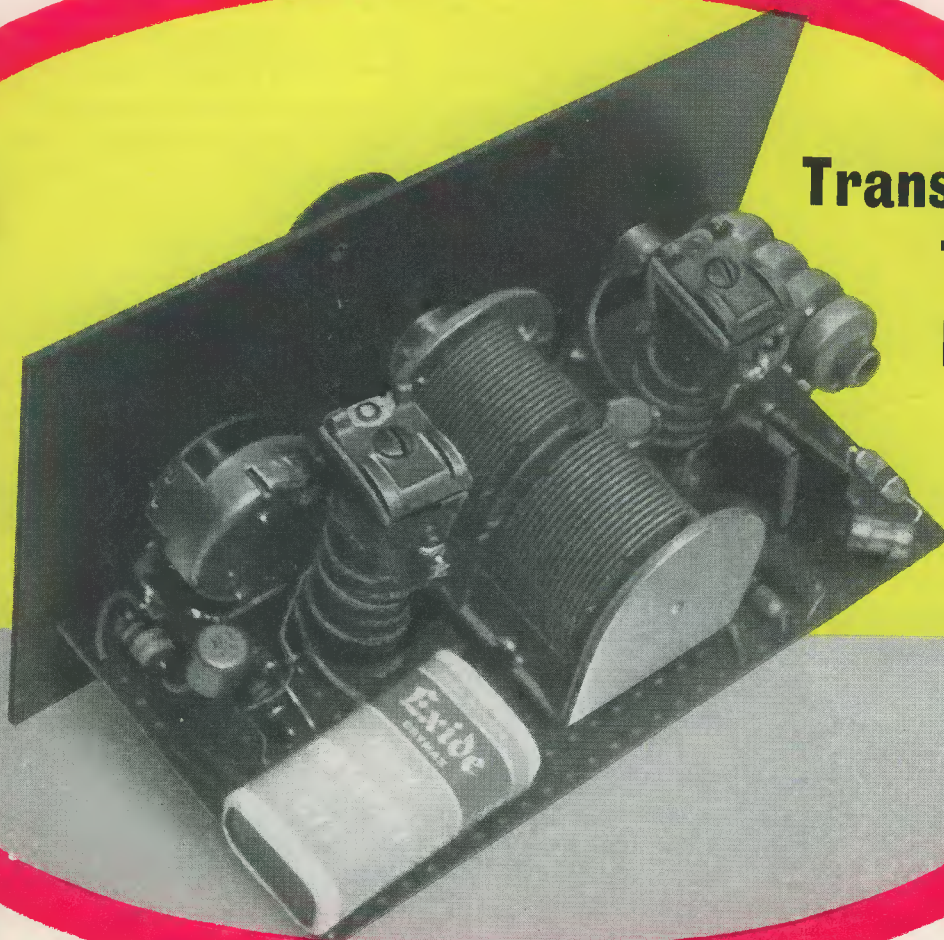
JULY 1966

2/3

A DATA PUBLICATION

THE **Radio Constructor**

**RADIO • TELEVISION
ELECTRONICS • AUDIO**



Transistorised T.R.F. Receiver

Basic Radio
Control ★

Experimental F.M.
Tuner ★

Transistorised Flashing
Indicator ★

Record-Player
Amplifier ★

Scottish Insurance Corporation Ltd

38 EASTCHEAP · LONDON · EC3



*TELEVISION
SETS,
RECEIVERS
AND
TRANSMITTERS*

Television Sets, Receivers and Short Wave Transmitters are expensive to acquire and you no doubt highly prize your installation. Apart from the value of your Set, you might be held responsible should injury be caused by a fault in the Set, or injury or damage by your Aerial collapsing.

A "Scottish" special policy for Television Sets, Receivers and Short Wave Transmitters provides the following cover:

- (a) Loss or damage to installation (including in the case of Television Sets the Cathode Ray Tube) by Fire, Explosion, Lightning, Theft or Accidental External Means at any private dwelling-house.
- (b) (i) Legal Liability for bodily injury to Third Parties or damage to their property arising out of the breakage or collapse of the Aerial Fittings or Mast, or through any defect in the Set. Indemnity £10,000 any one accident.
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SCOTTISH INSURANCE CORPORATION LTD.,
38 EASTCHEAP, LONDON E.C.3**

Sinclair Z.12

COMBINED
12 WATT
AMPLIFIER
AND PRE-AMP

For size alone, the Z.12 marks an important advance in quality design, for its amazing compactness opens up exciting new vistas in amplifier housing and application. Combined with this are the fantastic power and superb quality of the Z.12 which can provide an effortless output of 12 watts R.M.S. continuous sine wave from its unique eight transistor circuit. Basically intended as the heart of any good mono or stereo hi-fi system, the size and efficiency of this Sinclair unit make it equally useful for a car radio (with the Micro-6 for example), a high quality radio with the Micro FM, in a guitar, P.A. or intercom system, etc. Other applications are certain to suggest themselves to constructors. The manual included with the Z.12 details many mono and stereo tone and volume control circuits by which inputs can be matched (and switched in) to the pre-amp. The size, performance and price of the Z.12 all favour the constructor seeking the finest in transistorised audio reproduction—it is in fact today's finest buy in top grade high fidelity.

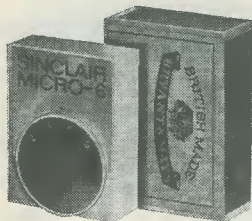
NEW A UNIQUE TRANSISTORISED POWER SUPPLY UNIT SINCLAIR PZ.3

The SINCLAIR PZ.3 Power Supply Unit uses new and original circuitry based on advanced transistorised techniques to achieve phenomenally good smoothing and thus assure ideal operating conditions for the Z.12 for which it was designed. Ripple is a barely measurable 0.05V and the PZ.3 will power two Z.12s with ease. Output—20V d.c. For A.C. Mains Operation 200-250V.

79/6

SINCLAIR MICRO-6

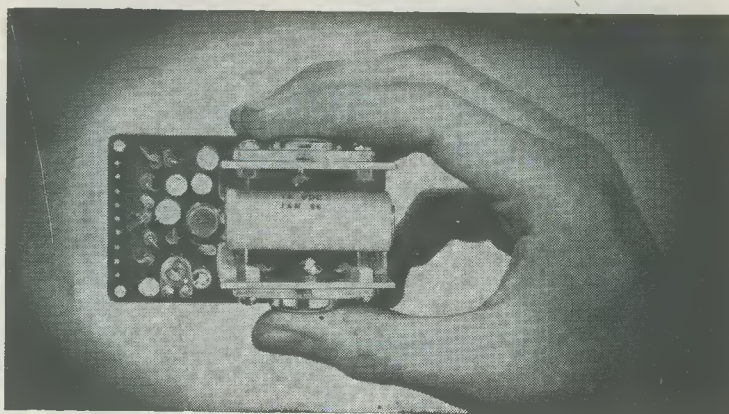
The
smallest
set
in
the
world



For power, selectivity and quality, this amazing six stage M.W. receiver is unequalled. 2 stages R.F. amplification, double diode detector, 3 stage A.F. amplifier, A.G.C. etc. Complete with self-contained aerial in white, gold and black case, size 1 1/2" x 1 3/10" x 1 1/2". Plays anywhere. Very easy to build. Complete kit of parts with ear-piece and instructions.

59/6

MALLORY MERCURY CELL ZM.312
(2 required) each 1s. 11d.



12 WATTS R.M.S. OUTPUT CONTINUOUS SINE WAVE (24 W. PEAK) 15 WATTS R.M.S. MUSIC POWER (30 WATTS PEAK)

- 8 special HF transistors.
- Ultra-linear class B output and generous neg. feed back.
- Response—15 to 50,000 c/s ± 1 dB.
- Output suitable for 3, 7.5 and 15 ohm loads. Two 3 ohm speakers may be used in parallel.

USE IT FOR HI-FI, RADIO,
GUITAR, INTERCOM, P.A. etc.

- Input—2mV into 2K ohms.
- Signal to noise ratio—better than 60dB.

Ready built, tested
and guaranteed
with Z.12 manual

89/6

Sinclair MICRO FM

COMBINED POCKET SIZE FM TUNER/RECEIVER

For less outlay, you can use the Micro F.M. both as a TUNER and as an independent pocket portable. This wonderful set is as outstanding in appearance as performance and it will operate in all but the worst F.M. reception areas.

TECHNICAL DESCRIPTION

Measures less than 3in. high x 1 1/2in. wide with a depth of 2in. The set's R.F. amplifier is followed by a self-oscillating mixer and 3 stages of I.F. amplification to dispense with I.F. transformer and all problems of alignment. A pulse-counting detector ensures improved linearity and therefore better audio quality at the output stages. After equalisation the signal is channelled to one output for feeding to amplifier or recorder and to another in which the receiver's own audio amplifying stage enables the Micro FM to be used as an independent self-contained pocket portable. A.F.C. is used to lock the programme tuned in; the telescopic aerial included with the kit will be found sufficient for all but the worst signal areas.

- ★ Supply voltage—9v from self contained standard battery.
- ★ Consumption—5mA
- ★ Sensitivity—Typically 3mV
- ★ Signal to Noise Ratio—30dB at 30mV
- ★ Audio frequency response—10-20,000 c/s. ★ A.F.C.
- ★ Inserting plug of ear-piece or tuner lead switches set ON.



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TRANSISTOR
SUPERHET
FM WITH
2 OUTPUTS

Complete kit inc.
transistors, aerial,
case, earpiece and
instructions.

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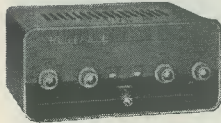
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RC7

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Telephone 52731

HI-FI AMPLIFIERS ~~~~~ TUNERS ~~~~~ RECORD PLAYERS



3+3W
STEREO
AMP.
S-33H



10W
POWER
AMP.
MA-12

10W POWER AMPLIFIER. Model MA-12. 10W output, wide freq. range, low distortion. For use with control unit. Kit **£11.18.0** Assembled **£15.18.0**

3 + 3W STEREO AMPLIFIER. Model S-33. An easy-to-build, low cost unit. 2 inputs per channel. Kit **£13.7.6** Assembled **£18.18.0**

DE LUXE STEREO AMPLIFIER. Model S-33H. De luxe version of the S-33 with two-tone grey perspex panel, and higher sensitivity necessary to accept the Decca Deram pick-up. Kit **£15.17.6** Assembled **£21.7.6**

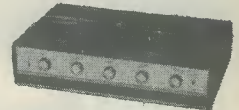
HI-FI STEREO AMPLIFIER. Model S-99. 9 + 9W output. Ganged controls. Stereo/Mono gram, radio and tape inputs. Push-button selection. Printed circuit construction. Kit **£28.9.6** Assembled **£38.9.6**

TRANSISTOR PA/GUITAR AMPLIFIER, PA-2. 20W amplifier. Four inputs. Variable tremolo. Kit **£44.19.0** Assembled **£59.10.0**

50W VALVE PA/GUITAR AMP., PA-2. Kit **£54.15.0** Assembled **£74.0.0**



GARRARD
PLAYER
AT-60



20+2
STEREO
AMP.
AA-22

TRANSISTOR MIXER. Model TM-1. A must for the tape enth. diast. Four channels. Battery operated. Similar styling to Model AA-22 Amplifier. With cabinet. Kit **£11.16.6** Assembled **£16.17.6**

20+20W TRANSISTOR STEREO AMPLIFIER. Model AA-22U. Outstanding performance and appearance. Kit **£39.10.0** (less cabinet) Attractive walnut veneered cabinet £2.5.0 extra. Assembled **£59.15.0**

GARRARD AUTO/RECORD PLAYER. Model AT-60. less cartridge **£13.1.7** With Decca Deram pick-up **£17.16.1** incl. P.T. Many other Garrard models available, ask for Lists.

HI-FI MONO AMPLIFIER. Model MA-5. A general purpose 5W Amplifier, with inputs for Gram., Radio. Attractive modern styling. Kit **£10.19.6** Assembled **£15.10.0**



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3" LOW-PRICED SERVICE OSCILLOSCOPE. Model OS-2. Compact size 5" x 7 1/2" x 12" deep. Wt. only 9 1/2 lb. "Y" bandwidth 2 c/s-3 Mc/s ± 3dB. Sensitivity 100mV/cm. T/B 20 c/s-200 kc/s in four ranges, fitted mu-metal CRT Shield. Modern functional styling. Kit **£22.18.0** Assembled **£30.8.0**

5" GEN-PURPOSE OSCILLOSCOPE. Model 10-12U. An outstanding model with professional specification and styling. "Y" bandwidth 3 c/s-4.5 Mc/s ± 3dB. T/B 10 c/s-500 kc/s. Kit **£35.17.6** Assembled **£45.15.0**

DE LUXE LARGE-SCALE VALVE VOLT-METER. Model IM-13U. Circuit and specification based on the well-known model V-7A but with many worth-while refinements. 6" Ernest Turner meter. Unique gimbal bracket allows operation of instrument in many positions. Modern styling. Kit **£18.18.0** Assembled **£26.18.0**

AUDIO SIGNAL GENERATOR. Model AG-9U. 10 c/s to 100 kc/s, switch selected. Distortion less than 0.1%, 10V sine wave output metered in volts and dB's. Kit **£22.10.0** Assembled **£30.10.0**

VALVE VOLTMETER. Model V-7A. 7 voltage ranges d.c. volts to 1,500. A.c. to 1,500 r.m.s. and 4,000 peak to peak. Resistance 0.1Ω to 1,000MΩ with internal battery. D.c. input resistance 11MΩ. dB measurement, has centre-zero scale. Complete with test prods, leads and standardising battery. Kit **£13.18.6** Assembled **£19.18.6**

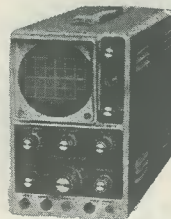
MULTIMETER. Model MM-1U. Ranges 0-1.5V to 1,500V a.c. and d.c.; 150μA to 15A d.c.; 0.2Ω to 20MΩ. 4 1/2" 50μA meter. Kit **£12.18.0** Assembled **£18.11.6**

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TRANSISTOR POWER SUPPLY. Model IP-20U. Up to 50V, 1.5A output. Ideal for Laboratory use. Compact size. Kit **£35.18.0** Assembled **£47.18.0**

Prices and specifications subject to change without notice



OS-2



IM-13U



V-7A



RF-1U



IG-82U

NEW! TRANSISTOR FM TUNER

Designed to match the AA-22U Amplifier. Available in separate units comprising Models TFMT-1 RF Tuning Unit **£5.16.0** incl. P.T. and TFA-1M (Mono) IF Amplifier, power supply, etc. **£15.3.0** kit or TFA-1S (Stereo) IF Amplifier, etc. **£19.2.0** kit. TFMT-1 14 transistor circuit. Pre-assembled and aligned "front-end". 4 stage IF Amplifier. AFC. Printed circuit construction. Walnut veneered, finished cabinet available as optional extra. Can be built for:



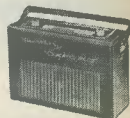
Total Price kit (Mono) £20.19.0 incl. P.T.

Total Price kit (Stereo) £24.18.0 incl. P.T.

Cabinet **£2.5.0** extra. Send for full details.

TRANSISTOR RECEIVERS

"OXFORD" LUXURY PORTABLE. Model UXR-2. Specially designed for use as a domestic, car or personal portable receiver. Many features, including solid leather case. Kit **£14.18.0** incl. P.T.



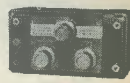
UXR-2

TRANSISTOR PORTABLE. Model UXR-1. Pre-aligned I.F. transformers, printed circuit. Covers L.W. and M.W. Has 7" x 4" loud-speaker. Real hide case. Kit **£12.11.0** incl. P.T.



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UJR-1

JUNIOR TRANSISTOR RADIO. Model UJR-1. Single transistor set. Excellent introduction to radio. Kit **£2.7.6** incl. P.T.

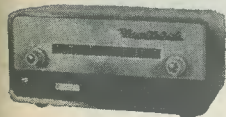
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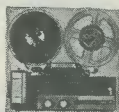
TAPE AMPLIFIERS ~~~~~ TAPE DECKS ~~~~~ CONTROL UNITS



FM TUNER
FM-4U



MAGNAVOX
DECK



TRUVOX
DECK



AM/FM
TUNER

HI-FI FM TUNER. Model FM-4U. Available in two units. R.F. tuning unit (£2.15.0 incl. P.T.) with I.F. output of 10.7 Mc/s, and I.F. amplifier unit, with power supply and valves (£13.13.0). May be used free standing or in a cabinet. Total Kit **£16.8.0**

MAGNAVOX "363" TAPE DECK. The finest buy in its price range. Operating speeds: 1½", 3½" and 7½" p.s. Two tracks, "wow" and "flutter" not greater than 0.15% at 7½" p.s. **£13.10.0**
MAGNAVOX deck with **TA-1M** Kit **£31.5.6**

HI-FI AM/FM TUNER. Model AFM-1. Available in two units which, for your convenience, are sold separately. Tuning heart (AFM-T1—£4.13.6 incl. P.T.) and I.F. amplifier (AFM-A1—£22.11.6). Printed circuit board, 8 valves. Covers L.W., M.W., S.W., and F.M. Built-in power supply. Total Kit **£27.5.0**

TRUVOX D-93 TAPE DECKS. High quality stereo/mono tape decks. D93/2, ¼ track, **£36.15.0** D93/4, ¼ track, **£36.15.0**

TAPE RECORDING/PLAYBACK AMPLIFIER. Thermometer type recording indicators; press-button speed compensation and input selection. Mono Model TA-1M. Kit **£19.18.0** Assembled **£28.18.0**
Stereo Model TA-1S. Kit **£25.10.0** Assembled **£35.18.0**

MONO CONTROL UNIT. Model UMC-1. Designed to work with the MA-12 or similar amplifier requiring 0.25V or less for full output. 5 inputs. Baxandall type controls. Kit **£8.12.6** Assembled **£13.12.6**

STEREO CONTROL UNIT. Model USC-1. Push-button selection, accurately matched ganged controls to ±1dB. Rumble and variable low-pass filters. Printed circuit boards. Kit **£19.10.0** Assembled **£26.10.0**

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SSU-1

SPEAKER SYSTEMS

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THE BERKELEY Slim-line SPEAKER SYSTEM, fully finished walnut veneered cabinet for faster construction. Special 12" bass unit and 4" mid/high frequency unit. Range 30-17,000 c/s. Size 26" x 17" x only 7½" deep. Modern attractive styling. Excellent value.

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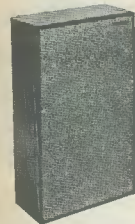
COTSWOLD SPEAKER SYSTEMS. Outstanding performance for price.

MFS: Size 36" x 16½" x 14" deep.

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Kit **£37.17.6** Assembled **£45.17.6**

AMATEUR BANDS RECEIVER. Model RA-1. To cover all the Amateur Bands from 160-10 metres. Many special features, including: half-lattice crystal filter; 8 valves; signal strength "S" meter; tuned R.F. Amp. stage.

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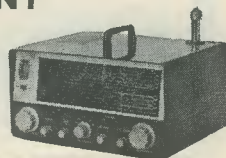
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COMMUNICATIONS TYPE RECEIVER. Model RG-1. A high performance, low cost receiver for the discriminating listener. Frequency coverage: 600 kc/s-1.5 Mc/s and 1.7 Mc/s-32 Mc/s.

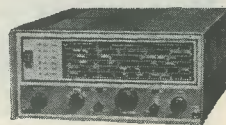
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GC-1U



RG-1



HM-11U

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Model HW-12 (80M) **£67.10.0**, Kit. incl.

Model HW-22 (40M) **£66. 0.0**, Kit. duty,

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80M Transceiver
HW-12

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FULL DETAILS OF MODEL(S).....
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Constructed to withstand adverse climatic conditions.

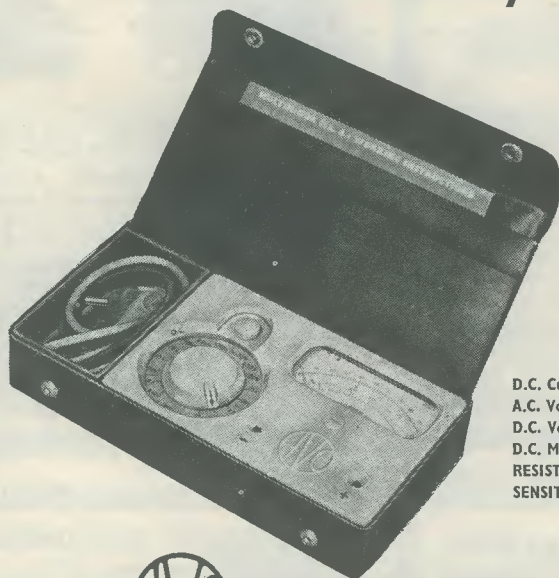
Ever ready case including leads, prods and clips.

Improved internal assemblies.

Re-styled scale plate for easy rapid reading. 2 basic scales each 2.5 inches in length.

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Available accessories include a 2,500V d.c. multiplier and 5, 10 and 25A shunts for d.c. current measurement.



The Mk. 4 MULTIMINOR, the latest version of this famous Avo instrument, supersedes all previous models. It is styled on modern lines, with new high standards of accuracy, improved internal assemblies, and incorporating panclimatic properties.

The instrument is supplied in an attractive black carrying case, which also houses a pair of leads with interchangeable prods and clips, and an instruction booklet. It is packed in an attractive display carton. Robust real leather cases are available, if required, in two sizes, one to take the instrument with leads, clips and prods, and the other to house these and also a high voltage multiplier and a d.c. shunt.

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MM/17

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5 1/2" 850ft. ... 14/6	1,200ft. ... 17/6	1,800ft. ... 29/6	
7" 1,300ft. ... 17/6	1,800ft. ... 22/6	2,400ft. ... 37/6	

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Each additional Reel 6d. All tape accessories stocked.

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PLASTIC REEL CONTAINERS (Cassettes): 3" 1/3, 5" 1/9, 5 1/2" 2/-, 7" 2/3.

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Osc. coil M. & L.W. 2/8 diam. 5/-
Midget Driver Trans. 9:1 6/-
Ditto O/Put Push-pull 3 ohms 6/-
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Condensers—150V wkg. .01mfd. to .04mfd., 9d. .05mfd., 1mfd., 1/-, .25mfd., 1/3. .5mfd., 1/6, etc.

Tuning Condensers. J.B. "OO" 208 + 176pF, 8/6. Ditto with trimmers, 9/6. 365pF single, 7/6. Sub-min. 2" DILEMIN 100pF, 300pF, 500pF, 7/-.
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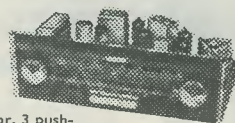
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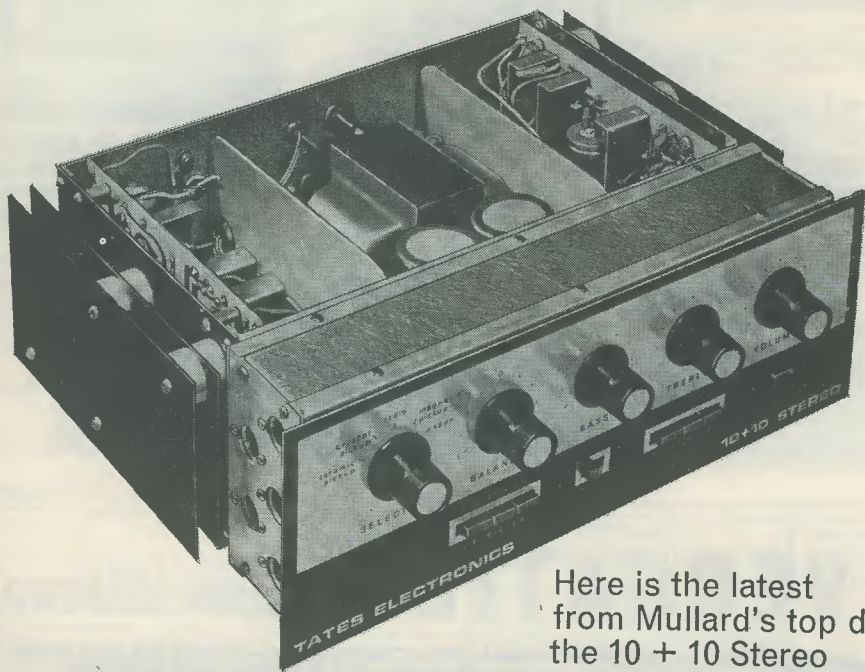
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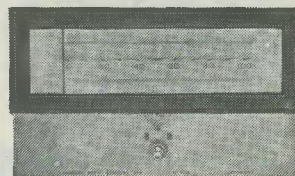
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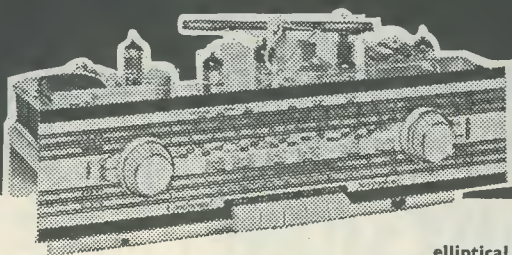
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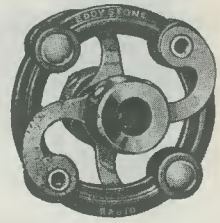
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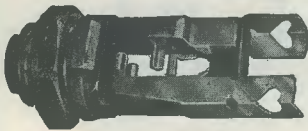
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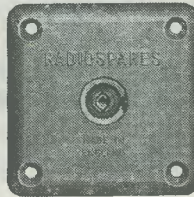
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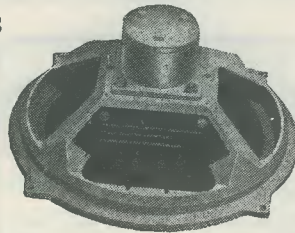
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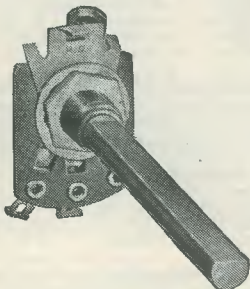
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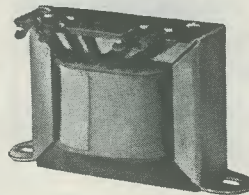
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JULY 1966

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BASIC RADIO CONTROL

Part 1

By F. L. THURSTON

In this article our contributor reviews the many different systems currently in use for the radio control of models. It will be followed, in next month's issue, by a full description of a single channel "carrier" transmitter working on 27 Mc/s, whilst the September issue will have an article describing a super-regenerative receiver intended for operation with this transmitter. Further articles by the same author are planned and these will cover increasingly more complex systems with full constructional details

OF ALL THE BRANCHES OF ELECTRONICS THAT are of interest to the amateur, none is more intriguing from the technical point of view, than the Radio Control field. Not only are a wide range of transmitter, receiver, and audio circuits employed, but so also are a whole mass of computer and general instrumentation circuits. In practice a radio control system may, at one end of the scale, be quite inexpensive and simple, giving rather crude operation of just a couple of controls on a remote model, or, at the other end of the scale, it may be as complex as a small computer, costing several hundred pounds to buy, and giving precision and independent control over a dozen or more remote surfaces.

