Vol 20 No 1

AUGUST 1966

2/6

A DATA PUBLICATION

THE Radio Constructor

RADIO · TELEVISION
ELECTRONICS · AUDIO

Transistorised Radio Control Transmitter

2.25kV Power Supply ★ Tape Recorder Tuner ★ CR100 Modifications ★ Circular Timebase

Eddystone RECEIVER

OF MAJOR INTEREST TO ALL RADIO ENTHUSIASTS

EC10 transistorized communications receiver

A most efficient transistorized communications receiver of light weight, compact dimensions, and capable of a really good performance. Five ranges give continuous coverage from 550 kc/s to 30 Mc/s (545 to 10 metres), and included are the medium-wave broadcast band, the marine (coastal) band from 1500 to 3000 kc/s, and all the short-wave broadcast bands. Also available are the six major amateur bands and many services in between.

The EC10 receiver accepts normal AM telephony and CW telegraphy, a special filter being provided to increase selectivity (and also reduce noise) in the CW mode, as is often desirable. Single sideband signals can be successfully resolved by appropriate setting of the BFO for carrier reinsertion. A total of 13 transistors and diodes is used, leading to high sensitivity and consistent results on all ranges. The main scales occupy a length of nine inches and are clearly calibrated direct in frequency. The standard Eddystone precision slow-motion drive controls the tuning, which is exceptionally smooth and light to handle. An auxiliary logging scale permits dial settings of chosen stations to be recorded.

An internal speaker gives good aural quality and a comparatively high audio output is available—one can easily believe the set is mains operated. For personal listening, a telephone headset can be plugged into the socket on the front panel, the speaker then being out of action.

Alternative aerial sockets are provided, for dipole, long wire, or short rod or wire. Power is derived from six cells housed in a separate detachable compartment. Current consumption is related to audio output and, for long life, HP2-type heavy-duty cells are recommended.

The receiver is housed in a metal cabinet, and, with robust construction throughout, it will stand up to hard usage over a long period with a high degree of reliability. The finish is an attractive two-tone grey. The dimensions are width 12½″, height 6¾″, depth 8″; weight with batteries is 14 lb.

Eddystone Radio Limited

Eddystone Works, Alvechurch Road, Birmingham 31

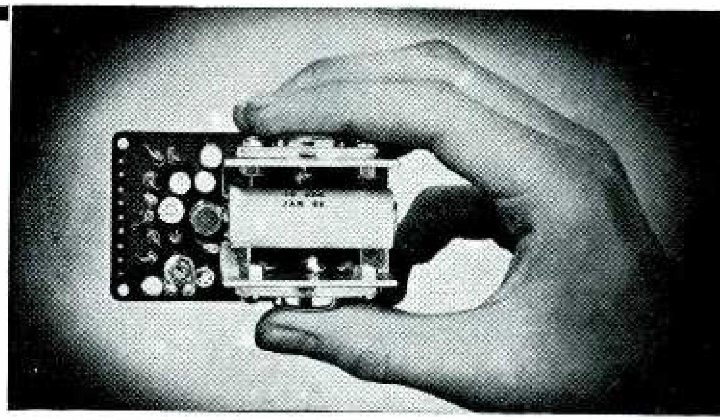
Telephone: Priory 2231 · Cables: Eddystone Birmingham · Telex: 33708

LTD/ED5

SINCLAIR Z.12

INTEGRATED 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 fantastic power and superb quality which can provide an effortless output of 12 watts R.M.S. continuous sine wave from the unique eight transistor circuit used. 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 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.



12 WATTS R.M.S. OUTPUT CONTINUOUS SINE WAVE (24 W. PEAK)

15 WATTS R.M.S. MUSIC POWER (30 WATTS PEAK)

- ★ Ultra-linear class B output and generous neg. feed back.
- ★ Response—15 to 50,000 c/s ±1dB.
- ★ Output suitable for 3, 7.5 and 15 ohm loads. Two 3 ohm speakers may be used in parallel.
- ★ Input—2mV into 2K ohms.
- ★ Signal to noise ratio—better than 60dB.

Built, tested and guaranteed.

89/6

SINCLAIR MICRO FM

COMBINED FM TUNER | RECEIVER

Less than 3" x 1¾" x ¾" and professional in every way, 7 transistor FM using pulse counting discriminator for superb audio quality. Low I.F. makes alignment unnecessary. Tunes 88-108 Mc/s. The telescopic aerial suffices for good reception in all but poorest areas. Signal to noise ratio—30dB at 30 microvolts. Takes standard 9 v. battery. One outlet feeds to amplifier or recorder, the other allows set to be used as a pocket portable. Brushed and polished aluminium front, spun aluminium dial. A fascinating set to build.

Complete kit inc. aerial, case, earpiece and instructions. **£5.19.6**

SINCLAIR MICRO-6

The world's smallest radio

Unequalled for power, selectivity and quality. Six stage M.W. receiver. 2 R.F. amplification, double diode detector, 3 stage A.F. amplifier. A.G.C., etc. The Micro-6 is completely self-contained in white, gold and black case, 1 4/5" x 1 3/10" x 1/2". Plays anywhere. Easy to build. Complete kit of parts with earpiece and instructions.

59/6

SINCLAIR STEREO 25

A NEW DE-LUXE PRE-AMPLIFIER AND CONTROL UNIT

Designed specially to obtain the very finest results used with two Sinclair Z.12's for stereo. The best quality components, individually tested before acceptance, are used in its construction, whilst the overall appearance of this compact de-luxe pre-amp and control unit reflects the professional elegance which characterises all Sinclair designs. The front panel is in solid brushed and polished aluminium with beautifully styled solid aluminium knobs. Mounting is simple, and the PZ.3 will comfortably power the Stereo 25 together with two Z.12's. When fitted, the Sinclair 25 will grace any type of hi-fi furniture. Frequency response 25 c/s to 30 kc/s ±1dB connected to two Z.12's. Sensitivity Mic. 2mV into 50kΩ: P.U. —3mV into 50kΩ: Radio —20mV into 4.7kΩ. Equalisation correct to within ±1dB on R1AA curve from 50 to 20,000 c/s. Size 6½" x 2½" x 2½" plus knobs.

BUILT, TESTED AND GUARANTEED **£9.19.6**

A HI-FI STEREO ASSEMBLY FOR £22.18.0

All you require is one Stereo 25 Unit (£9.19.6) two Z.12's (£8.19.0) and one PZ.3 (£3.19.6). As an optional extra, you could include the Micro FM (£5.19.6).

SINCLAIR PZ.3 Transistorised mains power unit specially designed for Z.12. Will power two Z.12's and Stereo 25 with ease. **79/6**

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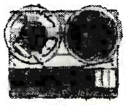
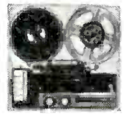
RC8

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: 1⅞″, 3¾″ 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-IM** 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,** ½ 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 **£9.2.6** Assembled **£14.2.6**

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 **£19.19.0** Assembled **£27.5.0**

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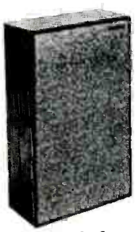
SPEAKER SYSTEMS

SSU-1



Berkeley

HI-FI SPEAKER SYSTEM. Model SSU-1. Ducted-port bass reflex cabinet "in the white". Two speakers. Vertical or horizontal models with legs, Kit **£12.12.0,** without legs, Kit **£11.17.6** incl. P.T.

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 7¾″ deep. Modern attractive styling. Excellent value.
Kit **£19.10.0** Assembled **£24.0.0**

COTSWOLD SPEAKER SYSTEMS. Outstanding performance for price.
MFS: Size 36″ x 16½″ x 14″ deep.
Kit **£25.12.0** Assembled **£33.17.0**
STANDARD: Size 26″ x 23″ x 14½″ deep.
Kit **£25.12.0** Assembled **£33.17.0**

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A wide range available including:

GLOUCESTER. Kit **£18.10.0** incl. P.T.

MALVERN. Kit **£18.1.0** incl. P.T.

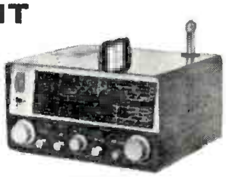
CHEPSTOW. Kit **£11.18.6** incl. P.T.

We can also make available the well-known RECORD HOUSING range of fully finished cabinets.

Malvern

"AMATEUR" EQUIPMENT

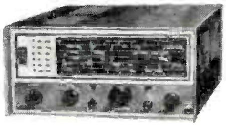
THE "MOHICAN" GENERAL COVERAGE RECEIVER. Model GC-1U. With 4 piezo-electric transfilters, variable tuned B.F.O. and Zener diode stabiliser, this is an excellent fully transistorised general purpose receiver for Amateur and Short wave listeners. Printed circuits, telescopic aerial, tuning meter and large slide-rule dial.
Kit **£37.17.6** Assembled **£45.17.6**



GC-1U

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.
Kit **£39.6.6** Assembled **£52.10.0**

160-10M TRANSMITTER. Model DX-100U. Careful design has achieved high performance and stability. Completely self-contained.
Kit **£81.10.0** Assembled **£106.15.0**



RG-1

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.
Kit **£39.16.0** Assembled **£53.0.0**

REFLECTED POWER METER and SWR BRIDGE. Model HM-11U. Indicates reliably, but inexpensively, whether the RF power output of your TX is being transferred efficiently to radiating antenna.
Kit **£8.10.0** Assembled **£10.15.0**

HM-11U

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Models for 80, 40 or 20 metre bands.
Model HW-12 (80M) **£67.10.0, Kit.** incl.
Model HW-22 (40M) **£66. 0.0, Kit.** duty,
Model HW-32 (20M) **£66. 0.0, Kit.** etc.

80M Transceiver HW-12

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0B2	6/–	9D7	7/6	DAF96	6/6	EF37A	7/–	GZ37	14/6	U25	8/6
1L4	2/3	10C1	12/6	DF96	6/6	EF39	5/–	HABC80	9/3	U26	8/6
1R5	4/–	10C2	12/–	DK92	8/–	EF41	8/–	KT66	12/3	U191	9/6
1S5	3/3	10F1	9/9	DK96	7/6	EF80	4/3	PABC80	7/6	U301	11/–
1T4	2/6	10F18	9/9	DL96	6/9	EF85	4/6	PC86	9/–	U329	9/–
2D21	5/6	10LD11	9/6	DM70	5/–	EF86	6/6	PC88	9/–	U404	6/–
3D6	3/9	10P13	12/–	DY87	6/9	EF89	4/6	PC95	6/9	U801	15/–
3Q4	5/3	10P14	11/6	E88CC	12/–	EF91	3/–	PC97	5/9	UABC80	5/–
3S4	4/3	12AT6	4/6	EABC80	5/9	EF92	2/6	PC900	9/6	UAF42	7/9
3V4	5/–	12AU6	5/9	EAF42	7/6	EF97	10/–	PCC84	5/6	UBC41	6/6
5Y3GT	4/9	12AV6	5/9	EB91	2/3	EF98	9/9	PCC85	6/9	UBC81	6/6
5Z4	7/6	12BA6	5/3	EBC41	6/6	EF183	6/9	PCC88	10/6	UBF80	5/6
6AQ5	4/9	12BE6	4/9	EBC81	6/3	EF184	6/6	PCC89	11/6	UBF89	5/9
6AT6	3/6	12BH7	6/–	EBF80	5/9	EH90	9/6	PCC189	8/9	UBL21	10/9
6AU6	5/9	19AQ5	7/3	EBF83	7/3	EL33	6/6	PCF80	6/6	UC92	6/3
6AV6	5/6	20D1	10/–	EBF89	5/9	EL36	8/9	PCF82	6/–	UCC84	8/–
6BA6	4/6	20F2	11/6	EBL21	10/3	EL41	7/6	PCF84	8/6	UCC85	6/6
6BE6	4/3	20L1	14/–	EC92	6/6	EL42	7/9	PCF86	8/3	UCF80	8/3
6BH6	5/3	20P3	12/–	ECC40	10/–	EL84	4/6	PCF801	9/6	UCH21	8/–
6BJ6	5/6	20P4	13/–	ECC81	3/6	EL85	7/6	PCF802	10/–	UCH42	8/–
6BQ7A	7/6	20P5	11/6	ECC82	4/6	EL86	7/3	PCL82	6/6	UCH81	6/–
6BR7	8/3	30C15	10/–	ECC83	4/6	EL95	5/–	PCL83	8/9	UCL82	7/3
6BW6	7/6	30C17	11/9	ECC84	5/6	ELL80	14/–	PCL84	7/6	UCL83	9/–
6CD6G	22/–	30C18	8/–	ECC85	5/3	EM71	14/–	PCL85	8/6	UF41	7/9
6CH6	6/–	30F5	8/3	ECC88	8/9	EM80	6/–	PCL86	8/6	UF42	4/9
6F1	9/6	30FL1	9/3	ECC189	11/6	EM81	7/–	PEN45	7/–	UF80	6/3
6J5G	3/9	30FL14	11/–	ECF80	7/3	EM84	5/9	PFL200	14/6	UF85	6/9
6J7G	4/6	30L15	10/3	ECF82	6/3	EM85	12/–	PL36	9/–	UF86	9/–
6K7G	1/3	30L17	11/6	ECF86	10/–	EM87	6/6	PL81	6/9	UF89	5/6
6K8G	3/3	30P12	10/–	ECH21	10/–	EY51	5/6	PL82	5/3	UL41	8/9
6L6GT	7/3	30P19	12/–	ECH35	6/–	EY81	7/3	PL83	6/–	UL84	5/6
6L18	10/–	30PL1	13/6	ECH42	8/–	EY83	9/3	PL84	6/3	UM80	8/3
6LD20	6/6	30PL13	10/6	ECH81	5/6	EY84	9/6	PY33	8/9	UY21	9/–
6Q7G	5/6	30PL14	11/–	ECH83	6/6	EY86	5/9	PY80	4/9	UY41	5/–
6SL7	4/9	30PL15	9/6	ECH84	9/–	EY88	8/9	PY81	5/–	UY85	4/9
6SN7	4/6	35W4	4/6	ECL80	5/9	EZ40	5/6	PY82	4/9	VP4B	12/–
6V6G	3/6	85A2	6/6	ECL82	6/6	EZ41	6/3	PY83	5/6	X41	10/–
6X4	3/9	8O7	11/9	ECL83	10/–	EZ80	3/9	PY88	7/3	X78	26/2
6X5	5/3	5763	7/6	ECL86	8/–	EZ81	4/3	PY800	5/9	X79	40/9

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5" 600ft. ... 11/6	900ft. ... 15/–	1,200ft. ... 23/6	4" 900ft. ... 25/–
5¾" 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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Midget I.F.'s—465 kc/s 7/16" diam., first, second or third, each 5/6
Osc. coil M. & L.W. 7/16" diam. 5/–
Midget Driver Trans. 9:1 6/–
Ditto O/Put Push-pull 3 ohms 6/–
Elect. Condensers—Midget Type 15V 1mfd–50mfd, ea. 1/9. 100mfd, 2/–. 2.5mH, 5mH, 7.5mH, 10mH R.F. Chokes 2/6 each.
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. ⅞" DILEMIN 100pF, 300pF, 500pF, 7/–.
Midget Vol. Control with edge control knob, 5kΩ with switch, 4/9, ditto less switch, 3/9.

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25/25V, 50/12V, 1/9; 8+8/450V, 4/6; 50/50V, 100/125V, 2/–; 32+32/275V, 4/6; 8/450V, 4/350V, 2/3; 50/50/350V, 6/6; 16+16/450V, 5/6; 60/250/275V, 12/6; 32+32/450V. 6/6; 100+200/275V, 12/6.

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EXPANDED ANODISED METAL —Attractive gilt finish ¼" x ¼" diamond mesh 4/6 sq. ft. Multiples of 6" cut. Max. size 4' x 3', 47/6 plus carr.
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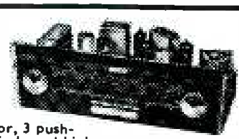
Volume Controls—5K–2 Meg-ohms, 3" Spindles Morganite Midget Type. 1⅛" diam. Guar. 1 year. LOG or LIN ratios less Sw., 3/6. DP. Sw. 5/–. Twin Stereo less Sw., 7/6. D.P. Sw., 9/6 (100 k to 2 Meg. only).

Condensers—Silver Mica. All values 2pF to 1,000pF, **6d.** each. Ditto Ceramics, 9d. Tub, 450V T.C.C. etc. 0.001 mFd to 0.01, 9d. and 0.1/350V, **10d.** 0.01–0.1/500V, 1/–. 0.25 Hunt, 1/6. 0.25 T.C.C., **1/9**, etc., etc.
Close Tol. S/Micas—10% 5pF-500pF, **8d.** 600-5,000pF, 1/–, 1% 2pF-100pF, **9d.** 100pF-500pF, **11d.** 575pF-5,000pF, 1/6. **Resistors**—Full Range 10 ohms-10 meg. ohms 20% ¼ and ½W, 3d., ¾W, **5d.** 1W, 6d., 2W, **9d.** 10% ¼W and ½W, 4d.
Hi-Stab. 5% ¼W, ½W, 6d. (100 ohms-1 meg.). Other values 9d. 1% ½W, 1/6, etc., etc.
Wire-wound Resistors—25 ohms to 10K ohms, 5 watt 1/3d, 10 watt 1/6d, 15 watt 1/9d.

6 VALVE AM/FM TUNER UNIT



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THE Radio Constructor

Incorporating THE RADIO AMATEUR

AUGUST 1966

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Vol. 20, No. 1
Published Monthly
(1st of month)

Editorial and Advertising Offices
57 MAIDA VALE LONDON W9

Telephone
CUNningham 6141

Telegrams
Databux, London

First Published
1947

Annual Subscription 36s. (U.S.A. and Canada $5) including postage. Remittances should be made payable to "Data Publications Ltd". Overseas readers please pay by cheque or International Money Order.

Published in Great Britain by the Proprietors and Publishers Data Publications Ltd. 57 Maida Vale London W9
Printed by A. Quick & Co. (Printers) Ltd. Clacton-on-Sea England

A 2.25kV POWER SUPPLY

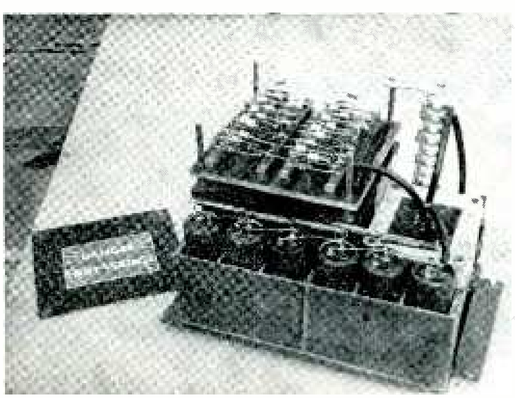
By **ARTHUR C. GEE, G2UK**

This compact power unit for amateur transmitter use employs solid-state rectifiers and offers an output of 2.25kV at 250mA (less bleeder current). It must be emphasised that very high voltages and currents appear in the circuit, that the risk of lethal shock is high, and that full safety precautions must be observed when building, testing and using the unit

THE HOME CONSTRUCTION OF LINEAR R.F. AMPLIFIERS for single sideband transmission is a comparatively simple project as far as the amplifier itself is concerned, but the high voltage d.c. supply required to operate many of the published designs is not so easy to build in the home workshop. Also, surprisingly little information of a constructional nature on this type of equipment appears to have been published in the amateur radio literature of this country.

The most helpful article which the writer has encountered in this respect is that written by E. Lawrence entitled "Transmitter Power Supply Using Semiconductors", which was published on page 280 in the November 1964 issue of *The Radio Constructor* (Vol. 18, Number 4). The design described therein appealed particularly to the writer as it made use of silicon rectifiers, thus enabling a very compact unit to be constructed. The unit was designed to give 1,000 volts at 220mA. The author of the article concluded by stating: "Initial tests both at reduced voltage with the aid of a Variac and then with full mains applied were successful, and there was every indication that the unit would perform as desired. Subsequently, with the transmitter in the hands of a relatively inexperienced operator, this has been confirmed.

"With this experience the writer is now a convert to solid-state rectifiers and hopes this article will encourage others to investigate their use in similar situations."



Side view, illustrating the layout of the electrolytic capacitors and the bridge rectifier components

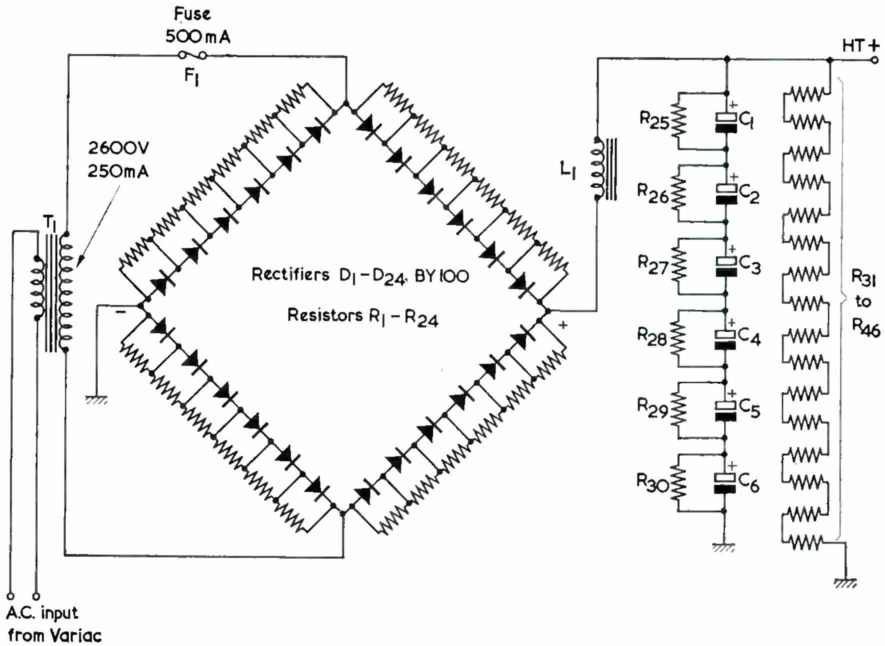
The Present Design

The power requirements of the present writer were considerably greater than those of the author of the previous article. The linear amplifier used by the writer requires some 2,500 volts d.c. at about 200mA for maximum p.e.p., and the first problem was to find a suitable mains transformer.

Amongst radio amateurs, there is a system known as "ways and means", and once the writer's requirements were passed along the "bush telegraph" one of his friends produced a massive surplus transformer with a secondary rated at 1,300-0-1,300 volts at 250mA, and with the usual British rated tapped primary winding. This was handed over with the instruction: "Mind you don't kill yourself with it!" The transformer provided an excellent starting point from which to design the final unit.

At this point, the reader is advised to read the previous article by E. Lawrence since it will save repeating essential design considerations here. Following these considerations, the writer decided to use the same type of bridge rectifier circuit, with the appropriate number of BY100 silicon rectifiers which would be needed for the higher voltages involved.

The next consideration was the type of smoothing circuit to be employed. In view of the fact that the power supply was to be used with an s.s.b. linear amplifier, where the voltage regulation in the



The circuit of the power supply unit. It is recommended that the supply to the primary of T_1 be obtained by way of a Variac, thus enabling voltage to be gradually increased from zero, both for testing and for later use. The supply output is fed to an s.s.b. linear amplifier, to which is fitted a voltmeter for monitoring the output voltage. Capacitors C_1 to C_6 each consist of a 100+64μF dual capacitor, the two sections being paralleled to form a single 164μF capacitor.

Components List

Resistors

R_1–R_{24} 24 resistors, 1MΩ, 2 watt, 10%
R_{25}–R_{30} 6 resistors, 47kΩ, 5 watt, 10%
R_{31}–R_{46} 16 Radiospares Power Resistor Sections, 2.2kΩ, 65mA each section (Home Radio (Mitchan) Ltd.)

Capacitors

C_1–C_6 6 dual electrolytic capacitors, 100+64μF, 450V wkg.

Transformer

T_1 Mains transformer, secondary 1,300–0–1,300V, 250mA (see text)

Choke

L_1 Swinging choke 5–25H, 250mA max. current

Rectifiers

D_1–D_{24} 24 silicon rectifiers type BY100 (Mullard)

Fuse

F_1 500mA (see text)

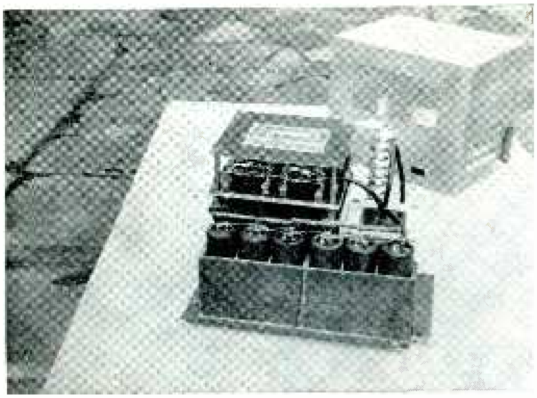
Ancillaries

1 Variac, 2.5A rating (Service Trading Co., 47–49 High Street, Kingston-upon-Thames)
1 Voltmeter, 0–3,000 or 0–3,500V (see text)

Miscellaneous

"High Voltage" warning sign (Panel Signs Transfer from either Set No. 3 or Set No. 4)
2BA studding (for R_{31}–R_{46})
Mains plug and socket
High voltage output plug and socket, type L.623/P and L.623/S (Belling-Lee)
High voltage wire
Chassis, case, etc.

presence of a greatly varying current must be as good as possible, a choke input filter was a foregone conclusion. In the interests of compactness, it was also decided to try and work with a single section filter; that is, to use one choke only. This could be of the "swinging choke" variety. The fact that the output voltage of a choke filter is lower than that of a capacitor input filter was of no concern, since the secondary voltage of the transformer was, if anything, higher than the voltage really required. The output voltage from a choke input filter following a bridge rectifier is, in fact, 0.9 times the input r.m.s. voltage. On checking the transformer, it



A protective sheet of Paxolin covers the bridge rectifier circuit after assembly

was found that, by using the highest primary tappings, the actual voltage across the secondary was 2,500 volts a.c. Ignoring the d.c. voltage drop through the silicon rectifiers and choke, we can therefore expect an output voltage from the choke filter of $2,500 \times 0.9 = 2,250$ volts d.c. This figure was adopted for the ensuing design calculations.

The characteristic of the swinging choke is that its inductance is high at low currents, decreasing in value as the current increases. A typical choke of this type gives an inductance of 25 henrys at 50mA, whilst at 250mA its inductance falls to 5 henrys. In order that a swinging choke circuit may function properly a minimum value of current must flow through the choke and this current is given by the equation:

$$\text{Current in mA} = \frac{\text{d.c. voltage}}{\text{Max. inductance in henrys}}$$

In the case under consideration:

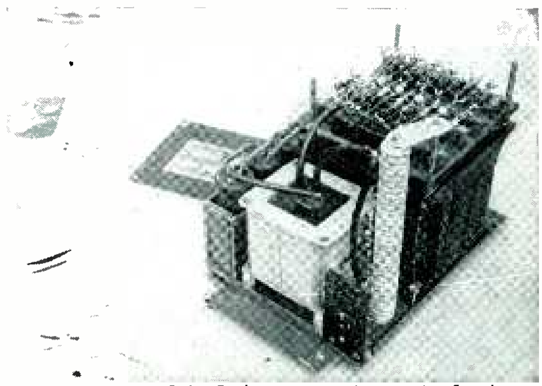
$$I = \frac{2250}{25} = 90\text{mA}$$

Thus, a current of not less than 90mA should always be drawn through the choke.

The minimum current drawn by the transmitter will usually be lower than the critical minimum current required in the choke. In consequence, a bleeder resistor is added to bring the minimum choke current up to the required value. The bleeder resistor also ensures that the smoothing capacitors are reliably discharged when the mains supply is turned off.

In the writer's case, the linear amplifier has a standing current of 30mA. There is also a further drain of about 10mA through the resistors bypassing the smoothing capacitors (which will be dealt with later). The bleeder resistor must therefore provide a drain of 90mA less (30+10mA); that is, 50mA.

