THE Radio Constructor

RADIO
TELEVISION
AUDIO
ELECTRONICS

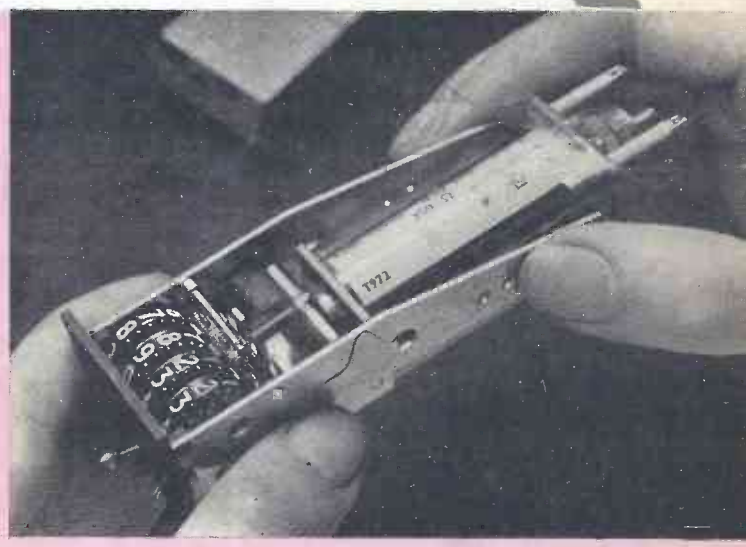
VOLUME 17 NUMBER 3
A DATA PUBLICATION
PRICE TWO SHILLINGS

October 1963

contents include

2-Valve S.W. Receiver

3-Transistor Tuner



Electro-Magnetic Counters

DESIGNING — EXPERIMENTING — BUILDING — OPERATING

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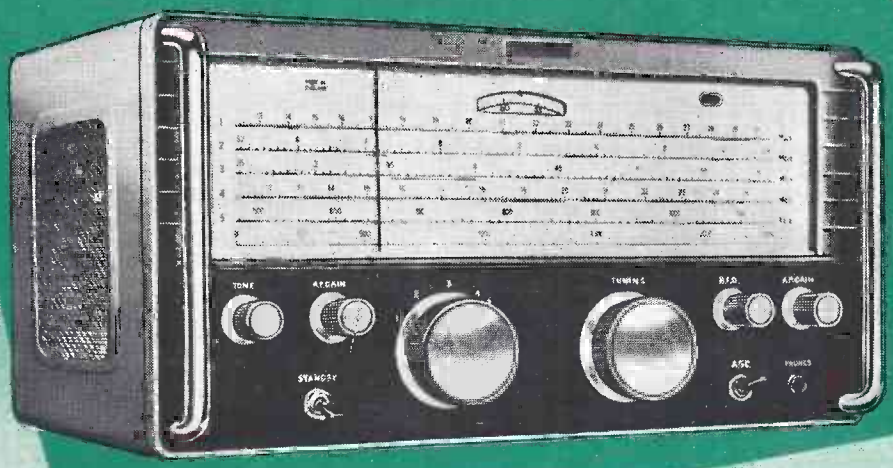
USE THE EDDYSTONE

General Purpose Communications Receiver 840c



With continuous coverage from
480 kc/s to 30 Mc/s

LIST PRICE
£58.0.0

- ★ MODERN STYLING AND PRESENTATION
- ★ GREATER EASE OF TUNING AND FREQUENCY RESOLUTION
- ★ LINEAR SCALES AND BETTER BANDSPREAD
- ★ IMPROVED ELECTRICAL PERFORMANCE
- ★ HIGH QUALITY WORKMANSHIP AND CONSTRUCTION

ILLUSTRATED BROCHURE GIVES SPECIFICATION AND FULL DETAILS

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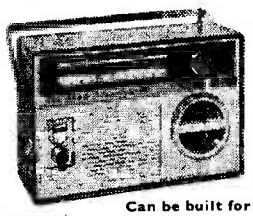
LASKY'S RADIO

THE FINEST RANGE OF TRANSISTOR RECEIVERS

We consider our construction parcels to be the finest value on the home constructor market. If on receipt you feel not competent to build the set, you may return it as received within 7 days, when the sum paid will be refunded, less postage.

LASKY'S FIRST AGAIN!

NOW OFFER TO THE HOME CONSTRUCTOR, FULL SHORT WAVE COVERAGE THE SKYROVER AND THE "SKYROVER" DE LUXE



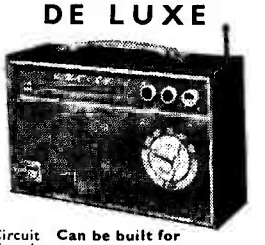
Can be built for

£10.19.6 *P. and P. 5/- extra*

GENERAL SPECIFICATION. 7 transistor plus 2 diode superhet, 6 waveband portable receiver. Operating from four 1.5 torch batteries. The SKYROVER and SKYROVER DE LUXE cover the full medium waveband, and short waveband 31–94 M, and also 4 separate switched band-spread ranges, 13M, 16M, 19M and 25M, with Band Spread Tuning for accurate Station Selection. The coil pack and tuning heart is completely factory assembled, wired and tested. The remaining assembly can be completed in under three hours from our easy to follow, stage by stage instructions.

SPECIFICATION: Superhet, 470 kc/s. All Mullard Transistors and diode. Uses 4-U2 batteries. 5" Ceramic Magnet P.M. Speaker. Easy to read Dial Scale. Band Spread Tuning. 500mW Output. Telescopic Aerial and Ferrite Rod Aerial.

WAVEBAND COVERAGE. 180–576M, 31–94M, and Band Spread on 13, 16, 19 and 25 metre Bands.



Can be built for

£12.19.6

P. and P. 5/- extra

THE SKYROVER. Controls: Waveband Selector, Volume Control with on/off Switch, Tuning Control. In plastic cabinet, size: 10" x 6½" x 3½", with metal trim and carrying handle.

All Components Available Separately. Data for each receiver, 2/6 extra. Refunded if you purchase the parcel. Four U2 batteries, 2/8d. extra. Four Leakproof batteries, 3/4d. extra.

THE SKYROVER DE LUXE. Tone Control Circuit is incorporated, with separate Tone Control in addition to Volume Control, Tuning Control and Waveband Selector. In a wood cabinet, size 11½" x 6½" x 3" covered with a washable material, with plastic trim and carrying handle. Also car aerial socket fitted.

THE SPRITE

INCLUSIVE PRICE OF **79/6**

P. and P. 3/6 extra

- ★ Six-Transistor Superhet Miniature Personal Pocket Radio
- ★ Long and medium wavebands
- ★ Ferrite Rod Aerial
- ★ I.F. Frequency 470 kc/s
- ★ 3" speaker
- ★ Printed circuit 2½" x 2"
- ★ Slow Motion Drive
- ★ In Plastic Case. Size 4" x 2½" x ¾".

In order to ensure perfect results, the SPRITE is supplied to you with R.F. and L.F. stages. Driver and Output stages ready built with all components mounted on the printed circuit. The SPRITE pre-assembled, plus cabinet, speaker and all components for final construction, at the inclusive price of 79/6. Postage and package 3/6 extra. Data and instructions separately 2/6. Refunded if parcel is purchased. Real calf leather case, wristrap, personal earphone and case for earphone and battery, 12/6 the lot extra. Make no mistake this is a SUPERHET receiver of genuine commercial quality. It is not a regenerative circuit.

TRANSFILTERS by BRUSH CRYSTAL CO.

TO-01B 465 kc/s ± 2 kc/s
TO-01D 470 kc/s ± 2 kc/s
TO-02B 465 kc/s ± 1 kc/s
TO-02D 470 kc/s ± 1 kc/s

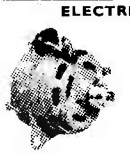
6/6 each P. & P. 6d.

TRANSISTORS

All Brand New and Guaranteed

GET.S1 2/6; GET.S5 2/6; GET.S6 2/6; GET.873A 3/6; GET.874P 3/6; OC44 7/6; OC45 6/6; OC70 6/6; OC71 6/6; OC72 8/–; OC73 16/–; OC75 8/–; OC76 8/–;OC81D 6/6; OC28 19/6; OC81 (matched) 6/6 pair 13/–. SPECIAL PRICES FOR QUANTITIES.

ELECTRIC MOTORS



Brand new tape recorder motors. Single phase, fully shrouded. 200–250V A.C. ⅜" x ¼" spindle with detachable pulley, fitted switch. Suitable for tape decks, record players and many other uses. P. & P. 3/6. **14/11**

The COROVER '6'

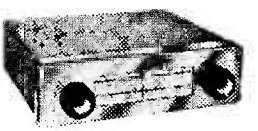
- ★ A 6-transistor plus 2-diode superhet
- ★ I.F. 470 kc/s
- ★ Covers the full medium and long wavebands
- ★ Sockets for personal earpiece or tape recorder and car radio aerial. Uses MULLARD Transistors Diode and large internal ferrite rod aerial.
- ★ Uses four 1.5V pen torch batteries
- ★ All components on a single printed circuit. Simple stage by stage instructions
- ★ Cabinet size 6½" x 4" x 1½". With carrying handle
- ★ All coils and I.F.s ready wound.

ALL COMPONENTS AVAILABLE SEPARATELY Data and instructions separately 2/6. Refunded if you purchase the parcel.

CAN BE BUILT FOR **£5.7.6** *P. and P. 4/- extra* Batteries 1/4.

LASKY'S CAR RADIO

Can now be built absolutely complete for **£9.19.6**



- ★ Small size. Will fit any car
- ★ 12 volt operation
- ★ New Hybrid circuit
- ★ Transistor output
- ★ New type Brimar valves
- ★ No Vibrator, 12 volt H.T. & L.T.
- ★ T.C.C. Printed Circuit and Condensers
- ★ Tuned R.F. stage
- ★ Medium and long waves
- ★ Permeability tuning
- ★ 7" x 4" elliptical speaker

Instruction Booklet giving full details, illustrations, dimensions, circuit diagram and shopping list, 2/6 post free (returned if you order).

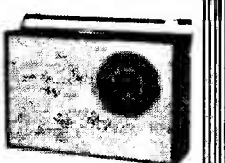
REALISTIC 'SEVEN'

- ★ 7 Transistor Superhet
- ★ 350 Milliwatt output into 4" high flux speaker
- ★ All components mounted on a single printed circuit board, size 5½" x 5½" in one complete assembly
- ★ Plastic cabinet, with carrying handle, size 7" x 10" x 3½" in Red/Grey, Blue/Grey or all Grey.
- ★ Easy to read Dial
- ★ External Socket for car aerial
- ★ I.F. frequency 470 kc/s
- ★ Ferrite rod internal aerial
- ★ Operates from PP9 or similar battery
- ★ Full comprehensive data supplied with each receiver
- ★ All coils and I.F.s, etc., fully wound ready for immediate assembly

An outstanding Receiver. **LASKY'S PRICE** for the complete parcel including Transistors, Cabinet, Speaker, etc., and Full Instructional Data: **£5.19.6** P. & P. 4/6

PP9 Batt. 3/9. Data and instructions separately 2/6. Refunded if you purchase the parcel.

REALISTIC 'Seven' De Luxe



By popular request a De Luxe version of the well-proven 'Realistic Seven' now available. With the same electrical specification as standard model—PLUS A SUPERIOR WOODCABINET IN CONTEMPORARY STYLING, covered in attractive washable material, with superchrome trim and carrying handle. Also a full vision circular dial, externally mounted to further enhance the pleasant styling. ALL FOR ONLY £1 EXTRA. P. & P. as for Standard model.

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6 volt battery operated. P. & P. 2/6 **7/11**

33 TOTTENHAM COURT ROAD · W1
2 mins. Oxford St. Nearest Station: Goodge St.
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TELEVISION SETS, RECEIVERS AND TRANSMITTERS

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

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

(*a*) Loss or damage to installation (including in the case of Television Sets the Cathode Ray Tube) by Fire, Explosion, Lightning, Theft or Accidental External Means at any private dwelling-house.

(*b*) (i) Legal Liability for bodily injury to Third Parties or damage to their property arising out of the breakage or collapse of the Aerial Fittings or Mast, or through any defect in the Set. Indemnity £10,000 any one accident.

(ii) Damage to your property or that of your landlord arising out of the breakage or collapse of the Aerial Fittings or Mast, but not exceeding £500.

The cost of Cover (*a*) is 5/– a year for Sets worth £50 or less, and for Sets valued at more than £50 the cost is in proportion. Cover (*b*) (i) and (ii) costs only 2/6 a year if taken with Cover (*a*), or 5/– if taken alone.

Why not BE PRUDENT AND INSURE your installation—it is well worth while AT THE VERY LOW COST INVOLVED. If you will complete and return this form to the Corporation's Office at the above address, a proposal will be submitted for completion.