The very first thing that the amateur should do when considering radio control is to ask himself: "Am I interested in radio control purely as a means of remotely controlling a model, or am I

interested in the model purely as a means of using the remote control system"? If the answer to the first part of that question is "Yes", and it is the actual model that is of the greater interest, you are advised to buy a ready-made radio control system rather than build your own. If, on the other hand, the answer is "Yes" to the second half of the question, and it is the actual electronics that is of the greatest interest, you are advised to save yourself a good deal of money and go ahead and build all of your own radio control gear; in this second case, this new series of articles should be of interest.

In the present article we shall consider the general principles of radio control and the different systems that can be used. Further articles, to appear at intervals, will be entirely practical, and it is intended to give constructional details of a range of fully transistorised transmitters, receivers, servo ampli-

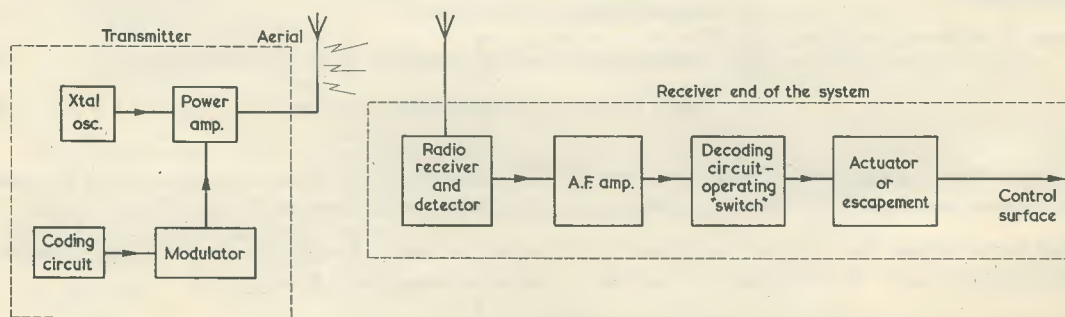


Fig. 1. The basic "blocks" of a typical radio control system

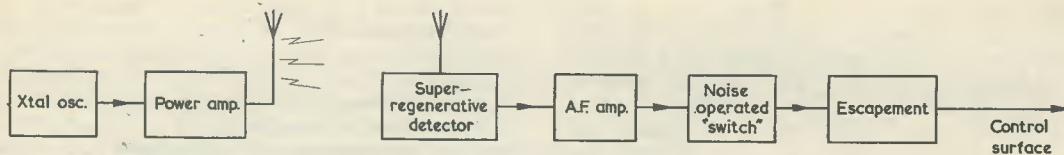


Fig. 2. Basic "blocks" of a carrier control system. This is the simplest of all radio control systems

fers, etc. These projects will range from a simple single channel system, to a dual proportional system, with a whole stack of circuits in between. So far as the immediate future is concerned, a description of a single channel "carrier" transmitter will appear in next month's issue, whilst the following issue will give details of a super-regenerative receiver.

Radio Control: General Principles

The basic circuitry of a typical radio control system is made clear in Fig. 1. Starting with the transmitter, a crystal controlled oscillator is used to establish the operating frequency of the carrier signal, which must lie within the limits of 26.96 Mc/s to 27.28 Mc/s or 458.5 Mc/s to 459.5 Mc/s. In practice, the v.h.f. band poses considerable practical problems and is rarely employed, whilst the 27 Mc/s band is almost invariably used.

The output of the crystal oscillator is fed to the power amplifier stage, and then to the aerial, which radiates the carrier signal. It is the carrier, of course, which forms the "link" between the transmitter and the receiver.

Generally, the carrier signal alone is not enough to give effective control over the remote model, and it has to be modulated with a code or instructional signal. For this purpose, the power amplifier is also fed from a modulator stage, and the input to the modulator is taken from a suitable coding circuit.

The coding signal is generally a sine or square wave operating at some accurately controlled audio frequency. Usually, the model can be made to carry out some particular manoeuvre simply by selecting one or other of a number of pre-set modulating frequencies at the transmitter.

At the model end of the remote control system the modulated carrier is picked up by the aerial and fed to a fairly conventional radio receiver and detector circuit, and then on through an a.f. amplifier. The output of the a.f. amplifier thus has the same form as the coding signal that was fed into the modulating stage of the transmitter.

The radio receiver and detector stage may be one of two types; either a super-regenerative detector, or a superhet. Each type has its own particular advantages and disadvantages, which will next be discussed.

Super-regenerative Detector

The super-regenerative circuit is very inexpensive, as it requires only a single transistor. Sensitivity is very good, usually being as good as that obtained from the average superhet. The circuit has an

inherent a.g.c. action. The only real disadvantage of the super regenerative circuit is that it suffers from very poor selectivity, whereupon it becomes very prone to interference from other transmitters. Thus, if two or more operators are working in close proximity (possibly within a few hundred yards) it is possible that they may "jam" one another's models, perhaps even causing the models to crash. For this reason, it is usual for operators working on a particular field to take it in turns to use their equipment. In practice, the failings of the super-regenerative detector are not nearly as bad as they seem in theory, and the circuit is the most widely used of the two systems.

Superhet Receiver

The superhet is generally very expensive, and has to be crystal controlled. The outstanding advantage of the circuit is that it has very sharp selectivity, and is thus virtually interference-free. If a number of models are to be operated within close proximity at the same time, superhet receivers are a virtual necessity.

Decoding

Returning to the block diagram of Fig. 1, the coded signal at the output of the a.f. amplifier is fed to the decoding circuit, which in turn operates some kind of relay or switch. The relay or switch may take any one of several forms, such as a conventional relay, a solid-state (transistor) switching circuit, or a reed bank, etc. The decoding circuit may feed one or several switches; thus, when a particular code signal is sent from the transmitter switch A may operate at the receiver, whilst, when an alternative code signal is transmitted switch B will operate.

The switch, when operated, is made to operate an *actuator* or *escapement* which, in turn, operates the controls (rudder, elevator, throttle, etc.) of the actual model.

An actuator may take any one of a number of forms, but it generally consists of a simple mechanical (rubber or clockwork driven) or electrical (motor) device which, when triggered, causes some mechanical movement to take place. This mechanical movement is then coupled, either directly or via a control rod, to the surface that is being controlled; e.g. when the actuator is operated a rudder may be made to move to the left, and when the actuator is turned off the rudder will return to the neutral position.

An escapement, or *sequential actuator*, sometimes also known as a *selector*, gives a slightly different type of operation. Here, when the device is made

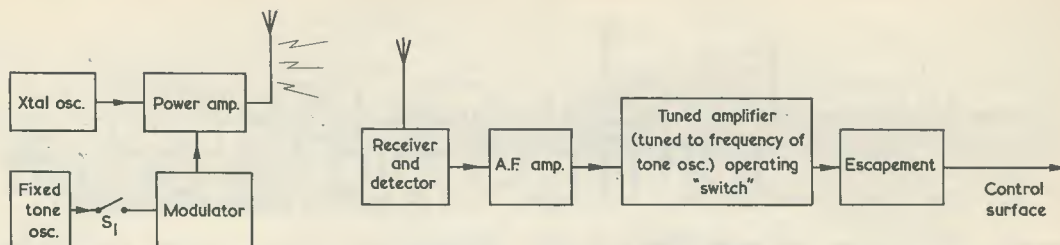


Fig. 3. A single channel tone system

to operate for the first time the rudder may move to the left and then return to neutral when the drive signal is removed, but when a second operating signal is given the rudder moves to the right then back again to neutral when the drive signal is removed. Thus, the sequence of operations may be as follows; left, neutral, right, neutral, etc.

It should be noted that this system gives either full left or full right. Any degree of turn of the model can be obtained, however, by simply varying the amount of time for which the control is held in one position. Thus, a full turn can be obtained by holding the control on for, say, a few seconds, whilst a mere degree or so of turn can be obtained by flicking the control switch sharply on and off.

These, then, are the general principles of radio control. A vast number of different systems are, of course, in use, but they differ mainly only in the methods that they use for the coding and decoding processes between transmitter and receiver; in other words, they differ in detail but not in broad general principle. In the remaining part of this introductory article we shall consider some of the more widely used systems in general use.

The "Carrier" Control System

The simplest and least expensive of all radio control systems is shown in block form in Fig. 2. Here, the transmitter consists simply of the crystal oscillator and power amplifier stage, which transmits an unmodulated carrier; the carrier can be switched on and off at will.

At the receiver end of the system a super-regenerative detector stage is used. One of the characteristics of this circuit is that, with no input connected (from the aerial), a very large amount of "noise" or "mush" is available at the output; when an unmodulated carrier is fed into the circuit, this "mush" disappears and the output can be considered as "silent".

The output of the super-regenerative stage is fed to an audio amplifier and then on to a noise operated transistor switch, which in turn operates an escapement. The switch is so arranged that when noise is present (no carrier) the switch is normally off; when the noise is removed (carrier switched on) the switch turns on and operates the escapement and, thus, the control surfaces on the model.

The greatest disadvantage of this system is that it is very prone to interference, not only from other transmitters, but also to r.f. "noise" from motors or

actuators, and even from the spark plugs of motor cars. In addition, the range is less than that obtainable with other systems. The system is, nevertheless, quite useful for the control of model boats and motor vehicles where temporary loss of control is not likely to result in a destructive crash. A practical example of this system will be given in the following two issues of this journal.

Single Channel "Tone" System

The single channel "tone" system is probably the most popular of all radio control systems, as it gives good results and is reasonably inexpensive. The block diagram of the system is shown in Fig. 3.

Here, the transmitter carrier signal is modulated by a fixed and accurately controlled tone or code signal, normally of sine wave form. Usually, the carrier is permanently switched on when the system is in use, the modulation being switched on and off at will via a control switch on the transmitter front panel.

At the receiver end, the carrier signal is picked up by the aerial and fed through the receiver and detector circuit, which is usually, but not always, of the super-regenerative type. The detected signal is then fed through an audio amplifier stage to the decoding circuit, which is simply a tuned amplifier and switch, the amplifier being tuned to the same frequency as the modulation signal of the carrier. The decoding circuit is so arranged that the switch is normally off, but is turned on whenever it is fed by a reasonably large signal at the tuned frequency. The switch operates the escapement and thus the control surfaces of the model.

This system of control has the advantage that it is relatively interference-free since, in order to "jam" the model, it is not only necessary to have another 27 Mc/s transmitter working in the vicinity but the second transmitter must also be modulated at the same frequency as your own. Thus, the system can be regarded as very good, within the limits of single channel operation. Range is as good as that obtained with any alternative system.

Single Channel "Pulse Proportional" System

When considering escapements, it was pointed out that, if a rudder (for example) is being controlled, the rudder is always at either full left, neutral, or full right. While this system gives acceptable results in the hands of a skilled operator, it is fair to say that, from the technical point of view,

this "bang-bang" form of control is rather crude. A far nicer system, known as "pulse proportional", is one that enables any required degree of rudder movement to be obtained by simply moving a "stick" on the transmitter by a proportional amount; e.g. five degrees of left movement on the transmitter control stick results in five degrees of movement to the left on the rudder of the model. The block diagram of this system is shown in Fig. 4.

At the transmitter end of the system, the carrier may or may not be modulated with a code tone, in the manner already outlined. In either case the carrier or the tone signal is pulsed alternately on and off by an additional pulse generator. This pulse generator operates at a fairly low frequency, in the order of tens of cycles per second, and gives a rectangular output with a variable mark-space (on-off) ratio.

At the receiver end of the system the carrier signal is picked up by the aerial and fed through the receiver and detector circuit. The detected signal is then fed, via an audio amplifier and filter circuit, to a switch or relay, which then switches on and off at the same frequency and with the same mark-space ratio as the pulse signal at the transmitter. The output of the switch controls an actuator or escapement so arranged that, when the switch is off, the rudder is driven hard left (say), and when the switch is on the rudder is driven hard right. Now, the actuator, being a mechanical device, takes a certain amount of time to operate fully and, although the switch is operating only at a few cycles per second, the rudder is unable to follow the *individual* changes in the "switch" state; instead, it responds to the *difference* between the On and Off states. Thus, if the pulser gives a 1 : 1 mark-space ratio, the On part of the signal tends to make the rudder move to the right, but, before it can move, the Off part of the signal arrives and tends to move the rudder by an equal amount to the left; consequently, the two signals cancel one another out and the rudder does not move at all.

If, on the other hand, the mark-space ratio is not 1 : 1 but is On for a longer period than it is

Off, the two signals will not cancel but will be predominantly On, and the rudder will move to the right by an amount proportional to the difference between the On and Off times. Similarly, the rudder can be made to move to the left by making the Off period of the pulser longer than the On period.

This system of control is very pleasant to use, within the limits of a single channel system, but is fairly expensive. One of the minor snags is that a carrier signal must be transmitted at all times, with consequent short battery life.

Multi-Channel Tone Systems

While it is true that a single channel control system may be used to give control of several different functions on a model by the use of suitable actuators and escapements, it is true to say that the system then becomes rather awkward to use. For example, an escapement may be made that gives control of six different functions on a model ship, the functions being selected sequentially as follows; (1) rudder left, (2) rudder neutral, (3) rudder right, (4) throttle opens, (5) throttle closes, (6) torpedo fires. Now, if a command has just been given to move the rudder to left and it is now required that the torpedo be fired, this function can be obtained by giving four sharp "blips" on the transmitter control button, followed by a fifth operation of the transmitter switch for a reasonable length of time until the torpedo fires. The "blips" are of such short duration that none of the other controls has time to operate during this sequence. It can be seen that, although the required results are obtained, the method of operation is rather doubtful, and it is not only necessary to press the transmitter control switch a number of times to get these results, but it is *essential* to know at all times just how many "blips" to give!

A far better system, which enables each of these functions to be selected independently, is known as the *multi-channel* system. There are many variations of this particular type of control, but a

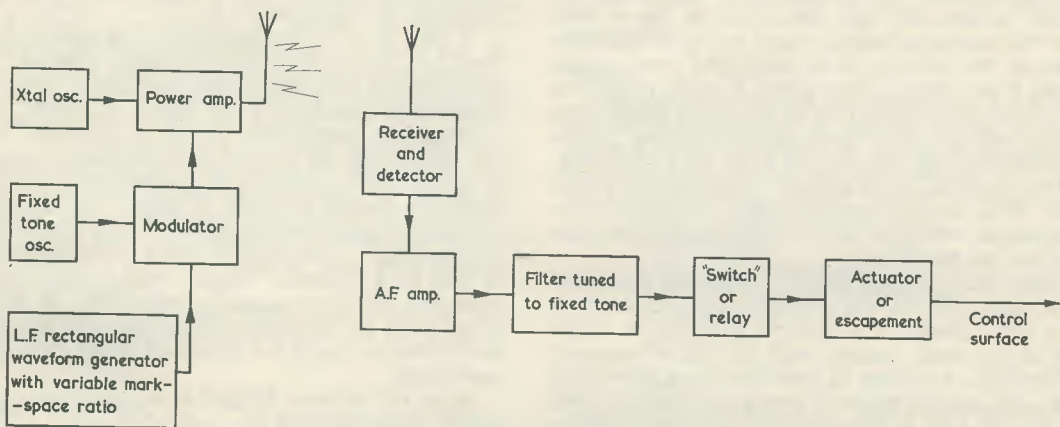


Fig. 4. A single channel pulse-proportional system

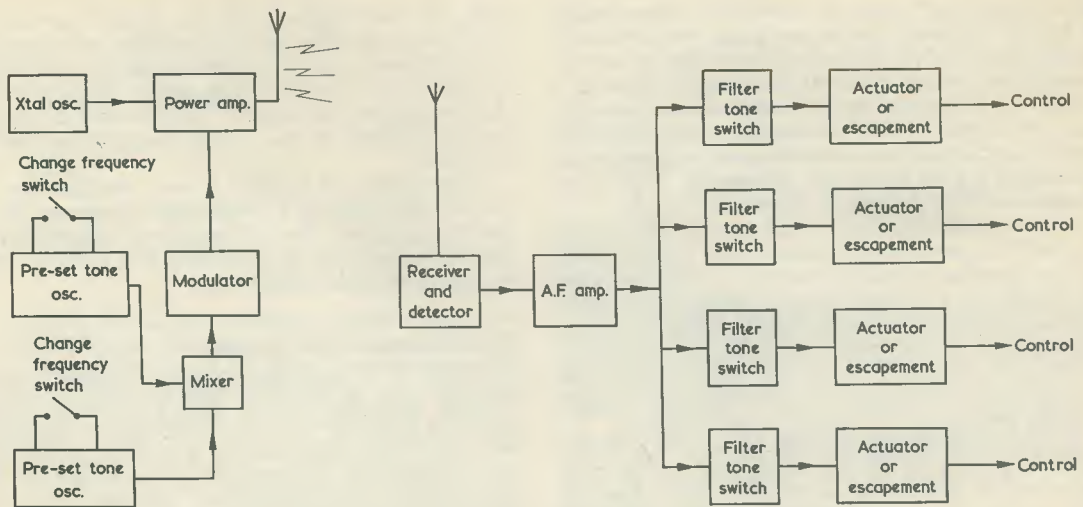


Fig. 5. A multi-channel tone system, giving 4-channel bi-simultaneous operation

typical one, giving 4-channel bi-simultaneous operation, is shown in block form in Fig. 5.

Here, the transmitter carrier is radiated continuously, but the modulation stage is fed from an audio mixer circuit. The audio mixer input is taken from one, or both, of two individual audio oscillator (sine wave) circuits. Each audio tone operates its own channel in the radio control link and, since two channels can be operated at once, the system is said to be "bi-simultaneous". In the example shown in the diagram, each oscillator operates at a known frequency, but this frequency can be changed by closing a switch. Thus, each oscillator has a choice of two operating frequencies or channels, and there are two oscillators, so that the total number of channels available is four. In practice, additional switching may be used, giving each oscillator a choice of six operating frequencies, so making a choice of twelve channels available.

At the receiver end of the system the modulated carrier is detected and amplified in the normal way, the amplifier output signal being of the same form as the individual or combined tone signals at the transmitter. This signal is then passed on to a set of four (in the case of 4-channel equipment) filter tuned switches, connected in parallel. These switches may take the form of reeds on a reed-bank, or they may be some kind of transistorised switch unit. Each switch controls either an actuator or escapement which in turn controls some particular function on the model.

Thus, each channel may be operated independently, and each of the channels can be made to carry out a single or a multiple function, as in the case of the single channel tone system, as required.

Typically, a system of this type may give 2, 4, 6, 8, 10, or 12 channel operation, usually, but not always, with bi-simultaneous facilities available.

This sort of equipment gives first class results,

and should satisfy most control requirements. The equipment is expensive to buy, but not so expensive as to be beyond the pocket of the average enthusiast.

Multi-Channel "Proportional" Systems

Although the conventional multi-channel tone control system is able to meet the control requirements of almost any model, the system does not, by any means, give the ultimate in performance. It has already been pointed out how inferior the single channel tone system seems, when controlling only a single function such as rudder, when it is compared with the single channel proportional system. By the same token, the multi-channel tone system can be considered as relatively rather crude.

Ideally, all channels should give proportional control, but such a system then becomes prohibitively expensive; nevertheless, many such systems are in production, some of them giving 8 or more channels of operation.

A very good compromise system is one that gives just two channels of proportional control, with facilities for bi-simultaneous operation. A typical example is shown, in block form, in Fig. 6.

Here, the transmitter carrier is switched on at all times, but the coding or modulating circuitry is more complex than any so far considered. Dealing with this coding circuitry in detail, we have, first, a sawtooth generator that is free running and variable in frequency. The output of the sawtooth generator is fed to a Schmitt Trigger, which converts the sawtooth into a rectangular waveform, as shown. Thus, since the frequency of the sawtooth generator is variable, so also is the frequency of the rectangular waveform.

Now, the Schmitt Trigger is an electronic switch which is operated by the level of its input voltage. The operating point of the switch can be adjusted,

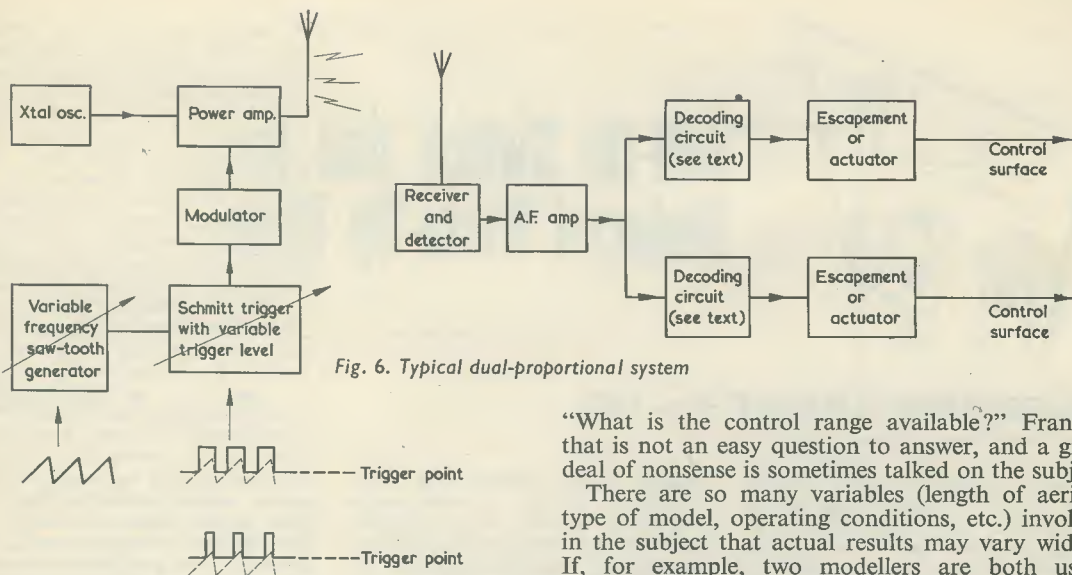


Fig. 6. Typical dual-proportional system

if required, by a simple control. Thus, as shown in the diagram, when the Schmitt circuit is set for one particular operating point it will give an output that is a rectangular waveform with a 1 : 1 mark-space ratio. By increasing or decreasing the level of the operating point, however, the mark-space ratio can be decreased or increased, as required.

Thus, the code signal that is made to modulate the carrier of this system is a rectangular waveform of variable frequency and variable mark-space ratio.

At the receiver, the carrier is demodulated, and the code signal is amplified and fed to two decoding circuits, wired in parallel; each decoding circuit controls an escapement or actuator, and controls one function of the model.

The decoding circuits may take any one of a number of forms but, typically, the mark-space circuit may be the same as that used on the single channel pulse proportional system described earlier. The frequency decoding circuit may take the form of a capacitance discharge device. A transistor circuit with a built-in C-R time constant can be arranged so that, at some particular frequency, the charge and discharge times of the C-R network are equal and cancel out, holding the d.c. level of the output of the circuit at some particular level; if the input frequency is increased the charge and discharge times do not cancel, and the output of the unit rises in level, or, if frequency is decreased, the output level falls, and the appropriate control surface on the model is made to move by a proportionate amount.

A system of this type cost about £100 to buy, and more complex systems may cost as much as £500 or more!

Range of Control

One of the first things that the average beginner wants to know about a radio control system is:

“What is the control range available?” Frankly, that is not an easy question to answer, and a great deal of nonsense is sometimes talked on the subject.

There are so many variables (length of aerials, type of model, operating conditions, etc.) involved in the subject that actual results may vary widely. If, for example, two modellers are both using similar equipment, but are operating in different conditions and with different models, one may get a range of a quarter of a mile and the other a range of two miles.

The important question here is: “What is the range that is needed in practice?” Consider the case of the modeller who only (!) gets a range of a quarter of a mile with his equipment. He is probably flying a model aircraft with a wing span of less than three feet; do you think that you could even see a model that small at a quarter of a mile range? It is very doubtful, and the range can therefore be considered as adequate.

As a rather sweeping generalisation, it can be said that “if range is much less than a quarter of a mile, something has gone wrong; if range is between a quarter and one mile, that’s normal, and if range is over one mile, you must have wonderful eyesight!”

It should be pointed out that the range obtained ground-to-air is usually about twice that obtained ground-to-ground, i.e., when making simple range checks by carrying the receiver away from the transmitter.

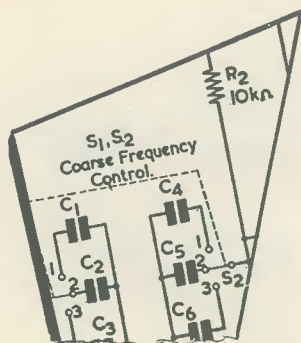
Licence

It is important to note that the use of a transmitter for the radio control of models is not permitted unless a licence is obtained. A fee of £1, payable in advance, is charged for each period of 5 years. Application for the licence should be made to:

Radio Services Department,
Radio Branch,
Amateur Licensing Section,
G.P.O. Headquarters Building,
St. Martins-le-Grand,
London, E.C.1.

Next Month

In next month’s issue we shall be giving constructional details of a transistorised “carrier” control transmitter.



Add-On Switch Unit for Reduced Warm-Up Time

SUGGESTED CIRCUIT No. 188

By G. A. FRENCH

SOME YEARS AGO THE "RADIO Topics" feature in this journal gave a brief description of an American a.m.-f.m. valve radio receiver in which "the valve heaters were never switched off".¹ This receiver was the Westinghouse model H-76 IN7, and it employed 7 valves in a series heater chain with the heater voltages adding up to a total of 122 volts. When the receiver was switched on, the American 117 volt mains was applied direct to the heater chain and the receiver worked in normal fashion. When the set was turned off by means of the switch fitted to it, a 500Ω resistor was inserted in series with the heater chain and the heaters continued to run at approximately half voltage. Also, the h.t. voltage was reduced.

Amongst the advantages claimed for this method of working were a reduction in oscillator drift, continual warm and low-humidity con-

ditions in the cabinet and, most important of all, a considerable reduction in the waiting period between switching on and receiver operation. The Westinghouse receiver commenced to play some 5 seconds after switching on, instead of after the usual 25 to 40 seconds. The receiver still, of course, consumed power from the mains when turned off by its own switch, but the cost of the current consumed was considered to be negligibly low.

Simple Add-On Circuit

There are obvious advantages to be obtained from this technique, and the writer has recently examined the question of producing a rather similar type of switching circuit to speed warm-up time in valve radio receivers operating from British mains voltages. After a little thought he realised that all that was needed here was the simple add-on unit, requiring only an on-off toggle switch and a BY100 rectifier, whose circuit is given in Fig. 1. This unit

can be added to most a.c.-d.c. mains radios operating from an a.c. supply and, provided the constructor is familiar with television circuits and operation and is prepared to investigate performance, to many television sets as well. So far as radio receivers are concerned it is merely necessary for the add-on switch unit to be inserted in the mains lead to the set. Alternatively, the added switch and rectifier can be mounted in the receiver cabinet if a more permanent installation is required.

Fig. 2 shows how the add-on unit works. In this diagram the unit is inserted in series with the mains supply to a typical a.c.-d.c. mains radio having a metal rectifier and a series heater chain with a dropper resistor and thermistor. Let us commence by assuming that the switch in the add-on unit is closed. If the radio is now turned on by its own switch, the receiver will warm up and operate in normal manner because the full mains voltage is applied to it. If, next, the switch in the add-on unit is opened, the BY100 rectifier is inserted in series with one of the mains leads, whereupon there are two changes of operation. Firstly, the rectifier allows only half-cycles to be applied to the heater chain, whereupon the heaters in the receiver run at half power.² Secondly, the rectifier in the add-on unit is so connected that only *negative* half-cycles are applied to the h.t. rectifier in the receiver, whereupon receiver h.t. voltage drops to zero.