The dissipation in a resistor passing 50mA at 2,250 volts is 112.5 watts, and it would seem that a very large component, and one that is difficult to obtain, would be required. However, this problem was very neatly solved by using Radiospares "Power Resistor Sections", these consisting of round wirewound resistance units which, in the value employed by the writer, have a diameter of 1in and a height of 0.5in. The resistance units also have a centre hole and a quantity of them may be assembled, one above the other, on a length of 2BA studding. The units employed by the writer each have a value of 2.2kΩ and are rated at 0.065 amps. Sixteen of these units connected in series make up the bleeder and give a total resistance of 35,200Ω, with the result that a bleeder current of 60mA flows at the power unit output voltage of 2,250. This current is comfortably above the minimum figure of 50mA just mentioned and is nicely within the rated current of the resistance units.[1]



The assembly of the Radiospares resistor units for the bleeder is clearly shown here

Smoothing Capacitors

Next to be considered were the smoothing capacitors. G. R. Jessop, G6JP, describing the design for a linear amplifier on page 290 in the *R.S.G.B. Bulletin* for May 1964 (Vol. 40, No. 5) states: "As with all linear amplifiers it is important that the h.t. supplies should be adequately smoothed and of good dynamic performance in order to maintain the voltages substantially constant during the changing operating loads". Continuing with the design considerations for his linear amplifier: "To obtain good dynamic performance of the anode supply, a capacitance of not less than 24μF will be required in the smoothing circuit."

Again, as with the bleeder resistor, suitable high voltage, large value, capacitors are not readily available, as single units, to the home constructor. The best the writer could locate were 3,000 volt 0.5μF components which, even at surplus prices, become a little costly for 48, quite apart from the volume taken up by such a quantity of capacitors!

[1] We are informed by Radiospares Ltd, that the minimum breakdown voltage between the studding and the resistor element in an assembly of this nature is 5kV d.c., whereupon it becomes possible to assemble all the sixteen units on a single piece of 2BA studding. The units may only be obtained through retail channels and not direct from Radiospares Ltd.—Editor.

So the writer fell back on lower voltage electrolytic components. Six dual electrolytic capacitors, each rated at 100+64μF, 450 volt working, and with each dual section paralleled, would give a working voltage of 2,700 volts and a total capacitance of 27μF, both figures being just on the right side of the values required. When capacitors are connected in series in this manner, it is necessary to shunt them with equal-value resistors to ensure that the total voltage is equally divided. The writer employed 47kΩ 5 watt 10% resistors across each dual electrolytic capacitor. This values ensures that correct voltage division occurs even when capacitor leakage current is relatively high. Also, the six 47kΩ resistors connected in series cause a constant drain from the power unit output of slightly less than 10mA, thus helping to keep the current through the swinging choke above the critical value.

The complete power supply unit in its ventilated case and with the associated Variac alongside. The "High Voltage" warning notice is provided in Panel Signs Transfers, Sets Nos: 3 and 4

The Bridge Rectifier

The final consideration is the design of the silicon rectifier circuit, the obvious choice being a bridge circuit. With this type of circuit, the peak inverse voltage per arm is 1.4 times the r.m.s. voltage presented by the transformer secondary winding. Remembering that there are four arms in a bridge rectifier circuit, this gives us 2,500 x 1.4=3,500 volts. The recommended maximum p.i.v. for the BY100 silicon rectifier is 800. Five in each arm would theoretically cope but, to be on the safe side, it was decided to use six, the whole bridge thus requiring twenty-four BY100's. It may be considered that this number is rather extravagant, but the writer felt it was better to err on the side of too many than too few as a weakness in this part of the circuit might well lead to disaster! The rectifiers are, of course, subjected to any "spikes" in voltage which may appear in the mains supply, so one cannot be too careful in providing plenty of reserve in regard to the p.i.v. requirements. The conventional way of smoothing out the effect of these surges is to connect equal-value capacitors of about 1,000pF across each rectifier but, in view of the safety factor afforded by using six rectifiers per arm instead of of five, it was decided to omit these capacitors. Constructional problems are considerably eased by this omission, and no trouble has been experienced in practice. It is still necessary to provide bridging resistors across each rectifier to ensure correct reverse voltage division, and the writer shunted each rectifier with a 1MΩ 2 watt 10% resistor.

Constructional Features

Next to be dealt with were constructional details. As has already been inferred, the general size and layout of the unit was partly determined by the dimensions of the transformer. The writer was anxious to make the unit as small as was reasonably practicable, so that it could be stowed away on the floor under the bench. It was, of course, to be totally enclosed in an earthed metal case. The linear amplifier itself is a separate table-top unit, a.c. power to the power supply being switched at, and taken down to the unit, from the linear amplifier itself. The h.t. supply is then brought up from the power supply unit to the linear amplifier by heavily insulated cable.

As can be seen from the photographs a very convenient arrangement of components was arrived at, and the writer had the good fortune to have on hand a well ventilated cabinet of suitable proportions to house all the components, with just a little room to spare. The cans of the electrolytic capacitors are, of course, at high potential, so a six-section container to take them was made from sheet Paxolin panels glued together with Araldite, the capacitors being push-fits in their individual compartments. Each capacitor is first covered with a rubber sleeve cut from a bicycle inner tube, and the container dimensions allow it to fit in tightly without further fixing. The capacitor box is mounted to the cabinet base by six small countersunk bolts, the heads of which are flush with the surfaces of small blocks of Paxolin, the latter being stuck with Araldite to the bottom of the box. Do *not* drill through the bottom of the box and insert the bolts through direct, or the bottoms of the electrolytic capacitor cans will short-circuit to the metal base.

The swinging choke is mounted on stand-off insulators as it was felt that there was no point imposing an additional strain on its insulation by earthing its metal casing. The bridge rectifier was assembled on a Paxolin frame fixed to the top of the transformer. Paxolin strip, ready drilled with holes at about ½in centres can be obtained, into which soldering pins can be inserted. This makes an excellent framework for mounting the BY100's, the layout being clearly apparent from the photographs.

The a.c. power supply is brought in by way of a plug and socket, the h.t. output being taken back to the linear amplifier via a high voltage plug and socket and a length of petrol engine ignition cable.

Two types of this cable are available at motor cycle shops, one being plastic covered and the other rubber covered. The rubber covered variety should be used for the connection to the linear amplifier as it is much more flexible. On the other hand, the h.t. wiring in the unit is better carried out with the plastic covered type, as the lack of flexibility in this is a useful feature in keeping the leads short and in the positions required. Reference to the photographs will illustrate this point.

Fuse

In the design by E. Lawrence, referred to earlier, a fuse was inserted in the earthed lead from the bridge rectifier. Subsequent correspondence in *The Radio Constructor*,[2] suggested that a better location for the fuse would be in one of the leads from the transformer secondary, as this would prevent currents circulating through one arm of the bridge rectifier if the rectifiers in an adjacent arm broke down. The fuse in the writer's unit was accordingly inserted in one of the leads from the secondary.

Voltage Control

Again referring to the article by E. Lawrence, it is very prudent indeed to test this unit by gradually increasing the primary voltage on the transformer from zero and observing the results. If the constructor uses a Variac for this purpose, he will immediately realise how useful such a power control unit can be if included as a permanent feature of the power supply. Apart from the fact that the circuit is working fairly close to the maximum working voltage of the electrolytic capacitor network, it is also desirable to avoid sudden surges of voltage as an on/off switch in the primary might produce. Again, it is extremely useful to be able to reduce voltage when tuning up a linear amplifier for s.s.b. or for operating it in continuous mode as for a.m. or R.T.T.Y.

The writer therefore decided to include a Variac in the primary circuit of the transformer. This stands on the operating bench alongside the linear amplifier, so that the voltage to the power supply can be brought up to the required level steadily, and with the surges resulting from on/off switching completely avoided. Excellent bench type Variacs, fully shrouded, can now be obtained at most reasonable prices. One carrying 2.5 amps will be adequate. If Variac control is included, a high reading voltmeter is almost essential to make the most of this power control facility. This feature is included on the panel of the writer's linear amplifier. Suitable meters reading up to 3,500 volts d.c. can be obtained from dealers in surplus equipment at very reasonable prices.

Finally, it must be stated that very high voltages at quite considerable current values are given in this unit. Treat it therefore with great respect and always remember that one moment of thoughtlessness may very easily lead to sudden DEATH.

[2] See "Radio Topics" in the April 1965 issue.

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

H.M.V. Radiogram Model 800.—J. B. Sladen, 213 Milnrow Road, Rochdale, Lancs,—service manual, willing to purchase.

* * *

Grundig TK20 Tape Recorder.—J. Cowley, 10 Westways, Bedhampton, Havant, Hants,—service sheet, circuit diagram or any other details.

* * *

Philips Record-Changer.—C. H. Leedham, St. Elmo, Sandersfield Gardens, Banstead, Surrey,—service sheet or manual for this type A.G.1015 changer, all expenses met.

* * *

Ferguson 204XL Receiver.—D. Witt, 3 Woodside, Cottages, Spital Road, Bromborough, Wirral, Cheshire,—any information. Also circuit or service sheet for Fidelity tape recorder Argyle Minor.

* * *

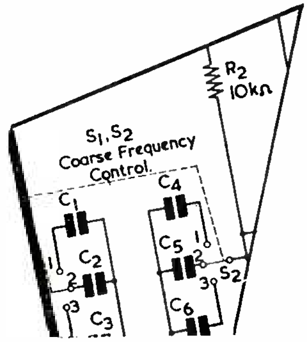
R1949 V.H.F. Receiver.—J. Donnelly, 19 Ashbrook Road, Old Windsor, Berks,—circuit or service manual, loan or purchase, all expenses met.

* * *

Power Supply and L. F. Amplifier.—J. Ayres, 7 Berrylands Road, Surbiton, Surrey,—circuit diagram loan or purchase. Unit bears the legend "Unit No. 2 ZA35737".

* * *

Pilot Record-Player.—P. S. Thomas, 6 Stevenson House, Boundary Road, London, N.W.8.—purchased some 8 years ago, this model is fitted with a Monarch BSR deck—circuit or any information.



Simple Add-On B.F.O. Unit

SUGGESTED CIRCUIT No. 189

By G. A. FRENCH

Many transistor and valve superhet radio receivers intended for domestic listening have short wave bands. Whilst the majority of these receivers give quite acceptable sensitivity and selectivity, they are not attractive for the keen short wave listener because they are not fitted with beat frequency oscillators to enable morse c.w. transmissions to be read.

It is, however, quite a simple matter to construct a separate b.f.o. unit which may be easily coupled to a domestic receiver of this type, and a suitable circuit is given in this month's article. The b.f.o. unit to be described employs a single transistor, and the complete circuit, together with its own battery, may be housed in a small metal case. A screened lead from this case couples into the receiver i.f. amplifier circuits. Advantages of the unit are that no direct connection to the receiver is required, that it may be employed with both transistor and valve sets having an i.f. between 450 and 475 kc/s, and that complete isolation is given if the receiver has a chassis which is connected to one side of the mains supply.

A secondary feature, and one which may appeal to the more experimentally minded, is that only two connections are needed to the oscillator tuned circuit. Experimenters interested in the arrangement may visualise other applications in which two-terminal connection to an oscillator tuned circuit can be of advantage. Despite the somewhat unusual method of oscillator operation, the circuit requires no more components than would be needed by a conventional oscillator with thermal stabilising.

The Circuit

The circuit of the add-on b.f.o. unit appears in Fig. 1. In this diagram the oscillator tuned circuit consists of the parallel combination of L_1, C_1 and C_2. Feedback from the collector to the base occurs via this tuned circuit and C_3, and the tuned circuit provides the requisite 180° reversal of phase needed between collector and base. A chassis connection (in this case a connection to the metal case which houses the unit) has to be made into the oscillator circuit at some convenient point. In Fig. 1 it is made at the collector itself since this enables the bush of C_1, which will be common to its moving vanes, to be mounted direct to the metal panel of the unit. It should be noted that the emitter of TR_1 is *not* at the same r.f. potential as the collector. The 1,000pF capacitor, C_4, in series with the emitter, offers a reactance of about 350Ω at the frequency of oscillation. Resistors R_1, R_2 and R_3 provide stabilising in normal fashion, and have the conventional values associated with thermal stabilising circuits. Further details concerning the oscillator are given later in this article.

As readers will be aware, a beat frequency oscillator in a superhet receiver operates close to the intermediate frequency, with the result that an audible heterodyne is formed with the i.f. resulting from any received carrier. If the received signal is a c.w. transmission the heterodyne is only given when the carrier is present, whereupon the morse signal is reproduced as an audible tone which is only present when the transmitting key is down. The pitch of the tone may be adjusted by varying the frequency of the b.f.o. In the circuit of Fig. 1 this change in pitch is achieved by C_1, which offers a limited range of control over b.f.o. frequency. Capacitor C_2 is a fixed silver-mica component having a value around 300 to 350pF, which has to be found experimentally, whilst L_1 is a standard medium wave coil with iron dust core. In the prototype a Denco Miniature Dual-

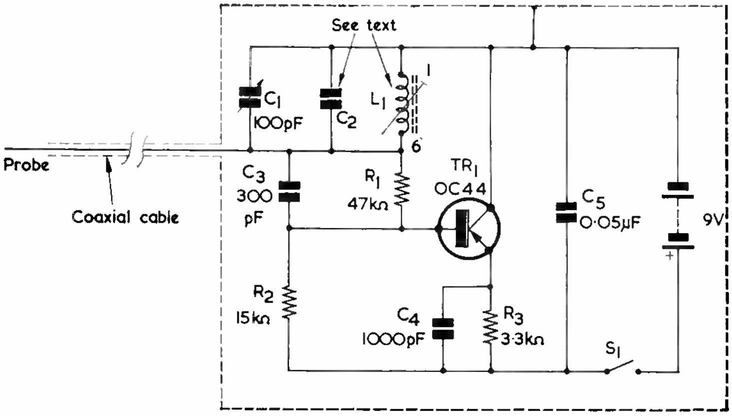


Fig. 1. The circuit of the add-on b.f.o. unit. All components are mounted in a metal case with only the coaxial cable protruding

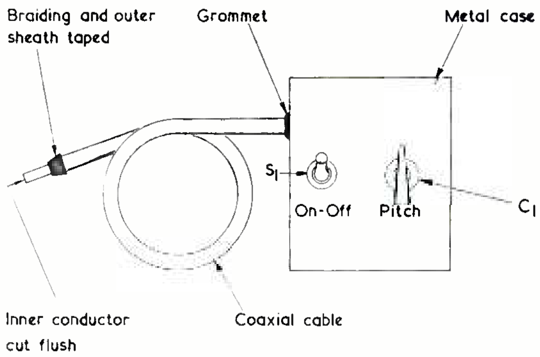


Fig. 2. How the unit may be made up in practical form. Component layout is not critical and if a battery such as the Ever Ready PP3 is used, the metal case can have small dimensions. The unscreened length of centre wire at the end of the coaxial cable forms a probe for coupling the oscillator into the i.f. circuits of the associated receiver

Purpose Coil, Yellow, Range 2, was used here. This is an intervalve coupling coil intended for medium waves and connection was made at pins 1 and 6 to the tuned winding only, the coupling winding being ignored.

Of the remaining components, C_3 should be silver-mica. C_4 can be silver-mica or ceramic, and both capacitors should have a tolerance of $\pm$ 20% or better. C_5 may be a paper or plastic foil component. The resistors should have a tolerance of $\pm$ 10%, and can be either ¼ watt or ⅛ watt.

The whole assembly may be mounted in a metal case, as shown in Fig. 2, from which only the coaxial cable used for coupling into the receiver protrudes. The metal case then provides complete screening for the b.f.o. components.

Receiver Coupling

Receiver coupling is achieved by simply placing the unscreened centre wire at the end of the coaxial cable close to an anode or grid connection, or to a collector or emitter connection, in the receiver i.f. amplifier stages. A capacitive coupling is then provided. The unscreened centre wire forms a probe and the level of b.f.o. injection, relative to signal strength, varies according to the distance between this probe and the wiring in the receiver, and the stage in the receiver i.f. amplifier at which the coupling takes place. Obviously, b.f.o. injection will be at a higher level relative to signal strength if the probe couples in at an early stage in the receiver i.f. amplifier than at a later stage. Most receivers have an a.g.c. delay, whereupon optimum b.f.o. injection occurs when the injection level is just below that which overcomes the delay. However, it is a relatively simple matter to obtain a satisfactory injection level, after the unit has been set up, by working from audible results. The anode and grid circuits in valve receivers operate at high impedance and adequate injection will occur with quite loose coupling from the probe. Transistor i.f. stages work at low impedance and fairly tight coupling from the probe will in consequence be needed. It may, in this case, be necessary to have the probe wire run close to an emitter or collector connection in an early i.f. stage. The degree of coupling depends also on the length of unscreened wire forming the probe. For most applications this could be about an inch in length.

The probe end of the coaxial cable is prepared by initially stripping back the braiding and outer sheath so as to leave about 3in of inner insulated wire exposed. The sheath should be neatly cut away by passing a razor blade around the cable, the strands of braiding then being cut back to the same point. The centre wire is next held in a pair of pliers and the centre insulation over it pushed back to cause it to become compressed. The centre wire and its insulation is then cut about an inch from the end of the outer sheath and braiding. The centre insulation may now be eased back to its natural length whereupon it will extend beyond the end of the centre wire and cause it to be completely covered. The end of the outer sheath and braiding are finally covered with p.v.c. tape to ensure that there is no risk of short-circuits to odd strands of braiding, whereupon the finished cable resembles that shown in Fig. 2. This method of finishing the cable causes both the inner conductor and braiding of the coaxial cable to be covered with insulating material, and the insulation should be adequate to enable the probe to be inserted into the chassis of a working receiver without risk of short-circuits. If further and more reliable insulation is required, the end of the centre lead could also be taped up. *It is essential that this additional tape to the centre lead be applied if the receiver has a chassis which is "live" to one side of the mains.* It will be noted that no connection is made to the receiver chassis.

The coaxial cable may have any convenient length up to about a yard or so. In the b.f.o. unit its braiding is connected to the metal case and its centre lead to the tuned circuit as shown in Fig. 1.

Setting Up

Setting up takes place after construction has been completed, and it consists of finding the value needed in C_2 which causes the oscillator to run at the intermediate frequency when C_1 is at mid-capacitance. Because of a number of variable factors, the value of C_2 has to be found by experiment. The variable factors include the self-capacitance applied across the tuned circuit by the coaxial cable, the effective capacitance applied across the tuned circuit by other components in the oscillator circuit, and the actual intermediate frequency, in the range of 450 to 475 kc/s, employed in the receiver.

A useful approach is possible if the receiver has a medium wave band. The receiver should be switched to this band and the probe of the oscillator unit loosely coupled into the frequency changer by positioning it close to the signal frequency wiring. The b.f.o. unit need not be completely screened at this stage. Also, C_2 is not fitted but is replaced by a 500pF variable capacitor connected temporarily into circuit by short leads. C_1 is set to mid-capacitance, and the core of L_1 about half way into its coil. The receiver is then tuned to a station at around 400 to 450 metres and the 500pF capacitor adjusted to produce a heterodyne. This will occur with the 500pF capacitor vanes nearly fully open, and establishes the fact that the oscillator is running. The correct heterodyne will be stronger than any others which may be heard as the 500pF capacitor is adjusted. The receiver is then tuned to a station at a lower frequency (higher wavelength) and the capacitance of the 500pF capacitor increased to produce the heterodyne again. This process is repeated until the last station at the low frequency end of the medium wave band is reached. The receiver is then kept tuned to this station and the 500pF capacitor further increased in value until another strong heterodyne is formed. This will be given by the b.f.o. running at intermediate frequency and can be confirmed by the fact that heterodynes are now given on *all* stations tuned in on the medium wave band of the receiver.

If the constructor has a capacitance bridge, the value of the 500pF capacitor may then be measured and a fixed capacitor of the same value fitted in the C_2 position. In the absence of a bridge, known fixed capacitors may be connected across the temporary 500pF capacitor, proceeding in "steps" of, say, 100pF, then 50pF, 20pF and so on, until the required capacitance has been "built up" and causes the b.f.o. to run at desired frequency with the 500pF capacitor disconnected. These fixed capacitors may then be replaced by a single capacitor equal to the sum of their values, this being permanently wired into the C_2 position. Any final adjustments which may be needed, as would occur when the probe unit is completely screened, should be within the range of the iron dust core of the coil. It should be added that the use of a temporary 500pF variable capacitor in the manner just described is very helpful because it first of all assures the constructor that the oscillator is operating at intermediate frequency, and it obviates the risk of setting up the oscillator at an incorrect frequency.

After the unit has been set up, the probe may be inserted into the receiver i.f. amplifier circuits as described above.

Oscillator Operation

Some further points concerning the oscillator, and which are not necessarily applicable to the present design, may be of interest. The fact that only two connections are needed for the tuned circuit can be of advantage in some applications. A disadvantage of the circuit is that oscillator components external to the tuned circuit cause additional capacitance to appear across it. These external components are C_3 and C_4 which, due to the forward- conducting base-emitter junction of TR_1, add capacitive reactance across the tuned circuit. In consequence, a wide tuning range with the aid of a variable capacitor is not feasible, since it is impossible to obtain a low value of minimum capacitance in the tuned circuit. With the values for C_3 and C_4 shown in Fig. 1, the tuned circuit behaves as though an effective capacitance of about 100pF were connected permanently across it.

The circuit was checked with two transistors type OC44. With one transistor the circuit continued to oscillate at battery voltages down to 1.4 but, with the second transistor, it ceased to oscillate at 2.3 volts. As a result, it was felt that the supply voltage of 9 specified in Fig. 1 should be more than adequate to cope with all OC44's likely to be encountered. The constructor may, however, reduce this supply voltage to 4.5 or 3 if he desires, provided that the particular OC44 employed oscillates reliably at such voltage.

The coil employed in the L_1 position should not be critical and any iron-dust cored medium wave coil of reasonable Q should function satisfactorily. The writer checked the circuit with a medium wave ferrite rod aerial winding, and found no change in operation.

The current drawn by the prototype with a 9 volt supply was 0.8mA.

Recent Publications

FOULSHAM-SAMS POCKET DICTIONARY OF COMPUTER TERMS. Compiled by the Howard W. Sams Technical Staff. 98 pages, 4 x 6½ in. Published by W. Foulsham & Co. Ltd. Price 10s. 6d.

This dictionary is of very convenient size for the pocket and contains some 1,000 words and terms, each having a definition taking up about one to three dozen words. Also included are several truth tables to illustrate particular terms. After the dictionary section proper, seven pages are devoted to abbreviations and acronyms, together with a list of computer manufacturers and their addresses.

In common with other titles in the Foulsham-Sams Technical Books series, this book has an American text with a short introductory chapter for English readers. This point is reflected in the fact that all the computer manufacturers listed are American.

The computer field is expanding at an almost fantastic rate, and new words are being continually coined as development proceeds. Any permanent record of such terms offers, therefore, a long-term advantage, especially in the prevention of future ambiguity. It should be noted that the dictionary under review deals with American terminology which is, in nearly all cases, common to English usage. The definitions are concise and to the point, and there are extensive cross-references. This will be a helpful book for the newcomer to computer work.

ABC's OF ELECTRONIC ORGANS. By Norman H. Crowhurst. 102 pages, 5½ x 8½ in. Published by W. Foulsham & Co. Ltd. Price 16s.

This book, which also appears in the Foulsham-Sams Technical Book series, deals with electronic organs at a fairly elementary level.

The first chapter discusses the nature of music and takes the reader from pipe organs to a general description of modern electronic organs. Chapter 2 covers sound synthesis as provided, for instance, by tone wheels or reeds, and also deals with square waves, sawtooths, vibrato, percussion and sustain. The third chapter gives brief details of electronic organ fundamentals at block diagram level, whilst the fourth covers organ mechanics with details drawn mainly from commercially made instruments. Chapter 5 is entitled "Choosing An Organ", and uses examples of American manufacture. The next chapter has some 15 pages on organ electronics, and includes basic circuits for transistor, valve and neon tone generators, for keying and vibrato, and for swell control. The final chapter deals with maintenance and trouble-shooting and is followed by a glossary of terms applicable to organs.

TAPE RECORDER TUNER

by G. MAYNARD

This simple receiver will give good medium wave reception for application to a tape recorder. It may also function as a headphone receiver in its own right. An optional feature is the provision of a jack socket for an external battery

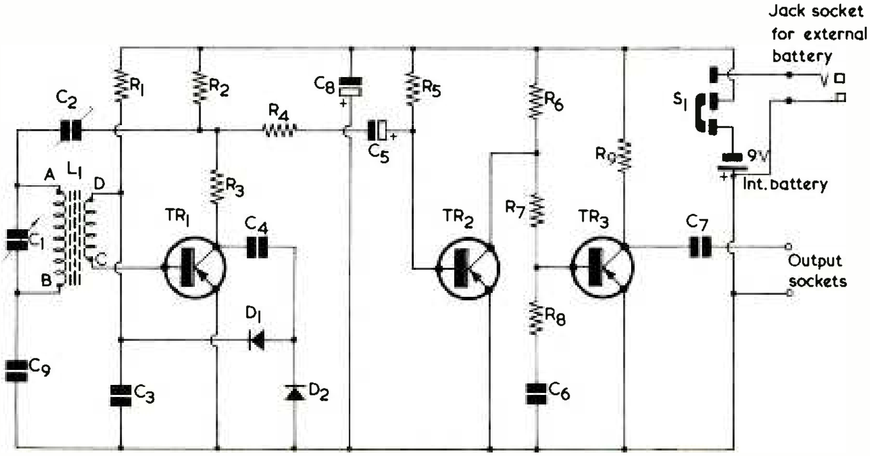


Fig. 1. The circuit of the tuner unit

Components List

N.B. As is described in the text, some components may not be needed if the 2-transistor version is built.

Resistors

(All resistors $^1/_{10}$ watt 10%)

R_1 220kΩ
R_2 1kΩ
R_3 1kΩ
R_4 10kΩ
R_5 220kΩ
R_6 3.9kΩ
R_7 100kΩ
R_8 22kΩ
R_9 1kΩ

Capacitors

C_1 500pF variable, solid dielectric (see text)
C_2 250pF trimmer
C_3 0.02μF ceramic disc
C_4 250pF silver-mica or ceramic
C_5 10μF electrolytic, 9V wkg.
C_6 0.01μF ceramic disc
C_7 0.1μF paper or polyester
C_8 500μF electrolytic, 9V wkg.
C_9 60pF silver-mica or ceramic (see text)

Semiconductors

TR_1 OC44
TR_2 OC71
TR_3 OC71
D_1 OA71
D_2 OA71

Inductor

L_1 Ferrite aerial with feedback winding (see text)

Switch

S_1 d.p.d.t. slide switch

Miscellaneous

Output sockets
Jack socket and plug (see text)
9-volt battery type PP3 (Ever Ready)

THE WRITER ENJOYS GOOD QUALITY MUSIC AND frequently makes tape recordings of broadcast programmes. Originally, the tape recorder microphone was held near the radio receiver loudspeaker, but an obvious lack of fidelity resulted from this method of recording. Also, it was impossible to stop people coming into the room and spoiling the recording just when it was reaching its most important point!

This provided the motive for constructing the tuner described here. The design is versatile and the tuner can be employed as a 2-transistor unit, or as a 3-transistor unit with bass boost. It may feed high impedance headphones instead of the tape recorder, if desired, and an optional jack socket can be fitted for running from an external battery.

A reflex circuit is employed, and this obviates the alignment problems necessary with a superhet.

The Circuit

The circuit of the receiver, in its 3-transistor form is given in Fig. 1.

The tuned signal is applied to the base of TR_1 via the coupling coil, CD, and is amplified at r.f. The amplified r.f. signal appears at the collector of TR_1 and some of this is fed back to the tuned coil, AB, via R_3 and C_2 to provide regeneration. The output from the collector of TR_1 is fed to the detector circuit, D_1 and D_2, by way of C_4, and the detected signal is next fed back to the base of TR_1 through the coupling coil CD. The amplified a.f signal at the collector of TR_1 is passed to the base of TR_2 via R_3, R_4 and C_5. The signal is amplified by TR_2 then taken through a bass boost circuit given by R_7, C_6 and R_8, to the base of TR_3. Resistors R_6 and R_7 provide base bias for TR_3. The amplified a.f. signal at the collector of TR_3 is finally passed to the output sockets via C_7.