NAME (*Block letters*).....
(*If lady, state Mrs. or Miss*)

ADDRESS (*Block letters*).....

...../JB

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ANOTHER TAPE RECORDER BARGAIN

Mfrs.' end of production Surplus Offer

A 24 gns. Tape Recorder offered at the bargain price of only **15 gns.** plus 10/- Carr. Supplied in 3 Units already wired and tested. A modern Circuit for quality recording from Mike, Gram or Radio, using latest B.S.R. Twin Track Monardeck Type TD2.

Valve line-up—EF86, ECL82, EM84, EZ80 and Silicon Diode.

2 tone Cabinet and 8" x 5" Speaker. Size 14" x 10½" x 7½"	**£3.10.0**	+ 5/- carr.
Wired Amplifier complete with 4 valves, Front Panel, Knobs	**£5.12.6**	+ 3/6 carr.
B.S.R. Monardeck Type T.D.2	**£7. 7.0**	+ 4/6 carr.
Accessories—Mike, Spare Reel Tape, Screened Lead, Plugs, etc.	**£1. 1.0**	+ 2/- carr.
COMPLETE KIT comprising items above	**15 gns.**	+ 10/- carr.

Leaflet, Circuit and Instruction 2/- post free

VALVES

New Boxed			Reduced Bargain Prices		
1T4	3/6	ECC83	7/-	PCC84	8/-
1R5	6/-	ECL82	10/-	PCF80	8/-
1S5	6/-	ECL80	9/-	PCL83	10/6
3S4	7/-	EF80	7/6	PCL84	10/-
3V4	7/-	EF86	8/6	PL81	9/6
DAF96	8/-	FL84	7/-	PL82	9/-
DF96	8/-	EY51	9/-	PL83	8/-
DK96	8/-	EY86	9/-	PY32	7/6
DL96	8/-	EZ81	7/-	PY81	8/-
ECC81	7/-	GZ32	9/6	PY82	7/-
ECC82	7/-	EM84	8/6	U25	10/6

Electrolytics All Types New Stk.

TUBULAR		CAN TYPES	
25/25V	1/9	8+8/450V	4/6
50/12V	1/9	16+16/450V	5/6
50/50V	2/-	32+32/275V	4/6
100/25V	2/-	50+50/350V	6/6
8/450V	2/3	60+250/ 275V	12/6
4/350V	2/3	100+300/ 275V	12/6
16+16/450V	5/6	2000+4000/ 6V	3/6
32+32/450V	6/6		
1000/25V	3/9		

Ersin Multicore Solder 60/40 4d. per yard. Cartons 2/6, etc.

NEW BRITISH RECORDING TAPE

Famous Mfr. Bulk Purchase—Genuine recommended Tape Bargain. Uncond. Guar. Fitted Leader & Stop Foils (except 3").

	Standard (PVC base)		Long Play (PVC base)		D'ble Play (Myiar base)	
3"	150ft. ...	3/9	225ft. ...	4/9	300ft. ...	6/6
5"	600ft. ...	11/6	900ft. ...	15/-	1,200ft. ...	25/-
5½"	850ft. ...	14/6	1,200ft. ...	17/6	1,800ft. ...	32/6
7"	1,300ft. ...	17/6	1,800ft. ...	22/6	2,400ft. ...	42/3

Post and Packing—3" Reels 6d. Each additional Reel 3d. 4" to 7" Reels 1/-. Each additional Reel 6d.

EMPTY TAPE REELS (Plastic): 3" 1/3; 5" 2/-, 5½" 2/-, 7" 2/3.
PLASTIC REEL CONTAINERS (Cassettes): 5" 1/9, 5½" 2/-, 7" 2/3

Jack Plugs. Standard 2½" Igranic Type, 2/6. Screened Ditto, 3/3. Miniature 1½", 2/3. Screened Ditto, 2/6.

Jack Sockets. Open Igranic Moulded Type, 3/3. Closed Ditto, 3/9. Miniature Closed Type, 1/9. Sub-min (deaf aid) ditto, 1/3.

Phono Plugs 1/-. Phono Sockets (open), 1/-. Ditto Closed, 1/6. Twin Phono Sockets (open), 1/6.

Soldering Irons. Mains 200/220V or 230/250V. Solon 25 watt Inst., 22/6. Spare Elements, 4/6. Bits, 1/- 65 watt, 27/6 etc.

Alumin. Chassis. 18g. Plain Undrilled, folded 4 sides, 2" deep. 6" x 4", 4/6, 8" x 6", 5/9, 10"x 7", 6/9, 12" x 6", 7/6, 12" x 8", 8/- etc.

Alumin. Sheet. 18g. 6" x 6", 1/-, 6" x 9", 1/6, 6" x 12", 2/-, 12" x 12", 4/6 etc.

MULLARD "3—3" HI-FI AMPLIFIER

3 VALVES 3 WATT

3 ohm and 15 ohm Output

A really first-class Amplifier giving Hi-Fi quality at a reasonable cost. Mullard's latest circuit. Valve line-up: EF86, EL84, EZ81. Extra H.T. and L.T. available for Tuner Unit addition. This is the ideal companion Amplifier for FM tuner units.

TECHNICAL SPECIFICATION—Freq. Response: ± 1dB. 10 kc/s. Max. Bass Boost 14dB at 80 c/s sensitivity: 100MV for 3W output. Output Power (at 400 c/s); 3W at 1% total harmonic distortion. Hum and Noise Level: At least 70dB below 3W.

COMPLETE KIT (incl. valves, all components, wiring diagram and special quality sectional Output Trans.) **ONLY £6.19.6 carr. 4/6.**

Complete wired and tested, 8 gns. Wired power O/P socket and additional smoothing for Tuner Unit, 10/6 extra.

Bronze Escutcheon Panel, Printed Vol., Treble, Bass, On-Off, supplied with each Kit.

Recommended Speakers—R. & A. 12" with tweeter 52/6, WBHFI0-12 £4.7.6, Goodmans Axiette £5.5.0, Axiom 10 £6.5.0. Carr. extra

Volume Controls—5K-2 Meg-ohms, 3" Spindles Morganite Midget Type. 1½" diam. Guar. 1 year. LOG or LIN ratios less Sw. 3/-. DP. Sw. 4/6. Twin Stereo less Sw. 6/6. D.P. Sw. 8/-.

COAX 80 OHM CABLE

High grade low loss Cellular air spaced Polythene — ¼" diameter. Stranded cond. Famous mfrs. **Now only 6d. per yard. Bargain**

Prices—Special lengths:
20 yds. 9/-. P. & P. 1/6.
40 yds. 17/6. P. & P. 2/-.
60 yds. 25/-. P. & P. 3/-.
Coax Plugs 1/-. Sockets 1/-. Couplers 1/3. Outlet Boxes 4/6

Condensers—S/Mica all values 2pF to 1,000pF 6d., .005, .01, and —1, etc., 1/-. Ditto Ceramic 9d. each. Paper Tubular 450V .001 mfd to .01 mfd and .1/350V 9d. .02-.1 m d 1/-, .25 mfd 1/6, .5 mfd 1/9.

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 megohms 20% ± and ½W 3d., ¼W 5d. (Midget type modern rating) 1W 6d., 2W 9d. **Hi-Stab** 5% ¼-½W 100 ohms 1 megohm 6d. Other values 9d. 1% ½W 1/6. **W/W Resistors** 25 ohms to 10K 5W 1/3, 10W 1/6, 15W 2/-. **Pre-set T/V Pots. W/W** 25 ohms-50K 3/-. 50K-2 Meg. (Carbon) 3/-.

TRANSISTOR BARGAINS

Brand New—BVA 1st Grade

OC44	8/6	OC70	5/6
OC45	8/-	OC71	6/-
OC81	7/6	GEX34	2/9
2/OC81	15/6	OA70	2/9
GET114	6/6	OA81	2/9
OC72	7/6	GEX13	2/9

Speakers P.M.—3 ohms 2½" E.M.I. 17/6. Goodmans 3½" 18/6. 5" Rola 17/6. 6" Elac 18/6. 7" x 4" Goodmans 18/6. 8" Rola 20/-. 10" R. x A. 25/-. 9" x 6" Goodmans 25/-. E.M.I. Tweeter 29/6.

Speaker Fret—Expanded gilt anodised metal ½" x ½" diamond mesh, 4/6 sq. ft., multiples of 6" cut. Max. width 4 ft. 4 ft. x 3 ft. 47/6. Carr. extra

TYGAN FRET (contemp. pat.) 12" x 12" 2/-. 12" x 18" 3/-, 12" x 24" 4/-, 18" x 18" 4/6.

BONDACOUST Speaker Cabinet Acoustic Wadding, 12" wide, any length cut 1/6 per ft.

BARGAINS 4-SPEED PLAYER UNITS

Single Players	carr. 3/6
Garrard-SRP10	£5.5.0
B.S.R. Latest Model TU12	72/6
E.M.I. Junior "985"	67/6
Auto-Changers	carr. 5/-
Garrard AT6 Mono	9 gns.
Garrard "Auto-Slim"	£6.15.0
Collaro C60	£6.19.6
B.S.R. (UA14)	£6.10.0

ENAMELLED COPPER WIRE—¼lb reels, 14g-20g, 2/6; 22g-28g, 3/-; 36g-38g, 4/3; 39g-40g, 46, etc.

PVC CONNECTING WIRE—10 colours (or chassis wiring, etc.)—Single or stranded conductor, per yd., 2d. Sleeving 2d. yd.

TRANSISTOR COMPONENTS

Midget I.F.'s—465 kc/s ⅞" diam.	5/6
Osc. Coil—⅞" diam. M/W.	5/3
Osc. coil M. & L.W.	5/9
Midget Driver Trans. 3.5:1	6/9
Ditto O/Put Push-pull 3 ohms	6/9

Elect. Condensers—Midget Type 15V 1mfd-50mfd, ea. 1/9. 100mfd. 2/-.

Ferrite Aerial—M. & L. W. with car aerial coupling coil, 9/3.

Condensers—150V. wkg. .01 mfd. to .04 mfd., 9d. .05 mfd., .1 mfd., 1/-. .25 mfd., 1/3. .5 mfd., 1/6, etc.

Tuning Condensers. J.B. "00" 208+176pF, 8/6. Ditto with trimmers, 9/6. 365pF single, 7/6. Sub-min. ¾" DILEMIN 100pF, 300pF, 500pF, 7/-.

Midget Vol. Control with edge control knob, 5kΩ with switch, 4/9, ditto less switch, 3/9.

Speakers P.M.—2" Plessey 75 ohms, 15/6. 2½" Continental 8 ohms, 13/6. 7" x 4" Plessey 35 ohm, 23/6.

Ear Plug Phones—Min. Continental type, 3ft. lead, jack plug and socket. High Imp. 8/-. Low Imp., 7/6.

JASON FM TUNER UNITS

Designer-approved kit of parts:
FMT1, 5 gns. 4 valves, 20/-.
FMT2, £7. 5 valves, 37/6.
JTV MERCURY 10 gns.
JTV2 £13.19.6. 4 valves, 32/6.
NEW JASON FM HAND-BOOK, 2/6. 48 hr. Alignment Service 7/6. P. & P. 2/6.

TRIMMERS, Ceramic (Compression Type)—30pF, 70pF, 9d.; 100pF, 150pF, 1/3; 250pF, 1/6; 600pF, 1/9.

PHILIPS, Bee Hive Type (conc. str spaced)—2-8pF, 1/-; 3-30pF, 1/-.

KNOBS—Modern Continental types: Brown or Ivory with Gold Ring, 1" dia., 9d. each; 1½", 1/- each: Brown or Ivory with Gold Centre, 1" dia., 10d. each; 1½" 1/3 each. LARGE SELECTION AVAILABLE.

METAL RECTIFIERS- STC Types—RM1, 4/9; RM2, 5/6; RM3, 7/6; RM4, 16/-; RM5, 21/-; RM4B, 17/6.

BARGAIN CORNER

Brand New. Mfrs. surplus 1st grade
1 OC44 & 2 OC45, 15/6.
1 OC181D & 2OC81, 15/6.
All above and OA81, 32/6 post free.
¼ Meg. VOL Controls D.P. Sw. ¼" flatted spindle. Famous Mfrs. 4 for 10/- post free.

RECORD PLAYER CABINETS

Contemporary style, rexine covered cabinet in two-tone maroon and cream. Size 15⅝" x 14½" x 8½", fitted with all accessories including baffle board and Vinair fret. Space available for all modern amplifiers and auto-changers, etc. Uncut record player mounting board 14" x 13" supplied **Cabinet Price 59/6.** Carr. and Ins. 5/-.