Thus, when the switch in the add-on unit is opened the receiver ceases to operate because it has lost its h.t. supply, and its heaters

² Half power heater operation was discussed in "Suggested Circuit No. 146—Employing Silicon Rectifiers as Heater Droppers" in the January 1963 issue.

¹ This report appeared in *The Radio Constructor* for November 1961.

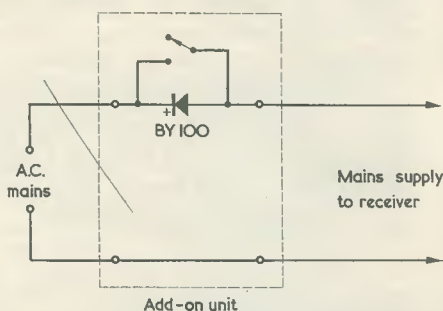


Fig. 1. This simple add-on unit may be inserted in the mains lead to a conventional a.c.-d.c. radio receiver or, in many cases, a TV receiver. When the switch is opened, h.t. voltage in the receiver falls to zero and the heaters run at half power. When the switch is closed, the receiver comes into operation very much more quickly than if it had been switched on from cold

continue to run at half power. If, at any later time, it is desired to have the receiver in full operation again, all that is necessary is to close the switch in the add-on unit. The already-warm heaters soon reach full emitting temperature, h.t. is restored, and the radio commences to play very much more quickly than if it had been switched on from cold. The add-on unit can be looked upon as a device which allows the receiver to be maintained in a "stand-by" condition. If it is required to turn the receiver off completely, this may be done by means of the on-off switch fitted to the radio itself.

With the device described here it is intended that the receiver be run with half power heaters only during the normal listening periods in the day. The receiver could, for instance, be switched on with half power heaters early in the evening, whereupon it can be brought into use almost instantly by closing the switch in the add-on unit. If dial lamps are fitted these will indicate, by glowing at reduced brightness, when the receiver is running with half power heaters.

Possible Difficulties

After checking the practicability of the add-on unit of Fig. 1, the writer investigated any possible difficulties that its use may incur.

One possible difficulty could result from the fact that, at the instant when the switch in the add-on unit is closed, the full mains supply is suddenly applied to a heater chain and series thermistor that are already partly warmed up. Could this sudden application of the mains voltage cause any surges which would, in the long run, prove deleterious? As is discussed later in this article, it was found that the heater switching arrangements are quite permissible, and no further attention will be made to the point at this stage.

A second possible disadvantage is that the act of closing the switch in the add-on unit is equivalent, so far as the receiver h.t. rectifier is concerned, to suddenly applying the full mains voltage when the reservoir capacitor is discharged. If the receiver employs a metal or silicon rectifier no long-term harm can result from applying the mains supply in this manner, because it is applied similarly abruptly when the receiver is switched on from cold in the normal course of events. With a valve h.t. rectifier, however, the sudden effective application of the mains supply when the switch in the add-on unit is closed occurs

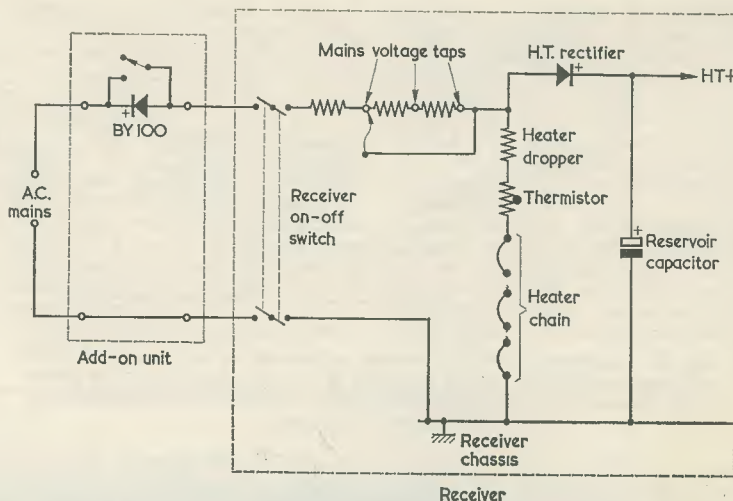


Fig. 2. The add-on unit inserted in series with the mains input to a conventional a.c.-d.c. radio receiver. The BY100 and switch appear in the mains lead which couples to the h.t. rectifier

when the cathode, due to its heater running at half power, may be just at emitting temperature. The surge current which then flows could, possibly, have harmful long-term results on the cathode coating. This effect is, of course, the same as is given when, with normal usage, the receiver is switched off and after a very short period switched on again, and the receiver will be fitted with surge limiting resistors having values which maintain the transient current which then flows within safe limits. But it has to be remembered that these limiting resistors guard against an eventuality which normally, only takes place occasionally. With the device described here, it is possible for the transient current to flow each time the switch in the add-on unit is closed. It must be stated, there-

fore, that it is conceivable that the use of the add-on unit *might* shorten the life of the h.t. rectifier in the receiver if this is a valve type. It should be added that this conclusion is based on the worst possible instance, because it assumes that, with the heater at half power, the rectifier cathode is still capable of a high level of emission. An incidental point which is relevant here is that most households in the U.K. have 240 volt mains supplies, whereupon the mains voltage selector in the receiver will be at its highest voltage tapping. This means that significantly more resistance than the minimum needed for hot-switching surges is certain to be in series with the rectifier and the situation becomes alleviated.

A third possibility is that heating the valves in the receiver for long

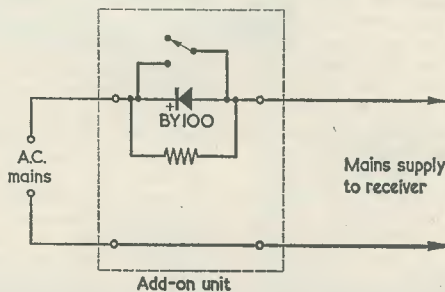


Fig. 3. If the receiver is to be run with heaters at half power for extremely long periods, a resistor may be added across the BY100 rectifier in the add-on unit. This resistor allows the appearance of a low h.t. voltage in receivers using metal or silicon rectifiers (and, in some instances, valve rectifiers), thereby obviating the risk of "cathode poisoning". The value of the resistor is discussed in the text.

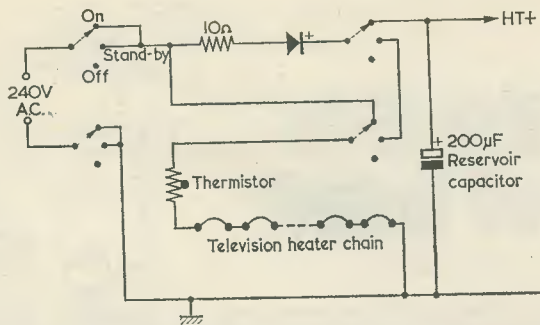


Fig. 4. A television switching circuit introduced by Mullard, Ltd. This demonstrates that the abrupt switching of a heater chain from half power to full power represents acceptable practice. All four switch sections in the diagram are ganged.

periods without an h.t. supply could result in "cathode poisoning". This effect would, normally, only require consideration when the periods concerned are of the order of at least several days, and it is doubtful whether the receiver would be run with the add-on unit rectifier in series for periods as long as this. Nevertheless, if the complication is considered worthwhile, it is possible to allow a small high tension voltage to appear in receivers employing metal or silicon rectifiers by connecting a resistor across the rectifier in the add-on unit in the manner shown in Fig. 3. This resistor allows a small current to flow on positive half cycles to the h.t. rectifier in the receiver when the BY100 is in circuit. The resistor should have a value which allows an h.t. voltage of about 20 to appear in the receiver when the switch in the add-on unit is opened, and this value has to be found experimentally since it depends upon receiver circuitry and components. The resistor will require a wattage rating of some 5 to 10 watts and it should be positioned well away from the BY100 to prevent excessive temperature rise in the latter. The writer checked the functioning of the added resistor with a radio receiver having a 100mA heater chain and found that, with this particular set, the resistor required a value of 3kΩ. The resistor may also be employed with receivers having a valve h.t. rectifier if the valve rectifier continues to emit when its heater is running at half power, and it will cause a reduction in hot switch-on transient currents. However, the writer feels that the resistor is only really needed when it is intended to run the receiver for very long periods with the switch in the add-on unit open. For the normal applications en-

visaged, and referred to earlier, the resistor should not be required. Further, and obvious, points, are that the add-on unit should only be employed with conventional radio receivers employing the a.c.-d.c. power supply technique and which have a resistive heater dropper. The unit should *not* be used with receivers having a mains transformer or autotransformer. The mains supply with which the receiver and unit operate must, of course, be a.c. and not d.c.

As was mentioned earlier, the add-on unit may be inserted in series with the mains supply to the receiver. With a conventional radio set it is not even necessary to identify which lead from the receiver corresponds to chassis. If the receiver mains lead is connected to the add-on unit the wrong way round, the receiver will continue to play after the switch in the add-on unit is opened, since h.t. will still be present. If the mains lead from the receiver is connected correctly, however, the radio will cease to operate as soon as the switch in the add-on unit is opened.

Heater Switching

It was stated earlier that switching a heater chain from half power to full power is permissible. It was whilst the author was looking into this point that he recalled that Mullard Ltd. introduced a "stand-by" switching circuit for television receivers some years ago. On checking back, he found that the circuit in question, reproduced here as Fig. 4, was demonstrated by Mullard at the 1962 Radio Show.³ As may be seen, the series heater

³ This circuit appeared in the Show Review in *Wireless World* for October 1962, to which journal acknowledgement is made.

chain in this circuit is fed via the rectifier for "stand-by" working. When the switch is moved to the "on" position, the full mains supply is applied to the heater chain, and the rectifier functions instead as an h.t. rectifier. A television heater chain has far less series dropper resistance than a radio receiver heater chain and it also includes the heater of the picture tube. In the Mullard circuit, the television heater chain is switched suddenly from half to full power, as occurs with the device described in this article. Since the circuit is presented by a valve manufacturer it would follow that the method of heater switching employed in the present circuit is also permissible.

TV Receivers

The add-on unit may be employed to reduce warm-up time with television receivers, but it is necessary to exercise caution here in case the sequence in which receiver circuits come into operation when the switch in the add-on unit is closed differs from that given in normal use. The constructor should check the circuit of the television receiver to ensure that no difficulties arise on this point. Heavy currents can pass in the line output stage if the booster diode and line output valve reach emitting temperature before line drive is applied to the line output grid, and it will be necessary to check that this does not occur when the add-on unit is employed. Also, it is desirable to ensure that the vertical timebase is scanning the tube before e.h.t. voltage appears. Despite the use of aluminised tubes, one still hears reports of screen "striping" due to the accidental running of a tube without vertical deflection. It will also be necessary to check that gated a.g.c. circuits function correctly without blocking and similar faults. If the television receiver on-off switch is incorporated in a circuit for the discharge of e.h.t. reservoir capacitance on switching off, the add-on unit should not be employed.

With TV receivers a relatively heavy forward current may flow through the BY100 in the add-on unit if, due to the mains connection from the receiver being applied the wrong way round, this passes both the heater and the h.t. current when the switch across it is opened. It is essential, therefore, to check the wiring when connecting the add-on unit into circuit to ensure that the rectifier in the add-on unit appears with correct polarity and in the correct mains lead. The latter is,

of course, the lead which is not at chassis potential.

The same remarks as for radio receivers apply with television sets. The television receiver must employ the a.c.-d.c. power supply technique with a *resistive* heater dropper, and it must not have a mains transformer or autotransformer. The mains supply must be a.c. Also, there is a possibility that h.t. rectifier life may, in the long term, be reduced if a valve rectifier is employed, and that "cathode poisoning" in the valves could occur if the receiver is run for very long periods

without h.t. The circuit of Fig. 3 may, in this respect, also be employed with television receivers.

Practical Results

The writer checked the add-on unit of Fig. 1 with an a.m.-f.m. radio and a television receiver. With the radio, warm-up from cold with normal switching took approximately 30 seconds. Warm-up from the instant when the switch in the add-on unit was closed took 6 seconds only.

With the television receiver, warm-

up from cold took the following times: sound, 33 seconds; line output transformer operation, 45 seconds; picture, 50 seconds. Warm-up from the moment when the switch in the add-on unit was closed took the following times: line output transformer operation, almost immediate; sound, 5 seconds; picture, 5 seconds.

In both cases, the switch in the add-on unit was closed after the set in question had been running sufficiently long with the switch open for heater temperature at half power to become stabilised.

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M.Sc.

Resistive Film Electron Multipliers

New techniques for electron multiplication do not require the conventional series of separate electrodes in an evacuated envelope, each connecting to a higher potential than the previous one. Multiplication occurs, instead, along a single resistive film to whose ends are applied the activating voltage. These new resistive film devices are smaller, more robust and require fewer external components than the earlier multi-electrode versions.

SECONDARY ELECTRON MULTIPLIERS ARE DEVICES in which amplification of electrons is achieved by utilising the phenomenon of secondary emission. Under suitable conditions an average of more than one secondary electron is emitted from a surface for each primary electron which strikes it.

Electron multipliers are most commonly employed in conjunction with a photocathode in photomultiplier tubes. It is possible to incorporate one or more stages of secondary electron multiplication into thermionic valves for u.h.f. use in order to increase mutual conductance⁽¹⁾ ⁽²⁾ ⁽³⁾, but serious difficulties arise. These include the poisoning of the surface at which the secondary emission occurs due to material evaporated from the oxide coated cathode⁽⁴⁾.

Modern uses for electron multipliers include the determination of the electron density in the upper atmosphere, the measurement of small ion currents (for example, in mass spectrometry), ultra-violet photon detection and the counting of charged particles.

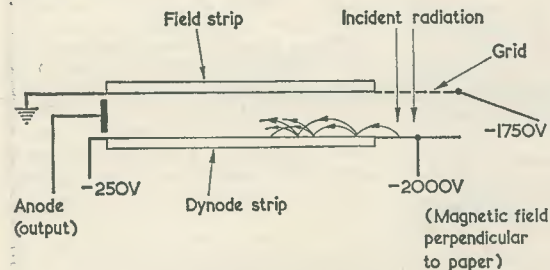


Fig. 1. The Bendix Magnetic Multiplier with typical operating potentials

Conventional Photomultiplier

The electron multiplier system employed in a conventional photomultiplier tube consists of a number of dynodes* (usually more than ten) arranged in a "Venetian Blind" or "Box and Grid" configuration. An external resistive potential divider is required to supply suitable potentials to each of the dynodes. Such systems are relatively bulky and quite unsuitable for applications such as space research. During the last few years a need has therefore arisen for rugged and compact electron multipliers which can provide a high gain for the counting of individual charged particles or photons.

This requirement has led to the development of new multipliers which are much smaller and more robust than the conventional dynode system and which do not require a large number of external connections or a large external resistive potential divider. The secondary emission in these multipliers occurs at various points on a single dynode surface instead of at the surface of a number of successive dynodes.

The secondary electrons emitted from any point must move to a point of greater potential so that they gain enough energy to enable them to cause further secondary emission. The emitting surface therefore consists of a film of high resistivity material deposited on an insulator so that a potential gradient can be maintained along it for the acceleration of the electrons. One type of resistive film multiplier employs a magnetic field.

Unlike the multi-dynode multipliers, these simple resistive film multipliers have the advantage that the

* A dynode is an electrode whose function is to give secondary emission of electrons.—EDITOR.

emitting surface is not damaged by contact with humid air; this greatly simplifies the procedure for their use both in laboratory vacuum systems and in space research. The emitting surface does not have to be specially activated. No window is normally employed.

The Magnetic Electron Multiplier

The Bendix magnetic multiplier was originally developed for the detection of ions in a time of flight mass spectrometer⁽⁵⁾, but it can also be used for the detection of photons in the extreme ultra-violet⁽⁶⁾ and low energy X-ray regions of the spectrum. This type of multiplier consists of a single glass dynode strip coated with a preparation of tin oxide and antimony. The resistance of the strip is typically 100MΩ. A similarly coated "field" strip is placed parallel to the dynode strip as shown in Fig. 1, the coated surfaces of these strips facing one another. The cathode may be either an extension of the coated dynode strip or a metal plate which is connected to the dynode strip. A grid of about 90% optical transmission is placed at the end of the field strip above the cathode.

Incident radiation passes through the grid and strikes the cathode so that the latter emits electrons. These electrons travel in a cycloidal path owing to the presence of a fairly uniform magnetic field (of an intensity of about 400 oersted) in a direction approximately perpendicular to the electric field between the strips. The electrons strike the dynode strip many times as they pass towards the anode, secondary multiplication occurring at the dynode surface. The cascade of electrons collected by the anode constitutes the output current.

A side window magnetic multiplier is shown in Fig. 1, but the cathode can be placed perpendicular to the dynode surface if an end window version is required. It is also possible to bend the dynode strip into the form of a cylinder with a cylindrical field strip inside it. If the radius of curvature of the dynode strip is much larger than the distance between two cusps† of the cycloidal electron motion, the operation of the multiplier will be unaffected by the curvature of the strip.

The Bendix magnetic multiplier requires a power supply of about 40μA at 2kV. The applied potentials are chosen so that the equipotential lines slope from right to left in Fig. 1 as one moves from the field strip to the dynode strip. The number of times multiplication occurs along the length of the dynode strip varies with the applied potentials. The gain changes by a factor of about 2.5 when the potential across the dynode strip changes by 100 volts. See Fig. 2. Gains of up to 10⁹ can be obtained. The dark current is about 10⁻¹² amp. at a gain of 10⁶, whilst the pulse rise time is less than five thousandths of a microsecond. In order to obtain maximum life, the output current should be limited to about 0.1μA.

The Bendix multipliers weigh about 2oz and are unaffected by the shock of rocket launching. They

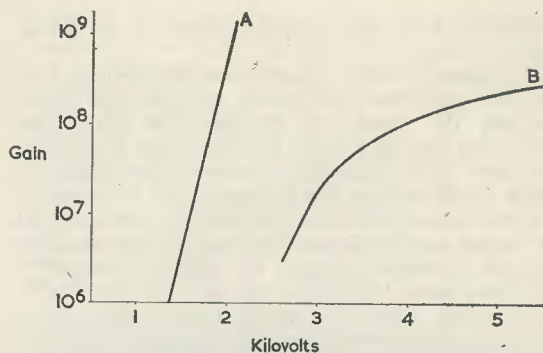


Fig. 2. Variation of gain with applied voltage. Curve A shows the variation of a magnetic multiplier gain with dynode strip voltage. Curve B shows the variation of gain of a Mullard tubular multiplier with the voltage applied between the ends of the tube

must be operated at a pressure of less than 10mm⁻³ of mercury. The resistive film may be cleaned with normal solvents. The multipliers show no sensitivity to visible and near ultra-violet light, but the photoelectric yields exceed 0.1% over the range 1,500Å to 2Å. They can also be used to detect neutral molecules which have sufficient energy to release an electron from the cathode.

Special forms of magnetic resistive film multipliers have been designed which have several output channels. The electrons can be switched to any one of these channels by means of a switching electrode in a few thousandths of a microsecond⁽⁵⁾. Cross talk between channels is less than one part in 10⁴.

Tubular or Channel Multipliers

Electron multipliers have been developed which consist of a glass tube containing a resistive coating on its internal surface⁽⁷⁾ (8). The incident radiation passes into this tube and secondary emission occurs when the radiation strikes the resistive film. The emitted electrons are accelerated along the tube by an applied potential (see Fig. 3) until they strike the resistive film again forming more secondary electrons. The number of times at which multiplication occurs along the length of the tube depends on the applied potential, the energy and the angle of incidence of the original particles.

The tubular multiplier recently developed by the Mullard Company⁽⁸⁾ provides a gain exceeding 10⁵ when the potential difference applied across the tube is 2,500 volts, but a gain of 10⁸ can be obtained at counting rates of less than about 1,000 pulses per second. The variation of the gain of a typical

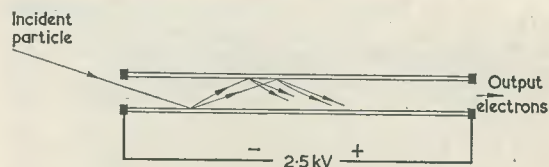


Fig. 3. A tubular channel multiplier

† That is, between two "points of contact" of the sections of the trajectory.—EDITOR.

multiplier with the applied voltage is shown in Fig. 2.

If a straight tube is employed, the positive ions formed from the gas during a pulse will move towards the input end of the tube and cause secondary electrons to be emitted when they strike the tube. This results in the output pulse amplitude being dependent on the gas pressure. If, however, a spiral tube is employed, the positive ions will not be able to move far enough along the tube for them to gain sufficient energy to generate secondary electrons when they strike the wall of the tube⁽⁸⁾. In a spiral tube the output pulse amplitude is therefore independent of the gas pressure (provided, of course, that the latter is reasonably low).

The size of the tube employed may be 5cm in length by 1mm in diameter, but this type of multiplier can be made smaller than a paper clip. The size can be varied over a wide range provided that the ratio of length to diameter is maintained. The resistance of the film is about 10^{10} to 10^{11} ohms over the length of the tube.

The maximum charge which can be drawn from the walls of the tube is limited by the resulting distortion of the electric field. The variation of the output pulse amplitude is very small owing to this internal limiting action. The maximum output current is about $0.2\mu\text{A}$.

The tubular multiplier may be employed for the detection of any charged particles or neutral molecules which have enough energy to cause secondary emission. Electrons with energies exceeding 50 e.v. may be counted. At low particle energies the multiplier is nearly 100% efficient, but at higher energies the efficiency is very much smaller. A gold layer may be evaporated around the input end of the tube for the counting of photons of a wavelength up to about $2,500\text{\AA}$.

Conclusions

The tubular multiplier is simpler and can be made smaller and lighter than the magnetic resistive film type, but the window area of the latter can be greater for a specified film length. A typical tubular multiplier requires a power input of only 0.25 milliwatt, whereas a magnetic multiplier requires about 80 milliwatts. The magnetic multiplier can provide a very high gain at a somewhat lower applied voltage than the tubular multiplier, but only two connections need to be made to the latter.

Apart from their uses in space research, the resistive film electron multipliers will certainly find a wide application in mass and ultra-violet spectroscopy, etc. They may also be used in new types of photomultiplier tubes.

Acknowledgements

The writer wishes to thank Messrs. Field-Tech Ltd. (the British agents for the Bendix Corporation) and Messrs. Mullard Ltd. for the information which they have kindly sent him about their electron multipliers.

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An EM87 Shorted Turn Detector

By M. J. DARBY

A SINGLE SHORTED TURN IN A POWER TRANSFORMER will normally cause overheating and component failure, whilst a shorted turn in such components as radio or audio frequency coils or chokes, or in a line output transformer, will normally render the component useless and may lead to a complete loss of the wanted signal. Thus, one shorted turn can completely affect the operation of a coil containing thousands of turns. It is often

impossible to see shorted turns if the wire is fine, even if the coil is dismantled. An instrument which will detect a shorted turn when a coil of wire is placed over a ferrite rod is therefore quite a useful piece of equipment.

Two shorted turn detectors have been described previously in this magazine by M. D. Roberts. A valve version was published in the August 1960 issue and a transistorised version in the September

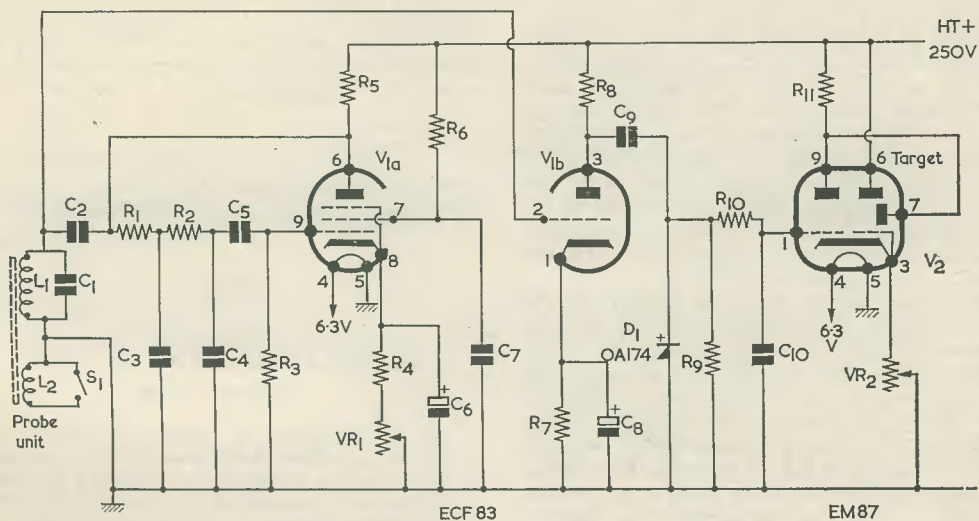


Fig. 1. The circuit of the shorted turn detector

Components List

Resistors

(All fixed values 10%, 1/4 watt, unless otherwise stated)

R ₁	1.2MΩ
R ₂	1.2MΩ
R ₃	3MΩ
R ₄	2.2kΩ
R ₅	220kΩ
R ₆	680kΩ
R ₇	1.6kΩ
R ₈	16kΩ, 1 watt
R ₉	1.2MΩ
R ₁₀	3MΩ
R ₁₁	100kΩ
VR ₁	1kΩ linear
VR ₂	5kΩ linear

Capacitors

C ₁	130pF
C ₂	80pF
C ₃	200pF

C ₄	200pF
C ₅	500pF
C ₆	50μF electrolytic, 12V wkg.
C ₇	0.04μF
C ₈	50μF electrolytic, 12V wkg.
C ₉	0.02μF
C ₁₀	0.01μF

Inductors

L₁, L₂ and ferrite rod. See text

Valves

V₁ ECF83. See text
V₂ EM87

Diode

D₁ OA174 or OA81

Switch

S₁ s.p.s.t. switch

1961 issue.* The presence of a shorted turn in a coil is indicated by these two instruments as a deflection of a meter. The instrument to be described here employs a fluorescent tuning indicator, which can be appreciably cheaper than a meter.

The EM87

At the front of the EM87 tuning indicator is a length of fluorescent material. When the tube is in operation the whole of this fluorescent material

may glow or there may be two small areas of illumination at the ends of the fluorescent strip. As the voltage at the grid of the EM87 is made more negative the two areas of illumination become larger until they meet at the centre of the fluorescent strip, the whole of which is then glowing.

In the instrument to be described, the whole of the fluorescent strip glows when a shorted turn is placed over a ferrite rod, whilst in the quiescent state there are only two small areas of illumination. If a good coil (that is, one without any shorted turn) is placed on the ferrite rod, the EM87 will continue to show the two small areas of illumination only.

* M. D. Roberts, "A High Sensitivity Shorted Turns Tester," *The Radio Constructor*, August 1960; and "Transistor Shorted Turns Tester," *The Radio Constructor*, September 1961. The first of these designs employed a 12AT7 and required a heater and h.t. supply, whilst the second used two transistors and a 6-volt battery.

Editor's Note

The ECF83 employed in the shorted turn detector is not manufactured in this country and may be difficult to obtain through normal retail channels. It is available, however, from Messrs. Britimpex Ltd. Since the valve functions consist merely of an oscillator with a variable cathode

resistor and a triode amplifier, those who care to experiment should be able to obtain similar results with the ECF82. This has different pinning to the ECF83, and slight adjustments to anode and screen-grid resistors may be necessary.