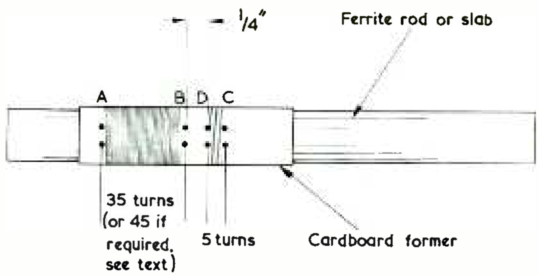


Fig. 2. Details of the ferrite aerial windings

In most reflex circuits a choke would be used instead of R_3, whilst C_2 would have a much smaller value and it would be directly coupled to the collector of TR_1; but the writer feels that these arrangements make the circuit more critical than the design shown here.

Another point worth noting is the presence of R_4. Without this resistor no reaction could take

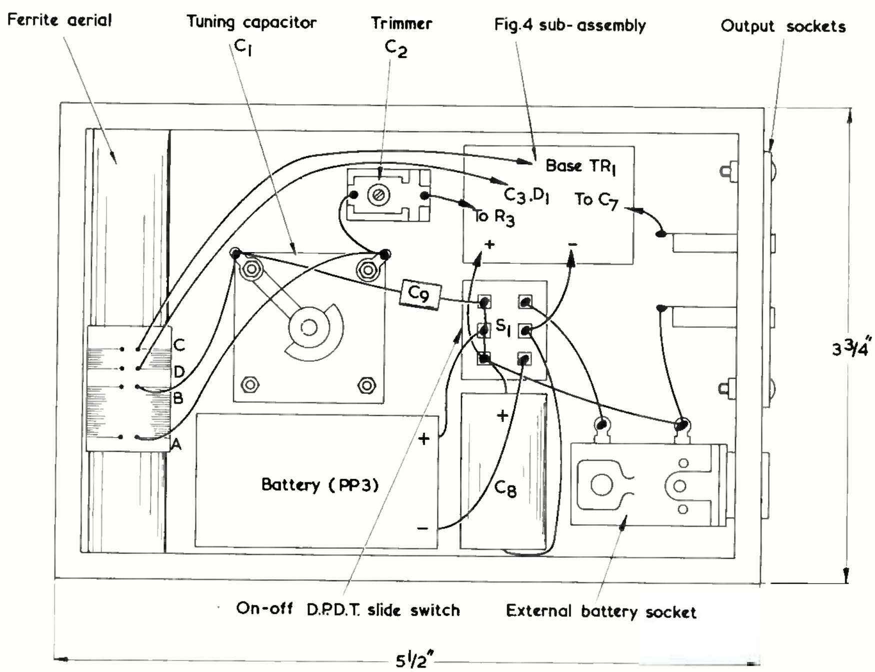


Fig. 3. The layout employed in the author's receiver for the larger components

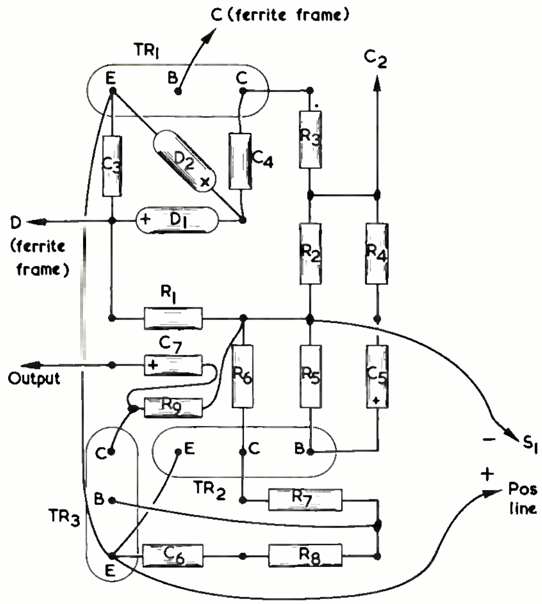


Fig. 4. The smaller components are fitted to a piece of Paxolin, making up a sub-assembly with the layout shown here. Note that the connection point for the collector of TR_2 is between the connection points for the emitter and base. With TR_1 and TR_3 it is the connection point for the base which is in the centre

place, since much of the feedback signal would be passed to the positive line by way of C_5 and TR_2.

No stabilisation is employed for any of the transistors, and no trouble has been experienced, over a considerable period of use, from thermal runaway or any similar effects.

If the constructor is interested in economy, the design may employ TR_1 and TR_2 only. R_7, C_6, R_8, R_9 and TR_3 may then be omitted, C_7 connecting directly to the collector of TR_2.

The small internal battery has a working life of at least 2 months but a saving can still be made, if desired, by using a large external battery when, for instance, the receiver is operated at home. When slide switch S_1 is set to disconnect the internal battery, it connects the negative line to the jack socket. If a jack plug connected to an external battery is then applied, the receiver will function from that battery. It should be noted that, with some jack sockets, a momentary short-circuit of the jack plug may occur when it is inserted. In consequence, the connections to the terminal clips of the external battery should only be completed after the plug has been inserted. The negative terminal of the external battery connects to the jack plug tip and its positive terminal to the jack plug sleeve. If the external battery facility is not required the jack socket can be omitted, whereupon S_1 functions as a simple on/off switch.

C_9 is included to obviate a breakthrough effect which is liable to occur when the output of the unit is connected to mains-driven equipment. Without this capacitor, connection to the mains equipment can result in excessive pick-up of local signals by way of the mains wiring. However, the low capacitance of C_9 prevents this effect and gives a considerable increase in selectivity. If the unit is to be used only as a receiver, without any connections to mains-driven equipment or to any other external wiring, C_9 may be omitted. The lower terminals of C_1 and winding AB then connect directly to the positive supply line.

The prototype picked up many stations, both home and Continental. When used as a receiver, acceptable results are given with an earpiece having an impedance of 1kΩ or more.

The Ferrite Aerial

Details of the ferrite aerial are shown in Fig. 2. The author employed a ferrite slab measuring $2\frac{1}{2}$ x $\frac{5}{8}$ x $\frac{1}{8}$in, but a short rod of approximately similar dimensions would also cope. The tuned winding, AB, has 35 turns, close-wound, of 36 s.w.g. enamelled wire, this being suitable for medium wave coverage with a 500pF tuning capacitor in the C_1 position. A 200pF tuning capacitor may also be used, in which case winding AB should have 45 turns. A slight adjustment in the number of turns may be required for ferrite rods or slabs having dimensions markedly different from the slab used by the author. Some adjustment of inductance is also, of course, given by sliding the coil along the ferrite core. Winding CD consists of 5 turns of 36 s.w.g. enamelled wire close-wound, spaced about $\frac{1}{4}$in from winding AB. Both coils are wound on a cardboard former giving a sliding fit over the ferrite core. The letters A, B, C and D in Fig. 2 indicate coil terminations, and correspond to the same letters in Fig. 1.

Construction and Testing

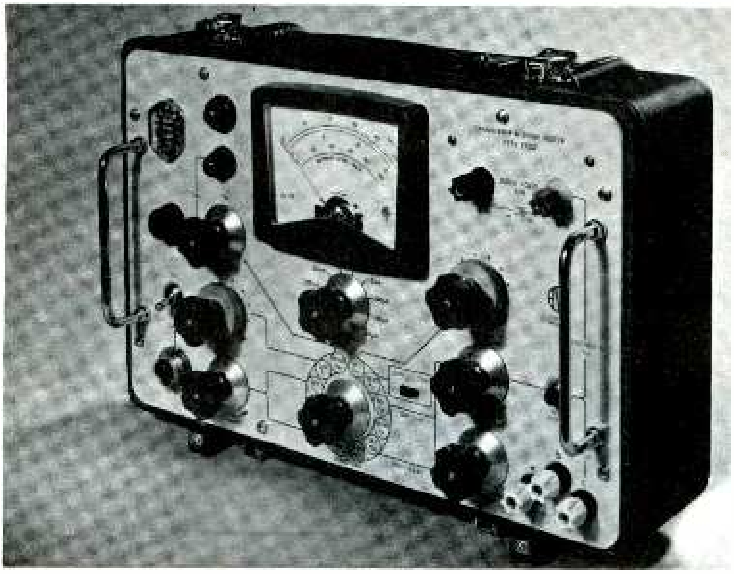
The writer built the prototype 3-transistor version in a cigar box using the general layout shown in Fig. 3. This layout may be modified, as desired, to suit alternative cases or components of different size. The semiconductors, resistors and most of the capacitors were fitted to a sub-assembly having the component layout shown in Fig. 4. This sub-assembly employed a small sheet of Paxolin to which the parts were secured and, by using miniature resistors and capacitors, the writer's version measured only slightly more than 1 x $1\frac{1}{4}$in. However, there is no necessity to make the sub-assembly as small as this, and some constructors may favour a more open layout on a larger piece of Paxolin.

Fig. 3 shows the wiring to the sub-assembly, and it includes the optional jack socket for the external battery mentioned earlier. The writer used a double pole slide switch for S_1, the three unused tags being connected together and employed as anchor tags for the positive supply line connections.

When soldering the semiconductors or miniature components (if used) always use a heat shunt such as a pair of long nosed pliers. Never cut the transistor wires too short because, apart from the risk of overheating during wiring, it may be impossible later to unsolder them without damage.

After completion, make a careful check of the wiring before switching on. To test if the receiver is working, touch the base of TR_1 with a screwdriver against whose blade a finger is held. This should cause a click to be heard in the headphones connected to the output (or in an amplifier speaker if the unit is coupled to an amplifier). Rotate the tuning capacitor until a station is heard, then increase the value of C_2 until more stations can be tuned in. Next, select a station at the high frequency end of the band, such as Luxembourg, and adjust C_2 until the receiver is just on the point of oscillation. The tuner is then ready for permanent use.

NEWS . . . AND .



Transistor and Diode Tester Type TT537

The Avo Transistor and Diode Tester type TT537 provides, in one instrument, facilities for both transistor and diode testing. The tester is a compact, simple to operate, direct reading instrument providing an accurate and convenient method for the measurement of transistor and diode characteristics.

Provision is made for the rapid and accurate measurement of transistor h_{fe} up to 1,500 at a frequency of approximately 1 kc/s and the measurement of leakage current with a first indication of 1μA for both p.n.p. and n.p.n. low medium power germanium or silicon transistors.

Both the forward and reverse characteristics of diodes can be measured, the reverse characteristics at voltages up to 1,000V under current limiting conditions.

The design of the instrument enables accurate measurements to be made with the minimum of adjustments and setting-up. The layout of the panel controls is such that operation of the instrument, which centres around a function switch and a transistor diode selector switch is largely self-explanatory. The panel markings are colour-coded and these features together with the protective devices incorporated in the instrument provide an ideal tester for use not only by engineers and technicians but also by unskilled personnel.

Announcement from Denham & Morley Ltd.

Tate Electronic Services Limited have been appointed Service Agents for servicing in and out of guarantee mains radios distributed by Denham & Morley Limited. Depots who will accept service are: The Grange, Hoole Road, Hoole, Chester. 31 Chapel Street, Halton, Leeds. 444a New Chester Road, Rockferry, Nr. Birkenhead. 21 Crossgates, Durham. Mandervell Road, Oadby, Leicester. Vicar Street, Sedgley, Staffordshire. 3 Waterloo Road, Stockport. The Green, Chorlton-cum-Hardy, Manchester 21.

Self Binders

Our advertisement columns contain details of a new type of self-binder available for those who like to retain their copies of *The Radio Constructor* in good condition.

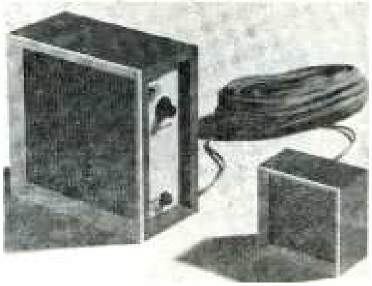
These self-binders are quite the best that we have seen. They are immensely strong, most attractive in appearance and delightfully simple in the ease with which copies can be inserted or removed. This latter is achieved by the use of especially constructed binding cords made from Super Linen very hard twisted and twice doubled attached to strong *rustless* springs.

We can recommend these binders with every confidence

New Baby Alarm

An intercom system with the great advantage of two-way communication is being produced as a baby alarm by Rovex Scale Models Ltd. Being a two-way system, mother can reassure her child without being disturbed or having to go to its nursery.

The Tri-onic baby alarm is battery operated and transistorised in a neatly designed modern housing made of polystyrene which is assembled with the aid of adhesive developed to give maximum efficiency with this material. The special adhesive used is one of a range of custom made adhesives supplied by BX Plastics Ltd. of Manningtree, Essex under the trade name Bexol.



The new baby alarm by Rovex Scale Models Ltd.

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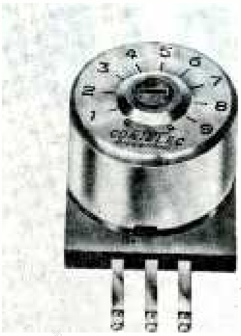
COMMENT



World Championships for Control Line Model Aircraft

Our many readers interested in radio control should find the above event of absorbing interest for, in addition to the championships, there will be the attraction of aerobatic displays in jet aircraft by pilots of the R.A.F.

The Royal Air Force, through its Technical Training Command station, R.A.F. Swinderby, near Lincoln, will be host from 26th to 30th August to the World Championships for Control Line Model Aircraft, for which 17 nations ranging from the U.S.S.R. to the U.S.A. have already entered, and for which entries are expected from a further 12 ranging from Japan to Monaco.

This will be the first time that world control line championships, of which the Duke of Edinburgh is 1966 Patron, will have been held in England, and the first time in which they will have been held on a fully-equipped Service airfield, with the variety of amenities and facilities which an R.A.F. station can provide.

Some 280 competitors, managers and others will be housed and fed at R.A.F. Swinderby, home of No. 7 School of Recruit Training, with the R.A.F. Model Aircraft Association handling the organisation jointly with the sponsor of the event, the Society of Model Aeronautical Engineers. Air Marshall M.K.D. Porter, Air Officer Commanding-in-Chief, R.A.F. Maintenance Command, is president of the R.A.F.M.A.A., and Air Vice-Marshal B.A. Chacksfield, Commandant-General, R.A.F. Regiment, is president of the S.M.A.E.

The Championships will open with a flying display to include formation aèrobatics by the aerobatic team from No. 1 Flying Training School, R.A.F. Linton-on-Ouse, Yorkshire, flying Jet Provosts, solo aerobatics in a jet fighter, gliding aerobatics by a pilot of the R.A.F. Gliding and Soaring Association, and possibly a display by the "Sky Divers", the Army's parachute display team. Cadets of the Northumberland Wing, Air Training Corps, will be helping in various ways with the organisational side. There will be a large static exhibition of models in a hangar, including those of the famous Peter Farrar Collection from Exeter. All proceeds from the admission charge to the exhibition will go to the R.A.F. Benevolent Fund.

The countries already entered— the U.S.S.R.'s party of over 16 will be the largest contingent—are Belgium, Canada, Czechoslovakia, Denmark, Eire, Finland, France, Great Britain, Holland, Hungary, Israel, Poland, Sweden, U.S.A., West Germany, and Yugoslavia. Countries from which entries are still awaited are Austria, Bulgaria, Italy, Japan, Luxembourg, Monaco, Norway, Portugal, Roumania.

Wirewound Potentiometers for Printed Circuits

W. Greenwood (London) Limited have introduced a new wirewound adjustment potentiometer specifically designed for direct mounting on to printed circuit boards.

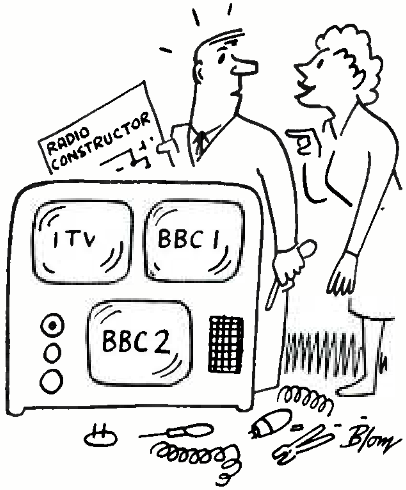
This precision component is a single turn potentiometer with outstanding humidity performance. It has a power rating of 1.5 watts at 50°C. and is available in a resistance range from 10Ω to 50Ω. The solder pins are gold plated.

The principal features of this potentiometer are: side mounting unit for printed circuit boards, screwdriver adjustment for accurate self-locking electrical settings, outstanding humidity performance, precious metal contacts, nickel and goldplated solderpins, stops provided at each end of travel, excellent shock and vibration stability. The potentiometer is one of a comprehensive range manufactured by Contelec of Switzerland.

Company Name Change

To bring the company name into line with its product range, the name of Standard Telephones and Cables (Transistors) Limited has been changed to S.T.C. Semiconductors Limited.

The company is the newly formed subsidiary of S.T.C. in which the semiconductor operations at Footscray, Kent, and Harlow, Essex, are now consolidated. Its product range covers transistors, integrated circuits, signal diodes, silicon rectifiers, Zener diodes and thyristors.



"... *Any Pirate TV?*"

Modifications to the CR100

by W. STUDLEY

Some simple modifications which can be carried out on the CR100 and similar receivers

Many amateur and short wave listening stations are equipped with Marconi CR100/B28 receivers. These receivers offer good value for money and can do an excellent job even in these so called "modern days" of high QRM and QRN levels! One criticism fairly aimed at the CR100, however, is that it tends to drift, since no stabilised h.t. supply for either the b.f.o. or local oscillator is fitted. The problem of local oscillator drift does not normally cause much inconvenience in practice and is simply overcome if the receiver is switched on for some time prior to operation. It is with the b.f.o. that the drift problem is most serious, because this is normally only switched in for c.w. or for s.s.b. reception and no preliminary running period can take place. Drift in the b.f.o. is particularly aggravating when attempts are made to resolve s.s.b. as constant resetting of the b.f.o. control is needed. Due to this factor it is not unusual for most of an "over" to be missed completely, and such a state of affairs is intolerable.

Stabilising the h.t. supply to the b.f.o. is, therefore, essential. Fortunately, this can be done fairly easily without any serious alterations to the receiver.

Stabilising the BFO Supply

Normally, h.t. is applied to the b.f.o. valve when the operational switch is set to either "CW—AVC" or "CW—MAN". Referring to Fig. 1(*a*), resistor R_{54} (100kΩ) is the b.f.o. valve anode load resistor and R_{46} (22kΩ) the decoupling resistor. A voltage slightly in excess of 220 should appear at the junction of these two resistors, and series connected voltage stabilisers may be connected to this point as is indicated by the heavy lines. It should be noted that if the d.c. potential at point "A" in the diagram is reduced overmuch, inadequate b.f.o. injection might result. Whilst this may not

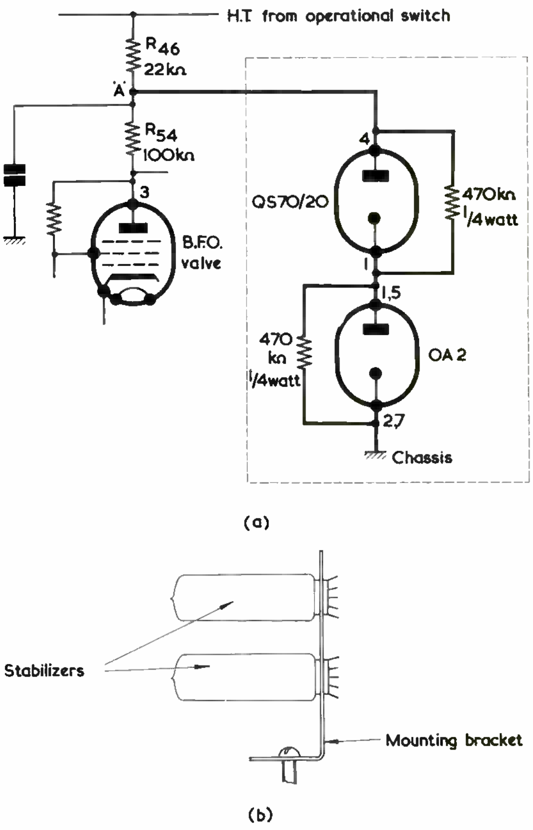


Fig. 1(a). Adding an h.t. stabilising circuit to the b.f.o. The additional circuit is shown in heavy line (b). Mounting the stabiliser valves be serious with c.w. reception, when s.s.b. signal are sought, difficulty will be experienced in reading them unless the r.f. gain is retarded excessively. The b.f.o. output needs to be as large as is conveniently possible and the use of a single stabiliser tube is thus ruled out. A single OA2 for example, would only permit a potential of some 150 volts to appear at point "A", and this may be considered inadequate as has been found by experiment. By using the two tubes specified, however, little difficulty will be experienced.*

Mechanical Details

If the CR100 is turned upside-down and its base plate removed it will be found possible to mount a small sub-chassis at the rear of the b.f.o. screening can. The B7G valveholders for the stabilisers are fitted to a small L-shaped piece of aluminium as indicated in Fig.1(*b*). This sub-chassis is wired beforehand and fitted with a flying lead for connection to point "A", the connection to chassis being made automatically when the assembly is bolted in position. The underside of the assembly—the pins of the tubes—should face the panel. Looking at the receiver chassis from the front, a strip carrying seven vertically mounted resistors and a capacitor will be seen along the left-hand side. The flying lead from the added sub-chassis should be connected to R_{46} the second resistor from the front panel (22kΩ), on the side more difficult to get at; i.e., the end of the resistor nearer the receiver chassis underside surface.

To test the modification set the Operational switch to "MOD—AVC". With the receiver switched on both stabiliser tubes should remain dead, but they should glow when the Operational switch is adjusted to "CW—AVC" or "CW—MAN".

Adding Side-tone/Muting Facilities

The CR100 and other receivers not equipped with side-tone and muting facilities can easily be adapted, although the modification is only normally required when a transmitter is to be used close by. The "front end" of a receiver not suitably operated can be heavily overloaded if left running whilst a transmitter tuned to the same frequency is radiating nearby (as occurs at amateur stations) and damage can result. For this reason it is advisable either to mute the receiver completely, perhaps by switching it off manually on "Transmit" (and the CR100 does have a "Stand-by" position accommodated on the Operational switch) or to silence it via a relay operated automatically by the transmitter. Partial and automatic muting is even better, for the operator may then monitor his own signals via the receiver when

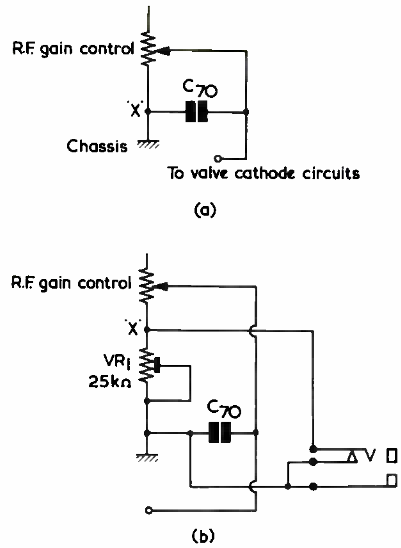


Fig. 2(a). The existing r.f. gain control circuit (b). Adding a preset gain control (VR_1) to give side-tone and muting facilities. The additional control is only brought into circuit when a plug is inserted in the jack

phones are in use. One practical system which can be adopted is illustrated in Fig. 2, where the existing r.f. gain control is shown connected to chassis at point "X", as in (*a*). By lifting the earthy end of the r.f. gain control from chassis and fitting a closed-circuit jack socket and a 25kΩ preset potentiometer, as in (*b*), it is clear that nothing is changed functionally until a jack plug is inserted, whereupon extra resistance due to VR_1 is introduced. If the leads to the jack plug are connected to a relay energised and operated by the transmitter, VR_1 can be switched in and out of circuit automatically via the "Transmit/Receive" switch. The relay contacts should be open during "Transmit". The effectiveness of VR_1 is determined by its precise resistance setting, and it should be adjusted so that when the associated transmitter is operating, the receiver passes sufficient signal for monitoring purposes. It should be added that a circuit of this type is already fitted to the CR100/2 which does not, in consequence, require altering.

Practical Modification

Fitting the additional items to a CR100 is simple. First remove all knobs and the front panel. Locate the earthy end of the r.f. gain control and disconnect the lead to this tag. Potentiometer VR_1 may then be mounted on the tuning capacitor frame, or nearby, by means of a small L-shaped bracket in such a position that its control shaft points upwards towards the lid of the receiver for subsequent adjustment

* The OA2 has a burning voltage of 150 and the QS70/20 a burning voltage of 70, and it might be considered that these would not strike reliably when the voltage at point "A" is of the order of 220 volts only. However, the author confirms that the stabilisers work excellently and never fail to strike in the CR100 modified by himself. Should difficulty be experienced in this respect, R_{46} could be reduced in value by connecting another 22kΩ resistor across it. The position of R_{46} in the chassis is discussed later in the text.—Editor.

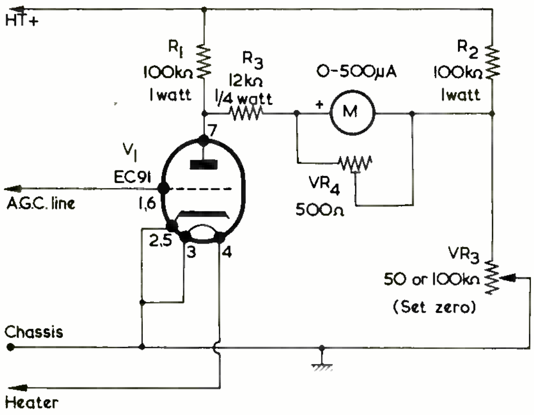


Fig. 3. An add-on circuit which enables a forward-reading S-meter to be incorporated

purposes. At the rear of the chassis a suitable point for locating the closed-circuit jack socket exists alongside the aerial connector. A single lead is then run from the jack to point "X" of Fig. 2(*b*) and VR_1 and the r.f. gain control wired appropriately. The receiver will now function as if unmodified in this respect, until switching due to an external transmitter-controlled relay is introduced via the jack.

Adding a Signal Strength ("S") Meter

Although S-meters are normally calibrated rather arbitrarily, they tend to give only approximate indications of received signal strength. They are, however, very useful aids when tuning or netting. Some operators rely on their S-meters more than others but it is thought that a great many of the "S" reports heard over the air have been aurally rather than visually assessed. Even so, an S-meter is of definite value, provided the limitations of the device are appreciated, at both amateur and s.w.l. stations.

There are various ways of adding an S-meter to a receiver, the usual plan being to sample the a.g.c. line voltage and use it to deflect the pointer of a meter. To avoid interfering with receiver constants excessively a small "add-on" type of meter actuating circuit is suggested, and a suitable bridge-type, forward-reading circuit is shown in Fig. 3. Here, under no signal conditions, V_1 passes a current through R_1, and the potential appearing at the anode of the valve is balanced out by the adjustable potentiometer circuit given by R_2 and VR_3. Provided VR_3 is correctly adjusted, the result is that the meter pointer remains at zero. If, now, the potential at the valve grid goes negative due to reception of a signal, the current passed by the valve falls and the potential at its anode goes positive, resulting in a deflection of the meter pointer. The amount of deflection depends on the negative potential applied to the valve grid and it follows that, by connecting this directly to the receiver a.g.c. line, changes in signal strength may be indicated by the meter. The fact that no grid resistor is shown in Fig. 3 is of no consequence, for the a.g.c. diode load resistor provides the necessary return circuit to chassis.

Preset resistor VR_4 is a meter sensitivity control, and enables full-scale deflection to correspond to the strongest signal it is anticipated will be received.

Modification Details

The EC91 valve is on the B7G base and it is an easy matter to build the oddment of added circuitry shown in Fig. 3 on a small L-shaped sub-chassis equipped with three colour-coded flying leads, the fourth (chassis) lead connection being automatically made when the assembly is mounted.