2-VALVE 2 WATT AMPLIFIER

EZ80 and Twin stage ECL82 with vol. and neg. feedback tone control. A.C. 200/250V with knobs, etc., ready wired to fit above cabinet. £2.17.6. P. & P. 1/6. 7" x 4" Speaker and trans, 22/-. P. & P. 2/-.

COMPLETE R/PLAYER KIT. As illinc. BSR UA14 Unit. New Bargain Price Now Only £11.10.0, 7/6 carr.

TRS Est. 1946

Send for detailed bargain lists, 3d. stamp. We manufacture all types Radio Mains Transf. Chokes, Quality O/P Trans., etc. Enquiries invited for Specials, Prototypes for small production runs. Quotation by return

RADIO COMPONENT SPECIALISTS

70 Brigstock Rd., Thornton Heath, Surrey
THO 2188 *Hours; 9 a.m., —6 p.m., 1 p.m. Wed. Terms C.W.O. or C.O.D. Post and Packing up to ¼ lb 9d., 1 lb,. 1/3 3lb., 2/3 5 lb., 2/9 8 lb. 3/6.*

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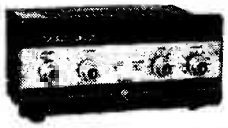
HI-FI AMPLIFIERS — TUNERS — RECORD PLAYERS

S-33 

S-99

GL-58

HA-12

HI-FI 6W STEREO AMPLIFIER. Model S-33. 3 watts per channel 0.3% distortion at 2.5W/chnl., 20dB N.F.B. Inputs for Radio (or Tape) and Gram, Stereo or Monaural, ganged controls. Sensitivity 200mV. **£13.7.6**

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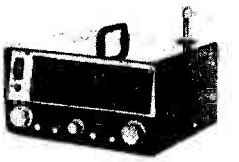

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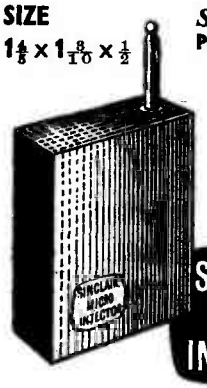

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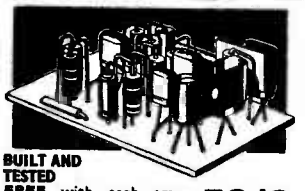

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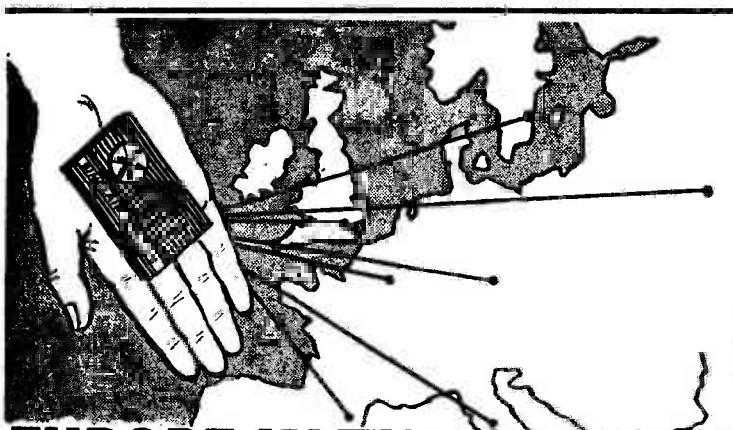

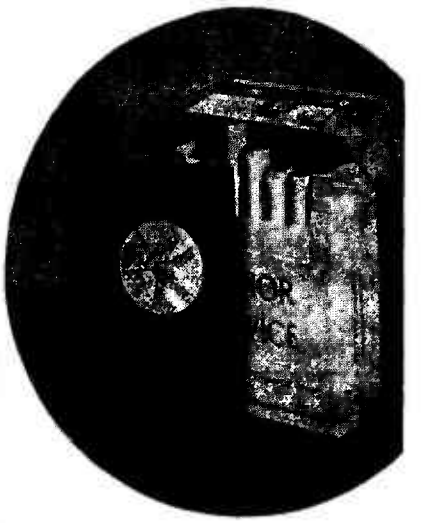

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6.9.63

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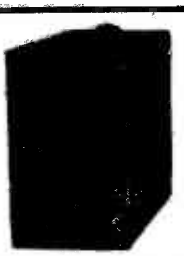

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THE **Radio Constructor**

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OCTOBER 1963

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TECHNICAL QUERIES must be submitted in writing. We regret that we are unable to answer queries, other than those arising from articles appearing in this magazine; nor can we advise on modifications to the equipment described in these articles.

CONTRIBUTIONS on constructional matters are invited, especially when they describe the construction of particular items of equipment. Articles should be written on one side of the sheet only and should preferably be typewritten, diagrams being on separate sheets. Whether hand-written or typewritten, lines should be double spaced. Diagrams need not be large or perfectly drawn, as our draughtsmen will redraw in most cases, but all relevant information should be included. Photographs should be clear and accompanied by negatives. Details of topical ideas and techniques are also welcomed and, if the contributor so wishes, will be re-written by our staff into article form. All contributions must be accompanied by a stamped addressed envelope for reply or return, and should bear the sender's name and address. Payment is made for all material published.

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3-TRANSISTOR TUNER

By A. S. Carpenter, A.M.I.P.R.E.

IN A PREVIOUS ARTICLE, DETAILS WERE GIVEN OF A 4-transistor audio amplifier.[1] The unit then described was intended as a gram. pick-up amplifier but the article stated that it could also form a receiver "back end", if preferred, simply by modifying the input circuit slightly.

Since then some experiments have been carried out in conjunction with this amplifier, and various tuners have been connected to it, these being of the t.r.f. and superhet variety.

As expected, no form of t.r.f. tuner was comparable to a superhet. The latter type cannot be excelled since it affords excellent selectivity and high sensitivity.

The weak point in most t.r.f. tuners is undoubtedly the low pre-detector amplification which makes the demodulating diode distort the signal. The distortion can be cured by providing sufficient r.f. amplification by means of added stages, but if this is done the expense becomes comparable to that of a superhet—and without its stability. Distortion due to the demodulator diode can also occur in a superhet, as may be proved by tuning such a receiver to a weak signal. However, a transistor superhet usually has two intermediate frequency amplifiers and a mixer/oscillator preceding its demodulating diode, and these are usually adequate for most purposes. The initial construction cost of the superhet is obviously greater, but this is readily offset by the added sensitivity and simplicity of operation it affords. No regeneration circuits are required!

The superhet tuner to be discussed here will, when used with the amplifier previously described, bring in Radio Luxembourg loud and clear and free from interference on its own in-built aerial indoors, the writer's location being the West Country where a local B.B.C. transmitter is putting out a strong

1 "A Transistor Quartet", by A. S. Carpenter, *The Radio Constructor*, May 1963.—EDITOR.

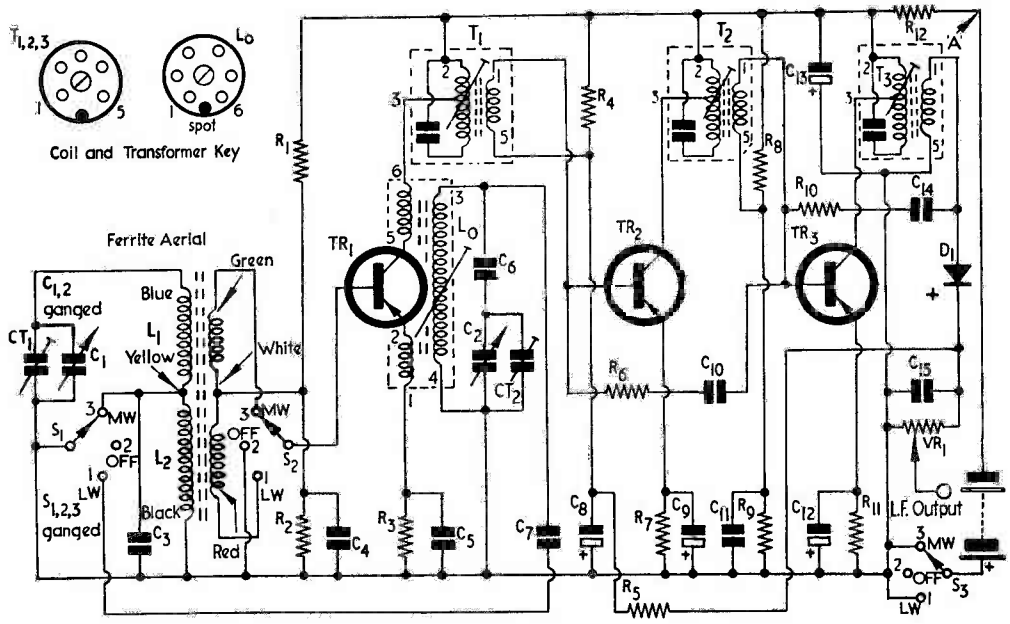

Fig. 1. The circuit of the tuner. The ferrite frame connects to the 208PF section of the 2-gang capacitor

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Components List

Resistors
All fixed resistors ¼W ±10%.

R_1	47kΩ
R_2	10kΩ
R_3	3.9kΩ
R_4	47kΩ
R_5	6.8kΩ
R_6	1.2kΩ
R_7	1kΩ
R_8	33kΩ
R_9	4.7kΩ
R_{10}	3.9kΩ
R_{11}	1kΩ
R_{12}	330Ω
VR_1	5kΩ pot.

Transistors

TR_1	OC44	Mullard
TR_2	OC45	
TR_3	OC45	
D_1	OA70	

Coils and transformers

L_0	P50/1	Weymouth
T_1	P50/2	
T_2	P50/2	
T_3	P50/3	

Miscellaneous
Ferrite aerial (with clip) RA2W Weymouth

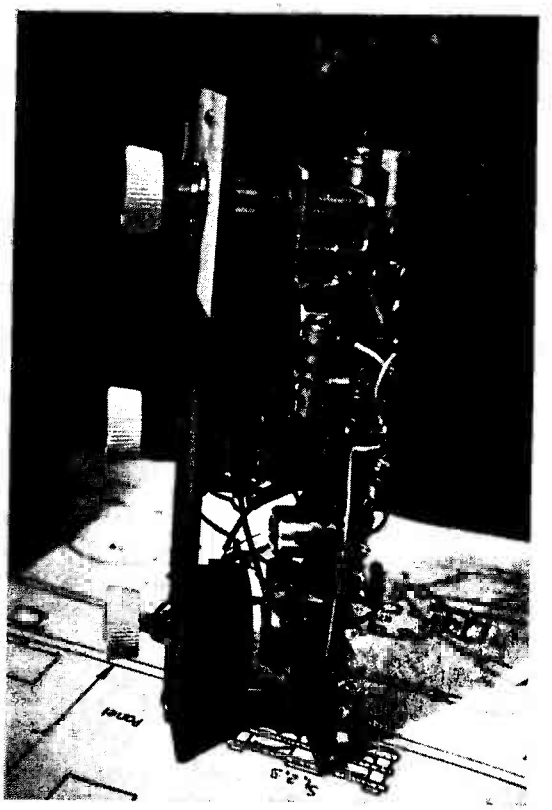
Capacitors

$C_{1,2}$	208 x 176pF with screen. Jackson Bros. Type "OO"
C_3	150pF mica, ±1%
C_4	0.1μF paper
C_5	0.01μF ceramic or paper
C_6	220pF mica, ±1%
C_7	180pF mica, ±1% (see text)
C_8	8μF, 6V wkg., Electrolytic
C_9	1μF, 6V wkg., Electrolytic
C_{10}	56pF mica, ±2%
C_{11}	0.1μF paper
C_{12}	1μF, 6V wkg., Electrolytic
C_{13}	50μF, 12V wkg.
C_{14}	18pF mica ±2%
C_{15}	0.01μF ceramic or paper
CT_1	60pF trimmer, mica
CT_2	30pF trimmer, Mullard concentric

Switch
4-pole, 3-way rotary, miniature

Tagboard
18-way, 6½ x 2¼in—Radiospares

Epicyclic Drive
Ball Drive, Jackson Bros. Cat. No. 5411



Top view of the tuner

Miscellaneous
Spindle coupler, control knobs (3), Battery (with plugs) PP9 or similar—9V, hardware, spacer, etc.

Components required for modification of "Quartet" Amplifier (see text))
1 2μF 6V wkg. electrolytic capacitor
1 4.7kΩ ¼W resistor

signal on 1457 kc/s (206 metres). The tuner, will, of course, function equally well if employed with suitable amplifiers other than that described in the previous article.

The Circuit

The circuit is shown in Fig. 1 and it will be seen that no "gimmicks" or trick circuits are employed, the aim being dependability.