MONITORING HEADSET FOR TAPE RECORDERS

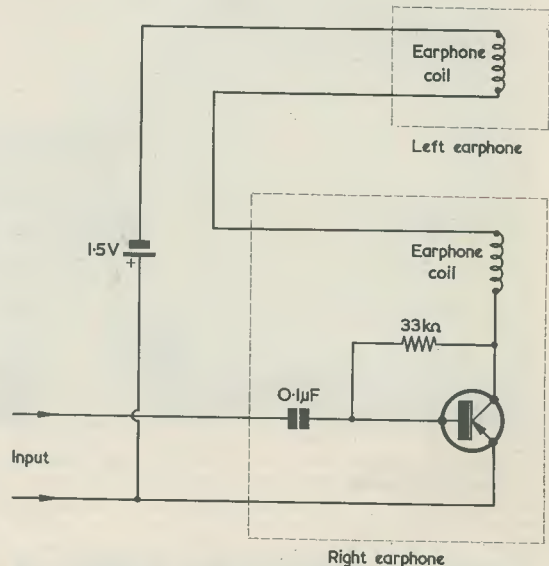
By G. MAYNARD

A neat method of achieving greater volume with low level outputs

MANY DOMESTIC TAPE RECORDERS PROVIDE AN output socket for headphone monitoring during recording, but the signal level available with some models is not always adequate for normal $2,000\Omega$ headphones.

In order to overcome this problem with his own tape recorder, the writer developed the simple single-transistor a.f. amplifier whose circuit is given in the accompanying diagram. Using a $1/10$ watt $33k\Omega$ resistor and a miniature $0.1\mu\text{F}$ capacitor it was found possible to fit these two components, and the transistor, into a $2,000\Omega$ earpiece itself. The necessary modification to the earphone requires a little care and there should, of course, be sufficient space available to take the components. Some of the earlier $2,000\Omega$ earphones were particularly bulky and offer quite a lot of space for additional parts.

The 1.5 volt cell, which can be an Ever Ready D21 or similar, fits into a holder mounted on the outside of the earphone. It is plugged in when the amplifier is required. The transistor may be an OC71 or any similar small a.f. type.



The monitoring headphone amplifier. Apart from the 1.5 volt cell, the components are housed in one of the earphones (shown here as the "right earphone"). The transistor may be an OC71 or similar.

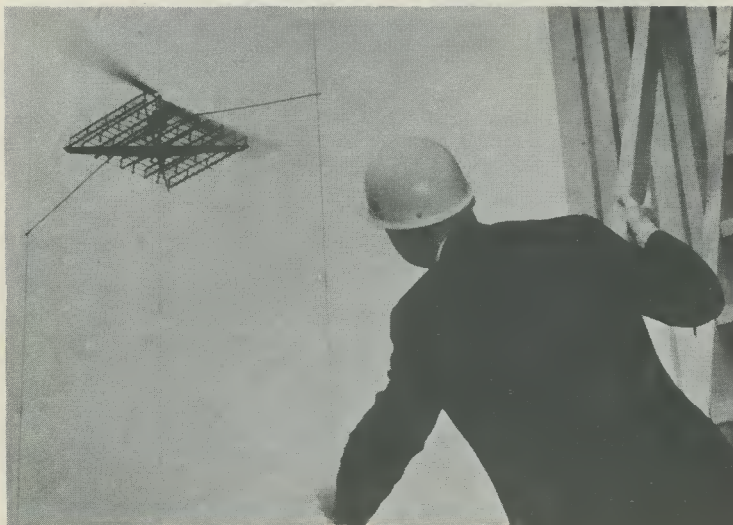
Normally, two $2,000\Omega$ earphones in a set are connected in series but, when the single transistor amplifier is used, they will have to be rewired. A convenient approach would consist of having the input lead connect direct to the earphone in which the amplifier is fitted, the connecting wires to the other earphone being carried over the headband.

Although intended for $2,000\Omega$ phones, the amplifier should function satisfactorily with phones of lower resistance.

In some instances, the gain provided by the transistor amplifier may be a little too high. In this case, a resistor, whose value is found by experiment, may be inserted in series with the input to the $0.1\mu\text{F}$ capacitor.

"BY PRECISION TO PERFECTION"

"By Precision To Perfection" is the title of the latest revised brochure issued by English Electric Valve Co. Ltd. This publication is exceptionally well illustrated and gives details of the most recent EEV products together with detailed information on their production and testing. Readers of *The Radio Constructor* may obtain a free copy by writing to Publicity Department, English Electric Valve Co. Ltd., Chelmsford, Essex.



Driven by a radio beam, this small helicopter rose 50 feet into the air and hovered for several minutes. The wires do not carry electricity, but keep the helicopter centred over the beam of invisible energy

ELECTRIC POWER BY RADIO IS WITHIN OUR GRASP?

The helicopter shown above carried no fuel. Its power came from the ground, via a radio beam.

This simple vehicle had six foot long rotary blades, an electric motor, and a bottom faced with semiconductor diodes. On the ground was a saucer-shaped aerial which focused five kilowatts of power into a narrow beam and transmitted it through the air to the helicopter.

The diodes changed the radio energy into electrical energy and passed it along to the helicopter's motor.

The success of the experiment suggests a new means of solving one of the contemporary world's fastest-growing technological problems—supplying adequate electrical energy wherever and whenever it is needed.

Cities have a perverse tendency to take root and grow in areas far from natural power resources.

Because of this, many generating plants are being located near the sources of coal, oil, and natural gas, and away from cities, and power is transmitted by power lines and underground cables. Few people, however, consider lines and cables as the ultimate in power transmission.

At least four such earth-return installations are in service or under construction. The longest of them runs between Italy and Sardinia, for a distance of 258 miles.

One alternative is to use the earth itself as a transmission medium. Current from the generating plant must be carried by conventional cables. But instead of a second cable carrying the current back to complete the circuit, the return current passes through the earth.

The chief attraction in transmitting power by radio is the fact that no wires or cables are needed.

William C. Brown, who was in charge of the model helicopter experiment, carried out by the Raytheon Company, says a valve has been developed with a power output that would enable a helicopter to hover at altitudes up to 50,000 feet.

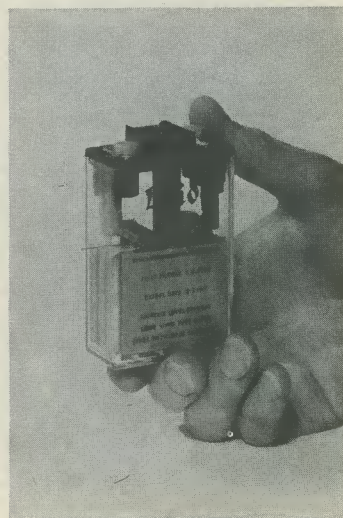
Who knows the future may find electric power zipping around the world via networks of radio relay stations.

LIGHT-WEIGHT LEAD ACID BATTERY

Rechargeable and Unspillable

A new compact 2 volt rechargeable Exide battery, known as type MRP7, has recently been announced, and should prove suitable for many electrical and electronic applications where a light-weight source of power is needed.

The MRP7 cell is completely unspillable even when inverted. The alloy used in the battery plates makes it ideal for duties where it will be maintained under floating and trickle charge conditions, and for those where frequent discharging and recharging are involved. The cell is capable of standing idle for long periods without deterioration thus making it suitable for intermittent and standby work.



The new compact 2 volt rechargeable Exide battery type MRP7 is completely unspillable even when inverted. It is designed for the many electrical and electronic applications where a light-weight source of power is needed

COMMENT

THIS MAGAZINE

We regret that, owing to substantial increases in costs of production during the past 2 years, the cover price of this journal will in future be 2s. 6d. This increase of 3d. is the minimum amount possible and, of course, we only receive part of the extra price because of trading discounts. Annual subscriptions will be 36s. p.a. post free.

There are a first rate selection of articles in stock ready for future publication, all of them conforming to the standards we have set for reliability and practicality.

As we enter into our 21st year of publication we look back with a certain amount of pride on the advances we have made. During our existence we have pioneered many designs and have been the first to publish much technical information of interest to radio constructors. This, together with the standards we have set, has been reflected in the steady growth of our circulation from some 3,500 copies per issue in our early days, to sales today of nearly 10 times that number.

NEW SOLID STATE TRANSMITTER

Communications operators in the 2 megacycle band have hitherto been obliged to rely upon conventional power supplies and truly mobile transmission has necessitated cumbersome equipment. These difficulties have now been overcome by the 2A10 Solid State Transmitter designed and manufactured by Contactor Switchgear (Electronics) Limited, of Wolverhampton. Working directly off a 12 volt car battery, and using a little over 1 ampere, the 2A10 operates at the full amateur licence rating of 10 watts input at 2 Mc/s on both AM and CW. The specification is comprehensive and the controls easy to read and use. The complete unit is housed in an aluminium container, attractively finished in black imitation leather. Overall dimensions are 8½in wide x 2½in high x 6½in deep. Weight: only 60oz.

NEW TEACHING METHOD AIDS R.A.F. EDUCATION

A new teaching method pioneered and developed by the Education Section of the Headquarters Unit of R.A.F. Bomber Command at High Wycombe, Bucks. has proved so successful that it may well be adopted by the Royal Air Force for wider use in certain education centres at home and overseas. Known as "Abalot One", an abbreviation of Audio-visual By Appointment Lessons on Tape, it incorporates many of the best aspects of programmed learning, teaching machines and language laboratories combined with the advantages of private tuition for every student.

The laboratory was built by officers and airmen using do-it-yourself methods, under the Senior Education Officer, Squadron Leader B. N. Purry. Study booths were built in an ordinary classroom from second-hand timber and scrap hardboard finished with light paint. Various devices are used in the study booths to present the programmes of instruction. In the simplest arrangement, lessons are recorded on tapes which are accompanied by carefully prepared visual aids. In some booths the programmes are in book form whilst in one an electronic device—not unlike a television set—displays pictures of the material to be mastered at the appropriate stages. All the lessons are carefully devised so that students progress by their own efforts and at their own speed, step by step.

"The criticism of many teaching machines and many programmed learning projects is that they depend entirely on the printed word," says Squadron Leader Purry, "but this cannot be said of the Abalot One laboratory. Automatic slide projectors are linked to tape recorders to give a fully audio-visual presentation, and this is controlled by just one switch on the student's desk. Students listen, watch, work and learn."

As students use the study booths by appointment, an Education Officer is available at any time to deal with any student difficulty arising. Such difficulties are rare but every programme concludes with a test piece which is marked by the Education Officer who discusses it with the student. Thus the close relationship between tutor and taught is maintained. "The paradox of Mechanisation is that it makes for far greater personal contact between the tutor and his student than can ever be possible in the ordinary class-room situation," says Squadron Leader Purry.



The "Pentonlector" Record Player Amplifier Circuit

By SIR DOUGLAS HALL,
K.C.M.G., M.A. (Oxon.)

A neat hybrid design which offers considerably higher fidelity than does the more conventional low-cost record player amplifier. An inexpensive transformer provides complete isolation from the mains.

THE TYPE OF RECORD PLAYER amplifier which uses a single pentode valve plus a rectifier (usually a UL84 and a UY85) is one of the most common in use at present. A typical circuit was described by G. A. French some time ago. More recently, Smithy and Dick became deeply involved with just such an amplifier in their Workshop.¹ The advantage of the circuit is that it is cheap to build and provides good volume. Disadvantages are that quality is not of a particularly high standard—there is insufficient amplification with only one stage to allow for the use of negative feedback and the chassis is connected to one side of the mains supply.

The Present Circuit

The circuit to be described in this article is a development of the last two stages of an arrangement recently discussed by the author as being suitable for the use in caravans² this having been adapted to make use of a power transistor and to take its power from the mains. The volume available is less than is given by the single UL84, undistorted output being of the order of 1.5 to 2 watts depending on the characteristics

¹ G. A. French, "Low-Cost Record Player Amplifier", Suggested Circuit No. 141, *The Radio Constructor*, August 1962. "In Your Workshop", *The Radio Constructor*, January 1965.

² Sir Douglas Hall, "Receiver Circuit For Caravans", *The Radio Constructor*, April 1966.

of the particular specimen used for TR₁. But the quality is strikingly better, chiefly as the result of a large amount of negative feedback which is made possible by the use of two stages instead of one. The author's amplifier, complete with power arrangements, can be built for about £3. This is about £1 more than the cost of the UL84/UY85 version. If volume is the sole criterion, then the UL84/UY85 circuit is the one to build. But music lovers who are satisfied with a volume level which is ample for a large room will find that the circuit to be discussed here will give them the results which good records deserve. The author does not claim Hi-Fi standards as he believes that true Hi-Fi is very rare and very expensive; but this amplifier will give much better quality than some which have been described as Hi-Fi by their advertisers.

The circuit appears in the accompanying diagram. A crystal pick-up is connected to the input terminals. The prototype is coupled to a B. S. R. Monarch GU7 deck, but many others will prove suitable. Some fixed compensation for lack of bass in recording is provided by C₂. Adjustable compensation is made possible by VR₁ in conjunction with C₁. Volume is regulated by VR₂.

Amplification is first provided by V₁, which has a heater rated at 16.5 volts. Heater current is obtained direct from the 17 volt secondary of a small charger transformer. Anode current passes through the base

emitter circuit of TR₁, the power transistor. It will be seen that there are no components for either load or coupling between V₁ and TR₁. D₁, a silicon diode rectifier provides a d.c. output at a voltage of about 20. C₄ is a high value electrolytic capacitor which provides sufficient smoothing for TR₁ and the anode of V₁, further smoothing for the screen-grid of V₁ being provided by means of R₂ and C₃.

Common Collector Transistor

It will be seen that TR₁ is connected in the common collector configuration. This means a comparatively high input impedance and a low output impedance. The one is dependent on the other. With the low output load needed for maximum realisable undistorted output from a large power transistor, the input impedance will be much lower than was the case in the caravan receiver previously described, in which much lower power levels were involved and the output load was, in consequence, much higher than the present case. In the present circuit V₁ must be looked upon as a power driver rather than a simple voltage amplifier, though it still does provide considerable amplification of voltage.

R₁ has a most important function. It settles grid bias for V₁, the voltage across it being dependent on the current passing through TR₁, which is some 50 to 75 times greater than the anode current of V₁. R₁ also acts as a most efficient stabiliser. If TR₁ heats up and passes more current, the voltage across R₁ increases. This is the bias voltage for V₁ and, as the mutual conductance of V₁ is high, the current passed through it is sensitive to small changes in voltage across R₁. The result is not only complete stability, with no chance of thermal runaway, but compensation for the individual characteristics of different specimens used for TR₁. For this reason it is unnecessary, as is after the case with power transistors, to have a variable control for setting up base bias. The value for R₁ which has been chosen will produce the conditions required—a current of the order of 200 to 300mA through TR₁—without further ado. Naturally, if a different type of transistor is used for TR₁, R₁ may need changing in value. It is recommended that the specified transistor be used, however, as it matches well with the valve chosen. Incidentally, a PL82 was selected for V₁ as it has the ability to pass an anode current of several mA with a very low voltage on anode and screen-grid together with sufficient grid bias to allow distortionless amplification.

Components List

Resistors

- R₁ 4.7Ω ½ watt 5%
 R₂ 1kΩ ½ watt 10%
 VR₁ 1MΩ potentiometer, log track, with switch S₁
 VR₂ 1MΩ potentiometer, log track

Capacitors

- C₁ 3,300pF
 C₂ 1,000pF
 C₃ 100μF, electrolytic, 25V wkg.
 C₄ 2,000μF, electrolytic, 25V wkg.

Transformers

- T₁ Output transformer type TT12 (Repanco)
 T₂ Charger transformer, secondary 3.5/9/17 volt (only 17 volt used) at 1 amp, type CT1 (Henry's Radio)

Valve

- V₁ PL82

Semiconductors

- TR₁ XC141
 D₁ Silicon rectifier type DD000 (Henry's Radio)

Loudspeaker

- 3Ω loudspeaker

Switch

- S₁ d.p.s.t., ganged with VR₁

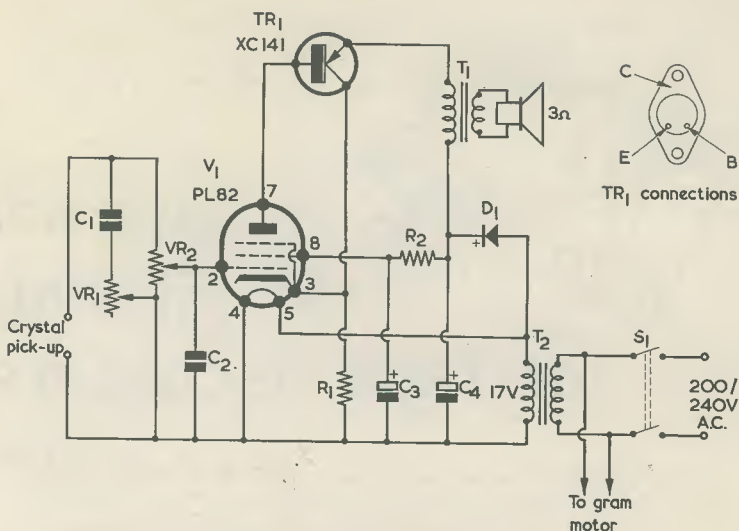
Miscellaneous

- Heat sink—Single Transistor Heat Radiator (Henry's Radoi)
 B9A valveholder

It also has the convenience of a heater which can be fed direct by the secondary of the mains transformer.

A silicon diode is strongly recommended for D₁. Diodes of this type are small and highly efficient. Also, their very low forward resistance means virtually no heating up, and practically no drop of voltage.

Although 18 volts is a little more than is usually fed to an XC141 transistor there need be no worry on this score. The negative feedback provided by R₁ removes all risk of thermal runaway and, provided a suitable heat sink is used (such as that specified in the Components



The circuit of the "Pentonlector" record player amplifier. The pentode drives the transistor, which is connected in the common collector mode

List), it will be found that TR₁ will never become hot rather than warm.³

No bypass capacitor is connected across R₁. This gives further negative feedback (over and above the voltage feedback inherent in TR₁ as a common collector amplifier) and further improves quality. Quality is also enhanced, of course, by the absence of any components between V₁ and TR₁.

Layout Requirements

In planning the layout it should be remembered that T₂ is designed as a charger transformer and, as such, is not shielded and may also produce some mechanical hum. It should be mounted at the opposite end of the cabinet from the amplifier and the angle at which minimum hum is induced should be tried by experiment. Mechanical hum can be minimised by wrapping it in plastic foam and enclosing it in a small, fairly tight fitting wooden box, which can be mounted under the motor board

³ The maximum rated V_{cb} for the XC141 is 40 volts. The heat sink will be at collector potential if insulating washers are not used, and will need to be insulated from the remainder of the circuit.—EDITOR.

at the required angle. The feet should not be screwed to the box. If these precautions are taken the hum level will be quite harmless.

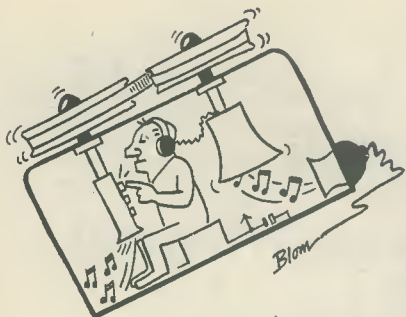
The only other precaution to be taken is to mount TR₁ away from V₁ as the valve heater gives off some heat, though this is not very considerable. It has not been found necessary to provide any ventilation in the cabinet for the amplifier.

It will be found that, with most classical records, VR₂ can be turned close to the maximum position before overloading starts. Many "pop" records, particularly of the 45 r.p.m. variety, will prove capable of loading the amplifier fully with VR₂ backed down by some 90°. Volume is ample for most purposes and both treble and bass responses are very good provided a good loudspeaker is used. This need not be more than 6½ in. in diameter but should have a free moving cone to reproduce the considerable bass which is available.

The chassis is, of course, isolated from the mains, and the only components at mains potential are the mains transformer (primary only), the switch, and the leads to the turntable motor.

The Design and Construction of Measuring Bridges

Part 2 of this short series, dealing with the design of a precision Wheatstone bridge for resistance measurement and a novel low-cost decade resistance box, will appear next month.



Internal Monitoring for Tape Recorders

By S. A. MARTYN

The addition of a B7G valve and a few other small components may, in many cases, enable you to monitor on your tape recorder's internal speaker.

IN MANY RECORDERS, AND ESPECIALLY those in the lower price bracket, the only provision for monitoring the signal being recorded is by way of a socket intended for headphones or an external amplifier. The small unit described in this article was designed to provide monitoring facilities via the recorder's internal loudspeaker. It should be pointed out that it may not be possible to use the unit with all tape recorders. If the reader is in doubt, he should check the circuit of the recorder and try out the unit in temporary form before constructing it for permanent installation in the recorder.

The Amplifier

The additional unit consists of an a.f. amplifier, and this requires a single low-power output valve only. In the author's unit an EF91 strapped as a triode was employed, the circuit being illustrated in Fig. 1. Miniature components must be used as there is not a great deal of spare space in the average tape recorder. It should be checked that no d.c. voltage exists at the monitoring socket; if such a voltage is present a 0.01 μ F capacitor should be inserted in series with the input connection to VR₁. This capacitor is shown as C₁ in Fig. 1.

In the author's version, volume control VR₁ is a pre-set component

which was set up to provide a comfortable volume level when the EF91 unit was initially installed. If recording is to be carried out from a microphone in the vicinity of the recorder, however, it is necessary to be able to turn VR₁ right down in order to prevent feedback. Because of this, many constructors will prefer to use a knob-operated volume

control for VR₁, this being mounted at a convenient point on the recorder cabinet.

It is necessary for a section of the Record/Playback switch to be available in order that the output from the EF91 speaker transformer can be disconnected from the internal loudspeaker during playback. This function is clearly shown in Fig. 1. The secondary of the EF91 speaker transformer is then loaded, on "Playback", by the 3 Ω resistor R₂. In most recorders the internal speaker is disconnected when recording, whereupon it is quite in order to use the internal speaker for monitoring purposes. An adequate 3 Ω match to the EF91, when triode-connected, is given by a 60 : 1 output transformer.

Power Supplies

The h.t. consumption of the EF91 is approximately 12mA and most tape recorder power supply circuits should be able to provide this. The EF91 amplifier may be run from the h.t. feed to a Magic Eye level indicator if such is fitted and if its h.t. supply is switched on only when recording. The EF91 will, then, similarly be supplied during recording only. The EF91 requires a heater supply of 6.3 volts at 0.3 amps. In the writer's instance this was taken from the recorder heater supply, a pilot lamp being taken out of circuit to maintain overall heater current at the same level.

If the recorder cannot supply the necessary additional current a small power-pack will be needed, and a suitable circuit is shown in Fig. 2. The mains transformer may be a small component offering an h.t.

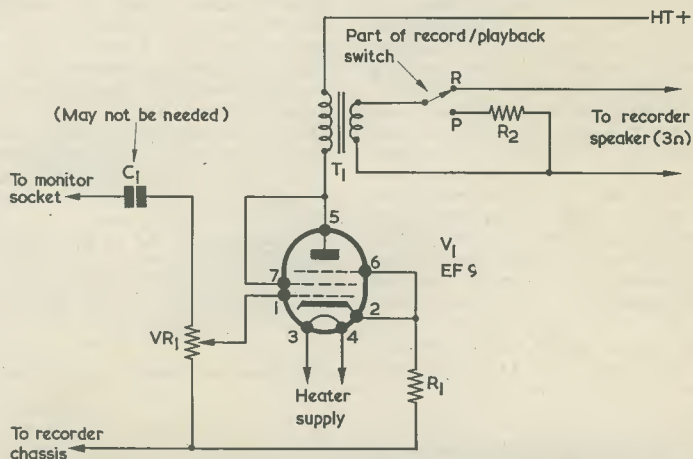


Fig. 1. The add-on amplifier unit. The lead to the monitor socket should be screened, and it may also be necessary to screen the lead from the slider of VR₁ to the grid of V₁. H.T. and heater supplies can, in many cases, be taken from the recorder power supply

Components List

Fig. 1.

Resistors

- R₁ 150Ω ½ watt 10%
 R₂ 3Ω 2 watt 20%
 VR₁ 500kΩ potentiometer, log track (see text)

Capacitors

- C₁ 0.01μF (see text)

Valve

- V₁ EF91

Transformer

- T₁ 60 : 1 miniature output transformer (primary current 15mA)

Fig. 2

Resistor

- R₃ 2kΩ 1 watt 20%

Capacitors

- C₂, C₃ 32μF, dual electrolytic, 300V Wkg.

Rectifier

- D₁ E250C30 (contact-cooled) or BY100

Transformer

- T₂ Mains transformer. Secondaries (minimum current ratings): 200V at 15mA, 6.3V at 0.3A

secondary voltage of approximately 200 at 15mA or more. The 6.3 volt heater winding has to provide 0.3 amps only. The h.t. rectifier, D₁, may be a small contact-cooled component or a BY100 silicon diode.

Fitting The Unit

The amplifier components can be

assembled on a small piece of aluminium or Paxolin. The volume control, VR₁, should be mounted on the unit, or on the front panel or cabinet side at a convenient point as desired. Screened cable should be used for the wiring from the monitor socket to VR₁. If C₁ is fitted, it may be mounted either at the monitor socket or at the volume control end of the screened cable. The lead from the slider of VR₁ to the grid of the EF91 should be screened also if layout requirements necessitate this being fairly long.

The EF91 chassis can be secured to a convenient point of the recorder chassis by means of angle brackets. The valve does not dissipate a great deal of heat, but it would still be desirable to position it near a ventilation aperture. Housing an

additional power pack may be more difficult, especially if the deck has three motors. One solution is to mount the smoothing components and rectifier (especially if this is of the contact-cooled type) on the amplifier chassis, and to fit the additional mains transformer elsewhere in the recorder.

In conclusion, the writer has found that this little unit gives quite adequate volume for monitoring purposes and that it offers a much more convenient method of monitoring than conventional headphones. As was mentioned earlier, its volume control must, of course, be turned right down when recording from a microphone in the vicinity of the recorder; as there will otherwise be feedback.

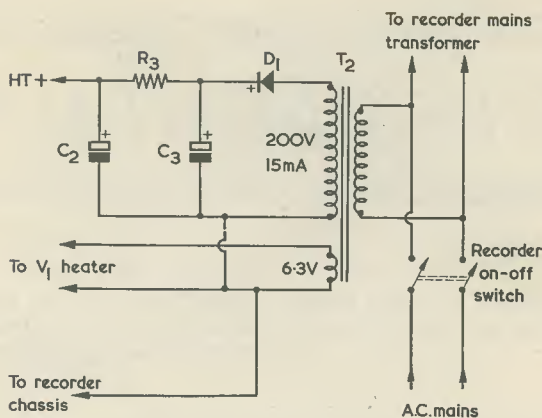


Fig. 2. If the recorder power circuits cannot provide the additional current needed for the EF91, a small power supply circuit may be made up as shown here

CAN ANYONE HELP?

Requests for information are inserted in this feature free of charge, subject to space being available. Users of this service undertake to acknowledge all letters, etc., received and to reimburse all reasonable expenses incurred by correspondents. Circuits, manuals, service sheets, etc., lent by readers must be returned in good condition within a reasonable period of time

Wanted.—R. Gayton, 23 Thornton Hill, Exeter, Devon—borrow or purchase circuit of the R209 receiver.

* * *

Crystals for Class D Wavemeter.—R. Jones, 24 Forest Avenue, Foresthall, Newcastle-upon-Tyne—source of supplies for the unit.