In the CR100 a small assembly can, with care, be contained under the chassis in the i.f. stages compartment that runs along the right-hand under-side, looking from the front. The heater fly-lead can be soldered to pin 2 of V_5 and the h.t. fly-lead to the receiver h.t. positive lead where it connects to R_{21}, the screen-grid feed resistor for V_5.

With the receiver switched off, locate R_4 (47kΩ), which is the second resistor from the front on the right hand side of the chassis (chassis upside-down and knobs to the front). R_4 is the a.g.c. feed resistor for V_5 and it connects, via the second i.f. transformer, to the top cap of V_5. Confirm this point with an ohmmeter. The end of R_4 remote from the i.f. transformer (which will, of course, measure 47kΩ to the top cap of V5) connects to the main a.g.c. line and should show a resistance of approximately 1MΩ to chassis when the Operational switch is in one of the two "AVC" positions, and zero resistance to chassis when the switch is in either "MAN" position. Having confirmed these points, connect the flying lead from pins 1 and 6 of the EC91 to the end of R_4 remote from the i.f. transformer (as just determined).

The meter movement itself may be mounted to the left of the main tuning dial and VR_3 may be located on the panel between the r.f. gain control and the tuning knob. If maximum S-meter indications are required it is beneficial to reduce the a.g.c. delay voltage, and this can be done by short-circuiting the 10kΩ resistor connected between the earthy end of the volume control and the chassis.

Testing the S-meter

With the receiver switched on and the Operational switch set to "MOD—AVC", VR_3 should be adjusted to give a zero meter reading when no aerial is connected. Immediately the aerial is connected and the r.f. gain advanced any signal tuned in should cause the S-meter pointer to move in the full-scale direction. If a commercial transmission is sought somewhere near the 40-metre band, where signal strengths tend to vary rather widely, the effectiveness of the S-meter may be assessed. The effect of the receiver aerial trimmer, the r.f. gain control and any externally used tuning unit will also be observable and it will soon be appreciated how useful the added S-meter can be.

Comprehensive Volume Control Circuit

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

The provision of an adequate volume control in straight and reflex receivers is not a simple matter. This article describes a comprehensive circuit which allows a single potentiometer to control regeneration, r.f. gain and a.f. gain

ALTHOUGH THE SUPERHET CIRCUIT is a good deal more complicated than most straight or reflex circuits, manual volume control is easier to design as the large amount of r.f. and i.f. amplification allows for the use of a considerable amount of automatic control. Manual control can be looked after by a simple potentiometer in the a.f. section.

Most straight and reflex circuits rely to a fair extent on reaction to provide the necessary amplification of weak signals. With some designs, reaction is fixed and a.f. volume control is used, as with superhets; but this often results in loss of sensitivity at some points on the tuning scale, and throughout the scale as the battery ages. Others rely on a variable reaction control, alone, to regulate volume. But with this arrangement it is often impossible to reduce volume satisfactorily when a powerful local station is being received. This difficulty applies with greater force when there is a good deal of high frequency amplification in addition to reaction. For satisfactory control in these circumstances it is preferable for a single control to regulate both reaction and some other form or forms of amplification used by the circuit. A possible solution is to apply pre-set reaction and control the voltage available for either the base or the collector of the transistor in the reaction circuit. But this is not ideal as it can result in overloading and bad volume stability at low volume settings, and there is sometimes interaction with the tuning control when critical reaction is used on weak signals.

A New Approach

Fig. 1 shows, in skeleton form, the circuit of a t.r.f. receiver employing TR_1 as a tuned radio frequency amplifier, TR_2 as a detector or reflex amplifier, and TR_3 as a transformer coupled a.f. amplifier. There would probably be a further a.f. stage or stages. VR_1 is the volume control, and to start with we may consider only that part of its track which lies between the slider and the end connected to the reaction coil, L_2. As there is a winding offering high impedance at a.f. in the output of TR_2, C_1 is kept down to about 1,000pF to preserve the high notes. It will be seen that, as the slider moves towards the end connected to L_2, reaction will take place. This is because the resistance between L_2 and earth is progressively reduced, earth being represented by the negative battery line. VR_1 is a 5kΩ linear control, preferably wirewound.

The decoupling resistor R_1 is an essential part of the circuit since it performs another function in addition to decoupling. It should have a value which will cause a voltage drop of about 0.33V across it. If, for instance, TR_1 passes 1mA, which is a typical figure, it is clear from Ohm's law that R_1 should then be 330Ω. The value of R_1 is, therefore, dependent upon the current passing through TR_1. R_2 has a value of 39kΩ. It will be seen that there is a diode between the high potential end of L_1 and the low potential end of L_2.

Let us assume that a weak station is being received and that, therefore, the slider of VR_1 is adjusted to be close to L_2 in order that reaction may take place. The resistance part of VR_1 being considered will be very small compared with the resistance of R_2, so that the negative end of D_1 (its "anode") will be at nearly −9V. The positive end of D_1 (its "cathode") will be at a potential of 0.33V positive to the −9V line owing to the voltage drop across R_1. The result is that the "cathode" of D_1 will be positive with respect to its "anode". In other words, D_1 is reverse-biased and, provided it is

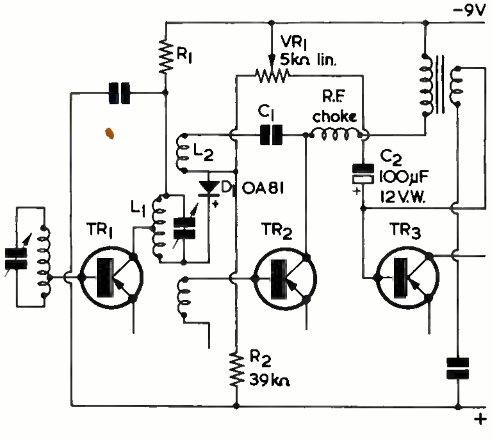


Fig. 1. The volume control circuit fitted in a typical t.r.f. receiver.

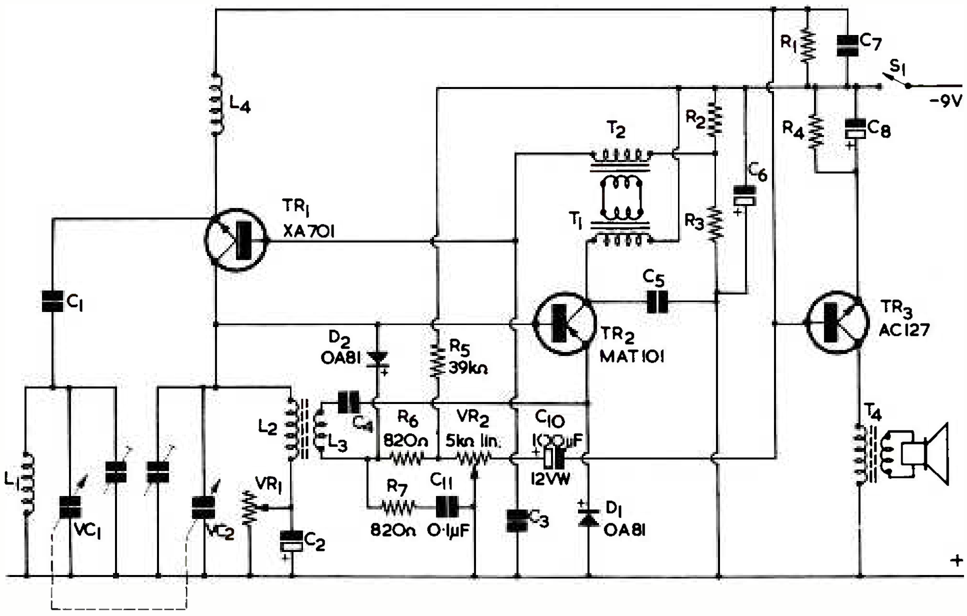


Fig. 2. Incorporating the volume control in the author's "D.R.4." receiver. This is shown switched to 3-transistor operation for reasons of simplicity.

diode of the OA81 type, will have a very high resistance which will cause negligible damping of L_1. Such damping can, in any case, be cancelled out by reaction.

Let us consider the instance where a powerful signal from the local station is received. As the slider of VR_1 will now be adjusted to a point well away from L_2 there will be a resistance of nearly 5kΩ between the negative battery line and the "anode" of D_1 which will find itself more positive than the "cathode". In consequence, D_1 will be forward-biased and will have a low resistance which, in series with VR_1, will damp L_1 considerably. There will still be a tuned circuit, unaffected by D_1, at the input of TR_1, which will provide such selectivity as is required at the low volume control setting used for the local station.

Many readers will see that the circuit just described is similar to the a.g.c. diode damping often used in superhets. The present circuit is, however, adapted for manual control.

A.F. Amplifier Control

It will now be found that there is good control over a powerful local station, though it may still be impossible to reduce it to zero volume level, as L_1 will still offer some impedance despite the shunting effect. This is looked after by a third action on the part of the volume control, this time on the a.f. signal. The section of VR_1 between the slider and C_2 is in parallel with the input to TR_3. At high volume settings the near 5kΩ involved will have little effect. But the signal will disappear when VR_1 is at zero because there is then a short-circuit at a.f., across the input to TR_3.

Complete control is now possible, but even though it will be found to be very smooth from zero to overload on strong signals, there is still the probability that, with weak signals which require critical reaction, there will be rather sudden increase in volume as the control is adjusted. One solution would appear to be to use a graded volume control for VR_1, so that variation of resistance is gradual at the high volume end. But this would require an anti-log control, which is something of a rarity, unless there were no objection to employing a long control wired in such a way that volume increased in an anti-clockwise direction. A more serious difficulty is that, as VR_1 carries a small current, it is important, in the interests of quietness and long life, that it should be wirewound. And wirewound log controls are rare indeed! Yet another snag is that a log control would result in rapid variation of the a.f. signal as zero was approached.

Modifying the "D.R.4."

It is possible to obtain some of the characteristics of a log control by using a fixed resistor across one half of a linear control. This, of course, leaves the other half of the potentiometer unaffected, which is what is wanted, and this dodge will often be found to improve results with reaction circuits. For example, readers who have made the receiver described by the author in the issue for November 1965 ("Simplicity and Sensitivity with 3 Transistors") may find an improvement if they shunt a resistor across the high sensitivity end of its volume control. Different resistors of from 390Ω to 1.8kΩ should be tried for best results. At the cost of slight extra complication, it is possible to arrange something a little better in a way which is especially suitable for circuits having a high degree of constancy in the setting for critical reaction. Such a circuit is the Spontaflex, and Fig. 2 shows how the "D.R.4. Receiver", described in the issue for March 1966 may be modified to incorporate a very satisfactory form of volume control*. Existing relevant components are numbered as in the earlier issue, and the circuit is shown in its 3-transistor form for the sake of simplicity.

First, the original panel control, VR_3, is removed, and the lead which had been taken to its slider is joined instead to the negative battery line. VR_2, originally used as a pre-set control, should be removed from its position inside the receiver and may, if it is suitable, be mounted on the panel and rewired as shown in Fig. 2. If the existing component is not a wirewound type it would be as well to replace it.

In studying Fig. 2 let us at first assume that R_6 is short-circuited and that R_7 and C_{11} are out of circuit. The only purpose of C_{11}, incidentally, is to prevent biasing arrangements being upset. It will then be seen that the volume control arrangements are similar to those in Fig. 1, necessary modifications having been made to suit the use of n.p.n. transistors for TR_1 and TR_3. VR_1 performs the duty of R_1 in Fig. 1. If an existing Spontaflex "D.R.4" is being modified, VR_1 will already have been adjusted in accordance with instructions in the earlier article. If the receiver is being built from scratch, VR_1 should be adjusted so that oscillation at the long wave end of the tuning scale starts with VR_2 set at the lowest point possible. This setting will be found correct both for bias for the base of TR_2 and for satisfactory working of the new volume control arrangements. R_5 is the 39kΩ resistor marked R_2 in Fig. 1, C_4 is the equivalent of C_1, and C_{10} of C_2. D_1 in Fig. 2 is the receiver's existing detector. D_2 in Fig. 2 takes the place of D_1 in Fig. 1.

In the Spontaflex circuit, using the coil specified for the "D.R.4.", it will be found that oscillation starts when there is about 550Ω between L_3 and earth. This assumes that the full negative voltage is applied to the collector of TR_2, as results from the removal of VR_3 from the original circuit. It will also be found that, on a really weak station, the effects of reaction begin to be obvious when there is a resistance of about 600Ω between L_3 and earth. If we still assume that R_6 is short-circuited and R_7 is out of circuit it will be seen that a variation from 550Ω to 600Ω is achieved by a movement of only 1% of the total possible travel of VR_2, and that the useful range for reaction purposes on a weak station will be from 88 to 89% of the total rotation of the potentiometer.

If R_6 remains short-circuited, but R_7 is connected into circuit in parallel with the high potential end of VR_2, it will be necessary to make a readjustment to produce an overall resistance of 550Ω and it can be shown from the formula governing resistances in parallel that approximately 1,600Ω of the track of VR_2 will be required, and 2,200Ω when an overall resistance of 600Ω is needed. The useful part of the track of VR_2 for a weak station now extends from about 56 to 68% of total rotation scale—a more satisfactory range. But about one third of the scale, from 68% upwards, is of no use.

If the short-circuit across R_6 is removed, it will be seen that the necessary 1,600Ω or 2,200Ω requires a resetting of VR_2 because of the constant resistance of 820Ω which is now in series with it. 1,600Ω minus 820Ω is equal to 780Ω, and 2,200Ω minus 820Ω is equal to 1,380Ω. In other words, to achieve a movement from 600Ω to 500Ω will now require a setting of VR_2 varying between about 72 and 84% of total rotation. The range is still 12% of available rotation, and most of the track of VR_2 is useful. The top 16% provides a reserve as the battery fails.

An additional useful effect of R_7 is that it makes the r.f. shunting effect at low settings of the control more marked, the effective resistance across L_2 being reduced from the resistance of D_2 plus nearly 5kΩ to the resistance of D_2 plus less than 820Ω. Thus the control of powerful signals benefits as compared with the arrangement shown in Fig. 1.

General Applications

This circuit, using R_6 and R_7, can, of course, be used in any straight or reflex circuit provided, preferably, that there are at least two tuned circuits, and that the oscillation point is fairly constant throughout the tuning scale. The position or size of the reaction coil should be adjusted so that oscillation starts with about 500Ω to 700Ω between the coil and the slider, R_6 being short-circuited and R_7 out of circuit. There is no need to use an ohmmeter as, if a scale is fitted to VR_2, the resistance of its track in circuit can be evaluated. R_6 and R_7 should each be 1.5 times this resistance.

The volume control circuit will be found to be unusually smooth from zero to maximum for all signals, and there will be no interaction with the tuning control. It is not recommended for use with circuits which offer wide variations of oscillation point for different settings of the tuning control, as the otherwise valuable spreading effect brought about by R_6 and R_7 will tend to make such variations even more marked.

* Sir Douglas Hall, "Simplicity And Sensitivity With 3 Transistors", *The Radio Constructor*, November 1965. Sir Douglas Hall, "The 'Spontaflex' D.R.4. Transistor Portable", *The Radio Constructor*, March 1966.

KUWAIT NATIONAL BROADCASTING STATION

A contract was signed recently for the supply and installation of broadcasting equipment which will give Kuwait the most powerful national broadcasting station in the world. The contract, with the Ministry of Guidance and Information, covers the supply of three Marconi 750kW High Power transmitters of the very latest design, which will provide the Voice of Kuwait with medium frequency programme transmissions giving extensive coverage of the Middle Eastern countries.

Each transmitter has an output of 750 kilowatts, probably the highest power output available from any single transmitter on the market. This is nearly twice the power of the 200 kc/s Light Programme transmitter of the BBC at Droitwich, the most powerful national service in Britain.

This order, worth over £1 million, was won in competition with offers from leading manufacturers in Europe, Russia, Japan and the United States. The transmitters, which are at present being assembled at Marconi's Chelmsford works, are due for delivery next year.

Engineers from The Marconi Company will install and commission the three transmitters, and the contract also provides for the training of six Kuwaiti engineers in the operation and maintenance of the transmitters. This training will take place at the Company's establishments in the Chelmsford area.

The 750kW transmitters are of the very latest design, and are fully transistorised throughout the low power driving circuits. Crystal control is used to give very high stability of the radiated frequency. Vapour cooled tetrode valves are employed in the modulator and high power radio frequency output stages. These valves have a much higher gain than the more conventional triode valves, and together with the use of patented high efficiency circuits, give the transmitters a very high overall efficiency.

CIRCULAR TIMEBASE

By **M. W. SHORES,** N.Z.I.S.T.

A simple experimental method of displaying circular and elliptical traces for purposes of frequency measurement

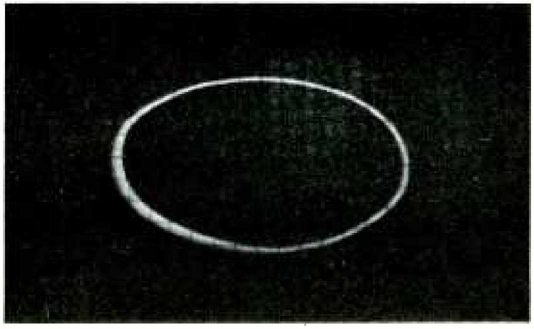
THE SUBJECT OF CIRCULAR AND ELLIPTICAL TIMEbase traces was originally pursued by the writer out of interest only, but at a later stage the practical advantage led to regular use.

The study and manipulation of audio tones and associated circuitry, particularly in the province of Radio Control, indicated a need for an uncomplicated method of establishing frequency. The writer found that the more conventional Lissajous figures in oscilloscope work tended, for him at least, to be confusing. A series of alternative methods were tried and the timebase described in this article was finally adopted as being most satisfactory.

The fundamental requirements for producing a circular trace on the c.r.t. screen are two sine waves of identical frequency 90° out of phase one with the other. One of these signals is applied to the vertical (Y) deflection plates and the other to the horizontal (X) plates.

The Circuit

The circuit employed by the writer appears in the accompanying diagram, and the component values shown relate to the mains frequency of 50 c/s, this being a very useful and stable standard. The use of a 50 c/s standard means that the c.r.t.



A 50 c/s ellipse, with no additional tone applied

Components List

Resistors

R_1	5kΩ	Potentiometer, linear track
R_2	5kΩ	Potentiometer, linear track
R_3	2.2kΩ	½W 10%
R_4	2.2kΩ	½W 10%
R_5	1MΩ	½W 10%
R_6	1MΩ	Potentiometer, linear track
R_7	500kΩ	Potentiometer, linear track
R_8	100kΩ	Potentiometer, linear track

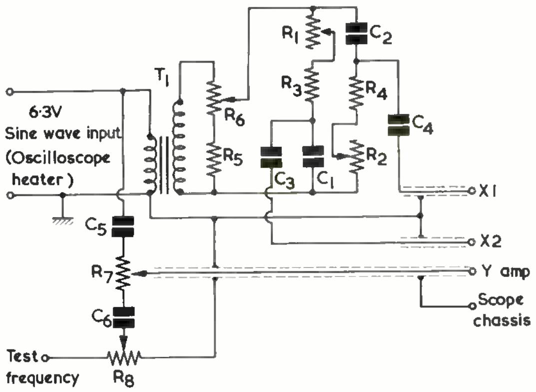
Capacitors

(The working voltage of C_3 and C_4 depends on the oscilloscope being used)

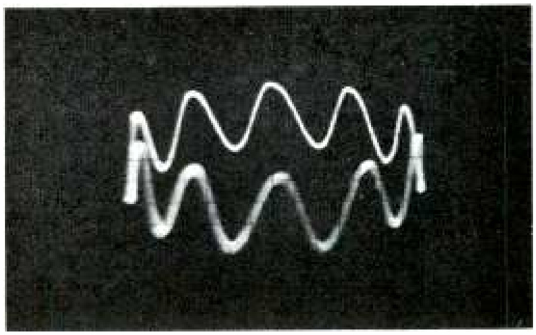
C_1	0.5μF paper 250V wkg.
C_2	0.5μF paper 250V wkg.
C_3	0.25μF paper
C_4	0.25μF paper
C_5	0.05μF paper 250V wkg.
C_6	0.05μF paper 250V wkg.

Transformer

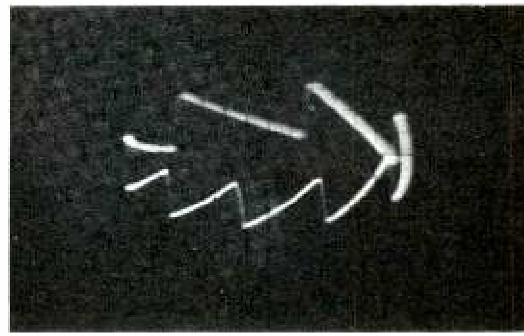
T_1 Step-up transformer (see text)



The timebase employed for frequency measurement



The trace given when a 500 c/s sine wave is applied



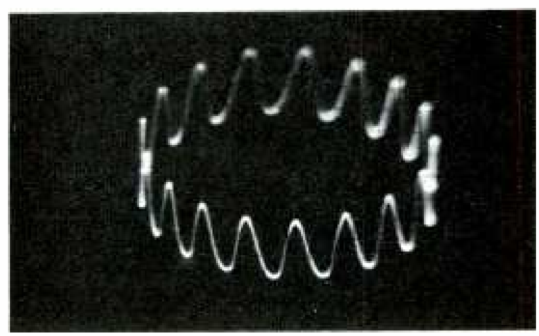
A sawtooth voltage having a frequency of 400 c/s gives this trace

spot takes $^1/_{50}$ second to traverse the full 360°. R_1 and R_2 are variable, allowing for adjustment to offset any difference between the values of C_1 and C_2. Ideally, these capacitors should be identical, as mismatching causes distortion of the trace. However, a considerable amount of correction may be made with the aid of R_1 and R_2. R_1 and R_2 may be preset if good quality components are used, whose value is unlikely to drift. If the amplitudes of the out-of-phase voltages are varied with relation to one another, an ellipse appears instead of a circle.*

Having reached thus far, it only remains to superimpose the tone whose frequency is to be measured. This is applied in the vertical plane only and is mixed with the vertical signal through R_7. The combination of the two signals fed at each end of R_7 appear at its wiper, and are applied to the Y amplifier of the oscilloscope. Using this control in conjunction with Y gain gives the desired visual amplitude of the tone.

Transformer T_1 dispenses with the need for an X amplifier, this being a luxury absent from the writer's home-built oscilloscope. The writer used an old speaker transformer with the 6.3 volt supply applied to its original secondary, whereupon approximately 130 to 150 volts r.m.s. appeared across R_5 and R_6. The 6.3 volt supply was obtained from the heater winding of the oscilloscope mains transformer, and has one side earthed.

It was found necessary to use X shift with the circuit. This raises no problems as C_3 and C_4 isolate any d.c. voltage on the X plates.



Applying an 850 c/s sine wave

The results shown in the photographs illustrate that it is only necessary to count the peaks and multiply by 50 to obtain the exact value of the tone being applied. This allows frequencies at 50 c/s intervals to be established, but a double trace gives the intermediates at 25 c/s intervals. For example if a double trace gives a count of 17 peaks then divide by 2 and multiply by 50 and the frequency is 425 c/s.

* To obtain a true circular trace, the deflecting voltages at X and Y plates should be exactly 90° out of phase, a state of affairs not necessarily provided by the circuit shown here. However, a phase difference of other than 90° can allow an ellipse to be produced, which may be similarly used for frequency measurement. Also, the potentiometers in the circuit provide a wide range of amplitude adjustment and consequent control over the shape of the trace. The oscilloscope timebase is, of course, kept out of action when the circuit is used. —Editor.

SUPER-SPEED GaAs DIODE

One of the factors which limits the speed of operation of computers is the storage of charge in diodes. A point contact gallium arsenide sub-miniature diode has been introduced by the Mullard Company under the development number 54CAY. The switching speed of this device approaches the limit of conventional measuring instruments. The reverse recovery time is only 300 picoseconds and the stored charge 6 picocoulombs. (The prefix pico signifies one million millionth.) Axial wire leads are used.

The diode is finding applications in super-speed switching circuits, oscilloscopes, sampling gates and circuits for measuring particle velocities, apart from a large number of microwave applications.

In Your Workshop

As is his normal practice during August, Smithy the Serviceman, accompanied by his able assistant, Dick, leaves the confines of the Workshop to sample the great out-of-doors. On this occasion the pair still, however, manage to find time to discuss the problems of mass-production and the question of tolerances

"ARE YOU," ASKED SMITHY sympathetically, "having trouble with your rowlocks?"

Dick raised his hand to a perspiring brow, but returned it hastily as he saw the oar it had been holding pass quickly over the side of the boat.

"I'll say I'm having trouble," he complained bitterly, catching hold of the oar just before if finally disappeared over the wale. "As soon as I pull one of these flaming oars it comes right out of the rowlock. What that darned rowlock needs is re-designing, that's what."

Again, Dick pulled on the oars, and again, half-way through the stroke, one of them abruptly disengaged itself and caught him sharply in the chest.

The Serviceman's Approach

Smithy leaned forward and peered inquiringly at the boat fitting which was causing his assistant so much trouble. A light of understanding suddenly gleamed in his eye.

"The fault is obvious," he exclaimed, "you've got it 180 degrees out of phase!"

Smithy turned the rowlock through the 180 degrees of his diagnosis, and manoeuvred the oar back into it.

"Now, try it."

Distrustfully, Dick pulled at the oars once more, to find that, this time, they both pivoted at the rowlocks without further trouble. Encouraged, he repeated the process.

"Now this," he admitted grudgingly, "is a bit more like it. But I don't quite understand what you did just then."

"If you look at that rowlock," explained Smithy, "you'll see that it's shaped like the letter 'C', the open bit being where the oar goes in. That open bit should be away from you but you had it towards you. With the result that, every time you pulled on the oar it just came out of the rowlock."

"Well, I'm dashed," said Dick, impressed. "Dead simple, isn't it?"

"Of course it is," replied Smithy. "But *you* were talking about re-designing it."

Dick forebore to reply and directed his energies to the oars. They were soon moving through the water at a very gratifying speed.

"I must confess," said Smithy, trailing a negligent hand in the water, "that this makes a very pleasant change from the Workshop. I think it was quite a good idea on my part to suggest that we pass part of our Summer outing this year with an hour on the local boating lake."

Dick pulled vigorously at the oars.

"I must admit that it *is* rather a bright idea," he said. "It's funny, though, that our conversation went on to this subject of re-designing."

"Why's that?"

"Because I'd just been thinking," explained Dick, "about the question of re-designing from the point of view of the service engineer."

Smithy sighed.

"And I was mistaken enough," he remarked sorrowfully, "to imagine that we would be getting *away* from the Workshop this afternoon. Blimey, Dick, you don't half keep the hangar door open, you know!"

But Dick had espied a clump of overhanging trees which would shade them from the hot August sun. Resolutely, he rowed the boat towards them and then, equally resolutely, shipped the oars. The boat came to rest, to float undisturbed on the lapping, gentle, water.

"There must," continued Dick inexorably, "be times when *you* do a bit of a re-design on a job that you're servicing."

"Not these days, there aren't," replied Smithy firmly. "I'll agree that we used to get up to tricks like that during and immediately after the war when parts were scarce, but I wouldn't do anything like that nowadays. And certainly not with modern receivers."

"I had a TV in the other day," offered Dick, "and the cathode bypass capacitor for the audio output valve had broken down. It was a 25μF 12 volt working job."

"I presume," said Smithy, his interest aroused despite his previous protestations, "that you carried out the normal service procedure of checking to see what had caused the capacitor to break down before you replaced it?"

"I did," confirmed Dick, "and I could find nothing wrong in the circuit whatsoever."

"The coupling capacitor from the preceding anode," suggested Smithy, "*might* have gone a little leaky. This wouldn't upset the audio quality too much if the leakage was slight, but it could cause the output cathode to rise a little in potential due to cathode-follower action." (Fig. 1).