The tuner covers both the medium and long wavebands and switching is so arranged that the tuner and the amplifier can become switched off when changing from one band to the other, thereby minimising the chance of accidentally leaving the battery to run down. The intermediate frequency is 470 kc/s and the total battery drain (tuner and amplifier) is 10mA under low or no-signal conditions

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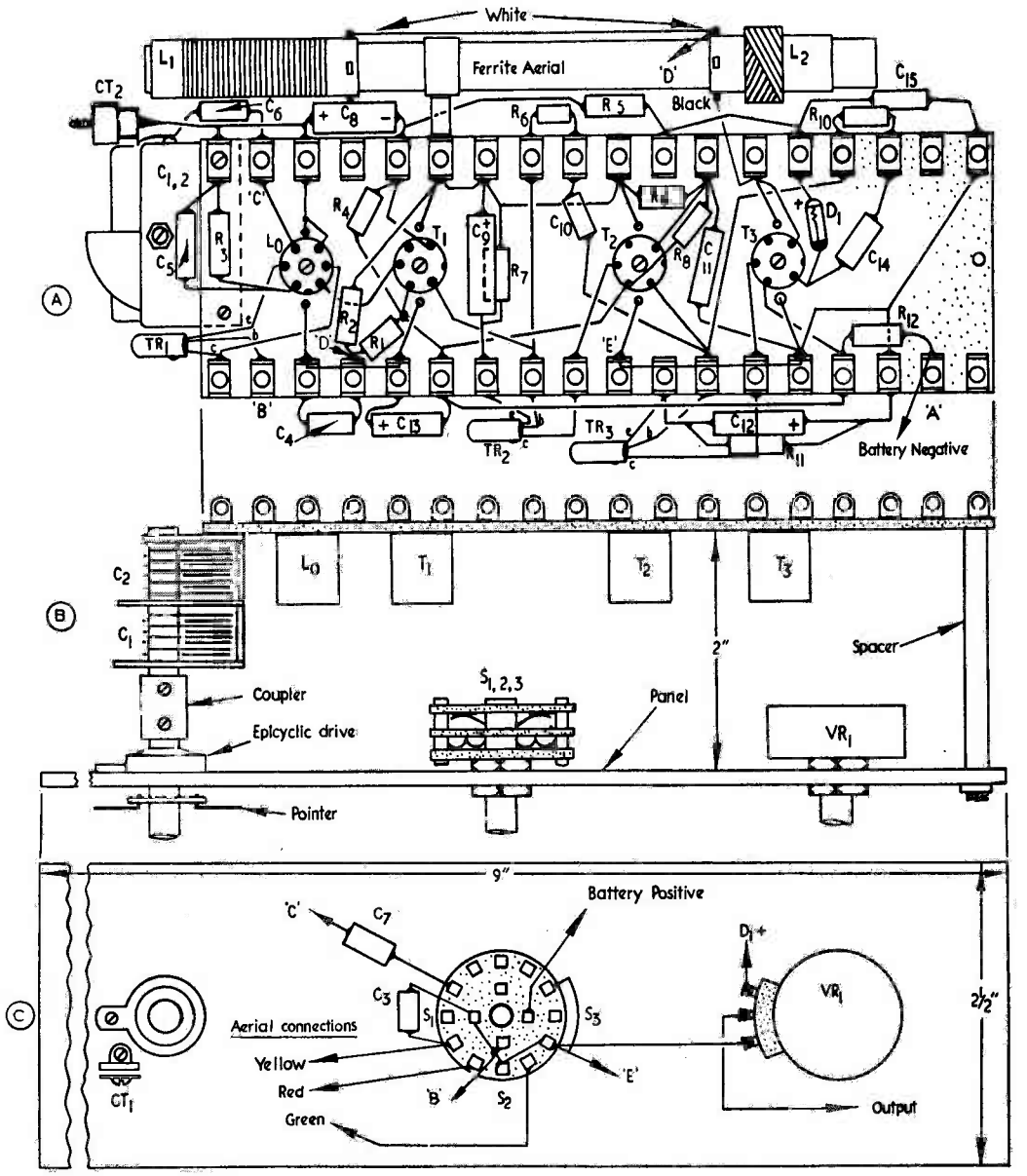

Fig. 2 (a). The tagboard layout and wiring; (b). A side view; (c). Panel details

rising to some 30–50mA, depending upon the volume control setting, when a strong signal is being received.

The tuner is temperature stabilised and neutralised, the latter feature being desirable to prevent the i.f. amplifier stages from becoming unstable. A measure of a.g.c. is provided by returning the lower end of the base feed potentiometer of TR_2 to the diode load, at which point the demodulated signal also appears. The amount of a.f. required is available at the slider of VR_1. All components specified for the tuner are readily available, the coils, aerial and i.f. transformers being selected from the Weymouth range. Various other components, such as VR_1, $S_{1, 2, 3}$ can be standard items, as may some of the capacitors. Inspection of component price lists shows that one must pay handsomely for the attractive sub-miniature items available, and it would seem a wasteful luxury to pay extra when suitable components of slightly larger proportions are

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already to hand.

Layout and General Constructional Notes

Looking at Fig. 2 it may be seen at (*b*) that a 2-deck arrangement is used, the main wiring being associated with a standard 6½ x 2¼in 18-way tagboard stood off from a panel and held by a spacer at one end and the twin gang tuning capacitor at the other. A "J.B." epicyclic reduction drive is also fitted as shown, and this eases station selection.

Fig. 2 (*a*) shows all the wiring on the tagboard, that around the transistors being expanded slightly for clarity. Whilst it is agreed that a neater final form would result from turning the tagboard through 180° and have the tags and wiring pointing inwards, this would tend to increase the overall depth. As it stands the wiring is easily accessible. The connections between the blue lead of the ferrite frame, C_1 and CT_1 are not shown in Fig. 2. The tuning capacitor frame is coupled to the positive supply line by a bolt passed through the top left-hand tag in Fig. 2 (*a*).

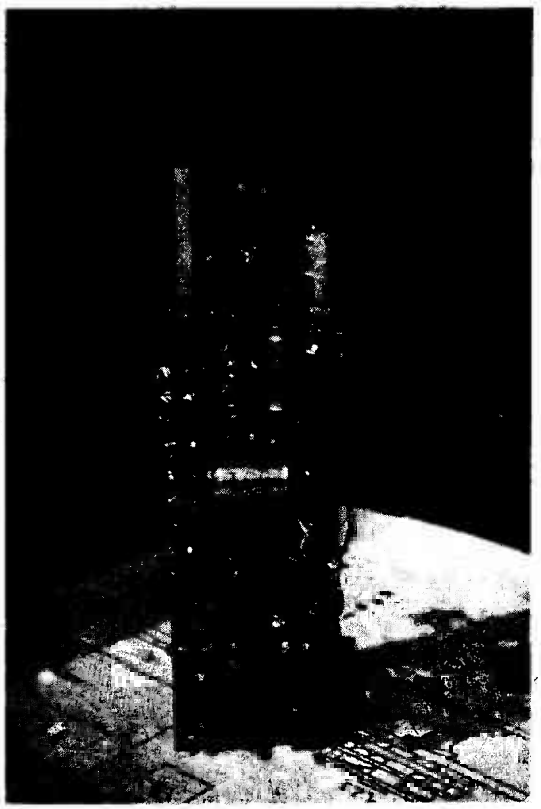
Fig. 2 (*c*) shows the wiring related to the metal panel, the dimensions of the latter being chosen to enable the unit(s) to fit a Clyne Radio "Wavemaster" cabinet.[2]

Some key signs such as "B" and "C" will be noted, and these are used to indicate connections between various points; for example, a wire is run from "B", Fig. 2 (*c*) to "B", Fig. 2 (*a*). An external connection is later made to points "E" and "A" on the tagboard if the amplifier previously described is used. There is only one point "A" in Fig. 2. All wiring can be easily accomplished with the two decks in position.

The i.f. transformers and L_o are mounted first. Although separate holes may be drilled in the tagboard for the pins, it is simpler to drill a single $\frac{7}{16}$in hole for each transformer, this being just sufficient to let the pins pass through without the can. Fixing is then accomplished by drilling a pair of holes close to each aperture on either side to accept the fixing lugs The fixing lugs are pressed out flat and soldered to tags on the board, as shown. These tags are then interconnected with external wiring to form the positive line. Connections carried via the transformer cans should be checked for reliable continuity, since the fixing lugs are only rivetted and might eventually cause trouble due to poor electrical contact. This did in fact occur during construction of the prototype. If in doubt, the fixing lugs of a transformer may be commoned by connecting them together with a piece of insulated wire passing round the pins.

Wiring up follows normal procedure and all transistor lead-out wires are sleeved but left unshortened. Pin designations for transformers T_1, T_2 and T_3 are shown in Fig. 1. No connection should be made to pin 4 of the i.f. transformers.

[2] The constructor should check whether the switch employed in the S_1, 2, 3 position has the same tag relationship between fixed and moving contacts as that shown in Fig. 2 (*c*). In the switch illustrated, the inner moving contact tag is in line with the corresponding fixed contact tag for position 2.—EDITOR.



Further view of the tuner

Modifying and connecting the Amplifier

Making the "Transistor Quartet" unit suitable for connection to this tuner is simple. Its volume control/On-Off switch, input socket, and battery are removed or disconnected, as also is resistor, R_1 (1.5MΩ). C_2, the input capacitor, is exchanged for a miniature 2μF, 6V electrolytic, its negative end being connected to the base of TR_1 and the junction of R_2 and R_3, and its positive end connected to the slider of the tuner potentiometer, VR_1, via a 4.7kΩ resistor. The free end of the amplifier negative feed wire (the other end connects to the White lead of the output transformer) is now joined to the tuner at point "A" whilst a further lead is taken from the amplifier positive line to point "E" on the tuner. Both units now come under control of S_3 for On/Off switching purposes.

Setting up

Provided all wiring is in order the battery is connected with correct polarity and the switch turned to position 3 (Medium waves). Alignment is now carried out in the following manner. The vanes of C_1, C_2 are fully enmeshed and a modulated 470 kc/s signal is fed to the ferrite aerial by holding the generator lead close to it. The generator output and VR_1 are suitably adjusted and the cores of T_3, T_2, and T_1 trimmed carefully in that order for maximum output, the generator output

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being readjusted to a lower level as alignment proceeds. The generator is next adjusted to 600 kc/s and the core of L_0 carefully adjusted until the signal is heard, this being peaked by sliding coil L_1 along the ferrite rod. Next, the generator is set to 1500 kc/s and the vanes of the twin gang are almost fully disengaged to bring in the signal, this being peaked by means of CT_1 and CT_2. The generator is now switched to 200 kc/s and the tuner switch rotated to position 1 (Long waves) whereupon rotating the twin gang to half setting should once more tune in the signal. L_2 is then moved along the ferrite rod as required. Should the 200 kc/s signals not appear at the correct point on the scale, or not at all, replace C_7 with a 150pF fixed capacitor paralleled by a 90pF trimmer and adjust for optimum results. Final slight adjustments may be made on signals, L_1 and L_2 being finally locked firmly. Alignment *can* be carried out without a signal generator, but the precise value of intermediate frequency will not then be known and incorrect adjustments might make it difficult to obtain results on 200 kc/s.

Conclusion

The two units are easily housed in a small contemporary cabinet together with a PP9 battery and 7 x 4in speaker, the whole representing a sensitive 7-transistor receiver that is comparable to many commercial models.

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.

Marconi VHF Transceiver Type 1585.—J. Cowley, 32 Fenton Street, St. Helens, Lancs, wishes to borrow or purchase handbook or circuit or information on 2 metre conversion.

* * *

Siemens Receiver.—R. Horton, 12c Vulcan Street, Waddington, Lincoln, has obtained this German receiver (Serial No. 053910) but valves are missing. Required information is the valve line-up and would appreciate circuit diagram.

* * *

TR10056 (R12352 and T12351).—B. J. Chesworth, 82 Orchard Road, Wednesfield, Staffs, would like to borrow the circuit diagram.

* * *

Hallicrafters S40B Receiver.—M. J. Wickstead, 99 Earlsfield Road, London, S.W.18, would like to borrow, hire or purchase, the circuit or manual and any modification details for this receiver.

* * *

46 Transreceiver.—M. Miller, The Post Office, Stanley Common, Derbyshire, requires to know where the crystals and coil box may be purchased and also details of the switch and its wiring.

* * *

MCR1 Receiver.—L. O. Tully, 120 Victoria Street, Fairfield, S3, Brisbane, Queensland, Australia, wants the alignment details of the Range 1 coil box and/or loan or purchase of the manual.

Howard 450A Communications Receiver.—R. J. Henville, 8 Greylands Park Grove, Newby, Scarborough, Yorks, requires the circuit diagram or any other information on both this and the Hallicrafters Super Skyrider receiver.