* * *

Jason Everest 7.—J. N. Pindar, 467 Woodway

Lane, Walsgrave, Coventry—circuit diagram or constructional details.

* * *

Circuit Wanted.—L. H. Reed, 32 Francis Road, Ladysmith, Natal, S. Africa—hand-held transceiver using British components.

* * *

Cossor CR1604 Tape Recorder.—R. Whitbread, 108 Gascoigne Road, New Addington, Croydon Surrey—circuit or service manual.

EXPERIMENTAL FM TUNER

The circuit described here is presented purely as an experimental project for those who enjoy working on unusual designs. Our contributor reports very good results with the prototype, but warns that tuning and setting-up adjustments tend to be critical

THE SIMPLE TUNER FOR F.M. RECEPTION IN BAND II which is described here can be quickly assembled in bread-board style, and it mainly uses materials from the spares cupboard or junk-box, together with two v.h.f. transistors. Some previous practical experience of v.h.f. circuitry is assumed, and all wiring carrying v.h.f. signals must be kept as short as possible. The constructional technique employed by the writer consists of mounting stages, or circuit groups, on individual tagstrips which may then be later screwed to a baseboard.

Basic Circuit

The basic circuit of the tuner is shown in Fig. 1. The signal from a simple dipole aerial cut to the correct half wavelength is applied direct to the emitter of transistor TR₁, which functions as

a buffer amplifier. L₁, in the collector circuit of TR₁, is tuned to resonate at signal frequency, and the signal which appears at the tap in this coil is applied via C₃ to the emitter circuit of TR₂.

TR₂ functions as an oscillator running at half the frequency of the incoming signal, oscillator level being controlled by VR₁. Feedback is via C₅, and oscillator frequency is controlled by L₂ and VC₂. The writer ascribes the functioning of the circuit to parametric amplification, with TR₂ operating as pump oscillator.* It is necessary for TR₂ to oscillate at *precisely* half the signal

*The electrode capacitances of a transistor can provide the varying reactance of a parametric amplifier, and it appears possible to obtain parametric amplification where pumping occurs at a multiple of oscillator frequency. See "Parametric Amplification with Transistors" by Ulrich L. Rohde, *Wireless World*, October 1961, and "Parametric Frequency Dividers" by F. Butler, *Wireless World*, January 1964.

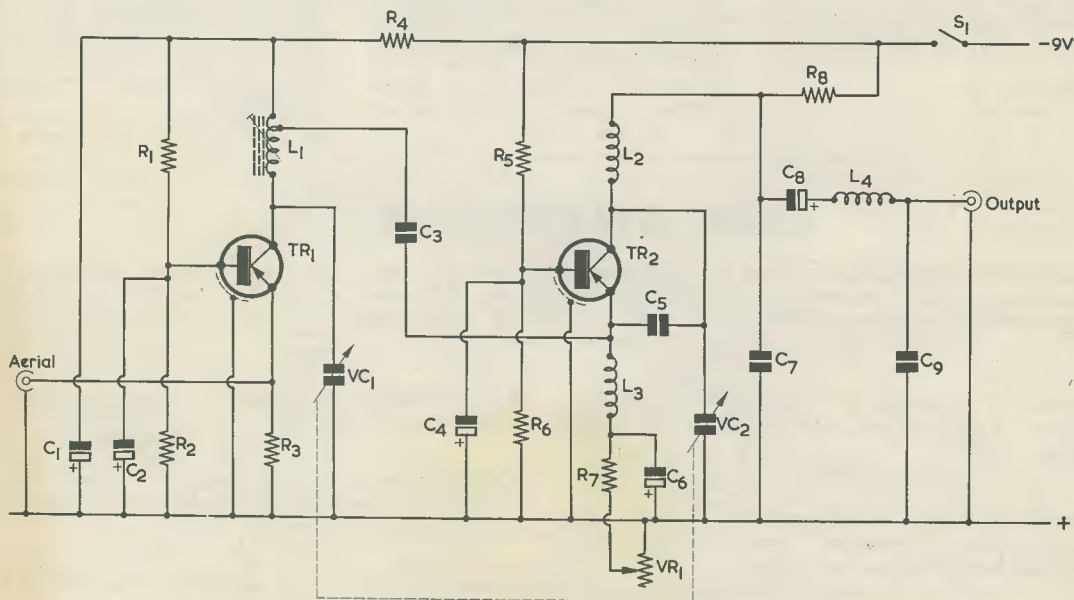


Fig. 1. The circuit of the experimental tuner

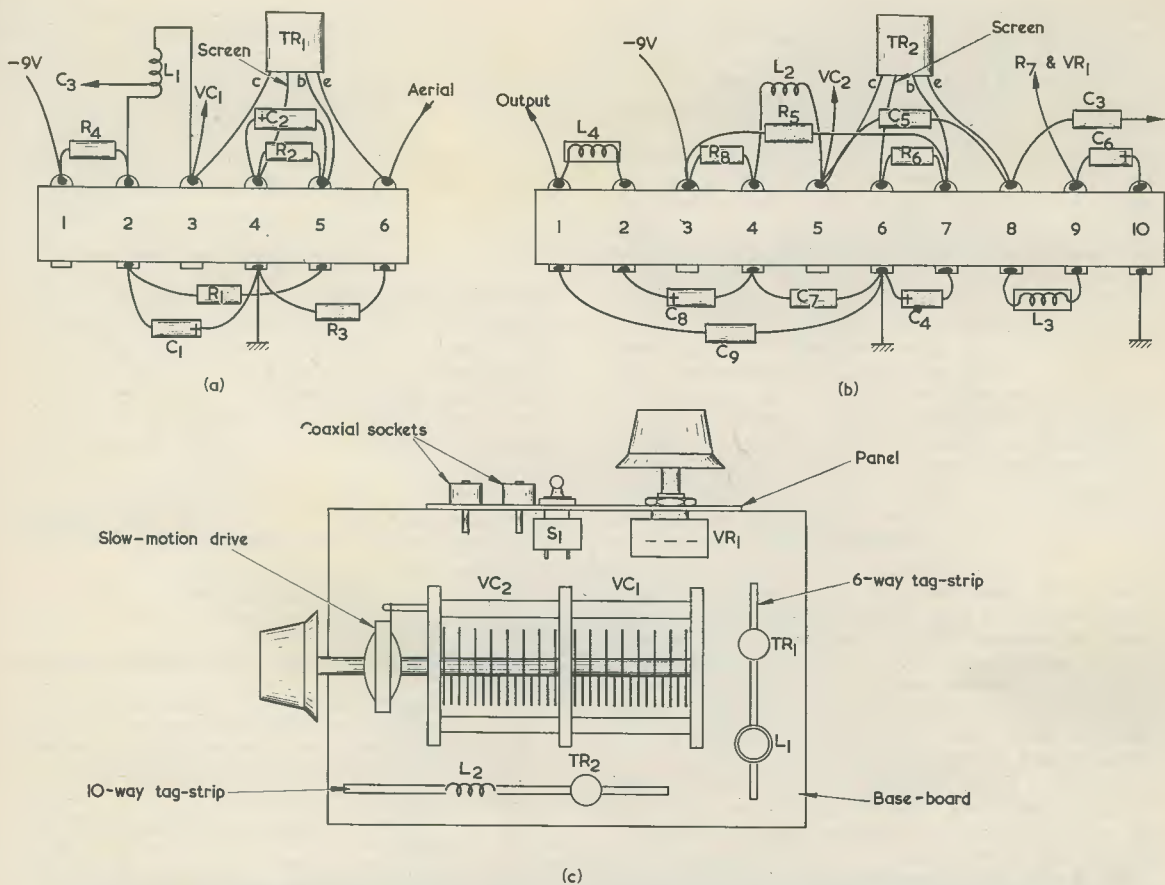


Fig. 2(a). The components around TR₁ may be assembled on a 6-way tagstrip as shown here. The chassis symbol corresponds to the positive supply line. L₁ is wound on a small former (not shown here) with its axis vertical
 (b). The TR₂ components are fitted to a 10-way tagstrip. L₂ is wound on a small $\frac{1}{4}$ in former, and has its axis horizontal
 (c) A suitable layout for the tuner

frequency, and for oscillator amplitude to be at a critical setting for the circuit to function properly. The extremely sharp tuning of the circuit enables f.m. signals to be demodulated due to frequency deviation being converted to amplitude variation. Tuning is very fine and the setting of VR₁ is critical. A regulator circuit can be added, if desired, and this eases the adjustment of tuning and oscillator amplitude. The regulator circuit is described later.

When correctly set up, an audio frequency corresponding to transmitter modulation appears across collector load R₈ and this, after filtering by L₄ and C₉, is passed to a subsequent a.f. amplifier.

With suitable modifications to the two tuning inductors, L₁ and L₂, the same circuit can be employed for TV sound or for the higher amateur frequencies.

The circuit will function without buffer amplifier TR₁, the aerial being applied to the emitter of TR₂ via a small capacitance; but it is most important, nevertheless, to retain TR₁ in circuit. Without

TR₁, radiation of the oscillator frequency via the aerial will occur, with consequent interference with neighbouring receivers. Also, tuning becomes more difficult.

A standard audio amplifier following the tuner should provide sufficient gain in localities where signal strength is good. If signal strength is poor, or an indoor aerial is used, it may be necessary to interpose an a.f. pre-amplifier. It is assumed, of course, that the amplifier has a volume control. If desired, a simple one- or two-transistor a.f. pre-amplifier could be incorporated in the receiver, to avoid long leads.

The current consumption of the tuner is of the order of 3mA.

Assembly

The layout of the tuner is largely dictated by the need to keep L₁ and L₂ close to VC₁ and VC₂. The author's version had the TR₁ and TR₂ components mounted on 6-way and 10-way tagstrips respectively, as shown in Figs. 2(a) and (b). These

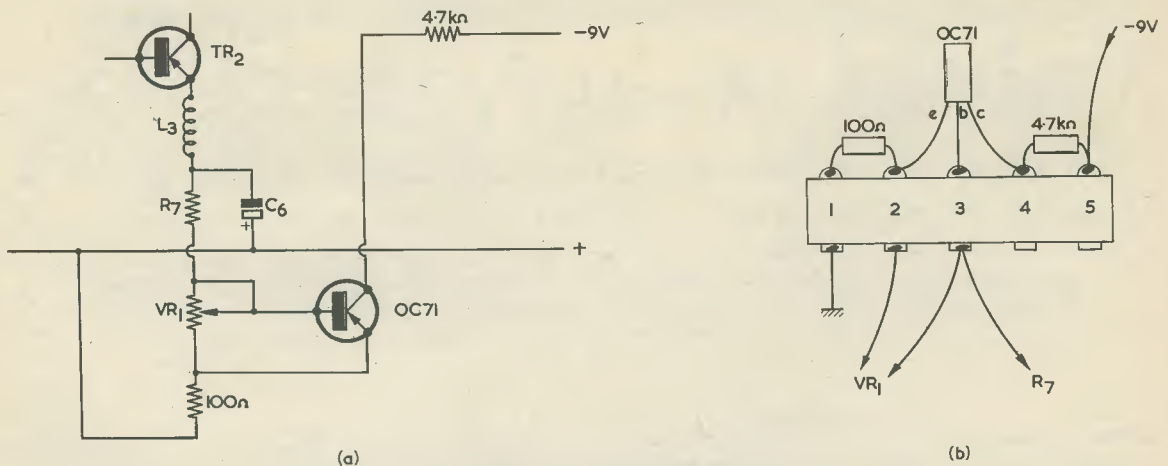


Fig. 3(a). Additional components for a regulator circuit
 (b). How the additional components of (a) may be mounted on a 5-way tagstrip

were then assembled on a wooden baseboard as shown in Fig. 2(c). The small two-gang capacitor may be screwed to the base-board or fitted on a panel, according to type. A vertical panel carries VR₁, the battery switch and "In" and "Out" coaxial sockets. An essential feature is the slow-motion drive for the tuning capacitor, which must be free from backlash.

In use, VR₁ is adjusted by trial and error until TR₂ is oscillating quietly just below the point at which audible oscillations (blocking oscillator effects and "motor-boating") occur spontaneously. This is the most sensitive region. The essential fixed bias for TR₂ is provided by the potential divider R₅ R₆, the precise value of R₆ being determined by trial for the particular v.h.f. transistor used. The value of 15kΩ appears to be suitable for most transistors tested.

Tracking

The tuning inductors L₁ and L₂ are wound and adjusted to provide a 2 : 1 frequency ratio when tuned simultaneously by the two-gang capacitor. For this purpose L₁ is provided with a trimming slug which is adjusted for maximum effect on the centre of the three f.m. transmissions to be received. Since L₁ is essentially flat tuning, this adjustment provides sufficiently close tracking over the three transmissions.

For setting up, a v.h.f. a.m. signal generator, operating around 46 and 92 Mc/s is helpful. But in an area of good reception a well-situated and directed single dipole aerial should provide powerful enough signals to work with when TR₂ is adjusted to the sensitive point, just below the "motor-boating" condition. The buffer circuit can then be adjusted, by the tuning slug, for optimum reception over the band. (Local TV sound, and the rattle of TV video, may be heard at higher frequency settings of TR₂).

Components List

Resistors

(All fixed values ¼ watt, 10%, unless otherwise stated)

R ₁	22kΩ
R ₂	4.7kΩ
R ₃	1kΩ
R ₄	470Ω
R ₅	47kΩ
R ₆	15kΩ 5% (may need adjustment)
R ₇	1kΩ
R ₈	4.7kΩ
VR ₁	5kΩ pot. linear

Capacitors

(All electrolytic capacitors should be miniature types. C₉ may be adjusted to give alternative treble cut level. C₈ may be 0.1μF if the following a.f. amplifier uses valves.)

C ₁	25μF electrolytic, 12V wkg.
C ₂	25μF electrolytic, 6V wkg.
C ₃	5pF ceramic
C ₄	25μF electrolytic, 6V wkg.
C ₅	2pF Ceramic
C ₆	25μF electrolytic, 6V wkg.
C ₇	1,000pF ceramic
C ₈	25μF electrolytic, 12V wkg.
C ₉	0.05μF paper
VC _{1,2}	Small two-gang capacitor with slow-motion drive, approx. 20pF per section.

Inductors

L ₁	4 turns of 18 s.w.g. bare tinned copper on ¼in former with slug, tapped 1 turn from earthy end. Length ¼in approx.
L ₂	8 turns of 36 s.w.g. enamelled copper close-wound on ¼in former.
L _{3,4}	V.H.F. r.f. chokes. Consist of ½ watt 20% high-value resistors close-wound overall with 36 s.w.g. enamelled copper

Transistors

TR_{1,2} OC171, or equivalent

Switch

S₁ s.p.s.t. on-off switch

Miscellaneous

Coaxial input and output sockets
Tagstrips
9-volt battery

Fine regulation of VR₁ should then give clear reception of all the three B.B.C. f.m. transmissions without further adjustments, subject to very careful tuning with VC₁ and VC₂. Any further adjustment of VR₁ will affect the tuning each time. After a short running time, a small tuning adjustment may be necessary to counteract frequency drift.

Regulator Circuit

Operating adjustments are simplified if TR₂

is controlled by a regulator circuit. Fig. 3 shows a simple additional circuit, which can be mounted on a 5-way tagstrip, with an ordinary a.f. transistor (such as an OC71) and two additional resistors, connected with VR₁ as shown. VR₁ is adjusted, once and for all (and usually with the slider near the earthy end) so as to set TR₂ as before, to about the most sensitive condition—but for optimum quality this time rather than for maximum loudness, which is the job of the audio amplifier. The additional 4.7kΩ voltage dropper is selected so as to provide about 1mA emitter current in the OC71.

This slight extra complication is recommended when the tuner is to be used for regular domestic listening, as it facilitates tuning and helps to cope with the troublesome frequency drift.

The action of this regulator is in general similar to that of certain types of conventional voltage-stabiliser circuits. Any increase in the emitter current of TR₂ produces a larger increase in the current passed by TR₃ with a resulting amplified back-e.m.f. across the common 100Ω resistor to oppose the original increase.

“New-Style” Heathkit Model RF-1U Signal Generator

The latest Heathkit model to be given a new presentation is the very popular R.F. Signal Generator model RF-1U. This instrument has established itself over many years and no circuit changes have been found necessary but, externally, changes have been effected to bring this model into line with our current styling.

An attractive two-tone grey front panel gives improved definition of control settings and scale readings. The charcoal grey cabinet and the black positive-grip knobs with their spun-aluminium inserts complete the new and striking presentation of the re-styled RF-1U.

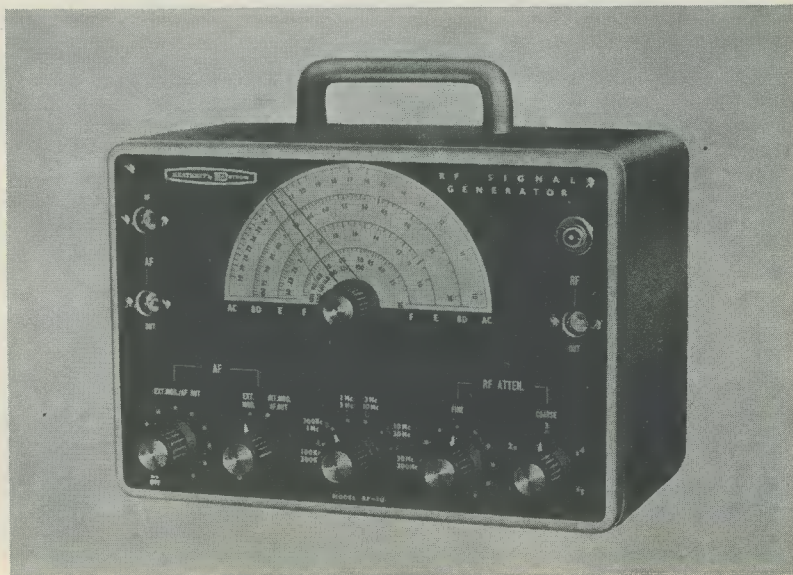
The RF-1U provides a source of accurate and stable r.f. signals ideal for aligning r.f. and i.f. circuits of all kinds and for fault finding. The 400 c/s signal is available for the testing of audio circuits.

The extended frequency range of the RF-1U is covered in 6 bands from 100 kc/s to 100 Mc/s on fundamentals and up to 200 Mc/s on calibrated harmonics of the fundamental frequencies. The frequency is indicated on six easy-to-read scales.

A built-in 400 c/s audio generator with an output exceeding 4 volts provides a convenient source of audio signal which may be used to modulate internally the r.f. output, or the r.f. portion of the generator may also be modulated externally by other frequencies through a socket mounted on the front panel.

Modulated or unmodulated r.f. output up to 100mV is available. This output is controlled by a continuously variable attenuator and a constant impedance step attenuator.

Featured in the RF-1U circuit is a 12A7 valve in a Hartley oscillator circuit to ensure stable operation over the entire frequency range. The pentode section of an ECF80 valve serves as a low distortion output amplifier while the other section of the valve is used for the internal 400 c/s oscillator. Heathkit R.F. Signal Generator model RF-1U. Kit price £13.8.0. Assembled price £19.18.0.

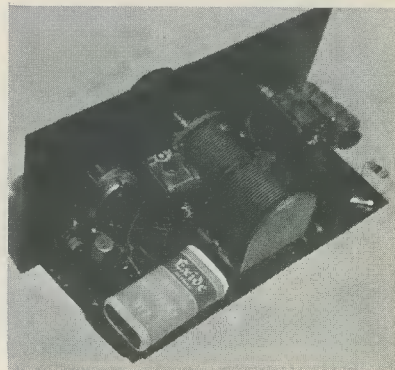




Cover Feature

Transistorised T.R.F. Radio Receiver

By WALLACE STUDLEY



This simple 2-transistor reflex radio, which may be housed in a case measuring $6\frac{1}{2} \times 3\frac{3}{4} \times 3\frac{1}{8}$ in only, is a particularly attractive project for the beginner. The receiver covers the medium wave band, and battery consumption is less than 2mA

EARLY ATTEMPTS AT RADIO CONSTRUCTION USUALLY begin with t.r.f. (tuned radio frequency) circuits, and this approach is a sensible one. T.R.F. circuitry has the advantage of being simple, and it is fairly easily understood even by complete newcomers to the hobby. Useful pieces of gear can be constructed with a low-cost outlay, and

alignment problems are virtually non-existent. Simple t.r.f. designs are also a fine way of learning in a pleasant and easy way something of what is involved in radio reception. However, it is wise to appreciate that, from the point of view of performance, a t.r.f. design is in no way comparable with a superheterodyne, and the price one must

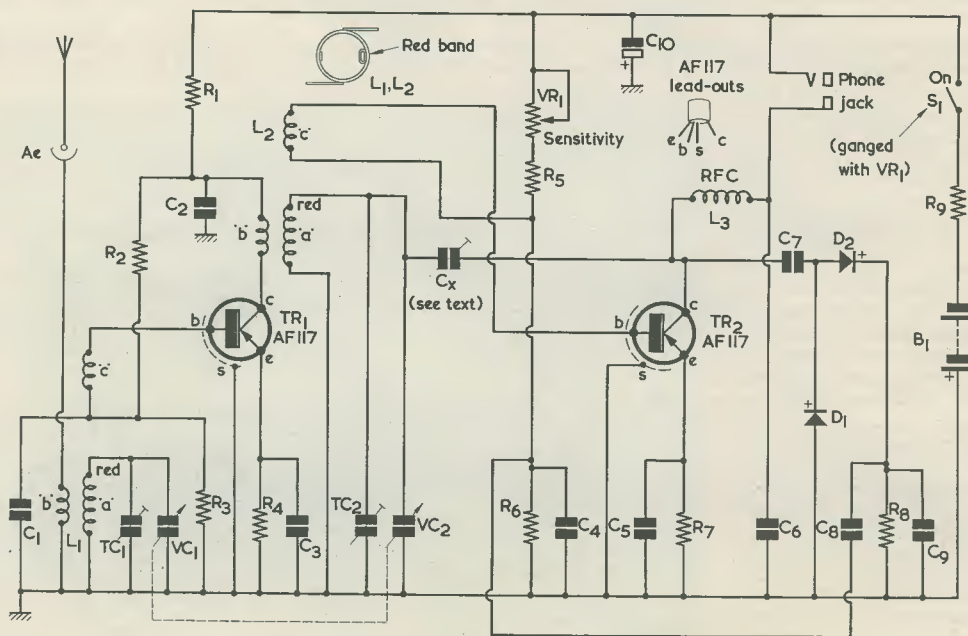


Fig. 1. The circuit of the t.r.f. radio receiver

Components List

Resistors

(All fixed valves $\frac{1}{2}$ watt 10%)

- R₁ 1k Ω
- R₂ 18k Ω
- R₃ 3.3k Ω
- R₄ 1k Ω
- R₅ 18k Ω
- R₆ 3.9k Ω
- R₇ 1k Ω
- R₈ 10k Ω
- R₉ 2.2k Ω
- VR₁ 100k Ω potentiometer, linear track, with switch

Capacitors

- C₁ 0.04 μ F paper 150V wkg.
- C₂ 0.04 μ F paper 150V wkg.
- C₃ 0.04 μ F paper 150V wkg.
- C₄ 0.01 μ F ceramic
- C₅ 0.04 μ F paper 150V
- C₆ 0.01 μ F ceramic
- C₇ 330pF ceramic or silver-mica
- C₈ 0.01 μ F ceramic
- C₉ 0.01 μ F ceramic
- C₁₀ 100 μ F, electrolytic 12V wkg.
- C_x Twisted pair (see text)
- VC_{1,2} Two-gang, 410pF, without trimmers, Type "O" (Jackson Bros) or equivalent
- TC₁ 50pF, postage-stamp trimmer
- TC₂ 50pF, postage-stamp trimmer

Inductors

- L₁ Coil type PA2 (Wearite)
- L₂ Coil type PHF2 (Wearite)
- L₃ 2.6mH r.f. choke type RFC.5 (Denco)

Semiconductors

- TR₁ AF117
- TR₂ AF117
- D₁ OA70
- D₂ OA70

Switch

- S₁ s.p.s.t. switch (part of VR₁)

Battery

- B₁ 9-volt battery type PP3 (Ever Ready)

Headphones

- 1 pair headphones, total resistance 2,000 to 4,000 Ω

Vernier Drive

- Drive type T502, 2 in diameter (Henry's Radio)

Miscellaneous

- Veroboard (0.2 in hole spacing)—see Fig. 3
- Miniature jack socket and plug
- Knob
- Battery clips
- Aluminium for two-gang capacitor support
- Paxolin for case
- Set No. 3, Panel Signs Transfers (Data Publications, Ltd.)
- Wire, sleeving, solder, etc.

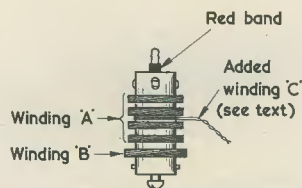


Fig. 2. How the additional winding is fitted to coils L₁ and L₂. Care must be taken to avoid damaging existing coil wire

pay for t.r.f. simplicity is relatively low sensitivity.

The Circuit

Normally, a t.r.f. receiver of simple form should comprise at least one stage of r.f. amplification, followed by detection and subsequent a.f. amplification. It is possible to assemble suitable circuitry for reception from 580 to 1,600 Kc/s (190 to 520 metres) around two transistors and two diodes in the manner shown in Fig. 1. Here, TR₁ functions as a conventional r.f. amplifier, signals picked up by the aerial being tuned by VC₁ and TC₁ and coupled inductively into the base of the transistor. The use of an aerial is obligatory with this receiver. No earth need normally be employed. Inductive coupling into the base of TR₂ is arranged by means of coil L₂, and after further amplification the signals appear at the collector of this transistor. These signals are at r.f. and pass through C₇ for application to the detecting diodes, D₁ and D₂.

The demodulated signals, now at audio frequencies, are fed back to TR₂ via C₈, whereupon the transistor functions in its second rôle of a.f. amplifier. The amplified a.f. signals at the collector of TR₂ pass through the r.f. choke L₃ and are then applied to the headphones. It may be noted that this process is only made possible by the presence of C₇ and L₃, both of which are frequency-conscious components. The purpose of C_x is to allow a minute portion of the r.f. signal to be fed back regeneratively across the transistor, and thereby increase sensitivity. In practice C_x is pre-set at the setting-up stage to bring TR₂ to the brink of oscillation at the high frequency end of the band when the resistance of VR₁ is almost fully in circuit. Thereafter, VR₁ may be used as a sensitivity control to vary the gain, within limits, over the whole of the band. In cases of non-oscillation, the connections of winding "c" in L₂ may be reversed.

It will be noticed that a 2.2k Ω resistor, R₉, is inserted in series with the negative battery supply terminal. So that the receiver may be completely self-contained a miniature battery is desirable, and the most convenient size generally available is the 9-volt PP3. However, the receiver offers best results in terms of signal-noise ratio with a supply voltage of the order of 6, and R₉ is inserted, in consequence, to act as a dropping resistor. Due to the very low current drawn by the receiver the loss of power in R₉, in terms of battery cost, is virtually negligible.