"I thought of that," said Dick, "and as I looked at the coupling capacitor, I suddenly realised that both this and the electrolytic were spares of the type we keep in the Workshop. What is more, I then recognised the set as one I'd fixed about three months ago for exactly the same fault. There had been a slight suspicion of leakiness in the coupling capacitor on the previous occasion and so I'd swapped it, as well as the electrolytic, just to be on the safe side. Everything else, including the valve and the cathode bias resistor, had checked good on that occasion. They still did yesterday, and the coupling capacitor I'd fitted previously was still perfectly O.K., so I just wired in another electrolytic. This time, though, I put in one with a working voltage of 25."

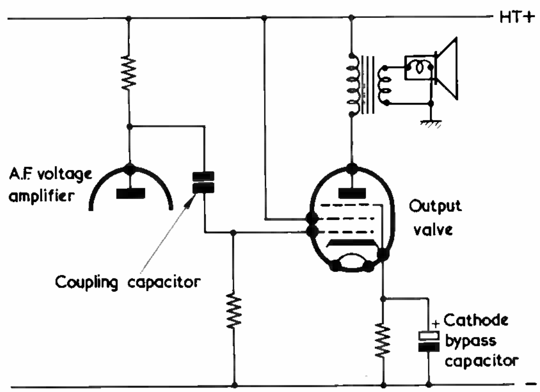


Fig. 1. A high resistance leak in an a.f. coupling capacitor may not seriously affect the quality of reproduction, but it can cause the cathode voltage of the following valve to become increased. A cathode bypass capacitor with a low voltage rating could then suffer risk of breakdown

Different Tolerances

"That," agreed Smithy, "is a reasonable course to take. There *might* be an intermittent in the set causing the cathode potential to go above 12 volts every now and again and make the capacitor break down. Alternatively, it could just be that a combination of high ambient temperature about the capacitor, plus a build-up of tolerances in component values in the circuit around it, has caused it to be on the verge of breaking down all the time."

"The point I now want to make," said Dick, "is this. If the manufacturers put in a 12 volt capacitor and I replace it with a 25 volt one, I'm changing the design. Aren't I?"

"Well, yes you are," admitted Smithy, "but only in a very minor way. Also, we've got to be realistic here. We're not going to get a good name for servicing if that TV you fixed has to come in every three months to have another 12 volt electrolytic fitted in it, are we?"

"What happens," argued Dick, "if it *is* an intermittent which is causing the capacitor to keep breaking down?"

"If there is an intermittent," said Smithy, "it will probably appear again. Should it cause the 25 volt electrolytic to break down as well, we'll then know we've got something serious to look for. And if it doesn't break down the electrolytic it will do something else, whereupon we'll have a helpful guide as to where the intermittent is. Incidentally, I'd have swapped the audio output valve in that set as well, just to be on the safe side."

"I did," said Dick, "on the second occasion it came in. The valve *might* have had an intermittent internal short. Although it seems a little doubtful, since you'd have to have the cathode short over to the screen-grid or the anode."

"The valve would also," Smithy reminded him, "have drawn excessive cathode current if the *grid* had shorted over to the screen, or to the cathode for that matter."

"That's a point," admitted Dick.

The pair fell silent for a moment. It was very peaceful in the shade of the trees. Smithy relaxed and allowed his thoughts to wander from matters electronic.

"In this servicing business," said Dick suddenly, "you've *got* to put in different replacement components sometimes. Which means, again, that you're making a change to receiver design."

Reluctantly, Smithy tore himself from his reverie.

"Have you?" he asked vaguely. "When?"

"If you're out of stock of the exact component," replied Dick. "Say a 20% resistor needs changing, and you've only got 10 per cent's in stock."

"There's no problem there," said Smithy, a little irritably. "It's always perfectly O.K. to change a resistor for another of the same value and a closer tolerance."

"What about the other way round?" asked Dick. "That is, replacing the resistor with another of wider tolerance."

"In that case you want to be a bit careful," said Smithy. "Manufacturers don't normally fit close tolerance resistors if they can use cheaper ones having a wider tolerance. I'll admit that, in practice, you'll very often get away with fitting a 20% resistor in place of a 10% one, and you'll find that the associated circuit still carries on O.K. But there *could* be a slight degradation of performance which isn't evident in bench tests. So far as particular circuits are concerned, TV timebases are probably the most fussy here. You should never use a wider tolerance resistor as a replacement in a TV timebase because you can easily run into difficulties with picture linearity, timebase speed control, and things like that. It's possible, of course, that the 20% resistor you use for a replacement just happens to have a value which is within the 10% tolerance. But you can't rely on this, unless you check its value on a resistance meter which is a bit more accurate than the ohms range of the average knock-about multi-testmeter. A further point is that if a resistor of 5% tolerance, or closer, has gone faulty, you should *always* replace with the same or a tighter tolerance regardless of the circuit it appears in. There'll be a very good reason for a manufacturer of domestic equipment using close tolerances in resistors of the order of 5% or less. So far as general servicing is concerned, a sensible approach here is to stock replacement resistors in 5%, or even closer if they're not too expensive. You're then covered for all replacements of that tolerance and wider, without any further worry at all."

"That," remarked Dick, "seems to be a good idea. Incidentally, whilst we're on the subject of re-design, the manufacturers of TV sets are doing it all the time!"

"How d'you mean?"

"Well," said Dick. "The manufacturers start a new model and then, whilst it's in production, keep on introducing mods all the time. What's more, they send out details about them in their bulletins and other publications. If they're going to make all these changes, why didn't they incorporate them in the original design?"

"That," said Smithy, "is one of the things the service engineer has to live with and learn to accept. As you know, some commercial TV designs are very good and have no changes at all during production, whilst others are shockers. But you have to look at the overall picture in the light of mass-production of a complicated product. A TV set is probably the most complex domestic device which is produced at a competitive price by largely unskilled labour. The initial design of a new TV set is thoroughly tested before it's put into production, and there may also be pre-production runs as well. All the bugs which appear on these first tests are ironed out, and the set then goes into full production. After that, it's just a question of numbers."

"How do you mean—a question of numbers?"

"There may," explained Smithy, "be an unforeseen snag which only occurs in one set in a thousand. To find what that snag is, you've got to *make* a thousand! And to see whether it's a snag which is likely to be recurrent, you've got to make quite a few thousand more, as well. The large manufacturers keep a very sharp eye open for recurrent snags on a model, and one or two of them even have reps travelling all over the country whose only job is to pick up gen from retailers in this respect. Manufacturers also rely on the reports which come back from their own service departments. If a recurrent snag seems to be in existence in a particular model, changes are made to the sets in production to ensure that it doesn't occur in the future sets leaving the factory. If the change is of sufficient importance, dealers and service departments are also advised. Other changes may also be introduced while a set is in production because they result in an improvement in performance. If these are of sufficient importance, the appropriate advice again goes out to the service engineer."

"Blimey," said Dick, impressed. "There's a bit more to it than I thought."

"There is," replied Smithy cheerfully. "If you think life is hectic as a service engineer, you want to have a spell on the manufacturing side!"

Build-Up Of Tolerances

The silence of the shade was suddenly broken by the splash of oars, and the sound of quiet music from a radio. The pair turned round, to see a slim young girl rowing very competently across the lake despite the fact that, due to the weight of her companion in the stern, her end of the boat was almost entirely out of the water. This companion, a heavily made-up, over-dressed and peroxided lady would, in the eyes of the ungallant, have notched up an obvious fifty summers with an equally obvious fifteen stone, and Dick threw a glance of vague repulsion at her before concentrating his gaze on the girl in the prow. This vision combined a trim figure with a comely face and flowing light brown hair. Dick's jaw had sagged to its fullest extent by the time the boat passed out of sight, and the music of the little portable radio in it had faded away.

"Now that," remarked Smithy appreciatively, "is what I *call* a pretty girl."

Dick brought his thoughts back to his immediate surroundings.

"I'll say," agreed enthusiastically.

"Especially," continued Smithy warmly, "the blonde hair. I really go for that."

"The *blonde* hair" repeated Dick. "You must be going colour-blind."

"No, I'm not," snorted Smithy indignantly. "I mean the blonde hair on the one who was sitting at the square end."

"That old horror?" gasped Dick incredulously. "Blimey, Smithy, she was diabolical!"

"No, she wasn't," said Smithy firmly. "She was a very pretty girl. What you forget is that a man of my age appreciates the finer points in the opposite sex."

"If," pronounced Dick, "that's an example of what old age does for you, I think I'll go out and shoot myself on my next birthday!"

"I don't think," said Smithy stiffly, "that remarks of that nature are called for. Perhaps we'd better get back to TV again."

"All right," said Dick hastily. "Why, blow me, I've forgotten what we were talking about!"

"Mass-production of TV sets."

"Oh, yes," said Dick. "So we were. Anyway, I think you've told me all I want to know about that. At the same time, there's something you mentioned just now which has been puzzling me."

"What's that?"

"You referred to a build-up of tolerances. What does that mean?"

"I think the best way of explaining that," said Smithy thoughtfully, "is by means of a mechanical example. Now, let's see if I can dream up a simple assembly which would demonstrate a build-up of tolerances to you."

The Serviceman stroked his chin thoughtfully.

"Ah, yes, I've got it," he said, suddenly. "Now, here's a nice little example which will show what I mean. Let's assume that we're designing a radio receiver for mass-production and that we intend to use a two-gang tuning capacitor which is mounted by way of three holes tapped 4BA in its base."

"Well," remarked Dick, "that's a good start at any rate! I've seen plenty of two-gang capacitors like that."

"Good," said Smithy. "Let's next assume that, when the capacitor is bolted to a flat chassis, the height of the spindle centre above the chassis surface is 0.875 inch plus or minus 0.01 inch." (Fig. 2(*a*)).

"Why 0.875 inch?"

"No particular reason," said Smithy. "It's a fairly commonly encountered dimension for tuning capacitor spindle height, and that's why it came to my mind. Incidentally, it's the decimal equivalent of seven-eighths!"

"Why, so it is!"

"Anyway, that's by the way," said Smithy. "Now we want to drive this tuning capacitor by way of a gear train, and the only requirement of this gear train that concerns us here is that the spindle centre must be 1.875 inch, plus or minus 0.02 inch, above the surface of the chassis." (Fig. 2 (*b*)).

"That seems easy enough," said Dick. "All you've got to do is to space the base of the capacitor away from the chassis surface by an inch to give you the 1.875 inch dimension. You could, for instance, use long 4BA bolts and put spacing pillars over them."

"How about," asked Smithy artlessly, "having four spacers for each bolt? Each of these spacers having a length of 0.25 inch plus or minus 0.005 inch?" (Fig. 2(*c*)).

"That would be fine," said Dick, promptly. "You've got to meet a tolerance of plus or minus 0.02 inch to satisfy the gear train requirements, so the 0.005 inch tolerances on the spacers should be more than close enough."

Smithy chuckled.

"If," he grinned, "they let *you* loose on mechanical design, the production line would come screaming to a halt every two minutes!"

"Hey?"

"I'm afraid," continued Smithy, "that the use of those four spacers would be quite unworkable for mass-production purposes. And I shall now explain why. For a start, it could easily happen that, in one of the assemblies, all the four spacers are at top tolerance. That means that they all have a length of 0.25 inch plus 0.005 in. Each one then becomes 0.255 inch long and the total amount of spacing they give is 4 times 0.255, or 1.02 ins."

"Blimey," said Dick. "That's 0.02 inch too much."

"I know it is," said Smithy. "Let's further assume that the 0.875 inch spindle height of the capacitor is also on top tolerance. That would give you 0.885 inch which, together with the 1.02 inch spacing from the chassis, results in the spindle centre height being no less than 1.905 inches above the chassis surface. (Fig. 2(*d*)). The maximum that can be accepted by the gear train is 1.875 plus 0.02 inch which is 1·895 inches so the spindle becomes 0·01 inch out of bonk!"

"I'd forgotten about the tolerance in the capacitor spindle height."

"It's one of those things," remarked Smithy, "that do tend to get forgotten. If we repeat the exercise with all the spacers and the capacitor spindle height on bottom tolerance, we'll find that the final spindle height is 0.01 inch *below* the lowest tolerance acceptable by the gear train. Again, the parts won't fit together properly. Now, the whole point of this excercise is to show you what a build-up of tolerances is. In the example, we've had a build-up of tolerances all in one direction, whereupon the final displacement is a lot greater than a casual first examination of the individual tolerances would lead you to expect. In a good

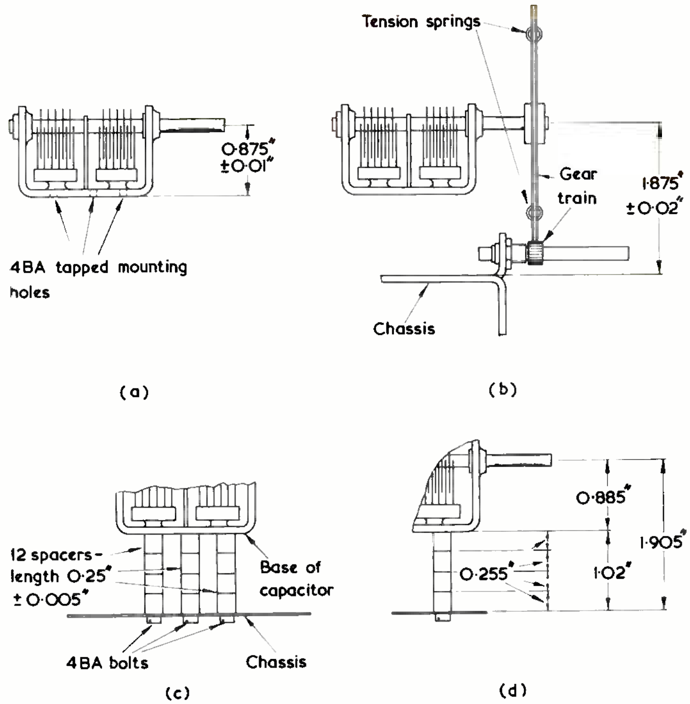


Fig. 2. Illustrating by a simple mechanical example how tolerances can "build up". It is desired to couple the variable capacitor of (a) to the gear train of (b). One method of spacing the capacitor away from the chassis surface could consist of using the spacing pillars shown in (c). If, however, all dimensions are at top tolerance level, as occurs in (d), the spacing between the capacitor spindle centre and the upper surface of the chassis becomes too great to meet the requirements of the gear train

mechanical design all individual tolerances in a system are taken into account whenever there is a possibility of their adding together in this manner. I must admit that the example I chose was a bit exaggerated, but it demonstrated the point quite well. A better approach towards mounting that capacitor would have consisted of using single 1 inch spacers, each with a tolerance of plus or minus 0.005 inch, whereupon the total build-up affecting the spindle height couldn't exceed 0.015 inch, and we'd have satisfied the requirements of the gear train, with a bit in hand."

"I see what you mean," said Dick thoughtfully. "In practice, though, would it really happen that the dimensions all went up to top tolerance, or down to bottom tolerance, at the same time?"

"It's certain to happen at some time or another," said Smithy, "if only because of the natural cussedness exhibited by inanimate objects when you try to assemble them together. Don't forget that, in our example, the individual dimensions don't have to go to the actual top tolerance figures to get you into trouble. You'd still be in trouble if they just *approached* the top tolerance figures. Or, of course, if they all just approached the bottom tolerance figures."

"Why," asked Dick, "do we have to have these tolerances anyway?"

"Because," replied Smithy, "it's impossible to make anything *exact*. You can only make things to a dimension with a tolerance on either side."

Back To Base

Smithy looked at his watch.

"It looks as though our time on this boat is nearly up," he remarked. "We'd better start getting back."

"Okey-doke," said Dick, inserting the oars into the rowlocks which, he was careful to check, were now correctly orientated. "Incidentally,

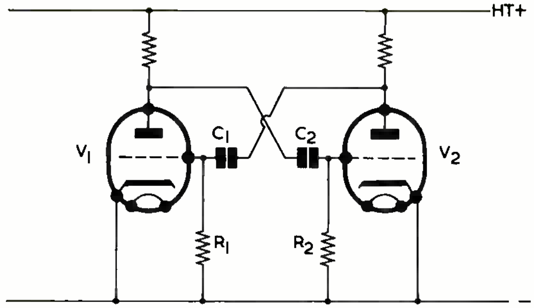


Fig. 3. A symmetric multivibrator. The time that V_1 is cut off during the multivibrator cycle is proportional to $C_1 R_1$, and the time that V_2 is cut off is proportional to $C_2 R_2$

how is it that I've been doing all the rowing this afternoon?"

"It's just the natural order of things," explained Smithy airily. "When we got into the boat I took the initiative by sitting in the stern first, whereupon you had to sit on the other seat. After which, the only obvious conclusion was that you also had to do the rowing."

"Trust me," grumbled Dick, as he pulled at the oars, "to get caught. Anyway, how does this build-up of tolerance affect things like TV circuits?"

"You can get a build-up of tolerances in such things as resistors and capacitor values," replied Smithy. "One instance which comes to mind is given in a timebase employing a valve multivibrator. (Fig. 3). As you know, the length of time that one of the valves is cut off during the multivibrator cycle depends on the time needed for its grid capacitor to discharge, into its grid leak, sufficiently far for the valve grid to go above cut-off. This time is proportional to the product of the capacitance and resistance. If the capacitor and resistor had maximum values, within their tolerance, the time the valve was cut off would be disproportionately longer than if they both had their nominal values. Let's say for the sake of argument, that the resistor is 100kΩ, that the capacitor is 100pF, and that both are 20% components. If both were on top tolerance they would have values of 120kΩ and 120pF respectively. The cut-off time is proportional to the product of the resistance and capacitance so it now goes up by a factor of 120 times 120 divided by 100 times 100, which is 1.44. So the time has gone up by 44%. The grid cut-off voltage is liable to vary for different valves and, if this were at the low end of the range offered by the valve type employed, the cut-off period would be longer. However, you can't talk of tolerances on grid cut-off voltage because the appropriate figures aren't normally quoted by valve manufacturers. Nevertheless, the multivibrator example gives an idea of the sort of build-up that can occur with electrical components. Hallo, we're getting near the landing point."

Dick turned round briefly. A young couple on the shore were chatting amicably together, waiting for the return of one of the boats so that they could have their turn. Out of the corner of his eye, he espied another boat which was also approaching the landing point.

"There's the boat with those two we saw in," he remarked, redoubling his efforts at the oars.

Dick was nothing if not opportunist, and the boat bearing Smithy and himself arrived at the landing at just the right time to enable him to jump out, tie up the girl's boat as it came alongside, and then offer a gentlemanly hand of assistance to its young female occupant.

"Thank you, dearie," came a hoarse voice from his rear, and the discomfited Dick suddenly found the hand of the peroxided lady clutching at his arm. A considerable amount of his time was then taken up in the process of hoisting up the bulk of this lady, and Dick's irritation at the unexpected turn of events was not reduced when he saw that Smithy had wandered up and was now in deep conversation with the young girl, who still sat in the prow of the boat. The couple on the shore had already claimed the boat he and Smithy had vacated, and were pushing her off.

When, at length, Dick finally succeeded in getting his charge safely ashore, he was further disconcerted to see Smithy hop into the boat and take her place. The brown-haired girl deftly unhitched the line and gave an expert pull at the oars.

"You might," said Smithy nonchantly, as he glided past his dumbfounded assistant, and out into the lake, "do me a favour and pay the man for another hour on this boat. This young lady's transistor radio seems to have gone wrong, and I'm going to fix it for her."

Smithy's voice faded as the boat bore him away.

"Well now, dearie, isn't it kind of your friend to offer to help my niece like that?"

Shuddering, Dick turned to look at his companion.

"You know, dearie," she continued, "I always do love being rowed about on the lake, and I'm certain that a handsome young man like you would be only too happy to oblige. Wouldn't you, dearie? Why, there's another boat coming back now, and it will be all nice and cosy for the two of us."

An arch smile created a network of deep ravines in the face-powder, and the lumbered Dick gritted his teeth. As he walked furiously to the little office at the landing-place he mentally fought down his rage at all the outrages to which he had just been subjected: his having to pay for both Smithy's boat and the one he was now about to take out; his having to pull the bulk of Madame Peroxide about the lake for a full devastating hour; and the thought of Smithy now taking his ease whilst the girl of the light brown hair rowed *him* around.

By a superhuman effort, Dick managed to keep his fury within bounds. A build-up of tolerances, indeed.

SIMPLE COMBINATION LOCK

By J. DAICH

THIS LOCK WAS DESIGNED SO THAT ONLY OPERATIONS in the right order would open it. Incorrect operations cause it to be re-set.

The basic requirements are: 3 relays with 2 single pole make contact sets each, 9 press switches, of which 3 are push-to-make and 6 are push-to-break, and a battery. The battery can be of small size as current is only drawn when buttons are pressed in the correct sequence.

The Circuit

The circuit is shown in Fig. 1. It will be seen that when S_1 is closed relay A operates and, in so doing, short-circuits S_1 by its contacts A1 and latches itself on. Contacts A2 also close, so that pressing S_2 causes relay B to operate. Relay B latches on by short-circuiting S_2. At the same time, contacts B2 close, enabling relay C to be energised by S_3, whereupon it latches on and its contacts C2 complete the external circuit and open the lock.

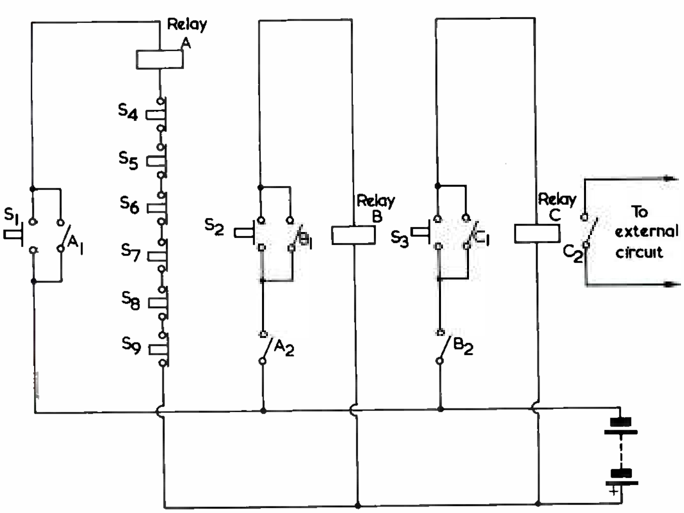


Fig. 1. The circuit of the lock. A solenoid or other device is energised when contacts C2 close, thereby causing the lock to open. Each relay has two sets of contacts which close on energising, these being identified as A1, A2, B1, B2, C1 and C2. Relay coils are shown as rectangles

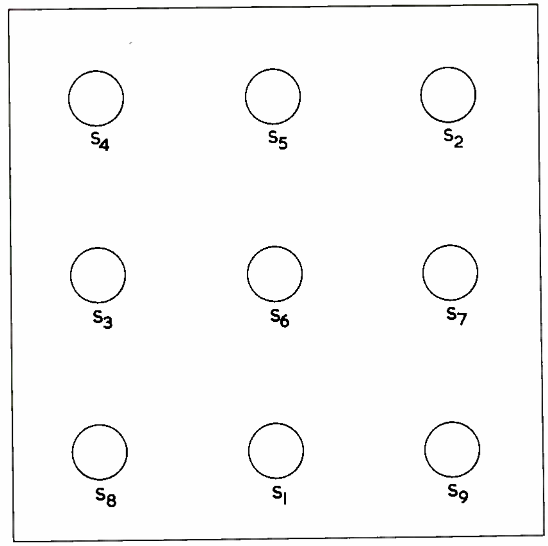


Fig. 2. The press switches may be laid out in random fashion, as in the example shown here

Components List

Relays
3 relays, each with 2 single pole make contact sets

Switches
S_1 to S_3 3 push-to-make switches
S_4 to S_9 6 push-to-break switches

Battery
Battery of suitable voltage to energise relays

There are 6 push-to-break switches in series with relay A. Pressing any of these causes this relay to de-energise and the lock to re-set.

A suitable panel layout for the press switches is shown in Fig. 2. The switches are positioned in random fashion, and any other random layout can be employed instead.

It will be noted that a considerable number of combinations is available, of which only one, the pressing of S_1, S_2 and S_3 in sequence, is successful in opening the lock. The number of combinations can be made greater by increasing the number of stages or by increasing the number of push-to-break switches in series with the coil of relay A.

Cover Feature

BASIC RADIO CONTROL

Part 2

By F. L. THURSTON

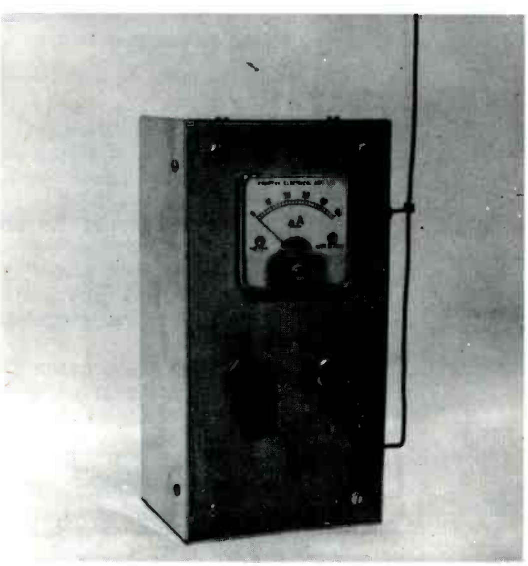
★ ***Field Strength Meter***

★ ***Single Channel "Carrier" Transmitter***

★ ***Output Monitor***

Last month our contributor introduced the subject of radio control by discussing the various systems which are currently in use. In this month's issue he describes a single channel "carrier" transmitter, whilst next month's article will be devoted to a super-regenerative receiver which is designed to work in conjunction with the transmitter

SINGLE CHANNEL "CARRIER" CONTROL SYSTEM. As was mentioned in last month's article, the most simple of all radio control systems, and thus the easiest to start with from the constructional point of view, is that using the single channel "carrier" principle. Here, no modulating signal is needed at the transmitter, and its design can thus be fairly simple and, consequently, comparatively inexpensive. At the receiver end of the system, a simple super-regenerative detector circuit is used, in conjunction with an audio amplifier and filter circuit and a noise operated switch. This system relies on the fact that, when no carrier signal is present, the output of the super-regenerative detector contains a great deal of noise, this noise disappearing when the carrier signal is picked up by the receiver aerial. In this month's issue we shall give a practical example of a transmitter of this type, to be followed by full constructional details of a suitable receiver system next month.



The field strength meter with its aerial fitted

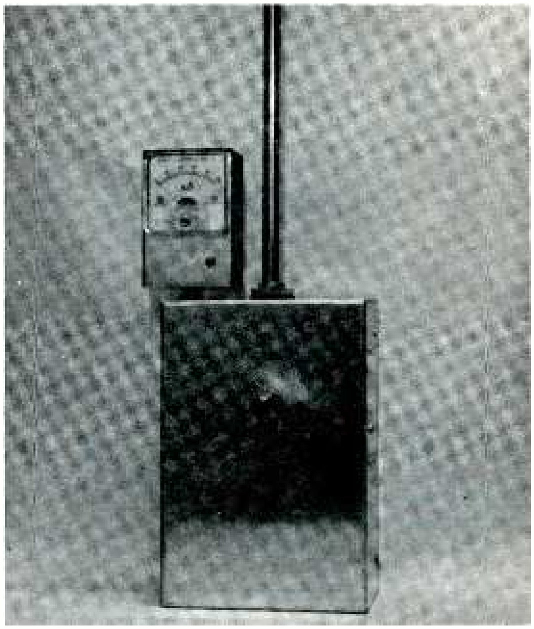
It must be pointed out that the advantages and disadvantages of single channel "carrier" systems should be evaluated before embarking on the building of the transmitter. These are discussed in this article immediately after the description of the field strength meter. A radio control licence is also required to operate the transmitter, and application for this 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.

Field-Strength Meter

One of the snags of building one's own electronic circuitry is that a certain amount of test equipment is needed if optimum results are to be obtained. In the case of home-built radio control transmitters one particular piece of test gear, not normally found in the electronic workshop, is essential. This is a field-strength meter. Fortunately, a field-strength meter is a very simple device, and is inexpensive and very easy to construct. It is used to indicate the relative strength of the "field" radiated by the transmitter aerial. The transmitter and aerial are adjusted to obtain the best possible reading on the field-strength meter, this ensuring that the radiated signal, and thus the range of the system, is at maximum.