* * *

Beam Echo "Avantic" SPA21 Stereo Amplifier.—P. W. Quested, 121 High Street, Sheerness, Kent, wishes to obtain, on loan, the circuit or other information on this equipment.

* * *

Associated Cine Equipments Tape Recorder TR11.—B. Smith, 4 The Glen, Hanham, Bristol, requires to borrow or purchase the circuit or manual of this unit.

* * *

Ferguson TV 6405/6407.—M. L. Hackett, Rosslea, 24 Doulton Road, Springfield, Nr. Dudley, Worcs, would like to hear from any reader who has modified this export TV to British 405 line operation.

* * *

HRO Senior Communications Receiver.—R. K. Harvey, Mossy Hill, Scousburgh, Shetland, requests the loan or purchase of the handbook.

* * *

Wavemeter Type W1310.—C. D. Crowder, 53 Frederick Road, Wylde Green, Sutton Coldfield, Warks, is anxious to obtain the circuit and operational notes of this unit which covers the frequencies 160 Mc/s to 220 Mc/s.

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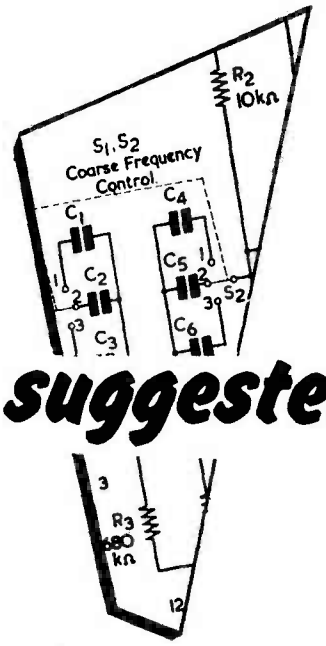

suggested circuits

The circuits presented in this series have been designed by G. A. French, specially for the enthusiast who needs only the circuit and essential data

No. 155 "Two-Station" Aerial Circuits Without Switching

A POPULAR CLASS OF RECEIVER with home-constructors is the "two-station" broadcast set. Receivers of this type are either simple t.r.f. or superhet valve sets, and they are provided with a switch which enables them to receive either the Home or the Light programme. The switch connects pre-set values of capacitance across medium wave tuned circuits, and the receivers have the advantages that no variable tuning capacitor, dial drive and tuning scale are required, and that there is no necessity to employ padding components or make any tracking adjustments. Since "two-station" sets are only intended to receive local transmitters, it is normal practice to omit a.g.c. circuits. In most instances, very good results are obtained with three valves only. The simplicity of operation of these receivers, combined with the fact that only two programmes are, in any case, available during most of the day, makes them very popular with the female members of the family for use in the kitchen.

When the "two-station" receiver employs a t.r.f. circuit it is usual to have an r.f. amplifier feeding a detector, which may employ regeneration. The function of the tuned circuit in the aerial stage is then largely that of ensuring that the desired signal is passed to the r.f. amplifier grid at adequate level, and it does not offer a large contribution to the overall selectivity of the receiver. The tuned circuit following the r.f. amplifier valve is only slightly damped, and it provides the major contribution towards selectivity. This fact is especially true when regeneration is employed. The selectivity offered by the aerial tuned circuit becomes even less important when a superhet circuit is used. The i.f. stages give adequate adjacent channel selectivity, and all that the aerial coil is called upon to do is to apply the required signal to the frequency changer signal grid at optimum level, and to ensure that signals at the second channel and intermediate frequencies are not passed on.

Obviating Switching

In both the t.r.f. and superhet versions of the conventional "two-station" receiver, part of the switching circuits have to vary the capacitance across the aerial tuned circuit when changing from one station to the other. This applies a restriction on the layout, because the aerial coil has then to be mounted close to the switch. A further factor is that switch wiring may cause undesirable feedback in the t.r.f. version unless the aerial circuit switch contacts and wiring are kept well away (or are, preferably, screened) from the detector wiring.

An interesting approach to the switching problem consists of using an aerial tuning circuit which offers optimum gain, simultaneously, at *both* of the frequencies it is desired to receive. Such a circuit may then be mounted at any point on the chassis, because it requires no connections to the station selector switch whatsoever. In the t.r.f. version of the receiver, both signals can be applied simultaneously to the grid of the r.f. amplifier whereupon, if the detector tuned circuit has sufficient selectivity to be able to select one or the other of these signals, the receiver will offer the same performance as with a conventional aerial circuit. When a superhet is employed, the proposed aerial tuning circuit offers both signals at optimum level to the frequency changer signal grid, with the result that the local oscillator selects either one or the other for application to the intermediate frequency amplifier. If the proposed aerial tuning circuit offers the same rejection at the conventional circuit to second channel and i.f. interference (as is the case with the circuit to be described here) the performance of the superhet remains unaltered.

Summing up, it may be stated that the use of an aerial tuning circuit which simultaneously selects both signals at optimum strength has the advantage of removing a restriction on layout requirements and of simplifying the station selector switching circuit. Its use is justified

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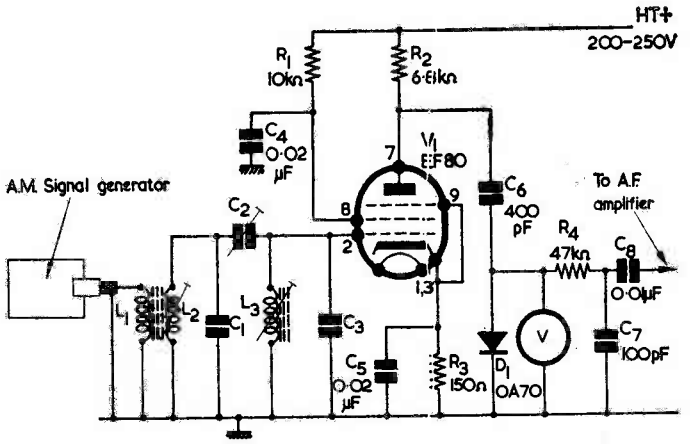

Fig. 1. The set-up employed to test the experimental "two-station" aerial circuit. The component values and valve specified are not critical, and are given purely for guidance. Component values not shown are discussed in the text. The voltmeter may be a valve-voltmeter or a high resistance (10,000 ohms per volt) moving coil instrument. Voltage readings will be in the range of 0.25 to 5 volts

in a t.r.f. "two-station" receiver if the subsequent detector tuned circuit is capable, on its own, of selecting one or the other of the required frequencies. With a "two-station" superhet its use is completely justified, since it guards against i.f. and second channel interference equally as well as a conventional circuit, and because the superhet configuration enables either of the two signals to be selected by the oscillator.*

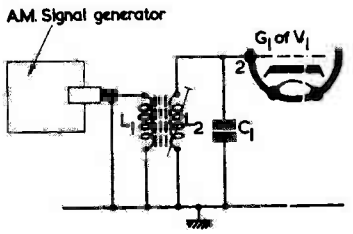

Fig. 2. For the second test, L_3, C_2 and C_3 were taken out of circuit, L_2, C_1 being connected direct to the grid of V_1

Employing a Bandpass Circuit

The most obvious choice for a two-frequency aerial tuning circuit is given by an over-coupled bandpass circuit. It is not generally appreciated that, by heavily over-coupling a bandpass circuit, it is possible to obtain two peaks having extremely wide separation. These peaks have the same amplitude as is given by critical coupling, with the result that either peak offers optimum amplitude at the frequency to which it corresponds. For the purposes of this article, the writer carried out an experiment to check whether a bandpass pair could, in practice, offer a suitable response. It was found that such a response could be achieved very readily, and that all that was needed was the addition of one trimmer and one tuned winding to the conventional switched aerial circuit. The writer should add that he has not tried the proposed circuit in a receiver itself, and that the information given here relates to the results obtained under the conditions described.

Experimental Set-up

It was considered that a typical application for a "two-station" tuning circuit would be that it should give optimum gain for the medium wave Light Programme transmission on 1214 kc/s, and to the London Home Service transmission on 908 kc/s.

The experimental circuit shown in Fig. 1 was then set up. In this, an amplitude modulated signal generator is applied to the coupling winding of a conventional iron dust cored medium wave aerial coil, L_1, L_2, the type employed being an Osmor QA8. The tuned winding is paralleled by a fixed capacitor, C_1, and is coupled by a trimmer to a second medium wave tuned winding, L_3. This latter is an Osmor QHF8 r.f. coupling coil, no connections being made to the coupling winding. A second fixed capacitor, C_3, is connected across L_3. Thus, the components L_2, C_1, C_2, L_3 and C_3 form a simple bandpass circuit, variable top-C coupling being given by C_2. Frequency adjustment is provided by means of the iron dust cores in the coils. The coils were mounted approximately 6in away from each other to minimise inductive coupling.

The voltage across L_3 is applied

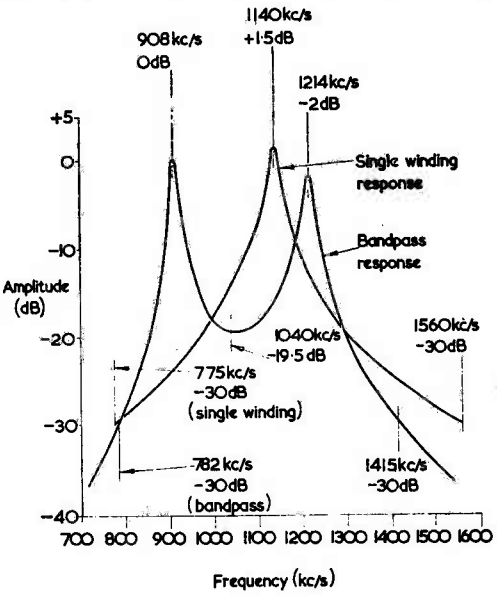

Fig. 3. The response curves given by the circuits of Fig. 1 and Fig. 2

* If one signal is *exceptionally* greater in strength than the other, there is a risk of cross-modulation in the frequency changer. This condition will not, however, occur in the majority of instances.

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to an r.f. pentode, V_1. The amplified voltage at the anode of the pentode is then fed to a shunt detector, D_1, the detected voltage across which is monitored by a high resistance voltmeter. It was found helpful to add the components R_4, C_7 and C_8 so that the detected a.f. voltage could be fed to an a.f. amplifier and loudspeaker, since this gave an audible indication of the response of the circuit during initial checks.

The r.f. pentode and subsequent components are employed merely to offer an impedance to L_3 which would be similar to that offered in a practical receiver circuit. Component values and valve type are shown in the diagram, but they are in no way critical.

After the coils and C_2 had been correctly aligned, the response curve of the circuit was drawn with the aid of the signal generator and voltmeter. The result is shown in Fig. 3. The circuit of Fig. 1 was then changed to that of Fig. 2, which corresponds to a conventional aerial input circuit. Without adjusting the dust core in L_1, L_2, a second response curve was taken. This is also shown in Fig. 3.

The two response curves are drawn on the same co-ordinates in Fig. 3 in order that they may be compared for shape and amplitude. The zero dB level corresponds to the higher of the two bandpass peaks, and it will be noted that the single peak given by the circuit of Fig. 2 is only 1.5dB higher than zero dB level. There is a slight "tilt" in the bandpass response, and the higher frequency peak is 2dB down. It may be said, therefore, that so far as the circuits of Figs. 1 and 2 are concerned, the bandpass arrangement offers, at worst, signals which are only 3.5dB down on that given by a *single* tuned coil.

After alignment had been carried out, the low frequency peak appeared at 908 kc/s (London Home Service) and the high frequency peak at 1214 kc/s (Light Programme), as had been required. There is a fairly deep trough, the lowest amplitude occurring, 19.5dB down, at 1040 kc/s. Apart from frequencies between about 990 and 1,120 kc/s the skirts on either sides of the bandpass peaks are as steep, or steeper, than those offered by the single tuned winding.

Setting Up the Circuit

The alignment of an over-coupled bandpass pair is difficult without an oscilloscope and a wobbulator covering the required range. Suitable equipment was not available to the writer and an alternative approach was employed.