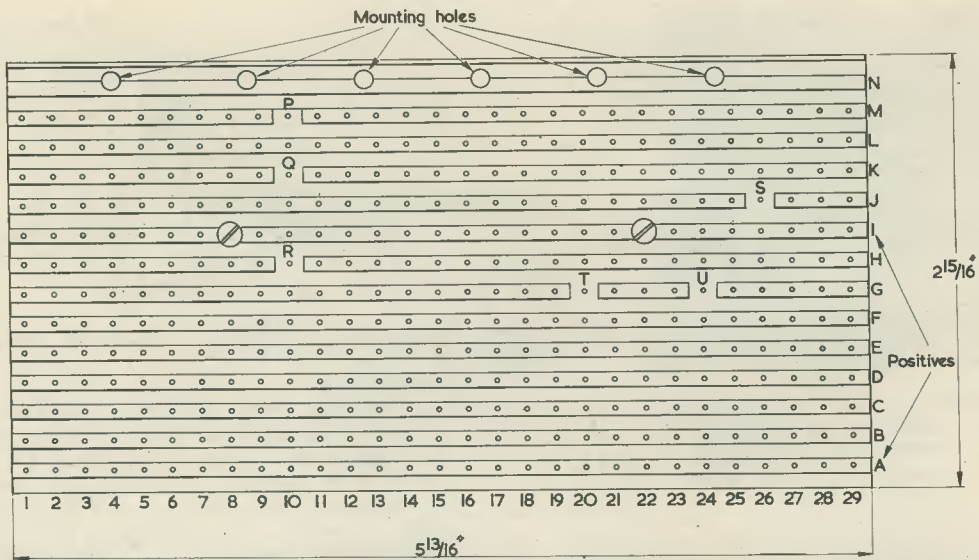


Fig. 3. The Veroboard (0.2 in hole spacing) required for the receiver. Note that this is cut in from the edge of a Veroboard sheet. The conductor strips are severed at points P, Q, R, S, T and U. Conductor strips A and I are earthy (positive supply line)

Tuning of this simple receiver is accomplished via a 2-gang capacitor, VC₁, VC₂, and this necessitates use of a pair of matched aerial and interstage coils. A pair of Wearite "P" coils are employed here, these being fitted with an additional winding designated "c". This is added as shown in Fig. 2 where, as may be seen, the existing tuned winding consists of four pies. The added base feed winding is placed centrally as illustrated and consists of

8 turns of fine double silk covered wire (around 36 s.w.g.), although the actual gauge and insulation does not seem critical, and the wire could probably be enamelled. Take care not to break the existing wire joining the two centre pies of the tuned winding. The coils have four tags at the top of the former, one of which is coded red; this tag and the one immediately opposite connect to the tuned winding ("a") and offer the advantage that a postage-stamp

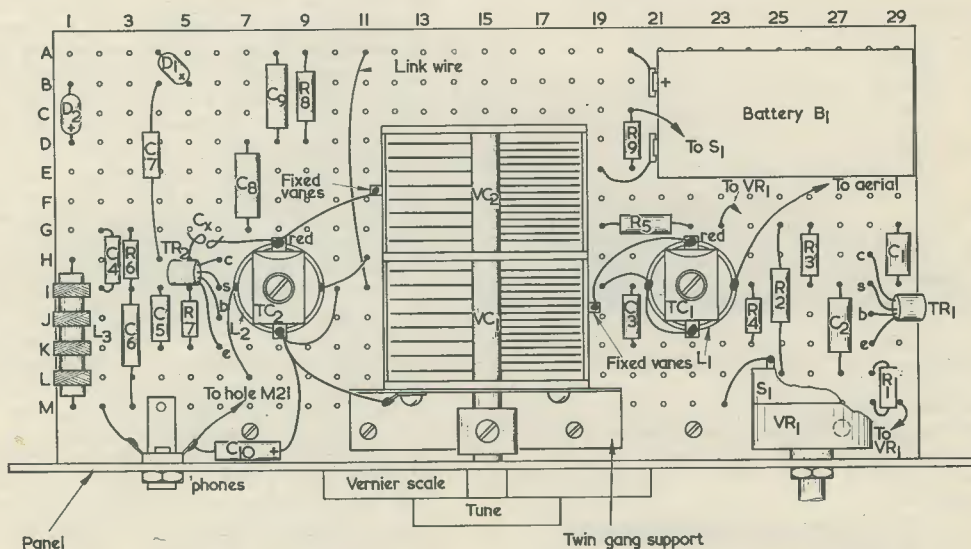


Fig. 4. Wiring and layout diagram

Winding C, L₁ terminates at holes G27, J27
Winding C, L₂ terminates at holes G10, J10

trimmer may be soldered directly across them.

Construction

By using an oddment of Veroboard affixed to a panel, work is greatly simplified. Initially, a piece of Veroboard should be cut to agree with the dimensions given in Fig. 3, in which there are 13 conductor strips each having 29 pre-drilled holes, plus 2 strips at the edge. The conductor strips are then severed at points "P" to "U" and holes I8 and I22 enlarged to accept 6BA bolts, which will later retain coils L_1 and L_2 . The "mounting holes" shown in Fig. 3 are those which normally exist along one end of a new section of Veroboard.

Next, the front panel is prepared (see Fig. 6) and the vernier drive and the sensitivity control tentatively mounted. The twin-gang shaft is coupled to the drive unit and measurements are then taken to enable a simple L-shaped aluminium bracket to be fashioned to hold the gang unit securely. (Further details on this are given below.) Wooden butts of $\frac{1}{2} \times \frac{1}{2}$ in cross-section are also required to be glued to the inside of the panel at the bottom and below the board assembly. A modern impact adhesive may be employed here. Eventually, small screws will be passed through the "mounting holes" of Fig. 3 into these butts to secure the Veroboard to the panel. Little weight is involved and this method of mounting is quite satisfactory. A miniature jack socket for the phones is also fitted to the panel.

Assembly then takes place as shown in Fig. 4. Note that the tuning capacitor support is secured by wood-screws at two of the "mounting holes" of Fig. 3, and that the earth connection to its frame is made via a solder tag at one of the bolts which hold it to the support. This tag, and the wire soldered to it, should be fitted before the final assembly of the tuning capacitor and its support to the board.

The two coils, L_1 and L_2 , are each fitted with the tag orientation shown. It is important to ensure that the heads of the 6BA bolts which secure these two coils maintain continuity along the whole of strip I. Each coil has a postage-stamp trimmer soldered across its upright tags, as shown. It is immaterial which way round winding "c" of coil L_1 connects into circuit.

Fig. 6. The assembly of a case for the receiver. The material is $\frac{1}{8}$ in Paxolin

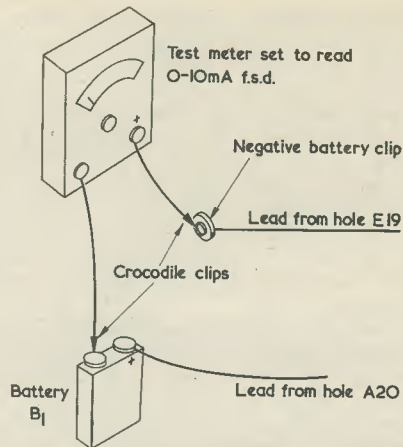
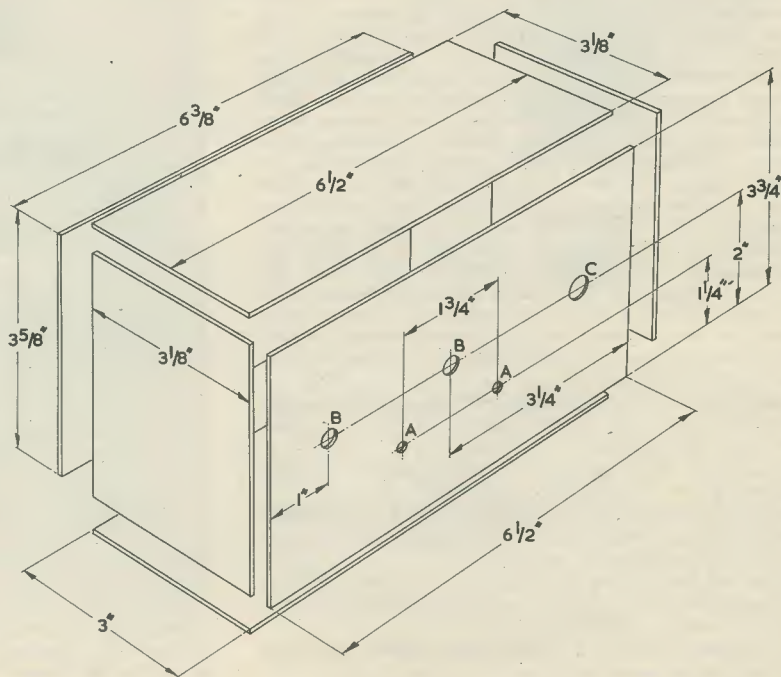


Fig. 5. Checking the receiver after wiring has been completed

Wiring then proceeds as in Fig. 4, the transistors and diodes being left until last. The usual precaution of employing a heat shunt to prevent diode and transistor damage during soldering must be taken and the lead-outs of these items must, in addition, be fitted with sleeving, preferably of different colours to identify them from each other. Great care should be taken, too, to make certain that the diodes, and the transistors in particular, are connected exactly as is indicated in the diagrams. Capacitor C_x is not fitted at this stage.

Finalising the Receiver

Prior to switch-on the whole assembly should be

checked for mistakes and errors in wiring, and if none are apparent the battery and its lead-outs should be temporarily connected up as shown in Fig. 5 using a testmeter adjusted to read 0-10mA. Headphones are then plugged in and S_1 closed, whereupon the meter should indicate 1.5 to 2mA depending on the setting of VR_1 . If the current reading seems to be in order the meter may be removed, the battery connected direct and the receiver again switched on. With the testmeter now adjusted to read 0-10 volts d.c., the potential existing across C_{10} may be read. The voltage here should be approximately 6 volts.

Now, with the receiver switched off, a short length of thin single strand p.v.c. insulated wire is soldered between hole H5 and the Red tag of L_2 , to form C_x . This lead is cut at about the centre point and the two ends twisted together for a few turns as in Fig. 4. The aerial is now connected (a socket for this may later be fixed to the rear of the case), the receiver switched on and, with VR_1 well backed off (i.e. inserting a large amount of resistance into circuit) a signal is sought with the vanes of the twin-gang about 80% disengaged. If oscillations are heard the wires forming C_x should be slightly untwisted until the condition just ceases. The signal is now carefully peaked to maximum strength by adjustment of the trimmers across L_2 and L_1 in that order, slightly altering the main tuning as required to maintain sufficient capacitance within the range of the trimmers. It might also be found necessary to re-adjust C_x whilst this is being done, the aim being to

keep the stage on the verge of oscillation. If no oscillations occur, reverse the connections from coil "c" of L_2 . When no further improvements are possible, C_x and the trimmers are left as set and VR_1 is used exclusively for sensitivity adjustments. These are necessary when turning over the band due to the changing L/C ratio involved.

Thereafter, it is only necessary to fashion a small case along the lines shown in Fig. 6. Since the whole assembly is extremely light, the case may be held together with interior-fitted wooden butts secured with an impact adhesive. The back should of course be made removeable and the aerial socket can be fitted there, as well, if required.

At this point all that remains to be done is to add suitable legends, viz., "TUNE", "SENSITIVITY", "PHONES", "ON" and "OFF" and this is best accomplished by means of Panel Signs, Set No. 3 (White Wording) available from Data Publications, Limited.

Results

Although simple in form this receiver can prove quite effective. It may additionally be used to form a "front end" to drive at low output a transistorised audio amplifier, the output being taken, from the junction of the r.f. choke and C_6 , via a 2 to $8\mu F$ electrolytic capacitor of 12 volts working. This capacitor will normally have its negative terminal connected to the r.f. choke, and the phone outlet may be bridged by a $4.7k\Omega$ resistor.

SCOPETRONICS 1150 MONO OR STEREO TAPE RECORDER

Line in. Sensitivity +8dB on 1mW. for zero level modulation. Record gain Control. 30 steps of 2dB. Line 'in'-line 'out' "Flick" switch. Instant comparison of signal at input and from tape. (Meter and audio.) Red neon indicates record 'on'. Meter scaled 1-7. 1-2=6dB thence divisions are 4dB apart providing range of 26dB. No. 6=maximum tape modulation=2% distortion level. Power on. Neon indicator. Meter calibration check switch. Playback equalisation switch. N.A.R.T.B. 7.5 and 15 i.p.s. C.C.I.R. 7.5 & 15 i.p.s. Monitor phone jack. (Phones should be 2000 ohms min. impedance.) Line out. 600 ohms for connection to power amplifier. Output 1mW. for zero level modulation.

Automatic Changeover of variable preset bias 7.5 and 15 i.p.s. Changeover of variable preset equalisation pre-emphasis. Change of record drive for correct tape induction for the two speeds. Level adjustment on each playback speed to ensure that the ppm indicates accurately zero level.

Safety Measure incorporated, ensures that if line out becomes accidentally short circuited it will not affect recording in progress.

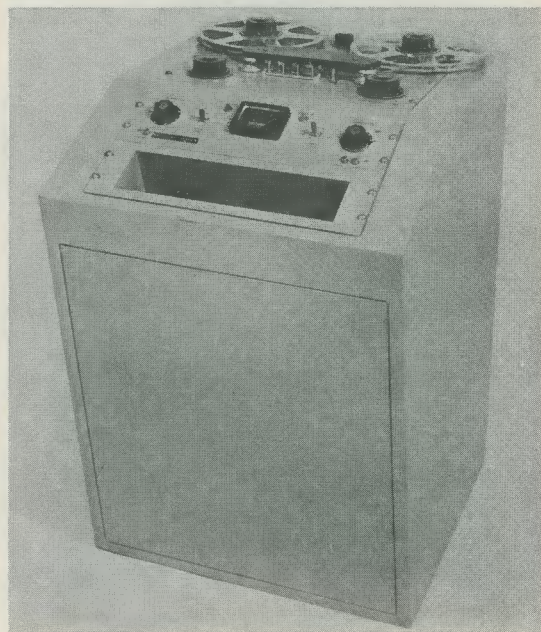
Erase Link provides for the connecting of variable resistor for erase fade out and fade in.

Frequency Response 40-15000 cps. $\pm 3dB$ both speeds.

Record Level Peak record level refers to a tape induction which produces 2% distortion.

Signal to Noise Ratio Measured as the difference between the residual noise of the system against maximum playback output. =57dB.

Record Input 600 unbalanced input signal +8dB on a milliwatt to provide zero level.



The 1150 Tape Recorder is manufactured by Scopetronics Ltd., Crown Works, Church Road, Kingston-upon-Thames, Surrey. Tel: KINGston 4135/1275.

IN LAST MONTH'S ISSUE WE COMPLETED OUR DISCUSSION on basic triode oscillator circuits, dealing with the Colpitts oscillator, the Meissner oscillator, the tuned-anode tuned-grid oscillator and the Franklin oscillator. We shall now turn to the question of oscillator frequency stability.

Frequency Stability

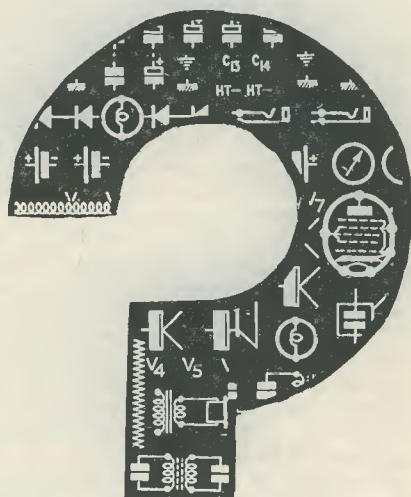
For most applications it is desirable that the frequency at which an oscillator works be kept as stable as possible. This is particularly necessary if the oscillator is employed in a transmitter, which should continually maintain a constant frequency. The frequency stability required of oscillators fitted to receivers depends largely on the type and function of the receiver. For high-grade short wave and v.h.f. receivers a very high level of oscillator stability is necessary.

5 kc/s, then the width of its channel becomes 10 kc/s, since the 5 kc/s maximum modulation frequency causes one sideband to appear at carrier frequency plus 5 kc/s and the other sideband to appear at carrier frequency minus 5 kc/s. Now, let us assume that, for ease of illustration, a transmitter has an oscillator which, due to shortcomings in design, changes in frequency by 1% after it has been switched on for a period. If the transmitter carrier frequency was 100 kc/s, the change in frequency would then be 1 kc/s, or one-tenth of a 10 kc/s channel. On the other hand, if the transmitter carrier frequency was 100 Mc/s, the change would be 1 Mc/s, which is equal to one hundred 10 kc/s channels. It is obvious that, in terms of practical radio communication, the 1% change in oscillator frequency at 100 Mc/s has a far more serious effect than has the 1% change

understanding

Frequency Stability in Tuned Circuit Oscillators

By W. G. Morley



radio



In normal radio work, the generalisation can be made that oscillator frequency stability requirements become more stringent as frequency increases. This is largely due to the numerical factors involved in practical radio communication. To appreciate this point, it will be helpful to recall some of the attributes of an amplitude modulated radio transmission. As we saw in the May 1965 issue an amplitude modulated radio signal has sidebands on either side of the carrier, these being spaced away from the carrier by the modulation frequency. In order to transmit an amplitude modulated signal it therefore becomes necessary to assign to the transmitter a band of frequencies which is sufficiently wide to permit the sidebands to appear, and we call this band of frequencies a *channel*. If the maximum modulation frequency of an amplitude modulated transmitter is to be, say,

at 100 kc/s, and this simple example illustrates the general necessity for increasingly improved oscillator stability as frequency increases.

Before proceeding further, it must be explained that the 1% figure for oscillator change just mentioned was chosen purely for purposes of example. In practice, such a change in frequency in a transmitter would be grossly unacceptable, and transmitter oscillators are required to have a frequency stability which is very much better, indeed, than such a figure. The 10 kc/s figure for channel width was also chosen to provide a simple illustration. The channel width taken up by a transmitter in practice depends on the type of modulation, the in-

formation to be broadcast and the avoidance of interference with other transmitters operating on adjacent frequencies.

An oscillator may suffer variation in frequency after it has been initially switched on due to the following causes: thermal effects resulting from, in particular, the rise in temperature given by the warming up of the oscillator valve; changes in supply potentials; ingress of moisture to components; and mechanical factors.

Thermal Effects

Variation in oscillator frequency due to thermal effects is almost entirely given by temperature increase in the oscillator valve and oscillator components as the valve warms up after being switched on from cold. The immediate effects occur in the valve itself, the rise in temperature causing expansion of the electrodes and a consequent change in self-capacitance. At the same time heat is transmitted to the valve base and, assuming a valve of the all-glass type, via its pins to the valveholder tags and, thence, to components soldered to those tags. The resultant temperature increase external to the valve may result in a change in stray capacitance between the valveholder tags (the valveholder insulating material being the dielectric) and a change in value in fixed capacitors soldered to the tags. Also, heat from the valve may be passed, by radiation and convection, to neighbouring components including those in the oscillator tuned circuit proper. A rise in temperature here can cause the tuned circuit coil to expand and change in inductance (usually the result is an increase in inductance) whilst the tuned circuit capacitance may vary according to its temperature coefficient. Similar effects can, of course, result if these components are raised in temperature due to heat radiated by other valves or by other heat-dissipating components in the equipment.

It has to be remembered that components and stray capacitances which are not directly in the tuned circuit proper may also affect oscillator stability. To provide a simple example of this point, Fig. 1(a) illustrates a tuned grid oscillator.¹ In this diagram the tuned circuit couples to the valve grid via a conventional grid capacitor, whereupon the series combination of this grid capacitor and the stray capacitance between the valve grid and cathode appears across the tuned circuit, as is shown in Fig. 1(b). Changes in either of these capacitances will cause variations in oscillator frequency. A design feature which follows from this is that, if the capacitance in the tuned circuit proper is large, the effects of varying grid-cathode capacitance are proportionately lower.

We referred just now to the temperature coefficient of the tuned circuit capacitance and, although this coefficient has been fully dealt with earlier in this series, it may be helpful here to briefly discuss it again. It is found that the cap-

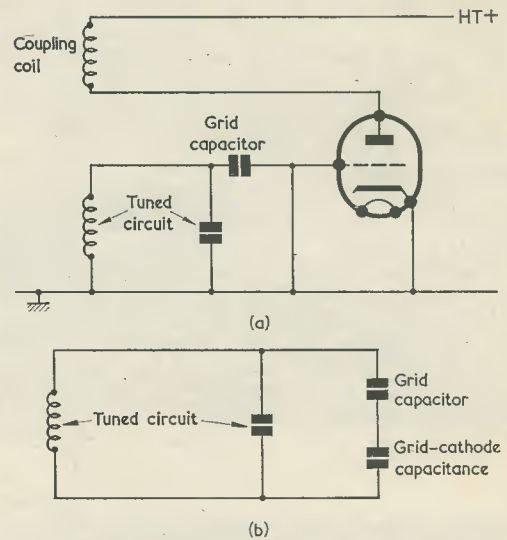


Fig. 1. Illustrating how changes in stray capacitances outside the tuned circuit proper can affect oscillator frequency. A normal tuned grid oscillator is shown in (a), whilst (b) demonstrates that the series combination of the grid capacitor and grid-cathode stray capacitance appears across the tuned circuit.

acitance of practical capacitors varies with temperature, the change in capacitance being due to a change in the dielectric constant of the insulating material between the capacitor plates. If capacitance increases as temperature increases, the capacitor is stated to have a positive temperature coefficient and, if it decreases, to have a negative temperature coefficient. The coefficient is expressed by the letter P (for positive) or N (for negative) followed by a figure which defines the change in capacitance in parts per million for a rise in temperature of 1° Centigrade. Thus, if a capacitor has a value of 1 μ F and a temperature coefficient of P100, this means that its capacitance will increase by 100 parts per million for a rise of 1°C in temperature. A millionth part of a microfarad is a picofarad, and so the increase of 100 parts per million would, in this instance, consist of an increase of 100pF. A well-designed air-spaced variable capacitor has a negligibly low temperature coefficient and, if such a component is employed to provide the capacitance in an oscillator tuned circuit, will normally suffer negligible change in value due to temperature rise. Silver-mica fixed capacitors have a very good performance in this respect, the temperature coefficient for these components lying between zero and P60. Low-K ceramic capacitors² are available with a wide range of temperature coefficients, the standard coefficients

² Ceramic capacitors may be categorised as low-K or high-K. Low-K ceramic capacitors are encountered in the lower values, from 1pF to around 500pF, and are normally made with the temperature coefficients quoted in the text. High-K ceramic capacitors employ a ceramic having a very high dielectric constant which enables a large capacitance to be provided in a small component. These are encountered as wide-tolerance capacitors having nominal values of 1,000pF, 5,000pF and the like, and they have extremely high temperature coefficients.

¹ Since the figure numbers in this series have become rather large and unwieldy, it has been decided to discontinue the practice of numbering diagrams consecutively from issue to issue. The diagrams in each article will now start at Fig. 1.

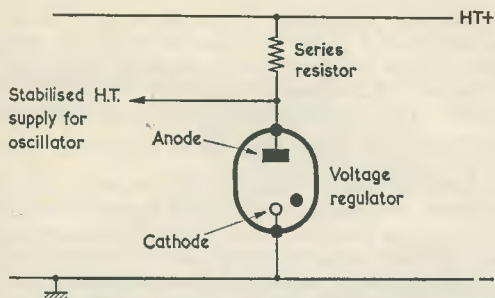


Fig. 2. Employing a voltage regulator to provide a stable h.t. voltage for an oscillator. This diagram also shows the circuit symbol used to depict this device. The "dot" inside the envelope indicates that it is gas-filled

being P100, NPO, N030, N080, N150, N220, N330, N470 and N750. (It is a convention to prefix the zero coefficient, NPO, with both the letters N and P. Also, a zero appears before the significant figures in N030 and N080 to maintain the three-figure group). Ceramic capacitors from this range are frequently incorporated in oscillator circuits in commercially made equipment to counteract changes due to temperature rise in other components. Thus, a tendency for oscillator frequency to drop due to warm-up may be counteracted by introducing a ceramic capacitor of a suitable negative temperature coefficient into the tuned circuit. Due to its negative temperature coefficient, the value of this capacitor falls as its temperature increases, thereby causing a counteracting rise in oscillator frequency.³

So far as the home-constructor is concerned, a good approach towards obtaining good frequency stability is to mount the oscillator tuned circuit components in a reasonably cool position and to employ silver-mica fixed capacitors (or ceramic capacitors between NPO and N080) at all circuit points where changes in capacitance could affect the oscillator frequency. For short-wave and v.h.f. working a good quality ceramic valveholder (whose insulation will have a low temperature coefficient) is desirable. Unless the constructor is prepared to spend the time needed for evaluation of frequency change with warm-up, it is better to design an oscillator so that its components keep as cool as possible rather than to allow them to become too warm and then attempt compensation with capacitors having high temperature coefficients. One reason for this recommendation is that the components of an oscillator circuit do not all rise in temperature at the same rate after switch-on, and it is very easy to fall into the trap of introducing a compensating capacitor which successfully counteracts frequency variation for a short period and then proceeds to cause a far worse frequency variation than the one it has cured!

Supply Potentials

Oscillator frequency may vary if there are changes in the supply potentials. This is particularly true of

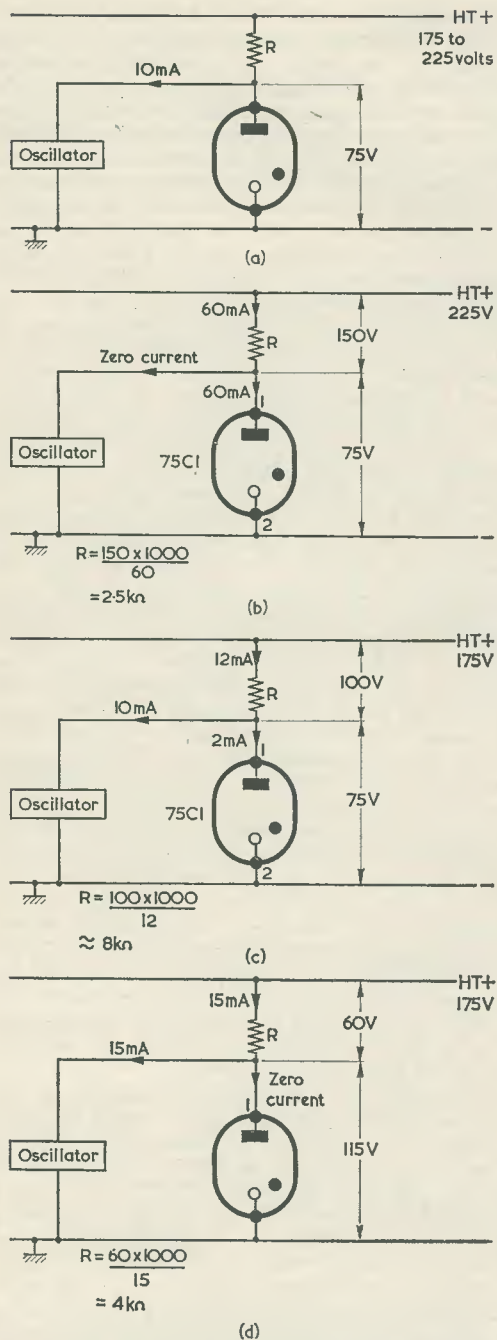
³ Fixed capacitors and temperature coefficients were fully dealt with in "Understanding Radio" in the April, May and June 1962 issues.

the h.t. supply, which has to be maintained at a constant voltage when a high degree of frequency stability is required. A commonly employed technique for obtaining a stable h.t. voltage for oscillators which must have good frequency stability consists of employing a *voltage regulator*, or *voltage stabilising tube*, in the circuit shown in Fig. 2. A voltage regulator fits into a valveholder and has the same external appearance as a valve. It normally incorporates two electrodes in a glass envelope filled with a gas. (As we shall see shortly, a third electrode is sometimes fitted.) When a sufficiently high voltage is applied across the electrodes the gas ionises and commences to glow in the same way as occurs with a neon lamp (some voltage regulators do, indeed, employ neon as the gas in the envelope). A tube of this nature has the property that the voltage across the electrodes remains very nearly constant over a wide range of currents. Thus, the voltage regulator can provide a nearly constant h.t. voltage for an oscillator, despite variations in the main h.t. voltage due to such occurrences as mains supply fluctuations or varying h.t. currents elsewhere in the associated equipment. The operating voltages and currents of specific voltage regulators depend upon the type of gas and its pressure in the glass envelope.