Fig. 1 shows the circuit diagram of a suitable field-strength meter; and this piece of test gear should be built before any attempt is made to construct a transmitter. The radiated carrier signal is picked up by the field-strength meter aerial, which consists of a 24in length of stiff wire, and is fed, via C_1, to the tuned circuit formed by L_1, C_2 and C_3. C_3 is a small variable capacitor, and enables the frequency of the tuned circuit to be varied by a small amount about a pre-set value. The signal from the tuned circuit is rectified by D_1 working into C_4, and the resulting d.c. is applied to the meter circuit given by M_1 and R_1. M_1 is a 50µA moving coil meter, and R_1 is used as a sensitivity control.

If preferred, the field-strength meter may be simply "lashed" together, using any meter that happens to be available, and acceptable results will no doubt still be obtained. It should be remembered however, that the unit may have to be used "in the field", and may take a certain amount of physical punishment in the process. It is therefore recommended that the unit be made as neat and robust as possible; in this context, the method of construction shown in Fig. 2 and in the photographs is strongly recommended.



The remote control transmitter, complete with output monitor

Here, the unit is housed in a strong and presentable case, which is in fact a standard 6 x 3in aluminium chassis with strengthened corners and having a depth of 2½in. Construction of the instrument is started by cutting and drilling an aluminium front panel to size, as shown in Fig. 2 (*a*). In the absence of a special cutting tool, the best way to cut the hole for

Components List

(Fig. 1)

Resistors

R_1	50kΩ variable	

Capacitors

C_1	50pF silver-mica
C_2	12pF silver-mica
C_3	25pF variable. Type C.804 (Jackson Bros.) or similar.
C_4	0.005µF ceramic

Inductor

L_1	12½ turns of enamelled 24 s.w.g. copper close-wound on former with iron dust core. Coil former 0.27in diameter (Radiospares)

Diode

D_1	OA70 or similar

Meter

M_1	50µA f.s.d. moving coil with 1⅝ x 1⅝in face. Imported. (Newbury Radio (Forest Gate) Ltd.)

Miscellaneous

2 aerial plugs (miniature plugs—Radiospares)
2 aerial sockets (miniature sockets—Radiospares)
6 x 3 x 2½in chassis and panel to fit
24in stout copper wire, or similar
2 knobs
Self-tapping screws (see text)

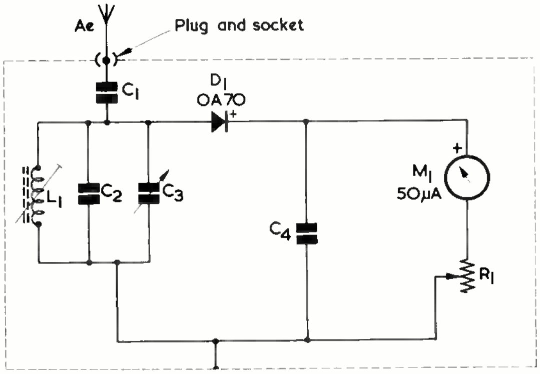
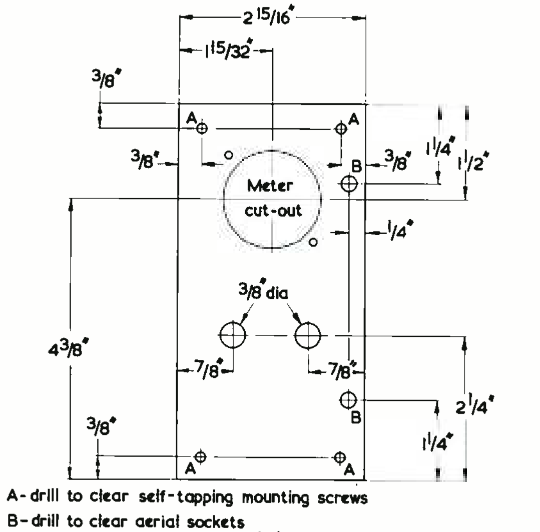
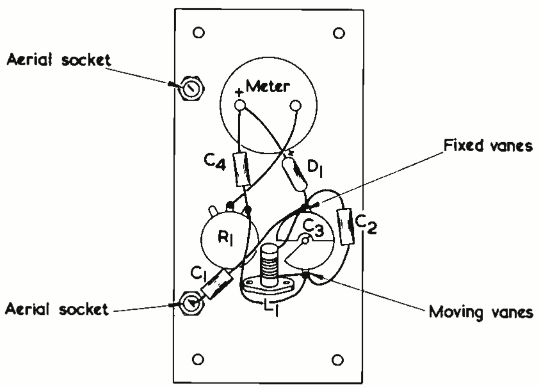


Fig. 1. The circuit of the field-strength meter. This must be constructed before commencing work on the transmitter



(a)



(b)

Fig. 2 (a). Front view of the aluminium panel for the field-strength meter. The four holes designated "A" take self-tapping screws which pass into angled strengthening brackets fitted in the case, and which enable the panel to fit flush

(b). The rear of the panel, showing the wiring and components. In the prototype the moving vanes of C_3 connect to the metal panel by way of its mounting bush

the meter is to mark out its outline with a pair of compasses, and then make the cut-out with a fret-saw fitted with a metal cutting blade; these blades are available from most tool stores for a few coppers. In the prototype, the meter was an inexpensive Japanese type having a face measuring 1⅝ by 1⅝in. Next, secure the meter, the tuning control (C_3) and the sensitivity control (R_1) to the front panel. Note that the aerial is secured to the instrument by a pair of Radiospares miniature sockets bolted to the front panel, and these should also be carefully secured in place at this stage.

Next wire up the unit as shown in Fig. 2 (*b*). The coil, L_1, is made by close-winding 12½ turns of 24 s.w.g. enamelled copper wire on a standard Radiospares 0.27in diameter coil former fitted with an iron dust core. After winding, the coil is secured to the coil former by a few dabs of polystyrene dope or similar fixative.

The aerial may be made, as in the case of the prototype, from heavy gauge copper wire, and it should have a total length of approximately 24in. Note that one side of the tuned circuit is connected to the metal front panel and case (via C_3 spindle in the prototype), and that this connection is essential for best results.

If a calibrated signal generator is available, the unit may be set up by coupling a 27 Mc/s signal to the field-strength meter aerial via a loop of wire (an actual physical connection is not necessary here) whereupon, with R_1 set to minimum and C_3 set to mid-travel, the iron dust core of L_1 should be adjusted for peak reading on the meter. If a signal generator is not available there is no need to worry, since this test is not essential but merely a matter of convenience. All transmitters to be described in this and subsequent articles are crystal controlled, and no trouble with carriers being radiated outside the permitted frequencies should be experienced.

Finally, the field-strength meter can be completed by securing the front panel to the case by means of self-tapping screws secured into angled strengthening brackets fitted at the corners of the case.[1] The front panel can be marked, if required, with the aid of Panel-signs or direct lettering.

The Transmitter

Before dealing with the constructional details of this particular transmitter, it is necessary to give the reader a few words of warning on the advisability or otherwise of using the unit.

First, it must be stressed that, as well as being the most simple of all radio control systems, the single-channel "carrier" type is the most interference-prone and inefficient. It should not, however, be thought that the system is "useless"; indeed, the system can be very effective as long as its limitations are recognised. These limitations are (1) that the system is exceptionally prone to interference from other transmitters and other sources of r.f. radiation, and (2) that the effective range of the system is far less than that obtained with other systems.

In practice, these two limitations mean that the system is not recommended for use in aircraft, where an incorrect reaction (due to interference) may result in the destruction of the model, but that it is still very useful for the control of model boats and motor vehicles, particularly where range is to be kept to far less than a couple of hundred yards. The effective (reliable) range of the "carrier" system to be

[1] The self-tapping screws used in the prototype field strength meter and transmitter were No. 4 P.K. (full diameter 0.112in.) by ⅜in with pan head (similar to cheese head).—Editor.

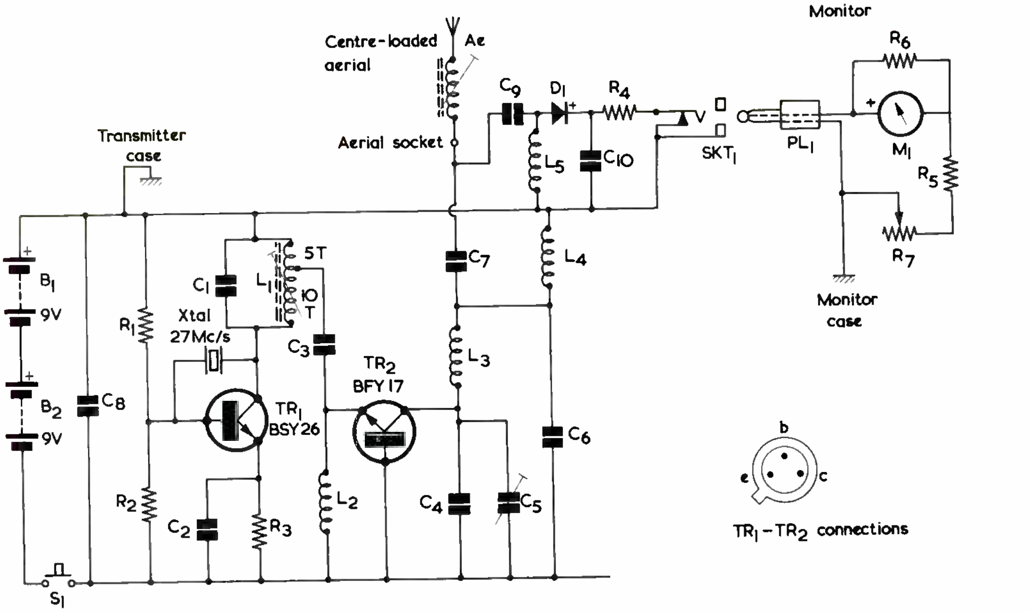


Fig. 3. The circuit diagram of the transmitter. The monitor unit is an optional extra, and it fits into the transmitter by means of an integral jack plug

Components List

(Fig. 3)

N.B. Components marked with an asterisk are only required if the monitor unit is to be used

Resistors

(All fixed resistors ¼ watt carbon, 10%)

R_1 22kΩ
R_2 10kΩ
R_3 120Ω
*R_4 2.2kΩ
*R_5 68kΩ (may require adjustment)
*R_6 330Ω
*R_7 50kΩ skeleton pre-set

Capacitors

(Fixed capacitors should be as small as possible and could be, for instance, subminiature ceramic. C_1, C_4 and C_6 should, however, be miniature silver-mica. Unless otherwise stated, working voltages are 18 or greater. The prototype employed sub-miniature capacitors obtained from Newbury Radio (Forest Gate) Ltd.)

C_1 22pF
C_2 0.01µF 12V wkg.
C_3 0.01µF
C_4 33pF
C_5 3–30pF concentric trimmer (Mullard)
C_6 47pF
C_7 0.005µF
C_8 0.1µF
*C_9 56pF
*C_{10} 0.01µF

Inductors

L_1 5+10 turns 24 s.w.g. enamelled wire on Radiospares 0.27in diameter former, with iron-dust core. Close-wound
L_2 50 turns of 36 s.w.g. enamelled silk-covered wire on 100kΩ ¼ watt 20% resistor (see text). Scramble or pile-wound
L_3 10 turns of 18 s.w.g. enamelled copper wire, ¾in i.d.
L_4 As L_2
*L_5 As L_2

Transistors

(Transistors are available from Newbury Radio (Forest Gate) Ltd.)

TR_1 BSY26 (S.T.C.)
TR_2 BFY17 (S.T.C.)

Diode

*D_1 OA70 (Mullard)

Crystal

Brush Clevite, midget radio control type in 27 Mc/s range. A matched pair (see text) is recommended if future projects are to include superhet receivers. (Teleradio, 325–327 Fore St., London, N.9.)

Aerial

Teleradio antenna type CLV80, with insulated socket. (Teleradio, 325–327 Fore St., London, N.9.)

Meter

*M_1 50μA f.s.d. moving coil with 1⅝ x 1⅝in face. Imported. (Newbury Radio (Forest Gate) Ltd.)

Switch

S_1 Miniature Push-Button Switch, Push-To-Make (Radiospares)

Batteries

B_1, B_2 9-volt battery type DT7 (Exide)

Plug and Socket

*PL_1 "Standard" jack plug (Radiospares)

*SKT_1 Closed circuit jack (Radiospares)

Miscellaneous

3-pin transistor holder, Cat. No. TR34 (Home Radio (Mitcham) Ltd.)

Veroboard, 0.1in hole matrix, dimensions as in Fig. 4 (*a*), (Newbury Radio (Forest Gate) Ltd.)

Battery connectors

Self-tapping screws (see text)

Material for chassis and brackets, etc.

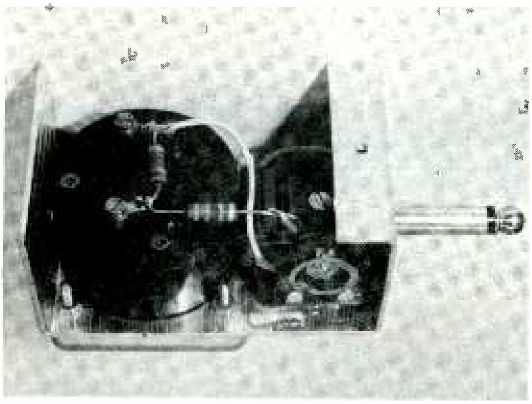
NOTES:

1. The address of Newbury Radio (Forest Gate) Ltd. is 274 Romford Road, Forest Gate, London, E.7.
2. Radiospares components may only be obtained through retailers.

described is approximately 150 to 200 yards ground-to-ground.

The second point that must be stressed is that, since the articles which will follow this 3-part series are intended to be progressive, (in that a whole range of systems, becoming progressively more complex, are to be described), components have been employed that are suitable for use with a whole range of circuits, and are not necessarily the least expensive types available for any *one* particular circuit. In particular, a fairly expensive centre-loaded aerial is specified for all transmitters to be described, although this may be considered as a luxury for some of the single channel equipment. Again, it is recommended that a special pair of matched sub-miniature crystals, at approximately £3 per pair, be purchased initially, bearing in mind that it may be decided to use a superhet receiver for radio control at a future date. For many applications, however, a normal crystal, costing approximately 25s., could be used.[2] Thus, the cost of building some of the equipment to be described is not as low as it could be.

[2] The matched pairs are intended for superhet working, one being fitted at the transmitter and the other at the receiver, and they are available with difference frequencies of 455, 465 and 470 kc/s. The radio control articles planned for publication later will require 465 kc/s spacing between the matched pair of crystals and readers should, in consequence, obtain matched pairs with this difference frequency. —Editor.



Internal view of the plug-in monitor unit

Having cleared up these points, it is now possible to get down to the details of the practical transmitter. Fig. 3 shows the circuit diagram of this unit.

As can be seen, the circuit uses only two transistors, both n.p.n. types, in a fairly simple circuit. TR_1 is wired as a crystal oscillator. For practical purposes this part of the circuit can be regarded as a conventional common emitter amplifier, with the base-bias network being given by R_1 and R_2, and with emitter bias resistor R_3 bypassed by C_2. The collector load is the tuned circuit L_1, C_1, and this, in conjunction with the crystal, gives 180° phase shift from the collector to the base at the crystal frequency of 27 Mc/s, whereupon the circuit oscillates at this frequency.

A fraction of the oscillator signal is fed, via C_3, to the emitter of the power amplifier stage, TR_2, which is wired in the grounded base configuration. The signal at the collector of TR_2 is fed into a complex tuned circuit, which includes the centre-loaded aerial and C_4, C_5 and L_3. This tuned circuit is necessary in order to suppress harmonic radiation, which would otherwise cause excessive TV interference on Band I channels. The p.a. stage is effectively a.c. decoupled from the supply line by L_4 and C_6.

The transmitter is "keyed" by means of a push-button On-Off switch wired in series with the negative supply line from the batteries. An 18 volt supply is used.

Also shown in the diagram is a "luxury" feature, which may, if preferred, be omitted. This is an output monitor, which is fitted into the transmitter case by means of a jack plug and socket. The signal that is fed into the aerial has a small part tapped off and fed, via C_9, to the inductive load L_5, and that signal is then rectified and filtered by D_1 and C_{10}, the d.c. output being fed to the meter socket and thence to the meter. This gives an indication of the presence of a signal at the base of the aerial. It must be emphasised that, in this particular transmitter, the output meter can *not* be relied on for use as a tuning meter, and a separate field-strength meter is still essential when setting up the transmitter. If the output meter facility is not required, C_9, C_{10}, L_5, D_1, R_4 and the socket need not be fitted in the transmitter.

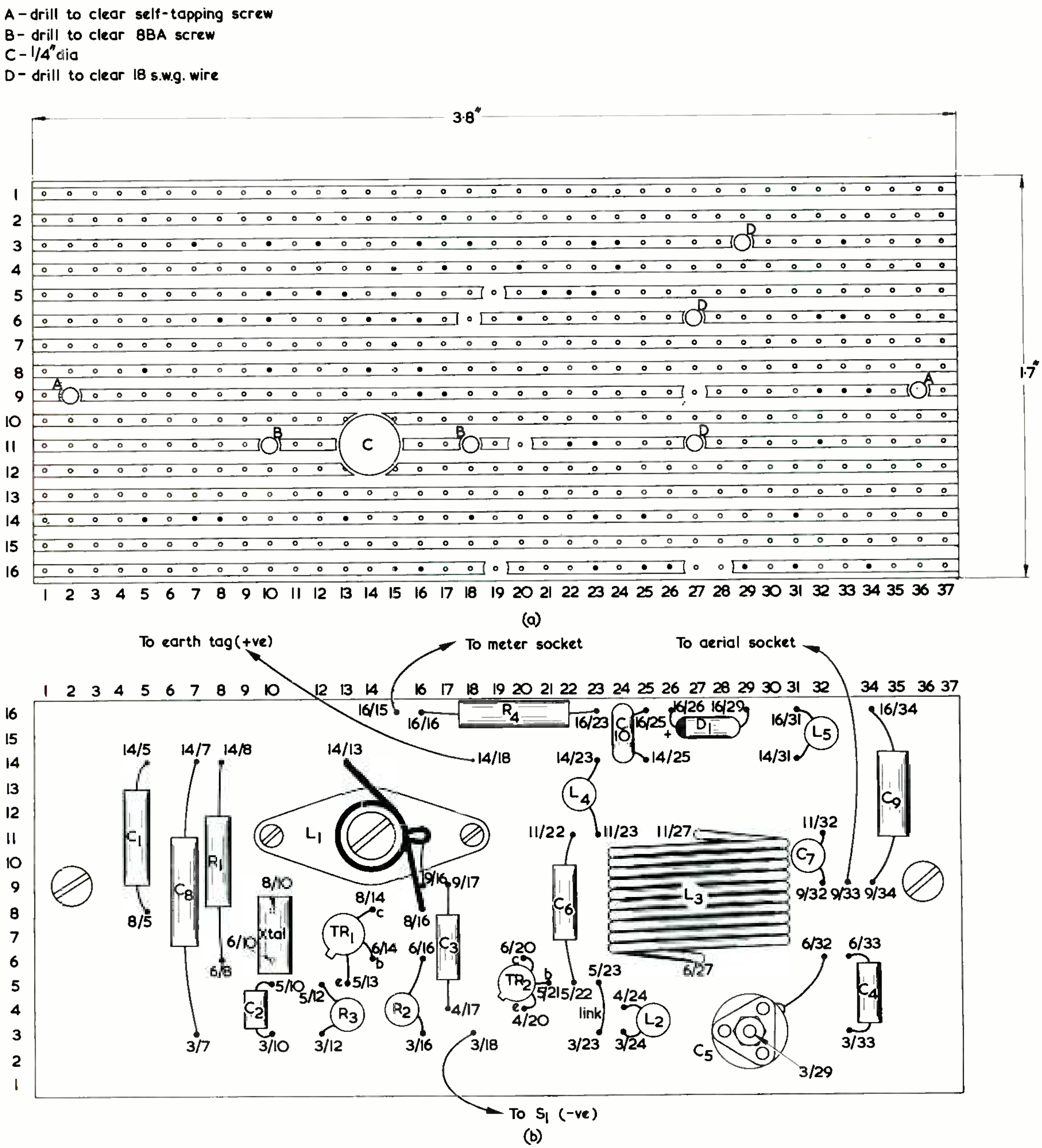


Fig. 4 (a). The copper side of the Veroboard after the strips have been cut and the holes drilled (b). The plain side of the Veroboard with components mounted. Each connection has a two-figure code, the first figure indicating the strip and the second figure the hole along the strip

Construction

The circuit is wired up on a piece of Veroboard panel, with 0.1in hole spacing. It should be noticed that this is a far smaller matrix than that usually used. In case of difficulty, suitable panels can be obtained from Newbury Radio (Forest Gate) Ltd. at the address shown in the Components List.

Start construction by cutting the Veroboard panel

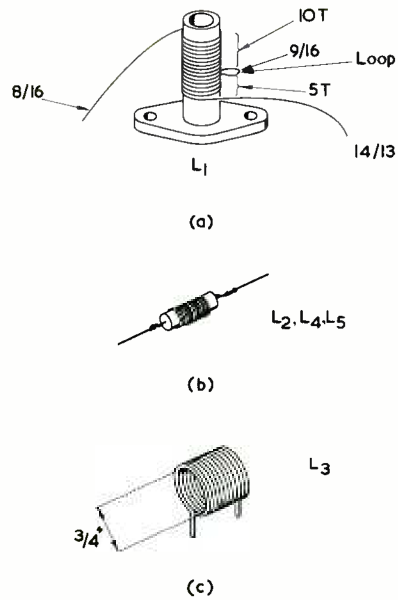


Fig. 5 (a). How coil L_1 is wound

(b). Coils L_2, L_4, and L_5. These each consist of 50 turns on a high value resistor

(c). Coil L_3 is self-supporting, and has 10 turns

to size and carefully break the continuity of the copper strips, as shown in Fig. 4 (*a*), with the aid of a small drill or special cutting tool that is available for this operation. Next, drill the small holes in the panel, as indicated.

Wiring up of the panel should be carried out "by numbers", in the following manner:

(1) Secure the 0.27in diameter Radiospares coil former, with iron-dust core, in place on the panel with the aid of two 8BA screws and nuts. Now, using 24 s.w.g. enamelled copper wire, close-wind the coil L_1 on the former, as shown in Fig. 5 (*a*). Wind clockwise from the base upwards for 5 turns, form a loop, and then continue the winding, still clockwise, for another 10 turns, finally soldering the free end of the wire in place on the Veroboard. Solder a lead from the tap to the Veroboard panel, as shown in Fig. 4 (*b*).

(2) Take a small 3-pin transistor holder (see Components List) and remove the centre pin; now solder the modified holder in place on the panel by means of the two remaining pins. Press the sub-miniature 27 Mc/s crystal in place in the holder.

(3) Wire R_1, R_2, R_3, C_1, C_2, and C_8 in place. Also solder transistor TR_1 in place, taking care to ensure that it is wired with correct connections, and using a heat shunt on the leads when soldering. Check the rear (copper side) of the panel and make sure that no short-circuits are occurring across the lands between the copper strips. The circuit can be given a simple functional check at this stage by temporarily connecting the 18 volt supply to strips 3 and 14, taking care to use the correct polarity (See Fig. 4 (*b*)), and placing the aerial of the field-strength meter very close to L_1. If no reading is obtained, adjust the core of L_1 until the circuit oscillates correctly.

(4) Remove the temporary battery connection and wire C_3 and TR_2 in place. Wire in the shorting link from the negative line to the TR_2 base circuit.

(5). Wind the three small inductors, L_2, L_4, and (if the output meter is to be fitted) L_5, in the following manner. Take a high value (100kΩ) ¼ watt 20% resistor; take a coil of 36 s.w.g. enamel and silk covered copper wire, bare ½in at one end and solder the bared wire to one lead of the resistor, close up to the resistor body[3]. Now wind 50 turns of wire tightly around the resistor body and finish off by baring the free end of the wire and soldering to the remaining lead of the resistor. The windings may be scramble or pile-wound. Wire these inductors in place on the Veroboard panel.

(6). Make coil L_3 by close-winding 10 turns of 18 s.w.g. enamelled copper wire on a ¾in diameter former; remove the coil from the former and solder

[3] The resistors available in the home-constructor market under the nominal description " quarter watt" vary somewhat in dimensions. The resistors used in the prototype for L_2, L_4 and L_5 had a body length of ⅜in and a diameter of approximately ⅛in, and resistors of similar dimensions should be employed by constructors—Editor.

An internal view of the transmitter. This also shows the angled corner brackets, to which the back plate is secured

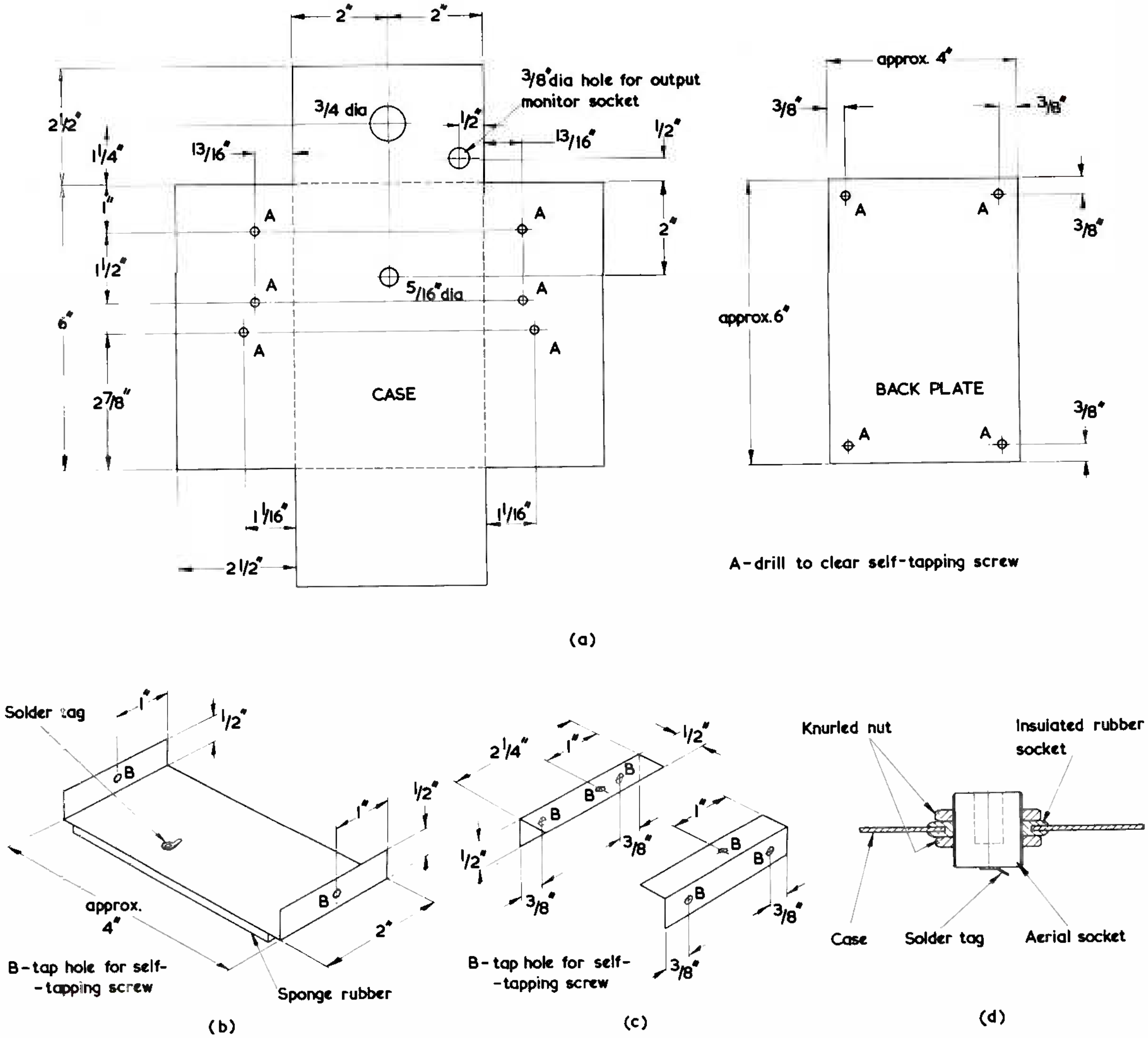


Fig. 6 (a). The case and back plate of the transmitter. The case is a standard 6 x 4 x 2½in chassis to which angle brackets are fitted (not shown here). The back plate is secured to these brackets

(b). The battery bracket. A piece of ¼in sponge rubber is glued to the underside of this and rests directly on the battery terminals

(c). The brackets used for mounting the Veroboard. A rubber grommet is glued above each "B" hole, as described in the text

(d). How the aerial socket is fixed to the case

in place on the Veroboard. Now wire the remaining circuit components, including, if required, those of the meter circuit, in place on the panel. Do *not*, at this stage, connect the battery supply to the circuit.