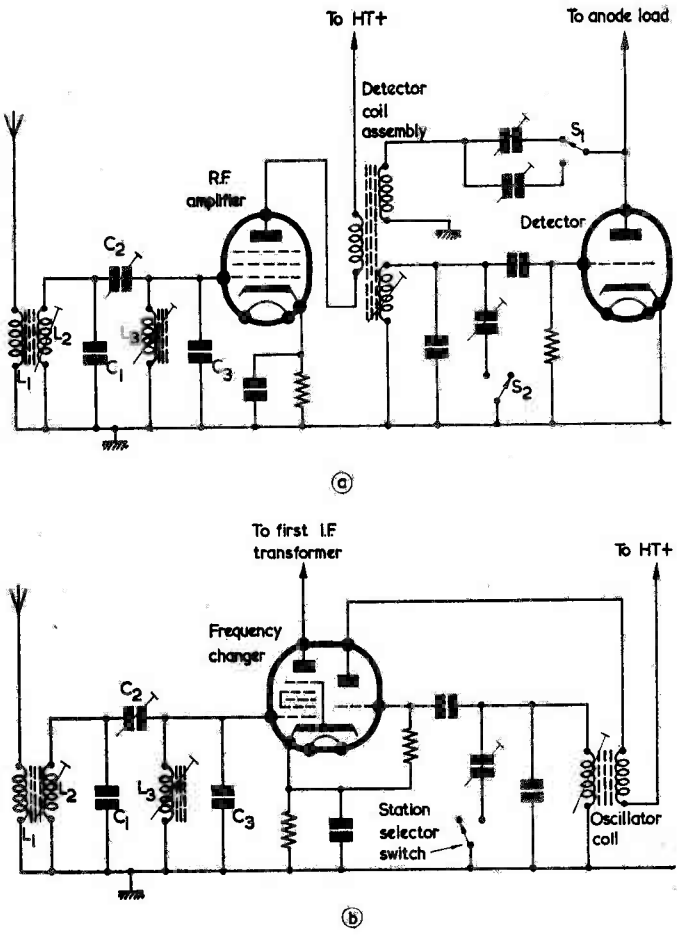

Fig. 4 (a). The proposed aerial circuit fitted to a fairly representative "two-station" t.r.f. receiver (shown in skeleton form and without the a.f. amplifier). S_1 and S_2 are ganged and offer station selection. Switch S_1 selects pre-set capacitance for the regeneration circuit, whilst S_2 connects additional capacitance across the tuned winding of the detector coil assembly

(b). The corresponding "two-station" superhet circuit

At first, trimmer C_2 of Fig. 1 was set to minimum capacitance, whereupon the coils became undercoupled. Each coil was then adjusted to the same frequency, this being initially chosen, at random, at a figure slightly below that for the desired high frequency peak. C_2 was then increased in value until the desired peak separation (306 kc/s) was obtained. At the first attempt, both peaks were higher in frequency than the desired figures by an amount which was noted down. C_2 was once more set to minimum capacitance and the two coils were then adjusted to a new fixed frequency, this being lower than the previous fixed frequency by the amount which had been noted down. C_2 was once more adjusted for correct peak separation and the error, which was now small, noted. Again, C_2 was set to minimum capacitance, after which the two coils were aligned to the corrected fixed frequency. It was possible, this time, to obtain two peaks at exactly the desired positions when C_2 was readjusted.

The alignment procedure just described may sound a little tedious, but it can be carried out quite quickly in practice. It was found that the a.f. amplifier and loudspeaker was extremely helpful, since it enabled initial adjustments to be made very quickly. The final alignment was made with the aid of the voltmeter. As was just mentioned, it is difficult to make adjustments to tuned

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circuits in a bandpass pair in the over-coupled condition unless a wobbulator and oscilloscope are available. It is much easier to employ a process similar to that outlined above.

It was found, when the circuits had been set up satisfactorily, that trimmer C_2 required a capacitance of approximately 65pF for correct peak separation.

The reason why it is necessary to start, in the under-coupled condition, with a frequency higher than the central frequency, is that the effective tuning capacitance across each coil becomes greater as the value of the top-C trimmer increases. It will be noted that, when the circuit was changed to the Fig. 2 condition, L_2 resonated at 1,140 kc/s, this being considerably higher than the central frequency.

Installation in a Receiver

If the circuit is to be installed in a receiver, it is preferable for the inductive coupling between L_1, L_2 and L_3 to be kept at a low value, since such coupling may cause a distortion of the bandpass response curve. Inductive coupling may be reduced by so mounting the coils that their axes are at right angles, and it may be eliminated by screening them from each other. Thus, one coil could be fitted above the chassis and one below.

The circuit required for a t.r.f. "two-station" receiver is shown in Fig. 4 (*a*), it being assumed that the detector tuned circuit switching includes a regenerative coupling. The bandpass coils and capacitors are identified by the same circuit references as in Fig. 1. The corresponding circuit for a superhet is shown in Fig. 4 (*b*). It will be seen that, in this case, station selection is achieved by the delightfully simple process of switching one capacitor in or out of circuit.

When the circuit is installed in a receiver it will need to be aligned by the use of a test circuit such as that of Fig. 1. This may be achieved quite easily by replacing the anode load of the r.f. pentode (in the case of a t.r.f. set) or the frequency changer heptode or hexode (in the case of a superhet) by a resistor, and adding the shunt detector components and voltmeter. Final adjustments may be carried out with the aerial connected, the signal generator being coupled into circuit via a capacitor of about 5pF.

With the experimental circuit, it was found that L_2 and L_3 resonated at the desired frequency with parallel capacitances of about 100pF. The fixed tuning capacitances required for different coils may vary from this value, however, and this is a point which will have to be experimentally determined. Obviously, different values will be needed in the parallel capacitors (and the trimmer) if frequencies other than those mentioned here are required. When an a.g.c. circuit is employed, the a.g.c. voltage may be applied, in normal manner, to the lower end of L_3, this being bypassed to chassis by a capacitor of some 0.01 to 0.1μF.

book reviews . . .

ELECTRONICS IN INDUSTRY. By John Stewart Murphy. 216 pages, 5½ x 8½in. Published by Oxford University Press. Price 25s.

The control of production machinery by electronics is now a well established practice, and it offers a fascinating subject of enquiry for the engineer or enthusiast whose main interests are with domestic entertainment equipment and the like. This book outlines the large number of electronic applications in the world of industry, and it explains the processes involved at a level which can be followed by anyone with a basic knowledge of radio and electronics.

The first four chapters deal with the science of electronics, valves, semiconductors and electronic circuits, and these start from basic elements. Chapter 5 then carries on to synchros and servomechanisms, to be followed by chapters covering measuring devices, transducers and actuators, digital and analogue computers, and electronic control and automation. The text is well illustrated with diagrams and photographs, and the information given is presented very clearly and concisely.

Despite its general approach, the book gives a considerable amount of specific information on the processes described. In consequence, not only is it of interest as a detailed introduction to industrial electronics, but it also provides a wide range of useful ideas and techniques which will be of direct value to engineers associated with the production line or with the building of automatic devices.

RECORD OF SEMICONDUCTOR OUTLINES, Second Edition. 88 pages, 7¼ x 9¾in. Published by The Electronic Valve and Semiconductor Manufacturers' Association. Price 12s. 6d.

Semiconductors come in all shapes and sizes. Nevertheless, they still have to conform to listed dimensional specifications, and such specifications are fully covered in the book under review. The term "outline" refers to outside dimensions, and the appropriate drawings also include details of mounting centres and similar relevant information.

The present edition contains 70 outline drawings, this being 27 more than in the first edition issued in 1962. The outlines include dimensional specifications raised by N.A.T.O., I.E.C. (International Electrotechnical Commission) and J.E.D.E.C. (Joint Electron Device Engineering Council of the Electronic Industries Association, U.S.A.). Frequently, a semiconductor outline satisfies the requirements of more than one of these bodies, and the appropriate specification numbers are cross-referenced throughout the book and, also, in an index at the end. The whole field of semiconductor devices, from integrated circuits to high-power thyristors, is dealt with.

Whilst not exactly falling within the field of home-constructor interests, this book will be invaluable to the engineer who is working on mechanical or electronic equipment design.

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"Double-Beam" Converter for your Oscilloscope

by A. G. Dowding

This converter, which will be of especial interest to the experimenter, can provide two simultaneous oscilloscope traces by sequential input switching. Amplifier components are suitable for a.f. inputs

THE WRITER IS SURE THAT ANYONE WHO HAS AN oscilloscope will appreciate how much more could be achieved with a double-beam instrument providing two signal displays at the same time. This would allow, for instance, the input and output waveforms of an audio amplifier to be compared side by side, a very useful facility when testing for distortion. It is not proposed, however, to explore these prospects here, but to describe the operation of this converter.

The Circuit

As may be seen from the circuit diagram, the converter is essentially an electronic switch which very rapidly switches from one input to the other, thus creating the illusion of two traces. This does, nevertheless, mean that the same timebase has to be used for both signals.

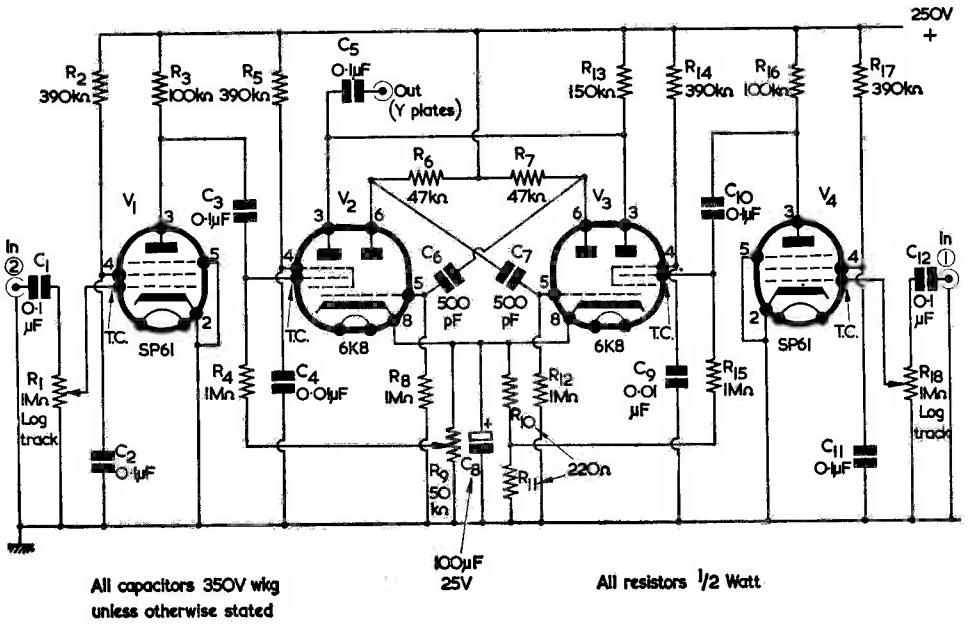
Switching is carried out by a square waveform generated by the multivibrator circuit around V_2 and V_3. The use of two triode-hexodes enables direct "gating" to be applied to the hexode section of each valve. Otherwise the "gating" signal, with suitable negative bias, would have had to be applied, say, to the suppressor grid of an ordinary pentode valve. This could be done if no suitable triode-hexodes were available. There is also provision for separating the waveforms, one above the other, by means of the 50kΩ potentiometer, R_9.

Almost any triode-hexodes should cope. 6K8's are suggested here but they may be, physically, on the large side. The two amplifier valves, V_1 and V_4, are not critical and practically any pentodes will suffice.

This circuit may be built up as a separate unit, its power supplies being taken from the oscilloscope and its output being applied directly to the Y plates.

EDITOR'S NOTE

Multivibrator operation may, possibly, be improved by returning R_8 and R_{12} to the cathodes of V_2 and V_3, rather than to chassis. Also, trace distortion might be reduced if cathode bias components (say 1.5kΩ and 25μF) were inserted in the cathode circuits of V_1 and V_4. Switching speed may be increased by decreasing the values of C_6 and C_7.



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O.K. for SOUND

A Simple Amplifier

by Wallace Studley

THIS SMALL AMPLIFIER WAS BUILT RECENTLY in order to discover whether the ECF80 triode-pentode valve could be made to perform audio tasks satisfactorily so that, in conjunction with a sensitive output pentode, 4 or 5 watts of reasonably good quality sound reproduction could be expected from a crystal pick-up source.

The final design which is presented here proves that such an arrangement is practical, the output afforded being more than that generally required. Separate bass and treble controls in conjunction with negative feedback ensure an excellent frequency response for such an unpretentious unit.

The layout in the original is very compact, the amplifier itself being contained on a chassis measuring 6in wide by 3½in deep by 4¾in high. A separate power supply section is used.

The Circuit

From the circuit diagram, Fig. 1, it will be seen that the input is fed straight to VR_1, the volume control, and thence to the triode section of V_1 The output developed across R_1 is next applied to the tone control circuit via C_2. A high degree of attenuation now occurs due to the circuit around the treble control VR_2 and the bass control VR_3. The pentode section of the ECF80 is arranged as a voltage amplifier feeding the output valve V_2. From the secondary of the output transformer the connection necessary to obtain negative feedback to operate is made, this feedback considerably improving the frequency response. Minor tone correction is applied to the output transformer primary in the form of capacitor C_{10}, this being connected across the transformer winding.