The voltage needed to cause the gas in the regulator tube to ionise, or *strike*, is known as the *starting voltage*, whilst the nearly constant voltage which then appears across the electrodes is referred to as the *burning voltage* or *maintaining voltage*. The burning voltage is lower than the starting voltage. Specifications for the tube will include a *minimum burning current* (below which stabilisation does not occur) and a *maximum burning current* (which should not be exceeded as damage may result to the tube). Series resistance is essential to ensure that the maximum burning current is not exceeded, and the calculation of its value is a fairly simple matter involving only the Ohm's Law relationship. In the present application it is preferable to ensure that maximum burning current is not exceeded if the oscillator circuit draws no current (as would occur, for instance, if the oscillator valve were removed from its socket).

Let us take a typical worked example of the procedure involved in finding the value of series resistance. This we can do by assuming that we have an oscillator which draws 10mA h.t. current at 75 volts and that we want to provide it with a stabilised h.t. potential of that value. At the same time, the available main h.t. voltage is liable to vary between 175 and 225 volts. The situation is illustrated in Fig. 3 (a). There are several voltage regulators which could be employed here, and a good choice is the Mullard 75C1, which is a small tube on the B7G base. This has a maintaining voltage of about 75, a starting voltage of 115 and minimum and maximum burning currents of 2 and 60mA respectively.

Our first requirement, when finding the value of the series resistance, is to ensure that the maximum burning current of 60mA is not exceeded when the main h.t. voltage is at its highest figure of 225 and the oscillator draws no current. See Fig. 3(b). Thus,



the lowest permissible value of series resistance corresponds to a flow of 60mA through the resistor and a voltage across it of 150 (225 minus 75), whereupon the corresponding resistor value, from $R = \frac{E}{I}$, is 2.5k Ω . Another requirement is that at least the minimum burning current of 2mA must flow through the tube when the oscillator is drawing its 10mA and

the main h.t. voltage is 175, as shown in Fig. 3(c). This involves a flow of 12mA through the series resistor (2mA for the voltage regulator plus 10mA for the oscillator) and a voltage of 100 across the resistor. The corresponding value of resistance, from $R = \frac{E}{I}$, is 8k Ω . The series resistance must, therefore, be greater than 2.5k Ω to ensure that the maximum burning current cannot be exceeded, and less than 8k Ω to ensure that the current in the tube does not fall below the minimum figure of 2mA. There is, however, a third factor to consider, this being that the value of the series resistor must not be too high to prevent the regulator from striking at its starting voltage of 115 when the main h.t. voltage is at its lowest figure of 175. The tube draws no current until it strikes and the oscillator can be assumed to draw proportionately more current at 115 volts—say 15mA—whereupon we need to find, as can be seen in Fig. 3(d), the series resistance value corresponding to 15mA at 60 volts. The 60 volts figure is given by 175 volts (the lowest main h.t. voltage) minus 115 volts (the starting voltage), and the corresponding value of resistance is 4k Ω . So although a series resistance of 8k Ω is sufficient to keep the minimum burning current above 2mA, it is too high, in this particular instance, to allow the regulator to strike initially when h.t. voltage is at its lowest level. So, if the series resistor in our example is to meet the three requirements we have presented to it, it should have a value between 4 and 2.5k Ω . It could conveniently be 3.3k $\Omega \pm 10\%$, which gives a useful safety margin in hand on either side.

It so happened that, in this case, the maximum resistance value which allowed the regulator to strike was lower than that needed to maintain minimum burning current. The converse may occur just as readily with other figures for voltage and current.

Similar calculations to that just given, and also working from first principles, may be carried out to find the value needed in the series resistor for alternative currents and voltages. Varying oscillator currents may also be catered for. In this case the value of series resistance required to maintain

Fig. 3(a). Finding the value required in the series resistor, R. In this example the oscillator draws 10mA at 75 volts, and h.t. can vary from 175 to 225 volts (b). The value of R must not be lower than that which causes maximum burning current to flow in the regulator tube (60mA with the 75C1) when the main h.t. voltage is 225 and the oscillator draws no current. (The figure of 1,000 in the numerator appears because current is in milliamps) (c). The value of R must not be higher than that which causes the minimum burning current to flow in the tube (2mA with the 75C1) when the main h.t. voltage is 175 and the oscillator draws its current of 10mA (d). The value of R must, also, not be higher than that which allows the starting voltage of the tube to be achieved (115 volts with the 75C1) when the main h.t. voltage is 175. It is assumed that the oscillator draws 15mA at 115 volts

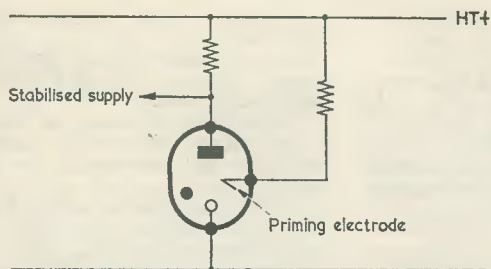


Fig. 4. In some voltage regulators a priming electrode is incorporated, this being connected to the main h.t. line or the anode via a high value resistor. The value of this resistor and its method of connection are specified by the tube manufacturer

minimum burning current should be worked out for the case when the main h.t. voltage is at its lowest and the oscillator current is at its highest. A condition of maximum oscillator current must also be assumed when finding the maximum value of resistance which allows starting. When finding the lowest value of resistance to meet maximum burning current requirements, minimum oscillator current should be assumed.

The two electrodes of the voltage regulator are described as its anode and cathode, as illustrated in

Fig. 2. The anode couples to the positive side of the supply. The cathode is not, of course, heated. Sometimes a *priming electrode* is incorporated, as in Fig. 4. This is mounted close to the cathode and, when connected to the h.t. positive line (or to the anode) via a high value of resistance, causes local ionisation. The local ionisation allows the tube to strike at a lower voltage than would otherwise be the case.

When describing the operation of series-fed oscillators (such as that of Fig. 1 (a)), we have assumed that the h.t. supply has a negligibly low impedance. The impedance of a voltage regulator tube is high at radio frequencies, but it is possible to achieve a low r.f. impedance by connecting a capacitor of some 1,000pF to 0.01 μ F (according to oscillator frequency) across the anode and cathode.

Apart from changes in h.t. potential, it is also possible for changes in heater and filament potentials to cause variations in oscillator frequency. With indirectly heated valves the effect is not normally of sufficient magnitude to require voltage stabilisation.

Next Month

In next month's issue we shall complete our review of factors affecting frequency stability, after which we shall discuss "squegging" and receiver reaction circuits.

RECENT PUBLICATIONS . . .

SCIENCE PROJECTS IN ELECTRICITY. By Edward M. Noll. 150 pages, 5½ x 8½in. Published by W. Foulsham & Co. Ltd. Price 24s.

This title is in the Foulsham-Sams Technical Book series, and it has an American text with an introductory chapter for English readers. The book deals with basic properties of electricity and magnetism, and the approach consists of describing the assembly of demonstration circuits on pegboard, seeing how these function and then drawing the appropriate conclusions.

The projects are very simple, evidence of current flow being given, for instance, by the illumination of low voltage m.e.s. bulbs, and the book is intended for the complete beginner who has virtually zero knowledge of electricity or magnetism. The projects range from a circuit consisting of a battery, switch and bulb, to a circuit which demonstrates resonance at mains frequency. Also described is the assembly of a crystal radio. Several of the experiments use 100 μ F and 50 μ F capacitors with a.c. applied across them, but no mention is made of capacitor type or polarity.

PRACTICAL TRANSISTOR SERVICING. By William C. Caldwell. 197 pages, 5½ x 8½in. Published by W. Foulsham & Co. Ltd. Price 24s.

Another title in the Foulsham-Sams list, and with an American text, this is a new revised edition of a book which approaches the subject of fault location in transistor radios from the viewpoint of a practical man with considerable work-bench experience in this field. The book is mainly concerned with the servicing of receivers manufactured in America, whose individual stage designs may differ from European practice, but the basic features remain the same and the author has the common-sense approach which is essential for good servicing: i.e. track down the defect as accurately and rapidly as possible.

After two chapters on basic transistor operation and the functioning of the circuit components about it, the book carries on to a.m. radios, a.m.-f.m. radios, normal and abnormal voltage readings, transistor testing, a.m. car radios and a.m.-f.m. car radios. A final chapter gives seven actual case histories, and the book concludes with a good index.

INSTRUCTIONS TO RADIO CONSTRUCTORS. By R. H. Warring. 144 pages, 5½ x 8½in. Published by Museum Press Ltd. Price 15s.

This is the second edition of a book which originally appeared in 1960 and was reprinted in 1962, and it incorporates additional material on receiver construction together with new chapters on sub-miniature receivers and printed circuits.

Instructions To Radio Constructors (no connection, incidentally, with ourselves) is written with the beginner in mind and includes ten designs which may be assembled by the reader. These comprise simple receiver circuits, starting with a crystal receiver and advancing to design No. 9, which is for a 4-stage reflex transistor receiver. Design No. 10 is the Sinclair Micro-6 receiver. Printed circuit layouts for five of the designs are also given.

The theoretical points applicable to each design are well covered, and the beginner who constructs the designs learns at the same time what the various components do. There is also a considerable amount of general information on radio transmission and reception, commonly encountered components and general constructional practice. Ten appendices at the end of the book cover subjects ranging from U.K. medium and long wave transmitter frequencies to mains power pack design, and there is a glossary which also serves as an index.

In Your Workshop

This month Smithy the Serviceman, aided as always by his able assistant Dick, eschews Workshop duties for a spell and devotes his time to discussing the latest hints received from readers.

THE MID-DAY JULY SUN, RICH in infra-red and ultra-violet, shone radiantly through the windows of the Workshop and illuminated a fitful dancing pattern of suspended dust motes. Outside the Workshop all Nature was astir: isolated tufts of grass thrust stoutly through the cracks in the concrete leading to the door; bees buzzed busily as they went in search of the odd drop of nectar, carrying out also their good deed for the day in the little matter of cross-pollination; and an army of ants marched industriously, and at considerable profit, in and out of a hole in the side of the Workshop dustbin.

Inside the Workshop, however, Dick and Smithy were far too preoccupied, as they stared intently at the printed board which lay on Dick's bench between them, to allow their minds to wander on thoughts of the bounteous world without. Frowning portentously, Smithy extended a hand and made an adjustment to the layout on the board. Satisfied with the result, he removed his hand.

A New Activity

"That's it," shouted Dick triumphantly, "I'm going to huff you!"

"Huff me?" snorted Smithy indignantly. "Where?"

"There!" said Dick, pointing a finger at the draughtboard. "That piece there! You should have taken me with that piece, but you didn't."

"Dash it all," protested Smithy, "it's my one and only king."

"Can't help that," said Dick resolutely, as he removed Smithy's draughtsman. "What's more, it's my turn now and—boy, oh boy—am I going to hop over you!"

Smithy gazed open-mouthed as his jubilant assistant moved one of his men no less than five times. Grinning hugely, Dick gathered in his booty.

"That's it, then," grumbled Smithy. "You've taken the lot."

"Sixpence, please," replied Dick briskly, as he rearranged the men on the board.



Grumpily, Smithy rummaged in his pocket.

"Don't bother to set them up again," he said. "I've had enough draughts for today."

"What else is there to do?" replied Dick. "There's still another half-hour of lunch-break to go yet."

Smithy pondered moodily. Suddenly his forehead cleared, as inspiration came to him.

"I know," he said. "Let's have a go through the latest collection of hints from readers. It's ages since we last had a session on these."

"Now that is an idea," agreed Dick pleased, as he pushed the draughtboard and its pieces to one side. "You must have stacks of hints collected by now."

Smithy walked to his bench, opened a drawer and took out a sheaf of letters.

"There's quite a pile," he admitted, as he returned and settled himself down on the stool at Dick's bench. "Let's have a quick look through them."

Smithy scanned the letters.

"Ah," he continued. "Now here's a jolly good one to start the ball rolling, and it has to do with finding the value of electrolytic capacitors."

"That's often a problem," commented Dick, "especially with the larger values."

"True enough," agreed Smithy. "The idea put forward in this hint is for finding the value of the electrolytic by measuring its time constant when it's being charged up via a resistor. There's a simple circuit involved with the process which you'd better have a look at."

Smithy showed Dick the circuit in the letter. (Fig. 1).

"The easiest way to explain the method of operation," he went on, "is by means of an example. So, let's suppose that we have an electrolytic which is marked as being 1,000 μ F at a working voltage of 50. For accurate results, it's better to make the time constant greater than a minute, and 100 seconds would be a convenient figure for us to use in this instance."

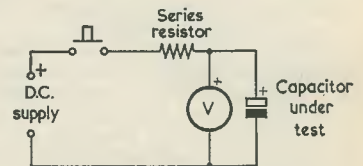


Fig. 1. Finding the value of an electrolytic capacitor by checking its time constant with a known resistor

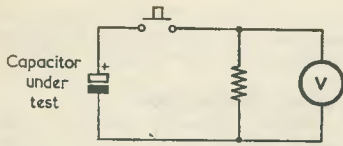


Fig. 2. An alternative scheme, suggested by Dick, in which the capacitor under test is initially charged and is then allowed to discharge through the resistor

"Hang on a minute," protested Dick. "Let me first of all get this time constant business straight in my mind. As I remember it, if a capacitor is connected to a d.c. voltage via a resistor, the time constant of the capacitor and resistor is the time needed for the voltage across the capacitor to rise to 63% of the d.c. voltage. Also, if a capacitor is charged and a resistor is connected across it, the time constant for the capacitor and resistor is the time needed for the voltage across the capacitor to fall to 37% of its initial value."

"That's right," confirmed Smithy. "Now, in this hint . . ."

"Another point," interrupted Dick, "which I just want to recap on is the relationship between the time constant and the component values. As I recall it, time constant in seconds is equal to capacitance in farads multiplied by resistance in ohms. Or, to use easier units, it's equal to capacitance in microfarads multiplied by resistance in megohms."

Smithy looked irritably at his assistant.

"Have you done?"

"I don't think," replied Dick loftily, "that I have anything further to offer on the subject at the moment."

"Good," grunted Smithy. "And I am reluctantly forced to admit that everything you've said is dead right. Anyway, let's get back to that capacitor with a working voltage of 50 and a nominal capacitance of 1,000 μ F. As I was saying before I was so rudely interrupted, it is helpful to use a time constant which is longer than a minute. In this case, 100 seconds would represent a convenient figure, whereupon the appropriate series resistor would be 0.1M Ω , or 100k Ω . Since time constant is megohms times microfarads, this gives us 0.1 times 1,000, which is 100 seconds."

"Assuming," put in Dick, "that the capacitor *does* have a value of 1,000 μ F."

"Exactly," agreed Smithy. "What we next do is to provide a d.c. voltage of 50, connect the capacitor and 100k Ω series resistor to it, and see how long it takes for the voltmeter across the capacitor to show 63% of 50 volts, or 31.5 volts. Let's assume that we get this voltage after 110 seconds. Then, 110 is equal to 0.1 times the capacitance of the capacitor."

"Which," chimed in Dick, with the agonised expression which always accompanied his mental calculations, "would then be 1,100 μ F."

"That's correct," confirmed Smithy. "It's quite a neat scheme, isn't it?"

"What about the voltmeter?" asked Dick. "Won't that draw current and upset the results?"

"The voltmeter," replied Smithy, "should have a resistance which is much higher than that of the resistor in series with the capacitor. I should add that, for accurate results, the applied d.c. voltage should be of the same order as the working voltage of the capacitor."

"I've just thought of something," said Dick suddenly. "Why not find the value of the capacitor by working in the opposite direction? Why not initially charge the capacitor to its working voltage and *then* connect the resistor and the voltmeter across it? (Fig. 2). You could then do your time constant calculation for the time needed for the voltage to drop to 37% of the initial value. This method of finding the capacitance would have the advantage that voltmeter resistance could be allowed for, because it would then be in parallel with the resistor across the capacitor and you could work out the value given by their parallel combination. Indeed, in some cases, the resistance which discharges the capacitor could be provided by the voltmeter on its own!"

Ferrite Rod Bracket

"Well, now," said Smithy, impressed, "that is an inspiration. And it only goes to show how often one good idea gives rise to another. Anyhow, we must get on to the next hint, or all our available time will be gone. This next hint offers a neat way of solving the problem of fixing ferrite aerial rods. The reader has sent in a sample of the method of mounting, as well."

Smithy passed the sample over to Dick, who examined it with interest. (Fig. 3).

"Like all the best ideas," continued Smithy, "this one is nice and simple. What you do is to make a strap from flexible plastic, and then clamp its ends between two pieces of Formica or Paxolin, or between one piece and the circuit board. The assembly has plenty of resilience and yet it still holds the ferrite rod very firmly. The secret lies in the plastic used for the strap, this being cut from a discarded detergent container of the 'squeazy' type. One bottle will provide at least a dozen straps."

"The strap is reasonably thick," commented Dick critically, as he looked at the sample, "and it shows no tendency to tear either. Right-ho! From now on, in our house we use nothing but 'squeazy' detergent bottles for the washing-up!"

"A most commendable attitude," said Smithy approvingly. "Let's see what the next letter has to tell us. Ah, there are two hints in this one. The first of these is for pluggable transistors."

"Pluggable transistors?"

"That's right," confirmed Smithy. "Pluggable transistors. The idea consists of mounting the transistor on a Radiospares 3-pin plug type M3(A), which will be available from any stockist of Radiospares components. (Fig. 4). You need

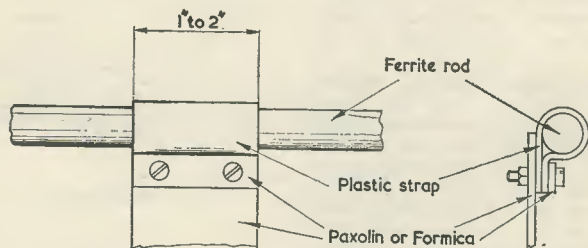


Fig. 3. Two views showing a simple but effective method of mounting a ferrite aerial rod. The rear piece of Paxolin or Formica is shown with the same width as the strap, but it could be wider, if desired. Avoid using the heat-resistant grade of Formica, which may have a lamination of thin metal foil in its structure

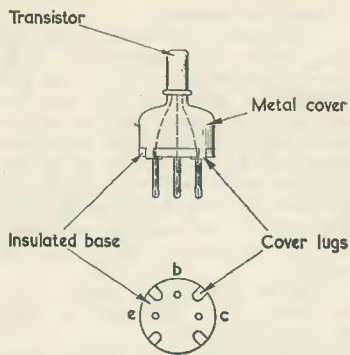


Fig. 4. Side and end views illustrating how a transistor may be fitted to a 3-way plug for experimental or educational applications. The plug pins could correspond to the transistor electrodes shown. The plug (consisting of the insulated base and pins) and metal cover are separate items, both having the Radiospares type number 'M3(A)'. The complementary socket is also under type number 'M3(A)'

a metal plug cover as well, and a socket to put the plug into. These also are Radiospares items, and they similarly have the same M3(A) type number. The hole at the top of the plug cover is a little less than a quarter of an inch in diameter and transistors of the OC72 class make a tight fit in it, whereupon the cover serves the secondary purpose of acting as a heat sink. The plug pins can be wired up in the usual emitter-base-collector order with, say, the collector pin identified by a spot of paint on the metal cover. You can't put the plug into its socket the wrong way round, and a set of transistor-cum-plug assemblies made up in this manner could be extremely useful for experimental or educational work."

"Jolly good," commended Dick. "What's the second hint in the letter?"

"A cooking-up device," replied Smyth, "for isolating the faulty component in TV intermittent snags which show up when the chassis is in the cabinet, but which never come on when you've got the works out to try and find where the trouble is. An aluminium cowl with a sharp vertex is made up and secured to the nozzle of a domestic hair-dryer with the aid of a Jubilee clip. (Fig. 5). The cowl causes a really strong current of hot air to appear over a very small area and, if correctly made up, will even heat

up small individual components. It's pretty brute-force in operation and some care is needed to ensure that you don't melt the wax on wax impregnated components. If you have an unsteady hand it's a good idea, also, to insulate the business end of the cowl in order to prevent accidental short-circuits against adjacent components. A bit of tape should do that job for you."

"A Jubilee clip, eh?" muttered Dick thoughtfully. "Isn't that the adjustable clip you use for securing rubber hoses to metal pipes?"

"That's right," confirmed Smyth. "As they say: 'Cure that drip with a Jubilee clip.'" Now, let's have a look at the next idea. This also takes advantage of the odd bits of plastic which nowadays enter our lives so much. Frequently, polythene stoppers are used in the bottles of pills you get from the chemist, and these make very attractive 'lenses' for indicator bulbs. (Fig. 6). All you have to do is drill a push-fit hole for the stopper in the panel of the equipment and pop it in. If the panel is thin, you may need to fit a small rubber band over the stopper on the rear side of the panel to hold it firmly. You can also put Panel-Sign letters on the inside of the front surface of the stopper to provide such terms as 'ON', 'H.T.', 'L.T.', and so on. There will normally be a decorative milled edge to the front part of the stopper and, since the material is translucent, you get an extremely attractive presentation when it's lit up by the bulb behind it. An obliging chemist will probably let you have a few of the stoppers for a few coppers, so you don't have to take any pills to get them! There's a second use for these polythene stoppers, too. Sometimes it's difficult to remove a small m.e.s. bulb from its holder. If a suitably sized stopper is pushed

over the glass, however, you get sufficient grip to remove the most stubborn of these bulbs."

Penlight Battery Saver

"We're certainly getting some useful hints today," said Dick, appreciatively. "This is a much better way of passing the lunch-hour than playing draughts."

"It's certainly cheaper," grumbled Smyth. "So far as draughts is concerned, I've already lost one and six to you today, to say nothing of three bob yesterday and three and six the day before. And a nicker last week, and eighteen bob the week before that! It seems to me that the only reason you introduced that draughtboard into the Workshop was to supplement your income. Anyway, I'm fed up with draughts and I'm not going to play it any more."

"As you like," said Dick equably. "I'll bring in the chess-men tomorrow."

Smyth cast a suspicious glance at his assistant, then returned to his letters.

"What," he asked, "do you use for lighting up dark corners inside a TV cabinet when you're doing a job in someone else's house?"

"Why," replied Dick, surprised at the unexpected question. "I use one of those little 'Penlight' torches."

He frowned as a grievance of long duration rose up in his mind.

"But," he added complainingly, "I do wish that the people who design these torches wouldn't combine the on-off switch with the pocket clip. If I leave my torch in the tool-kit or carry it loose in my pocket there's nearly always something which presses against the clip, and the battery runs down in no time."

"There's a simple idea for overcoming that trouble here," announced Smyth, looking at the last letter

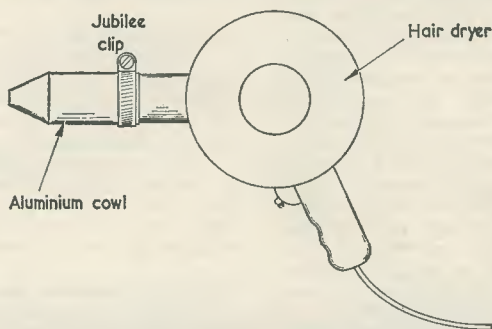


Fig. 5. A simple but effective arrangement for raising the temperature of components suspected of causing intermittent faults

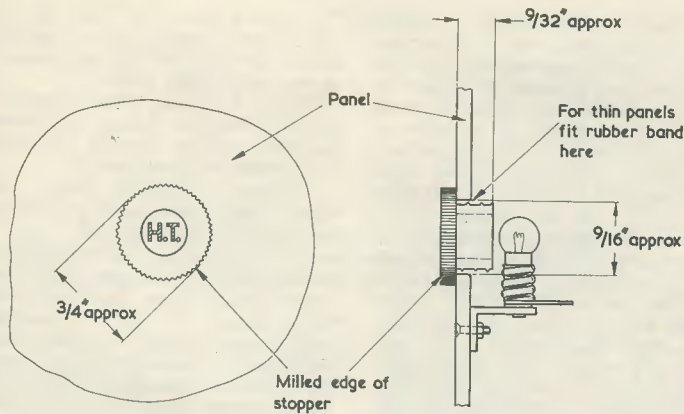


Fig. 6. Front and side view (partly in cross-section) showing how the polythene stopper referred to in the text may be employed as an indicator 'lens'

he had selected. "When you've finished using the torch, all you do is to take out the top cell and pop it back in again upside-down. Only a few seconds are required for this operation and the result is that, even if the clip switch *does* get accidentally closed every now and again, all that happens is that the two 1.5 volt cells become connected in parallel via the bulb. In consequence, the battery cannot get run down due to accidental pressure on the clip. When you want to use the torch, you take out the top cell and put it back right way round again."

"That is a neat idea," enthused Dick. "Now, why on earth didn't I think of that myself?"

"Here's another idea that falls into the 'why didn't I think of it myself' category," chuckled Smithy, as he picked up a further letter and passed it over to his assistant. "As you can see from the sketch (Fig. 7) it's a scheme for a quick-removal inspection cover or back-plate. This uses the idea of providing the panel with slots which have large holes at the end to pass over the heads of the securing bolts. The latter could fit into tapped holes or captive nuts if the main panel is made of metal, or they could be wood-screws if the cover is fitted to a wooden cabinet. When fitting the cover you pass the large holes over the heads of the bolts, slide the cover so that the bolts go fully into the slots, then tighten up. To remove the cover you proceed in the reverse direction."

"Why," asked Dick, "are the slots at an angle?"

"To ensure," replied Smithy, "that the large holes are not too near the

edge, whereupon you'd get a weakness with some materials. If, for instance, all the slots were vertical, then the large holes at the sides would be near the edge, and so on. Having the slots angled also means that no large holes are needed at all for the slots on two of the sides. These can be cut out very easily with tin snips, followed by a touch-up with a file. The other slots can be made with two drills, a large one for the large hole, and a smaller one having the same diameter as the slot width for the end of the slot. The land between can then be filed away. Our correspondent adds, by the way, that the slotted hole scheme works well even with

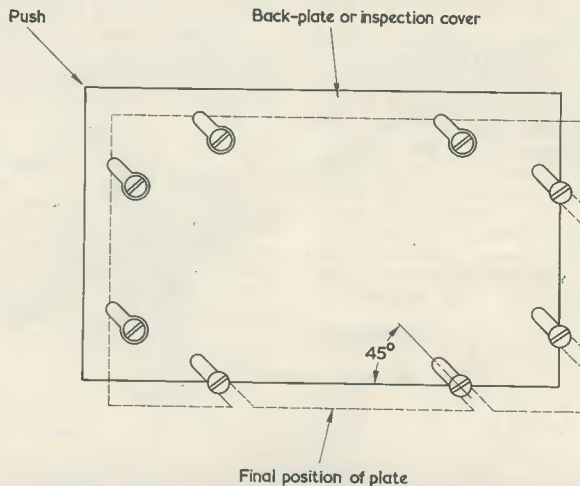


Fig. 7. A back-plate or inspection cover designed for quick fitting or removal. This diagram shows the back-plate fitted over the loosened holding screws on the cabinet or main panel. After it has been finally slid home, all the screws are tightened

materials as soft as hardboard."