(7). Make the transmitter case and metal-work, as shown in Fig. 6(*a*). On the prototype, a standard 6 × 4 × 2½in chassis, with angled corner brackets, was used as a case. The aerial specified, which screws into the holder fitted in the hole at the top of the case, *must* be used. The two batteries are held in place by the sponge-rubber faced bracket, which, in turn, is held in place by self-tapping screws. The Veroboard panel is held in place on the two small, angled brackets of Fig. 6(*c*), which, in turn, are secured to the side of the case by self tapping screws. To prevent the underside of the Veroboard panel short-circuiting against the angle brackets, a pair of rubber grommets are glued to the brackets with Bostik, and act as shock absorbing stand-off insulators. If the meter jack is to be fitted, short circuits can be prevented between the jack and the case by sticking a few pieces of Fablon or a similar self-adhesive insulating material to the inside of the case at the "danger" spots. The small push-button On-Off switch,

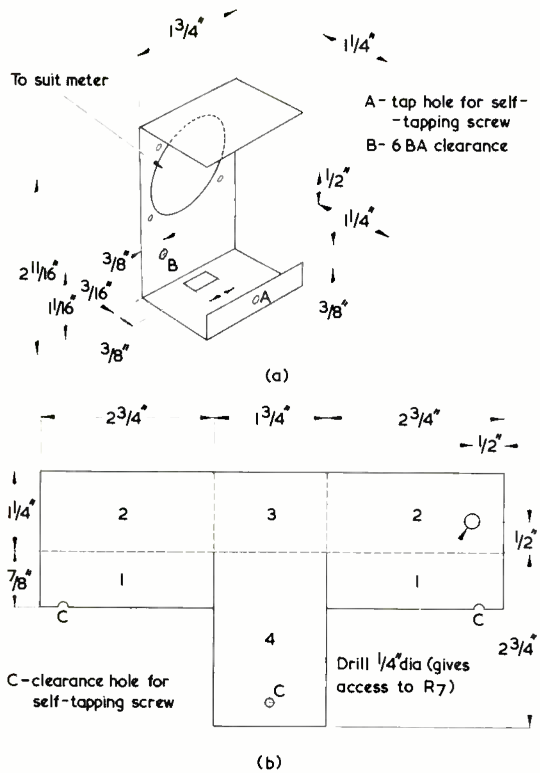


Fig. 7 (a). The front panel of the output monitor
(b). The monitor cover, before bending

which *must* be of the type specified, is mounted to the inside front of the case. The case is "earthed" to the positive supply line via an earth tag bolted to the battery securing bracket. See Fig. 6(*b*). The back-plate is secured to the case by means of self-tapping screws, which screw into the angled corner brackets on the case.

(8). When the case, metal work, and Veroboard circuitry are complete, solder one end of a 2½in length of insulated wire to a battery terminal (for the positive connections) and the other end to the earth tag on the battery bracket; solder an additional length of wire (approximately 5in long) from the earth tag to the positive supply connection on the Veroboard. Now take a 4in length of wire, solder one end to the negative battery terminal, and the other end to one side of the push-button On-Off switch. Solder an additional length of wire, approximately 4in long, from the remaining side of the On-Off switch to the negative supply connection on the Veroboard panel. Now solder a 2½in lead from the aerial point on the Veroboard panel to the aerial socket at the top of the case. If the monitor is to be fitted, wire the lead from the panel to the monitor jack. Finally, mount the Veroboard panel over the two rubber grommets and secure the panel to the small angled brackets by means of self tapping screws.

(9). Fit the two 9 volt batteries in place, joining them electrically by two terminals soldered to a short length of wire, and, after fitting the positive and negative output leads in place, clamp the batteries down with the battery bracket, making sure that no short-circuits occur to the case. Fit the centre-loaded aerial in place and extend it fully. Now place the field-strength meter a couple of feet away from the transmitter, and press the keying button; an indication should be obtained on the field-strength meter. Adjust the iron-dust core of L_1 for maximum signal strength, then turn the core back a full turn. Next trim C_5, for maximum signal, moving the field-strength meter to about 10–12 feet away from the transmitter, then alternately adjust the iron-dust core at the centre of the aerial and C_5 for maximum signal strength. As an indication of the results to expect, at a range of 10 feet with the centre of the field-strength meter aerial in the same plane as the centre of the transmitter aerial, the two aerials being parallel, an indication of between half and full scale should be obtained on the field strength meter when set for maximum sensitivity. The transmitter battery drain should be approximately 28mA when transmitting.

Once these adjustments have been made, the transmitter is complete and ready for use. **It must be noted that the keying button must not be pressed when the aerial is removed or fully retracted, as damage to the output transistor may result.**[4] The back panel can be secured to the case, any small adjustments for maximum output being made at the aerial tuning slug from this point on.

Output Monitor

Fig. 7 shows the constructional details of the output monitor, if required. The front panel is made in light gauge aluminium to the dimensions shown in Fig. 7 (*a*), the meter hole being cut, with the aid of a fret-saw fitted with a metal cutting blade, *after* the panel has been bent to shape. The jack plug is a Radiospares "Standard" type and it is locked in position by the body of the moving coil meter.

In Fig. 7 (*a*), hole "B" is 6BA clear. A solder tag is fitted at this hole, one tag of the skeleton potentiometer, R_7, being soldered to this tag.

The cover is made of very light gauge aluminium. It is initially cut as shown in Fig. 7 (*b*). Then, bend parts 1 upwards at right angles to parts 2. Next, bend parts 2 upwards at right angles to part 3. Coat the rear of parts 1 and the front of part 4 with Araldite adhesive, and bend part 4 upwards at right angles to part 3 until parts 1 and 4 are in contact. Bind with elastic bands and leave until the adhesive has set. Next drill hole "C" in parts 1 and 4 to line up with hole "A" in the front panel. A self tapping screw passed through these holes secures the assembly

[4] If desired, a separate on-off switch, in series with the negative supply lead, could be incorporated to obviate the risk of damage should S_1 be pressed inadvertantly.—Editor.

together. Before assembly, the ¼in hole which provides access to R_7 must also be drilled.

The wiring inside the monitor is of a simple nature and may be carried out after consultation of the circuit diagram and the photograph of the internal view. When completed, the case may, if desired, be covered with Fablon or a similar self-adhesive decorative plastic. Other finishes will also suggest themselves to the constructor. It should be noted that the value of R_5 may require adjustment after completion of the transmitter and monitor, in order to obtain best meter indications.

Finishing

To give a neat finishing touch to the transmitter and monitor, appropriate wording may be applied to the front panels by means of Panel-Signs transfers or direct lettering.

Next Month

This particular series of three atricles will be concluded next month when constructional details of a super-regenerative single channel "carrier" receiver, suitable for use with this transmitter, will be given. Scheduled for the near future are further articles by the same author describing the construction of more complex equipments.

THE DESIGN AND CONSTRUCTION OF MEASURING BRIDGES Part 2

by W. KEMP

In this second article in our 3-part series on general attributes of bridge circuits, our contributor discusses the design of a precision Wheatstone bridge for resistance measurement, and describes a novel design for a low-cost decade resistance box. Also introduced is the subject of a.c. bridges

IT WAS MENTIONED IN THE LAST ARTICLE that a practical limit is set to the maximum resistance which the bridge can read by the voltage available and the sensitivity of the indicator. There is also a practical limit to which the bridge can accurately read low values of resistance, and this is set by the contact resistance of the switches and by the unwanted resistance of the bridge wiring.

While neither of these problems can be completely eliminated, they can be reduced. The wiring should be kept as short as possible and should be of a reasonably heavy gauge in order to reduce trouble from its resistance, and all soldered joints must be well made.

Regarding the switching, there is of course a certain amount of resistance between the contacts and the wiper of any switch, and unfortunately this resistance is not constant. While it might only be of the order of 0.05Ω or less, it must be remembered that this represents an error of 5% to a 1Ω resistor. Special switches are available with very low contact resistance for use in precision instruments, but these only serve to reduce and not eliminate the problem, and they are rather on the expensive side. If desired, switching can be eliminated altogether from the bridge, terminals being used instead, but this will result in a bridge that is rather unwieldy to use, and it is not recommended unless it is essential that very low values of resistance be known to a great accuracy.

As in most cases in electronics, the best solution seems to be to arrive at a compromise and accept a unit that has a high degree of accuracy over most of its range, but a slight deterioration on its lowest range, and thus retain the advantage of ease of use.

Because of the errors that may be introduced by the switch contact resistance it is preferable not to use resistors of lower values than 10Ω as standards in the bridge unless absolutely necessary.

Designing a Wide Range Precision Bridge

Let us assume that it is desired to build a Wheatstone bridge capable of reading to an accuracy of better than 1% over the resistance range of 10Ω to 100MΩ and as accurately as possible down to a fraction of an ohm.

As a starting point, consider the variable arm R_2. (This is shown in Fig. 1, repeated from last month's article). Here, decade units are recommended. If only three decades are used the maximum accuracy over the entire range (say, when reading 112.5Ω

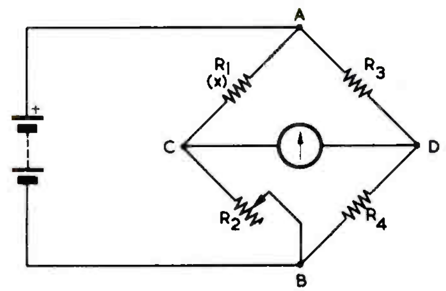


Fig. 1. The basic Wheatstone bridge. (This diagram is reproduced here for reference)

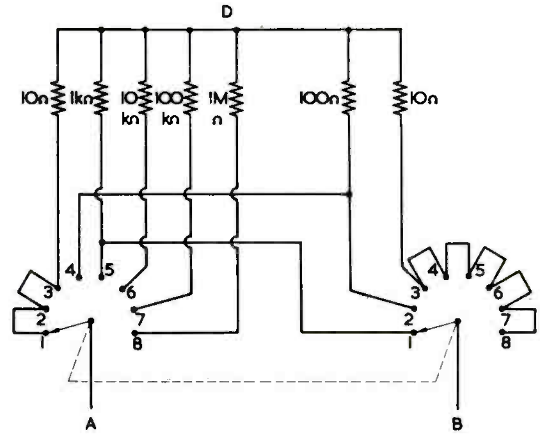


Fig. 6. A switching circuit which provides the ratio arms for a Wheatstone bridge with the minimum of resistors

on the 1000Ω range) that can possibly be obtained is slightly better than 0.5%, i.e. a reading of either 112 or 113Ω. If, therefore, a higher degree of accuracy than this is required, it will be necessary to use a four decade unit.

The lowest value of resistance that can be used with any degree of reliability of calibration in the decade box will be 1Ω, as already mentioned, and even here an error of several per cent may be expected.

Two possibilities now present themselves. Either a four decade box with the first decade reading in steps of 1Ω giving a total of 10,000Ω overall, may be used, or alternatively, a three decade box preceded by a calibrated wire-wound potentiometer of 1Ω or 10Ω may be used.

There is a great deal to be said in favour of the second alternative, using a potentiometer of 1Ω value, as it is by far the easiest to construct and can still be built to give a guaranteed accuracy, under even the worst conditions, of better than 0.1%, and will generaly read better than 0.05%. Such a decade box will therefore have an overall value of 1,000Ω, and from this the values of the remaining components can be deduced.

The maximum reading on the lowest range of the bridge will be 10Ω (see the Table) and successive ranges will go up in multiples of 10. As mentioned earlier, the lowest value of standard that will be used in the ratio arms is 10Ω.

Remembering that R_2 has an overall value of 1,000Ω and that the maximum reading on the lowest range is 10Ω, from the formula $R_1 \times R_4 = R_2 \times R_3$ it can be seen that $10 \times R_4$ must equal $1{,}000 \times R_3$. The minimum value for R_3 is 10Ω so that to satisfy the formula R_4 must be 1,000Ω. The component values for the first range, which will be called Range 1, have thus been deduced, and by a similar process the values of the remaining seven ranges can be established. The Table gives a tabulated list of the results obtained.

It will be noticed from the Table that the only time that two resistors of the same value are in circuit together is on Range 3, when two 10Ω resistors are used. It is therefore possible to arrange the switching of the ratio arms in such a way that only seven resistors need be used to cover the complete range of the bridge. Fig. 6 shows the switching layout that can be employed to achieve this. It can be seen that one 8-way 2-pole switch is used, but in practice this will probably consist of a ten way switch suitably modified. One end of each resistor is joined to a common point or bar. The

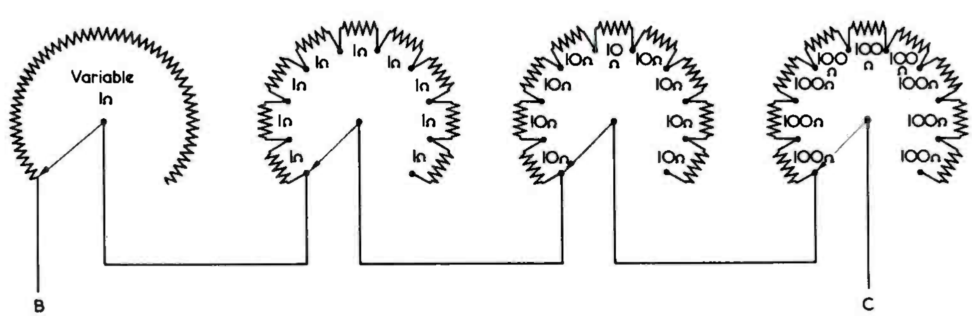


Fig. 7. A decade box which offers continually variable values of resistance from less than 1Ω to 1,000Ω

references A, B and D correspond to the similarly marked points in Fig. 1.

There are two possible ways in which the decade boxes may be built. Fig. 7 shows one method, in which three 10-way single pole switches and one potentiometer are used in conjunction with 27 resistors.

The alternative to this is based on quite a different system. It is a fact that if a series of numbers, starting with 1, are taken up to the power of two, i.e., 1,2,4,8,16,32, etc., then any number can be obtained from the sum of some of these. For example, 15=8+4+2+1. Again, 19=16+2+1.

In our case it is only necessary to go up to 9 and this can be done using resistors of 1,2,4, and 8 units value, so that it can be arranged that, instead of using nine resistors in each decade, only four need be used. A price has to be paid for this reduction in components in the form of more complex switching arrangements.

It will be noticed that with this four-resistance method that in order to obtain a value of 7Ω it is necessary to sum three resistors, i.e., 1,2 and 4Ω. This will necessitate the use of a 3-pole switch. If the 8Ω resistor is changed for one of 7Ω, however, the switching can be carried out with a 2-pole switch, as long as numbers greater than 9 are not required. Fig. 8 shows the wiring layout for the complete decade box using this system. Three 10-way, 2-pole switches and one 1Ω potentiometer are used, in conjunction with twelve resistors. The references B and C correspond to the similarly marked points in Fig. 1.

TABLE

Resistance values in R_3 and R_4 for Ranges 1 to 8 (R_2=0–1,000Ω variable resistor)

Range	x(Ω)	R_3	R_4
1	0–10Ω	10Ω	1k
2	0–100Ω	10Ω	100Ω
3	0–1kΩ	10Ω	10Ω
4	0–10kΩ	100Ω	10Ω
5	0–100kΩ	1kΩ	10Ω
6	0–1MΩ	10kΩ	10Ω
7	0–10MΩ	100kΩ	10Ω
8	0–100MΩ	1MΩ	10Ω

Choice of Resistors as Standards

The type of resistors used as standards in the bridge will depend on the accuracy required from the instrument. If only "rough" indications are required then 2% to 5% carbon resistors may be used. If it is required to have a final accuracy

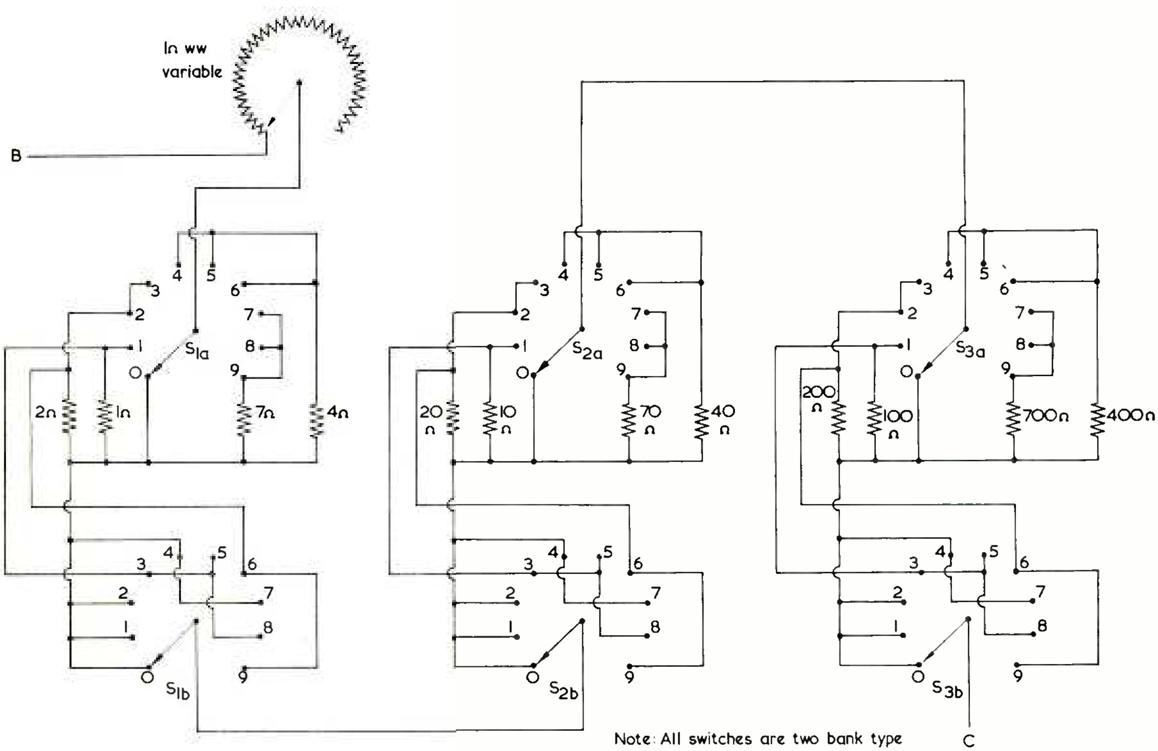


Fig. 8. A switching circuit which offers the same range as is given by Fig. 7, but with much fewer resistors

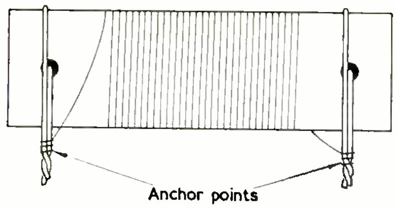


Fig. 9. Winding a resistor on a flat strip of Paxolin

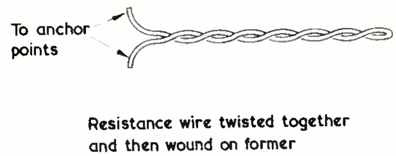


Fig. 11. Preparing resistance wire for a non-inductive resistor

of about 2% then 1% high stability or wirewound types must be used. At accuracies greater than this the cost of commercial components becomes prohibitive, and the amateur will probably find it necessary to make his own. This is a time-consuming but not difficult job, and there is no reason why the patient constructor should not end up with a bridge that can measure to an accuracy of a fraction of 1%.

Before going on to the actual construction of the resistors, it will be as well to make a few notes about the different types of resistance wire that can be used. Broadly speaking, there are three types, Eureka or Constantan, Manganin, and Nickel-chrome.

Nickel-chrome has a resistivity about 61.5 times that of copper which is the highest for the normal resistance wires, so that it is most used where very high resistances are needed and other types of wire would have to be excessively long. It can also be run at a high temperature without damage. Its temperature coefficient per degree Centigrade is 0.0002.

Eureka or Constantan has a resistivity about 28.5 times that of copper. Its temperature coefficient is 0.00001, far better than that of Nickel-chrome. It is easily soldered, but does not stand up well to excessive temperatures.*

Manganin has a resistivity slightly less than that of Eureka, but has an even better temperature coefficient. It is very difficult to solder and will normally need to be silver-soldered at red heat. After winding has been completed it should be completely coated with shellac varnish. It must then be annealed for at least 24 hours at about 135°C. This process can result in resistors that have a temperature coefficient of almost zero at normal temperatures, and for this reason Manganin is generally used for the better types of standard resistors.

It is unlikely that the reader will be willing to take all the trouble involved in the construction of the Manganin types. Eureka is nearly as good, and is definitely good enough for the present purpose, so it will be assumed that Eureka wire will be used.

The general procedure for making the resistors is to first decide which gauge of wire to use, and then look up a set of tables and work out the length of wire needed to give the desired resistance. When this has been decided, cut off a length slightly longer than that indicated.

A former is now made up from a strip of Paxolin or similar material, as shown in Fig. 9. The dimensions will generally be about ¼in by 1in. The heavy wires shown locked to the Paxolin in the diagram are used as anchor points for the resistance wire. One end of the resistance wire is soldered to one of the anchor wires and the rest is wound round the former. The other end is temporarily soldered to the remaining anchor point. The overall resistance should now be checked against a standard, and adjusted as necessary. When the adjustments have been finalised the soldered joints should be firmly made and the resistance re-checked. On the larger resistors, where considerable lengths of wire may

*There appear to be discrepancies between the temperature coefficients quoted by different sources for resistance wires and, whilst these discrepancies do not detract from the author's argument, they may be briefly referred to. Thus, London Electric Wire Company and Smith's Ltd. quote a temperature coefficient of ±0.00004 per °C for their Eureka wire, 0.000098 per °C for their "Vacrom 80/20" Nickel Chrome wire, and 0.000202 per °C for their "Vacrom 15%" Nickel Chrome wire.—EDITOR.

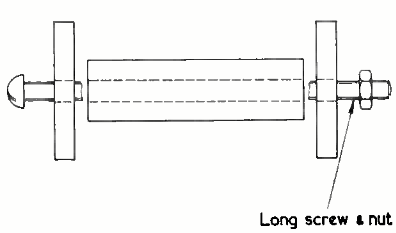


Fig. 10. Long lengths of resistance wire may require the use of a bobbin

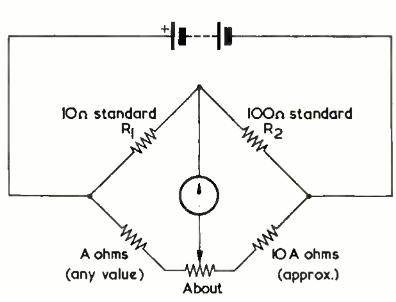


Fig. 12. A set-up which enables highly accurate resistors to be made up with the aid of two standards only

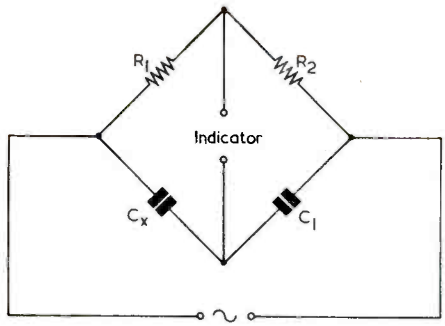


Fig. 13. The De Sauty bridge

be used, it may be necessary to make them up on bobbins, as shown in Fig. 10.

If any of the standards made in this way are to be used in a.c. circuits they must be non-inductively wound by winding the resistance wire back on itself so that the magnetic field set up by a current flowing in the wire is cancelled by an opposing field in another part of the wire, as shown in Fig. 11.

It has been mentioned that when making a resistor it is necessary to check it against a standard. Some readers will have such a facility at their place of work, but those that have not will probably find that the local technical college has one of very high accuracy, and if a letter is written to the Principal of the establishment explaining things he will no doubt give permission to use it.

Failing this, a third method is available. It will be necessary to purchase two resistors of as high an accuracy as possible at least 0.2% of 10Ω and 100Ω values. These are put in a temporary bridge. With reference to Fig. 1, the 10Ω resistor will be R_1 and the 100Ω resistor will be R_2. R_3 and R_4 are formed by a resistor, a potentiometer, and another resistor of about ten times the value of the first one in series. See Fig. 12. The indicator is connected between the junction of R_1 and R_2 at one end and to the slider of the potentiometer at the other.

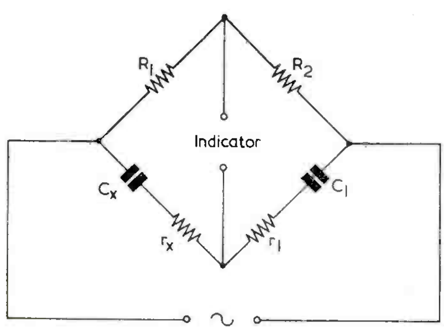


Fig. 14. The circuit which results when capacitor resistance is taken into account

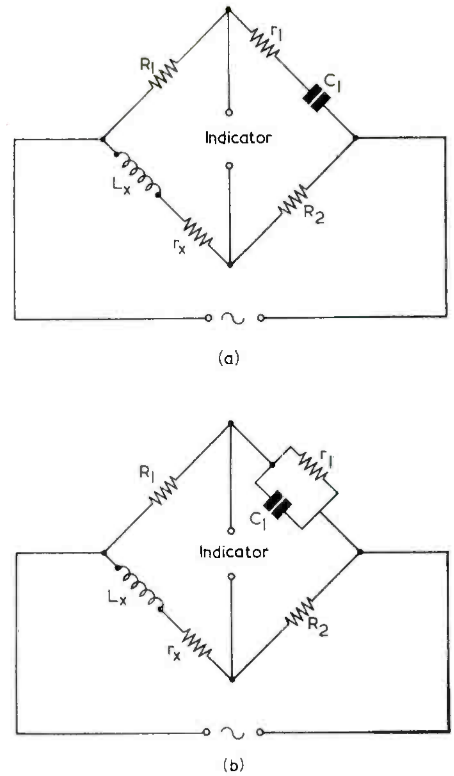


Fig. 15(a). The Hay bridge
(b). The Maxwell bridge

The potentiometer is now adjusted until the indicator shows a null. The ratio arms, R_3 and R_4, will now be in the exact ratio of 1 : 10. R_1 can now be removed and a home-made 10Ω resistor tried in its place, and adjusted if necessary. Any number of 10Ω resistors can be made in this way. When a sufficient number have been constructed R_1 should be replaced and R_2 removed, and any desired number of 100Ω resistors made in the same way.

R_2 should again be removed and replaced by R_1, the 10Ω resistor. In the R_1 position a 1Ω resistor will be needed to give balance, so any number of 1Ω resistors can be made. In the same way, when R_2 (100Ω) is removed and put in the R_1 position, 1,000Ω resistors can be made in the R_2 position. The resistors made in this way can then be substituted in the ratio arm positions and a further series of higher value resistors made.

When the decade box is made, the 1Ω potentiometer should first be calibrated at the 1Ω point only. Then a 1Ω resistor is made up, as above. R_3 and R_4 are next made, say, 10Ω each, so that a ratio of 1 : 1 is obtained. The 1Ω potentiometer and 1Ω resistor are now put in series in the R_2 position, giving 2Ω overall resistance. A 2Ω resistor can then be made up in the R_1 position. This is then put in series with the 1Ω resistor and potentiometer, making R_2 4Ω overall, and a 4Ω resistor can then be made up in the R_1 position. This procedure is repeated for the remaining resistors.