A high grade output transformer is desirable and in the prototype this item occupies a large area of the available top chassis space. A suitable type is specified in the components list.

Layout and Constructional Details

Those who consider duplicating the unit will find the small chassis requires that all components are carefully positioned. In the original, can type electrolytic capacitors for C_1 and C_4 saved space horizontally. The electrolytic capacitor C_7 must be isolated from the chassis, this being a wire ended type being securely held to the chassis front drop by a spring clip.

A simple tagstrip provides major anchor points and small components can be suspended in the wiring. Space exists for alternative input sockets

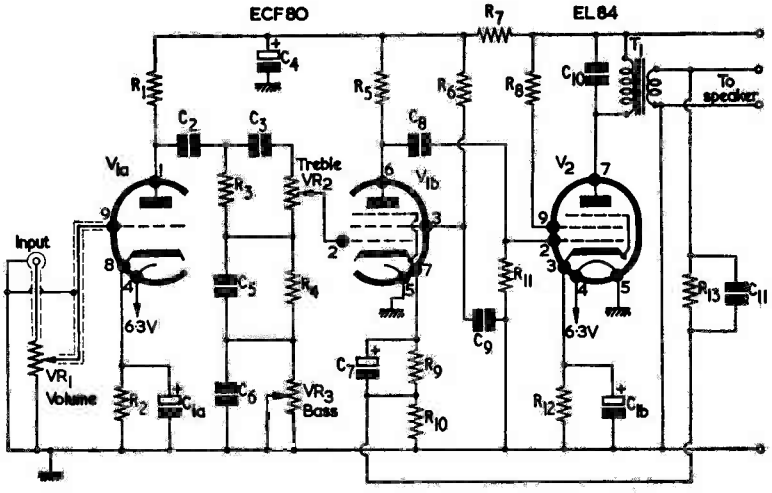

Fig. 1. Circuit of the amplifier

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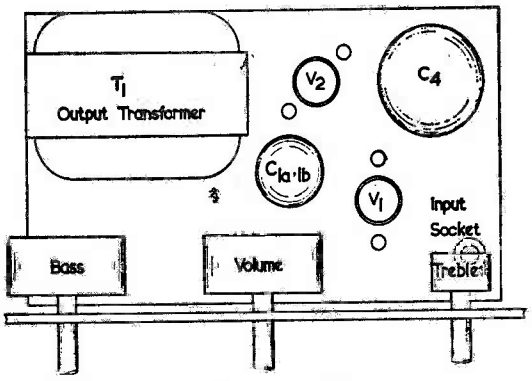

Fig. 2. Above-chassis layout

and, should such sockets be fitted, it will be desirable to extend the front panel on the side associated with the input and fit an input selector switch. Suitably modified input wiring is shown in Fig. 3.

Sockets for the loudspeaker are mounted at the rear of the chassis.

A large grommet is fitted to the rear upper surface of the amplifier at a convenient point near the speaker output sockets to enable connections to be made to the output transformer, T_1. This grommet also allows a 3-core power supply cable to pass through to the underside of the chassis, where connection is made to the h.t., 6.3V and chassis tags (see Fig. 4) of the tagstrip. The other end of the 3-core cable is terminated in an octal

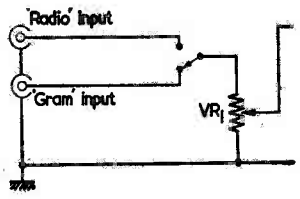

Fig. 3. Modified input wiring with selector switch

plug which fits a similar socket on the power supply chassis.

Two smaller grommets are needed at the front upper surface of the chassis for the leads to the panel. One may be positioned between the input socket and V_1 valveholder and the other below VR_3.

Panel Details

As may be seen from the photographs, it was convenient to mount the controls on a panel, and for this hardboard was used. Potentiometers of ex-Government type are used in the VR_1 and VR_3 positions, a miniature type being required for VR_2 in order that the coaxial input plug can easily be inserted into the socket provided.

The Power Unit

If no power unit exists one may be made up quite easily on a chassis of the same size as that used for the amplifier, and a circuit is shown in Fig. 5. A current rating of 60mA for the mains

Components List

Resistors
(All ½ watt unless otherwise stated)

R_1	180kΩ 20%
R_2	2.2kΩ 10%
R_3	270kΩ 10%
R_4	47kΩ 10%
R_5	270kΩ 20%
R_6	1.8MΩ
R_7	10kΩ 20%
R_8	330Ω 20%
R_9	2.2kΩ 10%
R_{10}	33Ω 10%
R_{11}	470kΩ 20%
R_{12}	180Ω 10% 1 watt
R_{13}	1kΩ 10%
VR_1	1MΩ log.
VR_2	1MΩ lin
VR_3	2MΩ lin

Valves

V_1	ECF80
V_2	EL84

Valveholders
B9A (2)

Chassis
6 x 3½ x 1½in

Capacitors
(All 350V wkg. unless otherwise stated)

$C_{1(a),(b)}$	50 + 50μF electrolytic 12V wkg.
C_2	0.05μF
C_3	100pF
C_4	32μF electrolytic
C_5	220pF
C_6	3,000pF
C_7	100μF electrolytic 6V wkg.
C_8	0.05μF
C_9	0.1μF
C_{10}	2,000pF
C_{11}	1,000pF

Output Transformer

T_1	Primary impedance 5kΩ, Gilson W.O.767 (3.7, 7.5, 15Ω secondaries)

Miscellaneous
Coaxial sockets (surface mounting type)
Control knobs
Speaker output socket
Octal plug and lead
Selector switch (if required)

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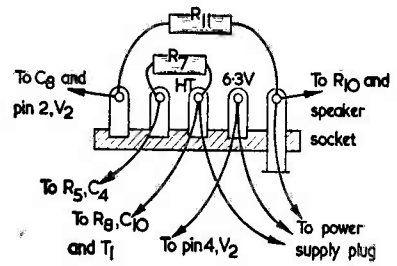

Fig. 4. Tagstrip connections showing, in particular, the connections to the 3-core power cable

Voltage Table

Location	*Reading*	*Meter*
HT rail at T_1	320V	1,000V range
HT rail at C_4	295V	1,00V ,,
Cathode $V_{1(a)}$	2.6V	10V ,,
Cathode $V_{1(b)}$	1.8V	10V ,,
Cathode V_2	8.6V	10V ,,

transformer secondary will be suitable for the amplifier on its own and a secondary voltage rating of 275-0-275V will be adequate if a 300-0-300V component is not available. The smoothing and reservoir capacitors $C_{1(a)}$, (b), can be mounted under the chassis and may consist of a double tubular type.

Phase of Feedback

When the amplifier has been completed, the wiring may be checked and a test made for possible h.t. short-circuits. It then becomes necessary to check the phase of the negative feedback. A loudspeaker should be connected to the amplifier and the latter switched on. If, after the valves have warmed up an audible oscillation is heard from the speaker, the amplifier should be switched off at once, and the connections to either the primary or secondary of T_1 reversed.

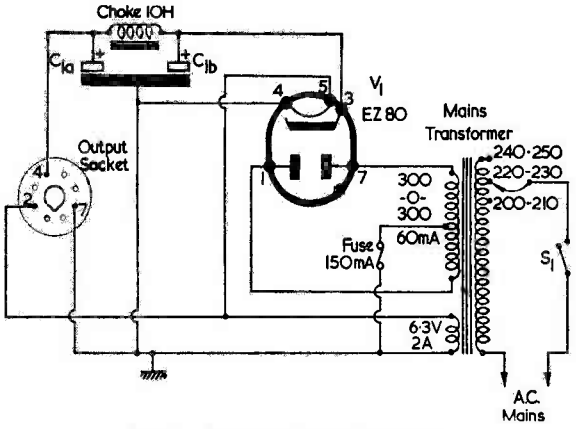

Fig. 5. Power unit circuit diagram

Components List

Power Unit

Mains Transformer
Secondary 300-0-300V 60mA, 6.3V 2A.
$C_{1(a),(b)}$ 16 + 16μF electrolytic 400V wkg.
V_1 EZ80
S_1 Toggle on/off switch

Chassis
As for amplifier

L.F. Choke
10H Gilson 808
Octal valveholder (1)
B9A valveholder (1)
150mA fuse and holder

NEW DOUBLE-TRIODE for TV Distribution Systems

A new special-quality, double-triode (ECC2000) for television v.h.f. distribution systems and aerial amplifiers, has been introduced by Mullard.

In addition to being suitable for the single-channel, broadband and distributed amplifiers commonly used in such systems, the valve can also be used in the Y amplifiers of broadband oscilloscopes.

A neutrode screen in the input section reduces anode-to-grid capacitance (and thus feedback), and enables the valve to be used in many circuits without neutralisation. Mutual conductance of the input section is 13mA/V at an anode current of 15mA and 17.5mA/V at 27mA. The ECC2000 has a 10-pin base (B10B) which enables the neutrode screen to be earthed separately or used in a neutralising circuit.

The output section of the valve is intended for grounded-grid operation. It is of conventional form and gives a mutual conductance of 17mA/V at an anode current of 15mA and 22mA/V at 27mA.

The valve can be operated in a low current condition when used as a small-single amplifier, or in a high current condition when used as a higher-gain voltage amplifier or power output stage.

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Car Anti-theft Device

By BRIAN CRANK

An unattended car is, these days, at the mercy of both the professional thief and the amateur "joy-rider". Our contributor describes an anti-theft device which he has successfully fitted to a car himself, and which has a number of ingenious features. Because of its transistor timing circuit the device, as described here, is only suitable for cars having 12 volt systems with positive earth

THE WRITER WAS RECENTLY ASKED by a friend, who had had his car stolen for a joy-ride, to design an anti-theft system which would prevent a repetition of this occurrence. The anti-theft device described in this article was the result, and it has proved very satisfactory in practice.

Operation

In the prototype system, microswitches are fitted to the doors, boot and bonnet, so that any unauthorised person opening one of these triggers the alarm system. The horn and an external warning lamp then operate alternately, regardless of whether the door is left open or is shut again. If the door is left open the alarm system operates continually, but if the door is closed the system shuts down after a pre-set period. However, the system will commence to operate again as soon as a door is opened. Once the system has been triggered, a small warning light on the dashboard becomes continually illuminated, and this informs the owner that his car has been tampered with during his absence.

Circuit Details

The circuit of the device appears in the accompanying diagram. This illustrates the relays with the "detached" method of presentation, in which each relay coil is represented by a rectangle identified by a letter over a figure. The letter identifies the relay, and the figure indicates the number of contact sets which the relay has. Each contact set is identified by a letter and a suffix number. Thus, relay $\frac{A}{2}$ has two contact sets, these being A_1 and A_2. The contact sets may appear anywhere in the diagram and are shown in the de-energised position.

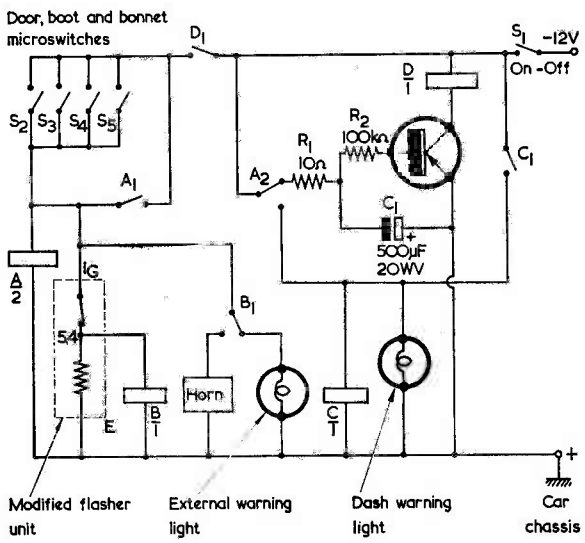
Relay $\frac{D}{1}$ has a 1,700+1,700Ω coil in the prototype, but other coil resistances would be satisfactory provided that the relay is capable of being energised by the transistor.[1] Due to the use of a transistor in the time delay section, the warning device, as it stands, is only suitable for cars having 12 volt systems with positive earth.

The device is switched on by closing switch S_1. The negative supply is then fed to R_2 and C_1 by way of R_1 and contact A_2. C_1 charges very rapidly to the full negative voltage, and TR_1 bottoms. Relay $\frac{D}{1}$ becomes energised and its contact D_1 closes.

When a door (or the boot or bonnet) is opened, its associated microswitch closes. Relay $\frac{A}{2}$ energises, and is held on by its contact A_1. Power is also applied to the flasher unit. Contact A_2 disconnects the negative supply from R_1 and applies it to relay $\frac{C}{1}$. Capacitor C_1 now commences to discharge, slowly, into R_2 and the base-emitter junction of TR_1. Relay $\frac{C}{1}$ holds on by means of its contact C_1, and stays energised until switch S_1 is opened. In consequence, the dashboard warning light becomes continually illuminated, and can only be extinguished by opening S_1.