"I must admit," said Dick thoughtfully, "that most of the electronic gubbinses I make up never get any backs to them at all. But that's all going to change now. In the future it's backs for everything, and all of them are going to have slotted holes!"

"Excellent," commented Smithy drily. "But I'm completely baffled as to how you're going to put backs, or inspection panels for that matter, on to chassis which have never had the benefit of a cabinet or, even, of a front panel."

"It's possible," retorted Dick indignantly, stung at this impugment of his constructional ability, "that *some* of the things I make up remain in their chassis form for a *little* while, but that's only because further adjustments or modifications to them are scheduled for the future."

"I'll take your word for it," said Smithy soothingly. "And, now, let's get on with the next hint. This is a little idea for removing grub screws from knobs when the screw material on one side of the screwdriver slot has got broken away."

"Don't talk to me about *them*," snorted Dick. "I've wasted more time than I like to think about tackling broken grub screws."

"Not so much time as I have," replied Smithy. "In the old days, practically *all* knobs on domestic equipment had grub screws, whereas they've been largely replaced, on modern equipment, with knobs

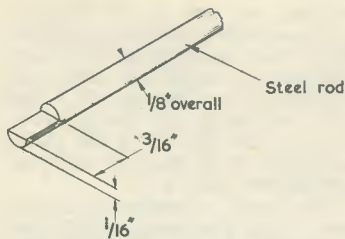


Fig. 8. A simple tool for removing broken grub screws from knobs

having fixing springs. Anyway, the gadget put forward for removing the broken grub screws consists of a steel rod with its end filed to a half-round section. There's a drawing of it in the letter."

Smithy showed Dick the drawing (Fig. 8).

"The cut-away section of the rod," he continued, "fits into the space previously occupied by the bit of grub screw which has broken off, and it gives you sufficient purchase in most cases to get the screw started. In practice, the tool can consist of the shaft of a small screwdriver filed to shape."

"That's rather knobby," commented Dick enthusiastically. "I'll knock up a little tool like that for myself later on. What's the next hint?"

Cell Holder

"This," replied Smithy, looking closely at the next letter in his

file, "is for a cell holder. It often happens that you want to incorporate a low-voltage battery or cell in a piece of equipment, either to enable transistors or valve filaments to be powered or to provide a reference voltage for test equipment and things like that. This hint describes how to make up a holder for a 1.5 volt cell using readily available components. Again, there is a sketch (Fig. 9). As you can see, the battery holder consists essentially of a B9A skirted valveholder and screening can, and this takes an Ever Ready 1.5 volt cell type U10 very comfortably. The first job is to remove all the solder tags from the valveholder. If this has a centre spigot you then pass a 6 or 4BA screw through this, so that the positive cap of the battery can press against it. If the valve holder doesn't have a central hole, then one will have to be drilled out and a 6BA screw fitted. Whatever type of screw is fitted, its head should be filed to give a nice clean contact to the positive cap of the cell. Also, a solder tag and nut are fitted to the screw at the underside of the modified valveholder. The screening can wants to be a longish type, and one of those with a height of 2½ inches should cope very nicely. Contact to the negative cell terminal, which is, of course, the zinc container, is then made via the valve retaining spring in the screening can."

"Now, that," pronounced Dick,

"is a good idea. Not only do you get a strong contact spring bearing on to the cell, but cell replacement is very quick and simple."

"Yes, it is a good scheme," agreed Smithy. "And, to follow it, here's another idea for providing heat sinks for transistors."

"Blimey," remarked Dick, "the hints have been coming through really thick and fast today."

"They have indeed," agreed Smithy. "Now, this last hint covers some simple ideas for heat sinks using scrap TV parts. Quarter-inch brass spindle couplers were used a lot in the earlier TV receivers, and these lend themselves admirably for the job. They fit very readily over transistors of the OC72 and OC81 class and any slight slackness can be taken up by packing, in the form of copper braiding from scrap coaxial cable. Cooling fins of sheet copper or tin can be easily bolted on, too. (Fig. 10(a)). Some of the early width controls had slider clips (Fig. 10(b)) which make a perfect spring-tight fit on to transistors with wider diameters, and cooling fins can be conveniently soldered to them, as desired. Another source of clips for the fatter transistors is given by the fuse holder panels fitted in these old TV sets. Again, fins can be easily soldered to these clips."

The Chess-man Cometh

Smithy glanced at the Workshop clock and started.

"Well, I'm blown," he exclaimed, "we should have started work quarter of an hour ago!"

He rose briskly and returned his sheaf of letters to the drawer in his bench.

"We've certainly," offered Dick, "had some tip-top ideas this time."

"They've been first-class," agreed Smithy. "We'll have to have another session fairly soon, too, because I've still got quite a few outstanding."

"I'll look forward to that," said Dick. "I'm looking forward to tomorrow's lunch-time as well."

"Why's that?"

"Because we'll be having a bash at the old chess," replied Dick promptly. "Incidentally, a shilling a game seems reasonable to me, since chess lasts longer than draughts."

"I'm not entirely sure," said Smithy doubtfully, "how you play chess."

"It's merely a question," replied Dick airily, "of learning the movements which each piece makes. After that, it's entirely a matter of skill and the intellect."

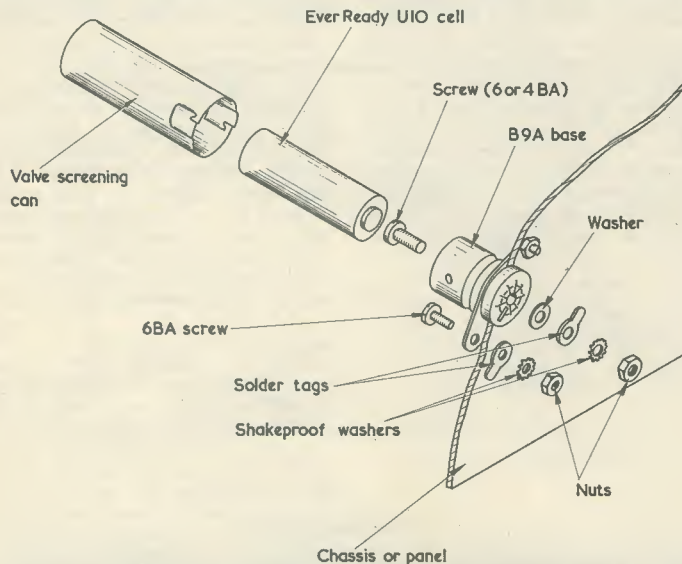


Fig. 9. A modified B9A skirted valveholder and screening can make a very convenient holder for a 1.5 volt cell. Connection to the battery is made via the two solder tags shown in the diagram

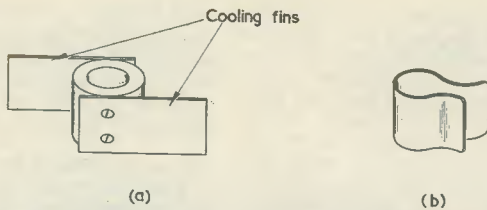


Fig. 10(a). A spindle coupler provides a useful heat sink, and cooling fins may be readily secured to it (b). A width control slider clip, to which a cooling fin may also be fitted, similarly lends itself to use as a heat sink

"Is it?"
 "Definitely," pronounced Dick.
 "The man who wins in chess is the man who's got the best brains."
 "That sounds O.K. by me then,"

said Smithy confidently. "Well, you bring in those chess-men, tomorrow, Dick boy, and we'll get stuck into our first game at lunch-time."

Whereupon Smithy returned, with his letters, to his bench whilst Dick, happy at the thought of a continuing source of small income, cheerfully put away the set of draughtsmen which had proved so profitable up to now.

Editor's Note

The hints described in this episode of 'In Your Workshop' were submitted, in the order in which they appear, by F. L. Ashford, N. Hoyle, W. M. Fraser, A. Roden, W. M. Stratton, T. E. Millsom, D. Macready, K. Raymond and W. D. Graham. Further hints for this feature are welcomed and payment is made for all that are accepted.

RADIO TOPICS . . .

by Recorder

BY THE TIME THESE NOTES APPEAR in print I have no doubt that you will be basking in the hot July sun with no other worries than whether your coming holiday will be in Spain or Majorca. (With a bit of luck I hope to get a week-end in Southend, myself.) It might be thought that the call of the sun could detract the attention of the constructor from the fascination of playing around with radio bits and pieces but, in practice, this doesn't seem to be the case. The radio hobbyist is just as keen during the Summer as he is during the Winter.

Under Control

I must hasten to add that I don't visualise constructors trundling car batteries down to the bay in order to operate miniature soldering irons and get the odd printed circuit wired up between dips. Apart from anything else, there is the fact that you've got to be jolly careful where you put a hot soldering iron down, these days, on Britain's crowded beaches. What I do mean is that the long Summer days allow plenty of work to be done in the shack, and they also enable the constructor to apply his specialised knowledge and experience to activities which necessitate open-air conditions.

Typical of such activities is the radio control of models, and I understand that, elsewhere in this issue, there appears the first of a series of constructional articles on

this particular subject. There is a very special fascination in seeing a model under control by radio, and in making it carry out movements and manoeuvres from a distance without any connecting wires whatsoever. The radio control of models has become, indeed, an art in its own right, and it uses many neat and ingenious systems which have been developed over the last twenty years or so. Furthermore it must be, surely, the activity which most pleasurably combines our hobby with sport and sunshine out of doors.

I'm certain that many readers will be following this new series with considerable interest. I know that I shall.

Symmetrical Transistors

In the April issue I referred to the fact that transistors can operate "in both directions", since they will amplify if the emitter and collector leads are changed over. I then listed the gains which are given

by such familiar transistors as the OC72 and OC44 when their emitter and collector leads are transposed.

A correspondent has since brought to my notice the fact that the reverse gain characteristic of transistors has been exploited in some switching circuits, and that the germanium n.p.n. transistors type OC139, OC140 and OC141 have been specifically produced with symmetrical working in mind. The gain offered by these transistors with reversed connections is somewhat lower than in the normal mode. I am indebted to my correspondent for the information and, on looking through my Henry's Radio catalogue, I note that both the OC139 and OC140 are available to home-constructors. It looks as though there may be a profitable field for the experimenter here.

Neon Lamp Modulation

Interest amongst readers in modulated light beam transmission continues to increase. You may recall that our most recent article on the subject was "Communication By Modulated Arc Beam" by H. S. King, this appearing in the February issue of this year.

A reader in South Africa, Mr. D. Goldfinch, states that he has had very good results at communication with modulated light

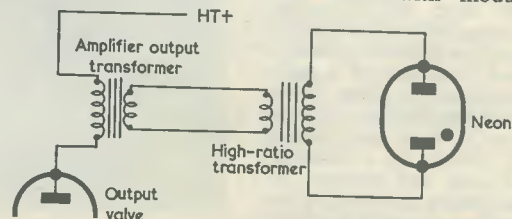


Fig. 1. A modulated light circuit, as used by a reader. The "high-ratio transformer" is a high-ratio output transformer connected backwards

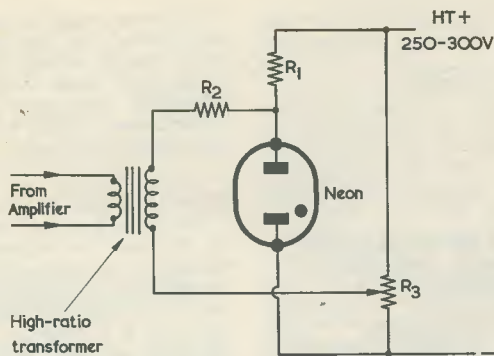


Fig. 2. An experimental circuit, proposed by Recorder, which causes the neon to be polarised. The high-ratio transformer is fed from the same source as in Fig. 1. The neon lamp should be operated without an integral series resistor, and the h.t. supply shown could be obtained from the a.f. amplifier

by using a neon lamp to provide the modulated illumination. Nobody has suggested using a neon lamp yet for this purpose, and it certainly seems to offer attractive possibilities. The circuit used by our reader appears in Fig. 1. The 3Ω output of a valve a.f. amplifier is stepped up by a high-ratio transformer, thereby enabling a neon bulb to become illuminated with an intensity which varies according to the level of the a.f. The output stage of the amplifier employs a 6BW6. Using the same receiver as was shown in Fig. 3 of H. S. King's article, and providing both the neon and the receiving phototransistor with a simple focusing lens, a range of 150 yards at night and 100 yards at day is claimed. An Osram neon rated at 220 volts 0.5 watt is used, and presumably this will have its own series resistor fitted in the base.

I cannot help but feel that some pretty heavy distortion should be present with this arrangement, because the neon will reach maximum brilliance *twice* in every single a.f. cycle. Also, as the voltage in each cycle falls below burning potential the neon will extinguish, and it will only ignite again when the voltage passes striking potential. Whether the neon will extinguish so readily during the complex pattern given by speech is another matter.

At any event the use of a neon for light modulation offers interesting possibilities for the experimenter, since it does not possess the thermal inertia of a filament bulb and it does not require the high voltage needed for striking an arc lamp; and we are most indebted to our reader for passing on the idea. It occurs to me that it may be

worthwhile making an attempt to obviate the risk of frequency doubling by polarising the neon, using a circuit arrangement such as that shown in Fig. 2. In this case the series resistor R_1 maintains the neon about half-way between maximum and minimum brightness whilst a.f. is applied via R_2 , which could have roughly the same value as R_1 . Potentiometer R_3 , which should have a value lower than R_1 or R_2 , is adjusted to provide the same average voltage as appears across the neon, i.e. the burning voltage. The circuit of Fig. 2 hasn't been tried out but it

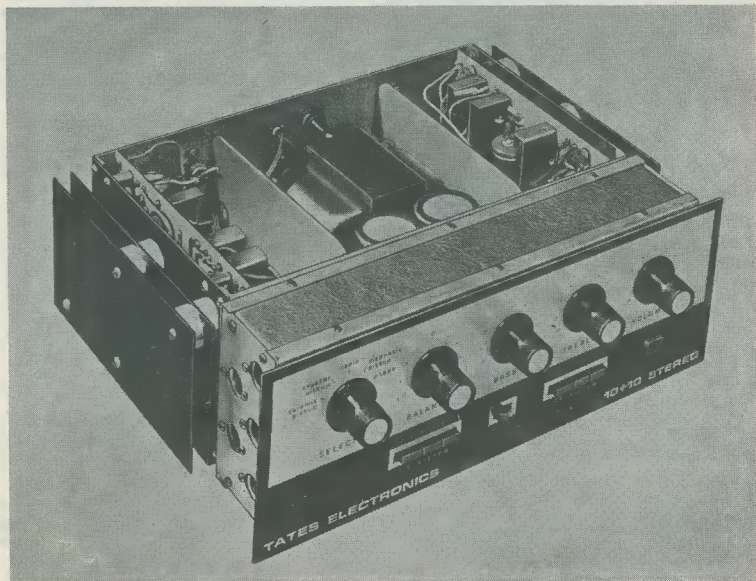
might offer a useful basis for experiment. I should add that I've avoided inserting a blocking capacitor in series with the a.f. feed to the neon to prevent the possibility of its running as a relaxation oscillator.

Stereo Amplifier Kit

The accompanying photograph will have an appeal for the constructor and high fidelity enthusiast alike, and it shows the new Tates Electronic Services "10+10 Stereo" amplifier which is now available in kit form.

The amplifier circuit comprises the Mullard 10 watt main amplifier and Mk. II high quality pre-amplifier designs, these using semiconductors throughout. The metalwork and layout of the amplifier is the result of Tates design. Specifications for the main amplifier include a harmonic distortion of less than 0.06% at the rated output of 10 watts. Output impedance is 15Ω . Non-reversible output sockets and loudspeaker plugs are used, and a loudspeaker phase reversal switch is fitted. The pre-amplifier circuit incorporates the recently released BC107 low-noise transistor and has a 5-position input selector switch catering for ceramic pickup, crystal pickup, radio, magnetic pickup and tape.

The integrated amplifier shown in the photograph is made up of seven different sections, each with its own kit reference number. There are two pre-amplifier kits type



The "10+10 Stereo" amplifier. This incorporates Mullard circuit designs and is now available, in kit form, from Tates Electronic Services

MA1, and two main amplifier kits type MA2. Also in the assembly is control panel kit type MA3, pre-amplifier metalwork kit type MA4, and power supply and metalwork kit type MA5. The power supply section is at centre rear of the integrated amplifier, with the two main amplifier sections on either side. The two pre-amplifier sections are immediately behind the control panel.

It is stated that the availability of the amplifier in kit form makes it considerably cheaper than equivalent high-grade manufactured amplifiers. The address of the suppliers is: **Tates Electronic Services, Ltd., 3 Waterloo Road, Stockport, Cheshire.**

Transistor Switching Dodge

Occasionally, transistors are em-

ployed to turn small pilot lamps on and off. The usual circuit arrangement consists of having the transistor in earthed emitter mode, with the lamp in its collector circuit. If the signal applied to the base causes the transistor to be cut off the lamp is not illuminated. If, on the other hand, the signal at the base brings the transistor on, the lamp lights up.

A snag with this method of working is that the cold resistance of the bulb is very much lower than its resistance when illuminated, with the result that the initial collector current in the transistor, when it causes the bulb to light up, can be proportionately very high. The cold resistance of a 6.5 volt 0.15 amp m.e.s. bulb is, for instance, of the order of 7Ω only,

which means that it can pass nearly an amp when the supply voltage is initially applied to it by the transistor.

One way out of this difficulty consists of connecting a resistor across the collector and emitter of the transistor, this resistor having a value which raises bulb filament temperature to just below the level where it gives visible light when the transistor is cut off. This causes filament resistance to be considerably higher than its cold value. When the transistor comes on to light the bulb, it then works into a collector load having a comfortably high value of resistance. The circuit still works in the same manner as it did without the resistor, but current surges in the transistor are considerably reduced.

Transistorised Flashing Indicator

By

M. J. HUTCHINSON

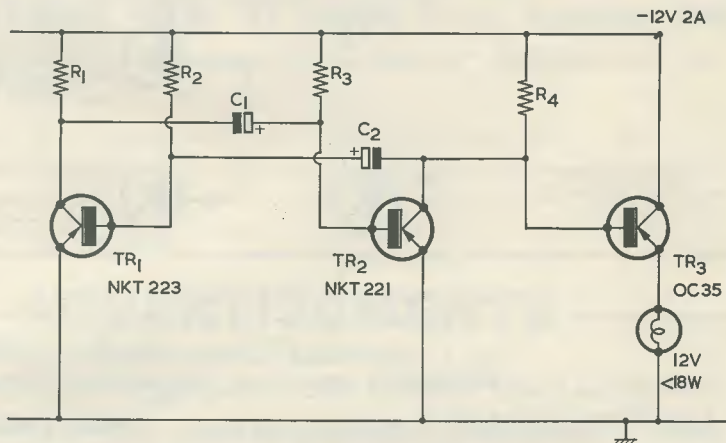


Fig. 1. The circuit of the flashing indicator. The controlled lamp is in the emitter circuit of TR₃

THIS CIRCUIT WAS ORIGINALLY DESIGNED TO operate the direction indicators on a car. It can however be put to a number of alternative uses, such as a warning circuit for pieces of electronic apparatus. (See Editor's Note below.)

The number of components has been cut down to a minimum, as may be seen from Fig. 1. The transistors shown can be replaced by their equivalents or near equivalents, as given in the Components List.

The Circuit

The circuit consists of a simple multivibrator coupled to a high power amplifier. No biasing is required, so all the emitters are grounded. The power transistor should be bolted to a heat sink, but this need not be large as the circuit is only in operation for a short time.

The exact layout of the components is not critical. The components could be mounted on a piece of Paxolin board using either tags or rivets for solder-

Components List (Fig. 1)

Resistors

R ₁	220 Ω 1 watt 20%
R ₂	1k Ω $\frac{1}{2}$ watt 20%
R ₃	470 Ω $\frac{1}{2}$ watt 20%
R ₄	100 Ω 2 watts 20%

Capacitors

C ₁	1,000 μ F electrolytic 15V wkg.
C ₂	500 μ F electrolytic 15V wkg.

Transistors

TR ₁	NKT223, NKT222, NKT212, GET103
TR ₂	NKT221, NKT228, OC83
TR ₃	OC35

ing. A piece of aluminium measuring 2 x 2in can be screwed to the board as a heat sink.

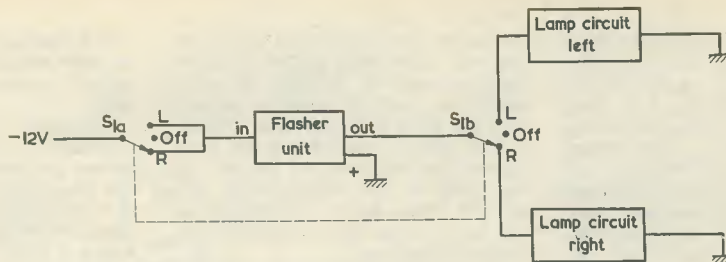


Fig. 2. The flashing indicator installed in a car having a positive earth.
S(a), (b) is a centre-off 2 way, 2 pole, switch

The circuit is powered by the car battery and up to 18 watts of lamps will run comfortably from the unit. A method of switching the circuit is shown in Fig. 2 using a centre-off 2 way, 2 pole,

be wound using a short length of 22 s.w.g. copper wire.

The additional transistor increases the output to about 30 watts.

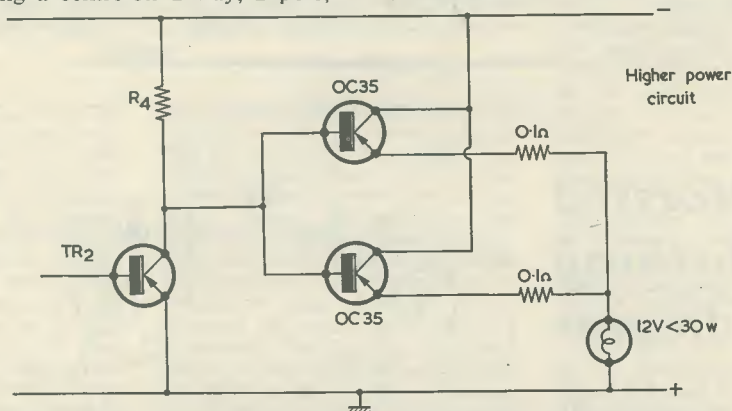


Fig. 3. Higher output powers are available by connecting an additional OC35 into the output circuit. The two 0.1Ω resistors are discussed in the text

switch. A suitable switch is available from Radiospares. Included in the circuit are the front and rear indicators and panel lamps on the dashboard.

The duration of the flash was found to be about right with the component values listed. At lower voltages the flashes tended to get longer and the value of R_3 needed to be altered.

If a higher powered circuit is required, then an additional power transistor should be added. This is coupled to the existing transistor, TR₃, with two resistors. See Fig. 3. The additional resistors should be about 0.1Ω in value. They can

Editor's Note

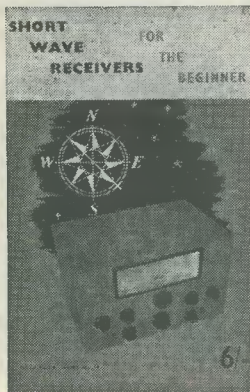
A requirement of flashing indicators fitted to cars is that these should provide not less than 60 nor more than 120 flashes per minute. Also, when the indicator is switched on, a warning readily visible (or audible) to the driver when in his seat should be given. The latter point may be met, as intimated in the article, by dashboard lamps connected in the lamp circuits. A further requirement is that the total rated wattage of the bulb or bulbs illuminating any indicator should be not less than 15 watts or more than 36 watts, with the result that the circuit of Fig. 3 will be normally required for the car application.

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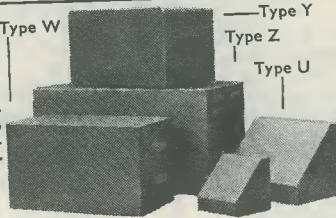
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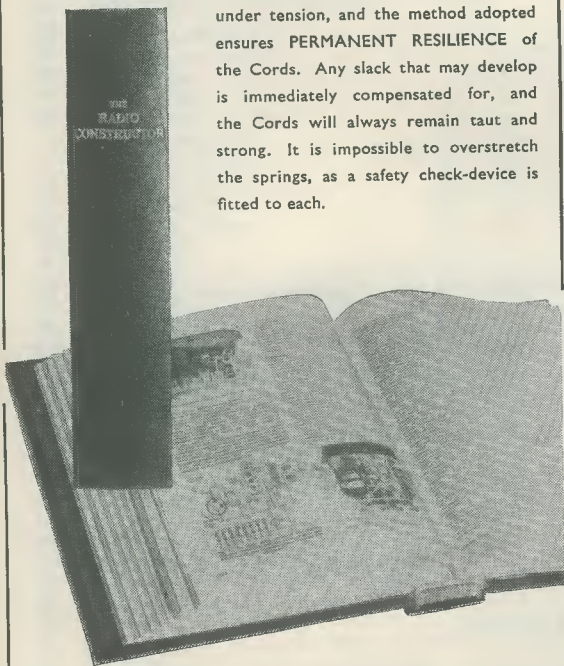
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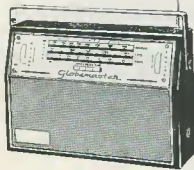
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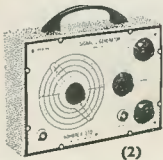
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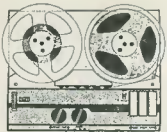
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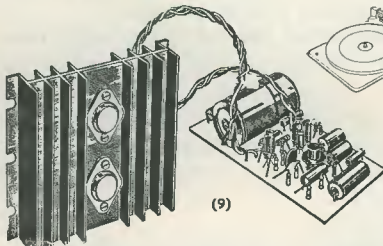
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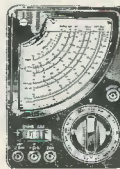
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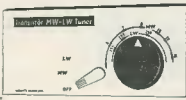
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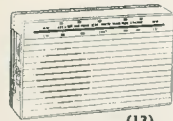
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(15)

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New matching Preamplifier, 6 inputs, treble/bass/selector/volume controls. 6-10mV o/put. 9-18V supply. 79/6, p.p. 2/-
For use with any Transistor Amplifier

DEAC CHARGER
To charge 3.6 volt and 9.6 volt packs. Fully mains isolated.
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AND TESTED
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7-Transistor MW/LW Car Radio. 12 volt operated. 3 watt output. Push-button wavechange. RF stage. Supplied built, boxed, ready to use with Speaker and Baffle. Car fixing kit and manufacturers' current guarantee. Special Bargain Offer. Buy Now!
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*AT6 mono . . . £8.19.6, stereo £9.10.0
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(*Deram cartridge add 60/- to mono price). All autochange (except SP25), complete with cartridge. Brand new.

(7) **VHF FM TUNER**
Supplied as 2 Preassembled Panels, plus metal work Superhet design, 88-108 Mc/s, 9 volt operated.
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Fully tunable superhet with excellent sensitivity and selectivity. Output up to ½ volt peak. Complete with front panel, etc. 9 volt operated. For use with any amplifier or tape recorder.
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