When making resistors of over, say, 1,000Ω it will probably be found best to buy a high stability resistor of just under the required value and put it in series with a home-made one to bring it up to the required value.

As a guide to the lengths and gauges of wire needed to give certain resistance values, the following list, for Eureka wire, should be of help. The lengths given are approximate only.

1Ω=9ins. of No. 28 s.w.g.
10Ω=23.5ins. of No. 36 s.w.g.
100Ω=65ins. of No. 42 s.w.g.
1000Ω=55feet of No. 42 s.w.g.

The Eureka wire used may conveniently be d.c.c. or similar.

A. C. Bridges

When considering the Wheatstone bridge it was pointed out that at balance $\frac{R_1}{R_2}=\frac{R_3}{R_4}$. This of course is true in a d.c. circuit only. In an a.c. circuit, impedances must be considered and the formula becomes $\frac{Z_1}{Z_2}=\frac{Z_3}{Z_4}$, so that reactances as well as resistances must be taken into account.

The basic Wheatstone bridge can therefore be modified to form the basis of a large variety of a.c. bridges, each with its own particular advantages and disadvantages, for the measurement of inductance and capacitance, etc.

The choice of a.c. bridges is so great that space does not permit a description of them all, and only the three that are of most use to the amateur will be dealt with here.

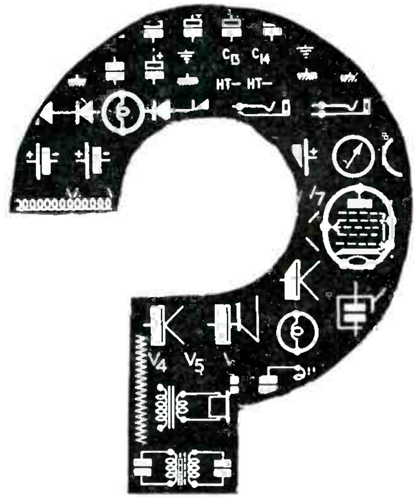
A suitable circuit for measuring capacitance is shown in Fig. 13. From what we have seen up to now, the circuit is self-explanatory. The bridge is to a large degree, independent of frequency. At balance $C_x=\left(\frac{R_2}{R_1}\right)C_1$. In practice all capacitors and inductors have some value of series resistance, so that the true circuit becomes as shown in Fig. 14. To obtain a true reading on the bridge this series resistance must also be balanced out. In Fig. 14 r_x represents the inherent series resistance of the unknown capacitor, and r_1 is the control used to balance it out. At balance $r_x=\left(\frac{R_1}{R_2}\right)r_1$. The r_1 control can be calibrated to give an indication of the power factor of the component under test. The bridge of Fig. 13 is sometimes described as the DeSauty bridge.

Two circuits for the measurement of inductance are shown in Fig. 15. It will be noticed that the reactive components are in opposite arms and that the inductance is balanced by a capacitor. The two bridges shown are the Hay (Fig. 15 (*a*)) and the Maxwell (Fig. 15 (*b*)). In each case it is found that at balance $L_x=C_1\times R_1\times R_2$. The Hay bridge is better for measuring large values of inductance.

In an actual test instrument one bridge can be converted to another type by suitable switching.

(To be concluded)

understanding radio



“Squegging” and Receiver Reaction

By W. G. Morley

In the last article in this series we introduced the subject of oscillator frequency stability and noted that there are four main reasons for variation in oscillator frequency after switching on. These consisted of 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 into components; and mechanical factors. We considered the first two or these factors in detail in the previous article, and we shall next carry on to briefly examine the remaining two.

Ingress of Moisture

Ingress of moisture into oscillator components can cause variations in oscillator frequency, these usually being of a long term nature. A short term effect under severe conditions is also feasible, if water is driven out of the components under local heat from valves and other components.

Since it is common practice to protect coils by impregnation with wax, varnish or similar materials, and to employ protective coatings for capacitors, frequency variation due to the effects of moisture ingress is not liable to give trouble provided that good-quality components are employed in the oscillator circuit. Nevertheless, the possibility of moisture ingress should not be completely dismissed from mind, particularly with oscillators which are required to have a high degree of long term stability.

Mechanical Factors

Mechanical factors may cause variations in oscillator frequency. A typical example is given by a poor mechanical design which allows components in the oscillator tuned circuit to move in position due to vibration or handling. Another example which falls into this category is *microphony*. Microphony describes the condition where oscillator frequency varies due to vibration or noise impinging on the oscillator components. A common instance of microphony occurs with air-spaced variable capacitors, whose plates may vibrate in sympathy with sound or vibration. If a capacitor of this type is employed in an oscillator circuit it can vary oscillator frequency at the frequency of the sound or vibration. This effect can prove troublesome in radio receivers when the sound from the loudspeaker reaches a variable tuning capacitor, either via the air or by way of the chassis. The capacitor may be mounted on soft rubber or p.v.c. grommets to prevent this trouble.

Amateur Transmitter Oscillators

When, in the June issue, we described the Franklin oscillator, we saw that it was possible to couple the single tuned circuit that this oscillator requires to the remainder of the circuit by way of two small fixed capacitors having values of the order of several picofarads or less. As was stated then, this gives the tuned circuit a high level of isolation from stray capacitances in the remainder of the circuit. We may now see that the benefit conferred is that the oscillator frequency is less likely to vary due to changes in self-capacitances in valves and other components during warm-up. If the capacitance across the tuned circuit is high compared with the small-value coupling capacitors, a very high degree of frequency stability is feasible.

This frequency stability makes the Franklin circuit attractive for amateur transmitter applications, since it is capable of providing a transmitter frequency which has good stability and is also

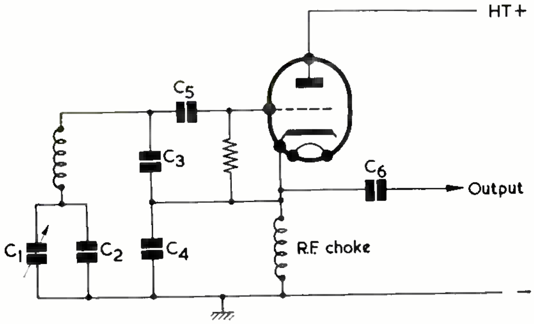


Fig. 1. The basic Clapp oscillator. C_5 is the grid capacitor, whilst C_6 is a coupling capacitor

capable of being varied by a panel control. In amateur transmitter parlance the oscillator then functions as a *variable frequency oscillator*, or v.f.o. The term "variable" distinguishes the oscillator, in this application, from the crystal oscillator (discussed later) which has a fixed frequency.

A variable frequency oscillator that is very popular for amateur transmitting work is shown in basic form in Fig. 1. This is the *Clapp oscillator*, and it will be seen that it is very similar to the Colpitts oscillator illustrated, in the June issue, in Fig. 347 (*c*). The two capacitors C_3 and C_4 have relatively high values, of the order of 2,000pF each, with the consequence that changes in stray capacitances in the grid-cathode circuit of the valve have proportionately less effect on oscillator frequency. The resonant frequency is adjusted by the variable capacitor C_1, which may have a maximum value, typically, of some 50 to 100pF. The fixed capacitor C_2, across C_1, may have a value of the same order, and it prevents the capacitance in series with the coil from falling to too low a value, whereupon oscillator output is liable to drop. The circuit oscillates with good stability over the relatively small range of frequencies which can be selected by C_1, this range being adequate for amateur transmitter applications. A practical Clapp oscillator will normally employ a valve having more electrodes than a triode, but this point will have to be discussed in a later article when we deal with such valves.

Crystal Oscillators

It is common to employ a quartz crystal in fixed frequency oscillators requiring a very high degree of frequency stability, the crystal providing frequency control instead of a tuned circuit.

The crystal consists of a thin slab cut from the natural quartz crystal along a specific axis, and it is placed between two parallel metal plates which form the electrodes. Due to piezo-electric effect the crystal vibrates when an r.f. signal is applied to the two plates. The crystal can exhibit a mechanical resonance (whose frequency depends on its dimensions) and, if an r.f. signal at a mechanical resonant frequency is applied to the plates, crystal vibration takes place at a very high amplitude. The crystal assembly then functions as though it were a tuned circuit having a very high value of Q and, when incorporated in an oscillator circuit, offers an extremely high degree of frequency stability. It is not proposed to go into any further detail here on the crystal oscillator, and it is only mentioned at this stage to present a balanced overall picture.

"Squegging"

We have seen that it is normal practice to employ a grid leak and capacitor to provide bias for an oscillator, and these are shown in the typical oscillator circuit given in Fig. 2. When grid leak bias functions correctly the capacitor becomes charged during each positive peak of the oscillatory signal appearing at the upper terminals of the tuned circuit, and partly discharges into the grid leak during the remainder of the cycle. It then receives a charge at the next positive peak. This process results in the oscillator valve receiving the correct amount of bias needed to maintain reliable oscillation, and the amplitude of the oscillation across the tuned circuit remains constant.

Let us now take our examination of the grid leak bias circuit a little further and follow its operation from the instant of applying h.t. to the oscillator when the valve cathode is at emitting temperature. There will be, initially, a small oscillatory voltage across the tuned circuit which, due to the positive feedback and the amplification provided by the valve, very quickly rises to its full operating amplitude. At this amplitude the circuit enters a state of equilibrium. If the oscillator amplitude tended to increase, the valve would receive more bias and the duration of the positive peaks which cause anode current to flow would be shorter. The feedback currents from the anode would then be weaker, with the consequence that oscillator amplitude would reduce, reverting to its previous level.

However, should the grid capacitor be given a value which is grossly too large, the oscillator works in quite a different manner. In this instance

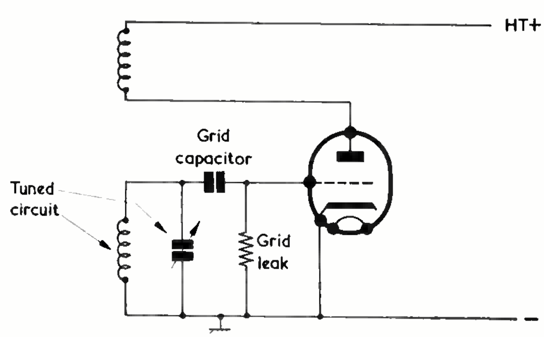


Fig. 2. The tuned grid oscillator. In company with other tuned circuit oscillators employing grid leak bias, this is subject to "squegging" if the grid capacitor has too large a value

we have the same increase in oscillation amplitude from the moment of switching on, but this time the grid capacitor charges and discharges more slowly. The oscillation amplitude rises to a level higher than occurred previously when the grid capacitor had the correct value, because the large-value capacitor takes longer to charge up to the potential which causes the requisite bias to be applied. Moreover, when the voltage across the capacitor reaches this potential, the still high amplitude of oscillation can cause it to slightly exceed the potential. The valve cannot then offer sufficient amplification to maintain the oscillation, whose amplitude commences to fall. A grid capacitor of correct value would cause the grid bias to fall at once to compensate for the reduced amplitude, but our present high-value capacitor cannot do this. The potential across its plates drops at a lower rate than the fall in oscillation amplitude, with the result that the oscillation ceases altogether. The grid capacitor continues to discharge into the grid leak until the slowly reducing grid bias on the valve becomes sufficiently low to allow oscillation to commence once more. Again, oscillation amplitude increases, and the whole process is repeated.

The overall result is that the valve goes continually in and out of oscillation, the effect being referred to as "*squegging*". The frequency at which squegging occurs depends mainly upon the values of the grid leak and capacitor and it can fall within the audio frequency range or it can occur at frequencies above the audio range.

It is, fortunately, a simple matter to avoid squegging since all that is required is to choose a grid capacitor whose value is not too great. A practical approach consists of employing an oscillator grid leak of 20 to 50kΩ and a grid capacitor of around 50 to 100pF; and these values should cope for most oscillators working between 500 kc/s and 10 Mc/s. Since, however, the onset of squegging is partly governed by factors in the oscillator circuit other than the grid leak and capacitor, these including the amplification provided by the valve and the tightness of coupling in the positive feedback circuit, it is difficult to state values for the grid leak and capacitor which will prevent squegging in all practical oscillators. But should squegging occur, and its existence may normally be readily recognised by the behaviour of the equipment in which the oscillator is fitted, all that is required is that the value of the grid capacitor be reduced until the effect clears.

We used the tuned grid oscillator of Fig. 2 to provide an example for our discussion of squegging. The effect can similarly occur with any other tuned circuit oscillator employing a grid leak and capacitor.

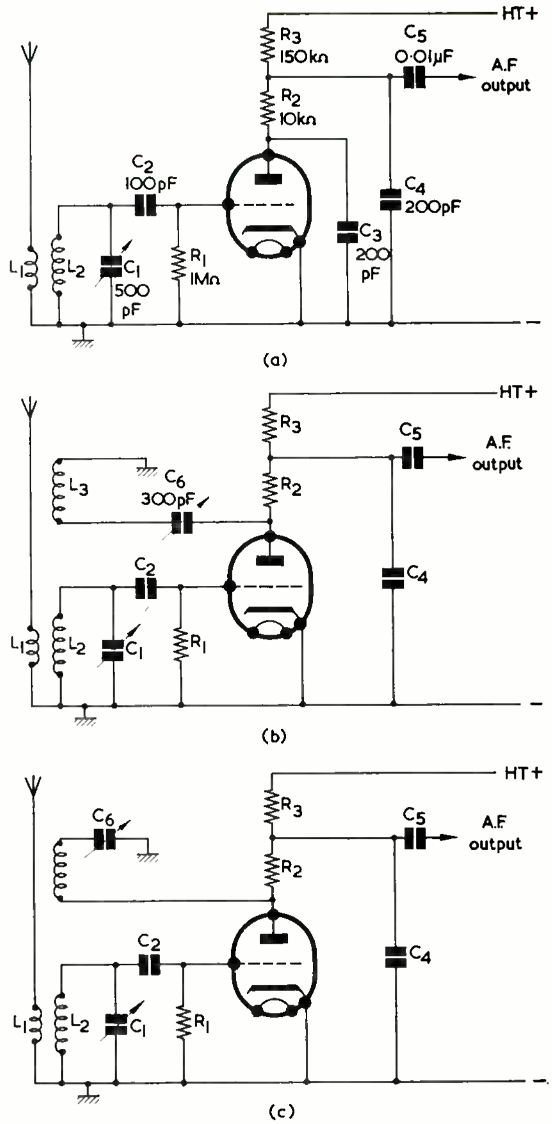


Fig. 3 (a). A typical grid leak detector circuit, with representative component values for medium wave operation. A subsequent a.f. amplifier feeding a loudspeaker or phones is assumed

(b). In this circuit C_3 is omitted, and is replaced by the reaction components L_3 and C_6. Adequate filtering of r.f. from the a.f. output is still provided by R_2 and C_4 when C_6 is set to minimum capacitance

(c). If C_6 is inserted on the chassis side of L_3, the frame of this capacitor may be mounted direct to chassis

Reaction Circuits

We have already discussed the grid leak detector,[1] and a typical circuit incorporating this detector is given in Fig. 3 (*a*). In this diagram the aerial is applied to winding L_1, which couples to the tuned winding L_2. The latter, in combination with C_1, forms a tuned circuit, and the aerial signal selected by this circuit is then applied, by way of

[1] In the October 1965 issue.

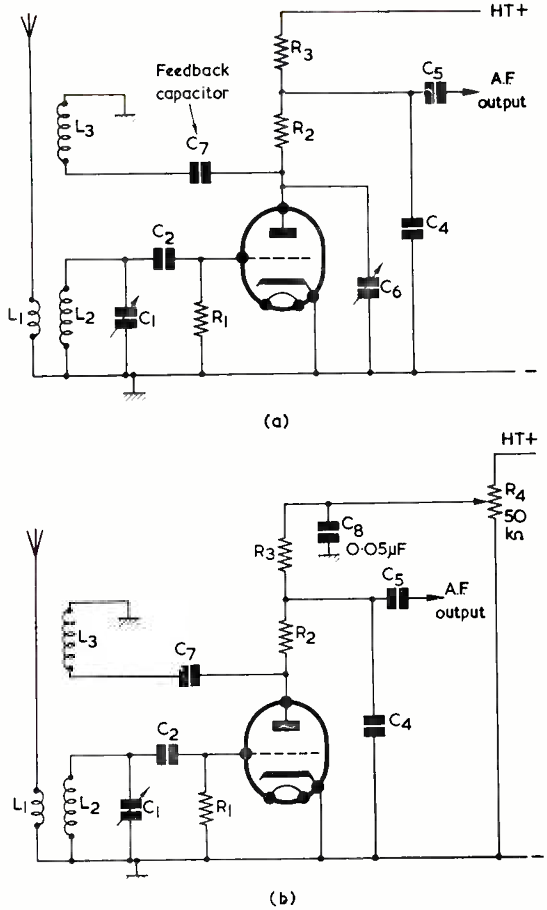


Fig. 4 (a). An alternative method of obtaining a variable control of reaction. The fixed feedback capacitor, C_7, would have a value, typically, of 100pF The remaining capacitors and resistors have the same values as in Fig. 3
(b). Obtaining a control of reaction by means of a potentiometer. C_8 is an a.f. bypass capacitor and can have the typical value shown. Since R_4 will dissipate a small amount of power, it would preferably be a wirewound component

grid capacitor C_2 and grid leak R_1, to the grid of the triode. An amplified version of the detected signal appears at the anode. So also does an amplified version of the radio frequency applied to the grid and, since it is normally undesirable to feed an r.f. signal to a following a.f. amplifier, this is removed by the low-pass filter given by C_3, R_2 and C_4. R_3 is the a.f. anode load for the triode and C_5 the a.f. coupling capacitor to a subsequent a.f. amplifier stage. Typical values for medium wave operation are given for the resistors and capacitors.

In Fig. 3 (*b*) we introduce a second coupling winding, L_3, this being coupled to the triode anode by way of variable capacitor C_6. The amplified r.f. signal which previously passed through C_3 now passes through C_6 and L_3. It can at once be seen that we have the basic circuit for a shunt-fed tuned grid oscillator and that, if the value of C_6 is high enough to provide sufficient feedback, the circuit will go into oscillation. In a circuit using conventional components and coils, this will occur when C_6 has a value of the order of 100 to 200pF.

At capacitances in C_6 below that which allows the circuit to go into oscillation, a proportion of the amplified r.f. signal is still fed back to the tuned circuit, whereupon the amplitude of the signal across this circuit increases. When we considered the basic characteristics of tuned circuits[2] we saw that the current magnification factor which occurs in a parallel tuned circuit is equal to its quality factor, or Q. In the circuit of Fig. 3 (*b*) we are, by positive feedback, increasing the current at radio frequency which flows in the tuned circuit, whereupon we are causing an increase in its *effective* Q. As a result the tuned circuit offers increased selectivity together with an increase in signal level.

The increase in selectivity and signal level becomes more and more evident as C_6 is adjusted to insert more capacitance, and is at its greatest when the capacitance in C_6 is just below that at which oscillation occurs. If a circuit of the type shown in Fig. 3 (*b*) is designed carefully, the increase in selectivity and sensitivity it provides can be extremely high. The design aim is to so arrange component values and coupling between coils that the circuit goes "smoothly" into oscillation as the capacitance inserted by the variable reaction capacitor increases. It then becomes possible to bring the circuit extremely close to the oscillation point without actually going into oscillation. The audible effect from the audio amplifier loudspeaker or earphones when a circuit of this nature goes into oscillation is the appearance of a low level hiss. In a badly designed circuit, oscillation may occur suddenly as C_6 is advanced, the change in state resulting in a "plop" from the loudspeaker or earphones. An even worse condition is *backlash* in which oscillation, once commenced, can only be stopped by reducing C_6 to a significantly lower value than that which caused the onset of oscillation. Neither of these conditions allows a fine setting in C_6 which is just below oscillation point, and which enables the considerable increase in sensitivity and selectivity of which the circuit is capable, to be realised.

Feedback circuits of the type shown in Fig. 3 (*b*), in which the degree of feedback is controlled, are described as *reaction* or *regeneration* circuits. In American terminology, the feedback winding (L_3 in Fig. 3 (*b*)) is given the colourful name of *tickler* winding. Domestic and home-constructor receivers using detectors with reaction were very

[2] In the February 1963 issue.

popular before the war, but they have now been largely superseded by the superhet receiver, whose functioning will be described later in this series of articles. The superhet is more complex in operation than a receiver employing a detector with reaction, but it offers improved selectivity and sensitivity without the necessity of adjusting the reaction control. Nevertheless, a receiver employing a detector with reaction is an excellent project for the home-constructor, and particularly the beginner, because it is very simple to set up and its operation is easy to understand.

In detector circuits employing reaction, it is usual to give the grid leak a value considerably higher than would be employed in the corresponding oscillator circuit. Typical values range between 200kΩ and 3MΩ, the grid capacitor being of the order of 25 to 150pF. When a directly-heated battery valve is employed as the detector, it is normal practice to return the lower end of the grid leak (which, in Fig. 3 (*b*), connects to the cathode of an indirectly-heated valve) to the positive rather than the negative end of the filament, it being found that this method of connection improves the "smoothness" of reaction control due to the small positive grid current which then flows below the oscillation point.

In practical circuits, it is preferable to have the reaction capacitor, C_6, on the chassis side of the reaction coupling winding, as in Fig. 3 (*c*), rather than on the anode side, as was illustrated in Fig. 3 (*b*). The capacitor still controls the feedback current flowing through coupling winding L_3, but its frame may now be mounted directly to the chassis or to a metal front panel. The method of connection shown in Fig. 3 (*b*) has the further disadvantage that *hand-capacitance* effects are possible. As the hand approaches the capacitor, its capacitance to the capacitor spindle can upset the balance of capacitances to chassis in the circuit, and make it difficult to reliably approach the optimum reaction point. The relatively large mass of the body would have, in this instance, a sufficiently high capacitance to the receiver chassis for the effect to occur. Hand-capacitance effects will be absent with the circuit of Fig. 3 (*c*), particularly if C_6 is fitted to a metal front panel connected to chassis.

A fairly commonly encountered variant to Figs. 3 (*b*) and (*c*) is illustrated in Fig. 4 (*a*). In this case the feedback capacitor is fixed, and the variable capacitor, C_6, is connected between anode and chassis. C_6 controls reaction because, as it is increased in value, it reduces the r.f. current flowing in the feedback circuit. An interesting feature is that C_6 works "backwards" since, when it is set to maximum capacitance, minimum r.f. current flows in the feedback circuit. As the capacitance in C_6 is reduced, more and more r.f. current flows in the feedback circuit until the detector eventually goes into oscillation. Such a circuit is sometimes referred to as a "throttle" reaction circuit.

Another variant is illustrated in Fig. 4 (*b*), where C_7, the feedback capacitor, is again a fixed component. In this circuit, reaction is controlled by the potentiometer R_4. When the slider of R_4 is advanced from the chassis end of its track, an increasing h.t. voltage is applied to the anode load of the valve until the circuit eventually goes into oscillation. The value of C_7 will be such that oscillation occurs when the potentiometer slider is near the h.t. positive end of its track, this ensuring that the valve receives an adequate h.t. voltage at the point immediately below oscillation. This circuit has the minor advantage that the potentiometer also functions partly as a volume control. Very strong signals can be reduced to a low level by setting the potentiometer slider near the chassis end of the track, whereupon the detector has a low h.t. potential. Another advantage is that, whereas a reaction capacitor has to be mounted close to the valve and tuned circuit to enable short interconnecting leads to be used (as is necessary in leads carrying r.f. currents), the potentiometer can be mounted at any convenient point on the chassis or front panel since it only varies the direct voltage applied to bypass capacitor C_8. This point can be helpful in easing layout problems.

In all the reaction circuits we have seen, the resistor R_2 in the anode circuit may be replaced by an r.f. choke. It should be pointed out that, when the detector goes into oscillation, the circuit functions as a transmitter and radiates at oscillator frequency by way of the aerial, with the risk of interference with neighbouring receivers.

A final point is that, when a signal is tuned in on a receiver having a detector whose reaction is advanced so far that oscillation is occurring, a *heterodyne* or *beat note* is formed. This consists of an a.f. tone whose frequency is equal to the difference between the transmitted carrier and the detector oscillation frequency, and it decreases as the detector comes more and more into tune, falling below the audio frequency range when the detector oscillation frequency is very close to that of the carrier.

Next Month

A great deal of ground has been covered in this series up to the present, and it now becomes possible to put all the theoretical points dealt with into use by building practical demonstration equipment. It is hoped to give more details of this approach in next month's issue.

RODING BOYS' SOCIETY

Following the resignation of the leader of the Roding Boys' Society on the 29th April, 1966, this society has now been disbanded. However, some of the ex-members of the Society have now formed the REDBRIDGE SCIENTIFIC SOCIETY, meeting at the same premises, Wanstead Community Centre, The Green E.11.

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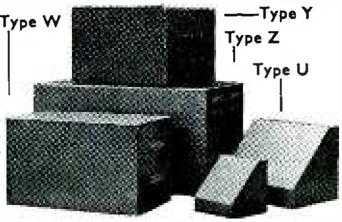

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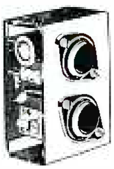
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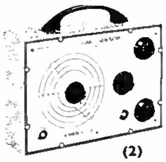
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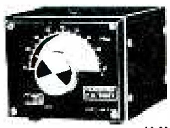
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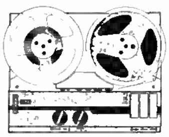
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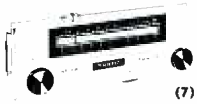
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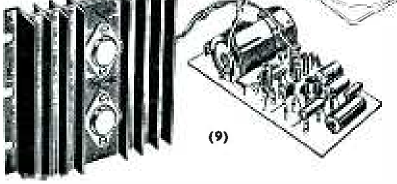
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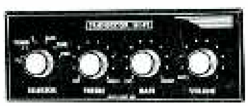
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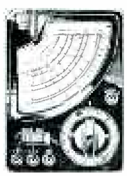
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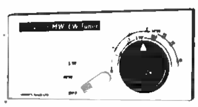
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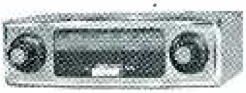
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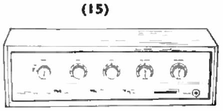
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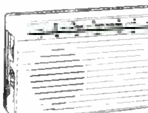
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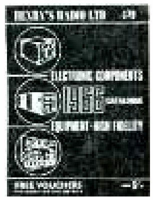

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Special purchase reduces prices

Full 3-waveband tuning. Pushbutton wavechange. Superhet printed circuit. Black-chromed cabinet 11 × 7½ × 3½". (SW 17–50 metres). Ear/Record sockets.

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87/105 Mc/s Transistor Superhet. Geared tuning. Terrific quality and sensitivity. For valve or transistor amplifiers. 4 × 3½ × 2½".

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(9) **POWER AMPLIFIERS.** 10 watts RMS output. 100mV input. 30 c/s to 20 kc/s ± 1dB. 6-Transistor Push-pull. Panel size 4 × 2½ × 1". H/S 4 × 4".
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SP4 Mono/Stereo. 9 × 3½ × 1½". **£10.19.6,** P.P. 3/6 (front panel plate 12/6)

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(3) 5 WATT AMPLIFIER

6-Transistor Push-pull, 3 ohms. 6mV into 1K. 12/18V supply. 2½ × 2 × 1½".
BUILT AND TESTED 69/6 P.P. 2/–
(optional mains units **54/–**)
1½ watt version **59/6.**
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 in moulded case. **45/–** P.P. 2/–

(13) REGENT-6 MW/LW POCKET RADIO TO BUILD

6-Transistor superhet. Geared tuning. Push-pull output. Moulded cabinet 5 × 3 × 1½". Phone socket

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Special purchase reduces price

(15) HI-FI Equipment

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(4) DEAC CELLS

Rechargeable Batteries

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(p.p. 5/– any type)

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*SP25 mono	**£10.10.0.**	stereo	**£10.19.6**
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