As soon as the supply is passed to the flasher unit by the closing microswitch and contact A_1, this commences to operate. The unit employed in the prototype is a type intended for direction indicator circuits, and it is slightly modified as

[1] The minimum coil resistance of relay $\frac{D}{1}$ could be of the order of 500Ω. The main requirement of the relays is that they should be capable of operating reliably at 12 volts. It should be noted that contacts D_1, A_1 and B_1 are called upon to carry the relatively heavy current drawn by the horn and external warning light, and that these contacts should, preferably, be capable of handling this current. The fact that they are employed very infrequently may, however, allow the use of lighter contacts than would normally be required for continuous operation.—EDITOR.



The circuit of the car anti-theft device. The microswitches, S_2 to S_5, close when the associated door (or boot or bonnet) is opened. Further microswitches could be added in parallel, if desired

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explained later. It causes relay $\frac{B}{1}$ to continually energise and de-energise, with the result that contact B_1 switches on the horn and external warning light alternately.

As C_1 discharges, the negative potential at the junction of R_2 and R_1 decreases. After a period, this negative voltage is sufficiently low to allow TR_1 collector current to fall, with the result that relay $\frac{D}{1}$ eventually becomes de-energised.

When relay $\frac{D}{1}$ de-energises, contact D_1 opens, thereby breaking the negative supply to relay $\frac{A}{2}$, the flasher unit and relay $\frac{B}{1}$. The relays de-energise and the flasher unit ceases to operate. Contact A_2 reconnects R_1 to the negative supply, whereupon C_1 becomes charged and TR_1 bottoms once more. Relay $\frac{D}{1}$ becomes energised again, and its contacts D_1 close.

If, when this occurs, any of the door microswitches are closed, the warning system commences to operate once again, and continues to do so until the end of the timing period controlled by C_1 and R_2. Should a door microswitch still be closed at this instant, the warning system will commence a further operation. In other words, the warning system operates continually whilst any door microswitch is closed.

If, at the end of a timing period, all microswitches are open (corresponding to all doors, boot and bonnet being closed) the warning system reverts to the "ready" condition. It will immediately commence to operate again as soon as any microswitch is closed.

Additional Points

There are several further points which need to be mentioned with respect to the device.

It is desirable to employ a relay having a fairly high resistance in the $\frac{C}{1}$ position, and to ensure that the dashboard warning light is a low-consumption type. Battery drain will then be minimised when these components are operated. A fairly high resistance for the $\frac{D}{1}$ relay coil would, for the same reason, be desirable.

The time delay offered by R_2 and C_1 in the prototype was 2 minutes. This period can readily be changed, if desired, by altering the values of these components.

The flasher unit is one of the "Navigator" series available at Woolworth's stores. It is necessary to remove the case and cut the heater lead between terminal IG and terminal 54.[2]

It is not essential to use microswitches on the doors, etc., as any other device which can be made to close a pair of contacts or operate a switch could be used. The writer is at present experimenting with a pendulum switch to operate the system.[3]

The on-off switch can be a concealed switch, or one of the type operated by a key.

A device such as this is very adaptable, and a large number of modifications could be made to that described here.

As a final note, it should be pointed out that it is advisable to employ a test lamp or meter in place of the horn when checking the system, in order to avoid possible annoyance to neighbours.

[2] Because of possible variations here, it is advisable to carefully check the internal circuit of the flasher unit before modifying, to ensure that it meets circuit requirements. —EDITOR.

[3] This consists of a very sensitive pendulum inside a heavily damped pendulum. The damping is provided by suspending the pendulum in heavy oil. The outside pendulum takes up the angle at which the car is parked. If the car is then moved, the inner pendulum contacts the outer pendulum and triggers the alarm system.

Computer will aid Planning of Water Pipe Networks

A new device which enables the cost of certain types of analogue computing installations to be reduced by over 50% has been developed by EMI Electronics Ltd. This price reduction means that the analogue computer is now more economically acceptable to engineers, particularly those working on water distribution and allied problems.

The device consists of special plug-in units which can be fitted into a standard EMIac II analogue computer module. These units increase the computing capacity so that up to 36 computing amplifiers can be utilised in a module.

It is expected that the modified EMIac computer will be of particular interest to water boards who are frequently faced with difficult computational problems when considering the maintenance of their present pipe systems and possible extensions to serve new regions.

Various system changes can also occur as a result of burst mains or increased demand in certain areas. In these situations the boards have to ensure that their systems are adequate to cope with the changes. If not, new mains must be built to provide the increased flow rate or to replace existing but inadequate main pipes. In most cases, due to the methods by which water networks have been built up, the best routes and sizes for new mains are not obvious.

The analogue computer is the ideal tool for water board engineers working on such problems, but up till now the cost of these computers has limited their application. The price of the modified EMIac II is approximately £2,400 complete.

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News and Comment

R.S.G.B. Golden Jubilee

One of the highlights of the Golden Jubilee Year will be the International Radio Communications Exhibition.

The Feature Stage Presentation will be a display of equipment covering the life of the Society, and even earlier. Two transmitting stations will be on the air, GB3RS operating on the 10, 15, 20, 40, 80, and 160 metre bands and GB3VHF on the 2 and 4 metre bands. Mobile licensed vehicles can be talked in. The B.B.C. will be exhibiting for the first time and there will be the usual services stands. Manufacturers' new products will be shown on the commercial stands.

The show will be at the Seymour Hall, Seymour Place, near Marble Arch, London, and will be open daily from Wednesday, 30th October to Saturday, 2nd November, 10 a.m. to 9 p.m., admission 3/–.

We were interested in the comments in *Mobile News*, the monthly journal of the Amateur Radio Mobile Society, on the dropping of the term "XYL" by the Radio Society of Great Britain when referring to the wives of prominent members present at some of the Golden Jubilee celebrations.

For the uniniated, "XYL" is short for ex-young lady. We, ourselves, are not too keen on the term but we feel that referring to the wife of a licensed amateur as "Mrs. G3XYZ" is also not satisfactory and may mislead people into thinking that the lady has a call sign in her own right.

Perhaps the time has come to re-examine some of the terms used in amateur radio—our pet aversion is the term "Ham", or even worse, "Radio Ham"!

For Music Lovers

Hi-fi has been "guyed" quite frequently during the last year or two and readers may have seen the very amusing item "Hi-Fi-Fo-Fum" which was shown in the B.B.C. programme "Monitor" some time ago. Unfortunately, High Fidelity has attracted its quota of those who give the impression that they consider themselves much more sensitive to the appreciation of music than we lesser mortals. It is therefore with the greater pleasure that we mention the recommencement of a series of recitals of recorded music which have given much pleasure to many musically minded people in the past.

The recitals will be given at a church on the east side of London, the Woodford Green United Free Church. The church is a large attractive building with very good acoustic qualities. Immense care is taken by the organiser, Mr. Don Steven, to present programmes which both from the reproduction and content points of view are very satisfying to the music enthusiast. To enable this to be done, first-class equipment is used which briefly is as follows:

Playing Desk: Connoisseur "Craftsman" two-speed motor (33⅓ and 45 r.p.m.), Decca "ffss" and L.P. heads on an SME 12 in. arm. *Pre-Pre-amplifier*: Lowther transistor Stereo Head Amplifier, working on 400V d.c. supply from one of the amplifiers. *Pre-amplifier:* Leak Point One Stereo. *Filters:* Leak Steep Slope Filters, variable at 10 kc/s, 8 kc/s and 6 kc/s. *Amplifiers:* Lowther LL26. These units each have an output of 35 watts (r.m.s. value), are flat within less than ½ dB from 10 to 40,000 c/s and produce a very good square wave at 15,000 c/s. *Speakers:* On each channel there are four speakers, viz: (1) Audiom 70 on air coupler, 39–175 c/s. (2) Audiom 70 on folded baffle, 175–875 c/s. (3) Midax pressure unit, large horn, 875–5,000 c/s. (4) Reslo pressure unit, Vitavox 3-cell horn, from 5,000 c/s. *Speaker Control Unit:* This houses the six crossovers, volume controls for speakers 2, 3 and 4 in each channel, and monitor speaker. There are facilities for receiving the output of a second amplification system, for adaptation to twin 3-speaker systems, and for bypassing all the crossovers and volume controls.

Programmes range from works by Purcell to Poulenc and, in addition to well known classics, some lesser known works are included. An example of the latter occurs in the January recital when a trio by Hadyn includes a unique instrument called the baryton. This instrument has 6 strings which, when they are bowed, cause 9 metal strings on the instrument to resonate in sympathy.

Commencing on Saturday, 12th October the recitals are given on the second Saturday in each winter month, starting at 8 p.m. The nearest station is Woodford, on the Central line, and readers requiring further information should contact Mr. D. J. Steven, 36 Glengall Road, Woodford Green, Essex. There is a silver collection to defray the expenses.

G.C.E. By Radio

This is not a plea for more educational programmes but is a report of an unusual service given from an R.A.F. station.

In Adeni, students can put their summer holidays to good use by listening to a new series of broadcasts for Arab schools just started by the Aden Forces Broadcasting Association at R.A.F. Khormaksar.

Flying Officer H. Lake, A.F.B.A's Head of Drama and Talks, who is an R.A.F. helicopter pilot, says: "The series is aimed principally at Arab schoolchildren who are studying for the G.C.E. examinations. The first set of programmes, broadcast every Monday, will discuss English Literature, studying extracts from Shakespeare, the Brontes and other classics".

At the end of next month further programmes on G.C.E. standard music will be introduced. These are being prepared especially for A.F.B.A. by Mr. R. Shaw, music teacher at the R.A.F. Khormaksar Junior School, a programme director with the Association.

The schools broadcasts are at present experimental but A.F.B.A. hope to start a formal course of study next term, in consultation with local education authorities.

Commented the Headmaster of one Arab school: "The school holidays are an ideal time for pilot programmes of schools broadcasting. Our pupils will jump at the chance to do some extra studying—*we can't give them enough homework for their liking*"!

Appeal

We have in the past referred to the excellent work done for physically handicapped radio amateurs by The Radio Amateur Invalid and Bedfast Club. We are informed that the club is in desperate need of representatives in London and the Home Counties. Representatives have to service and repair equipment of a group of members in a given area.

For those with the time and technical ability, the foregoing would seem to offer an ideal way to use the hobby for the benefit of those less fortunate. Will interested readers please write to the Hon. Secretary of The Radio Amateur Invalid and Bedfast Club, Mrs. F. E. Woolley, G3LWY, 10 Sturton Road, Saxilby, Lincolnshire.

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2-Valve Design for Short Wave Operation

By JAMES S. KENT

The interest in simple receivers capable of operating over the short wave frequencies continues apace and in this article our contributor, well known for his earlier designs of this type, describes a receiver which should prove of interest to the beginner

IT IS OFTEN CONVENIENT FOR THE established short wave listener, already equipped with a standard communications receiver, to operate a second, or standby receiver, especially when listening to cross-band QSOs or a contact taking place at differing frequencies on the same band. Additionally, of course, there is the advantage of tuning the standby receiver to a broadcast station in which one is particularly interested—either to compile a period reception report or to await the identification signal at quarter or half-hour intervals whilst, during the lulls, searching for other signals on the same or other bands.

Further to the foregoing, a small inexpensive standby receiver will often prove to be of advantage whilst modifying the main receiver, in which case the short wave listener station would not become QRT whilst the project was in hand. Should the main receiver suffer a breakdown at any time, then the standby receiver would prove to well justify its existence.

The design about to be described was designed and built for the above purposes and has proved to be satisfactory in every way.

Circuit

The circuit of the receiver is shown in Fig. 1, and from this it will be seen that it is a 2-valve 3-stage design constructed around V_1 (12AT7) a miniature high slope double triode having separate cathode connections and V_2 (6BW6) an output beam tetrode having characteristics very similar to that of the octal based 6V6G/GT. Both valves are B9A (noval) based.

The r.f. signals from the aerial are fed, via the variable capacitor C_1, to the wiper arm of $S_{1(a)}$, the latter being part of a Yaxley switch of the 3-pole, 2-way variety. $S_{1(a)}$, (b), (c) is the wavechange switch; $S_{1(a)}$ connecting either L_1 or L_2 (the aerial windings) into circuit, $S_{1(b)}$ selecting the grid windings L_3, L_4, and $S_{1(c)}$ bringing the appropriate reaction windings L_5, L_6 into circuit.

The capacitor C_1 has been inserted in series with the aerial in order to eliminate reaction dead spots. Electrically, variations of C_1 will effectively lengthen or shorten the aerial. C_1 must not be connected to chassis in any way and should be mounted on the front panel by means of a small piece of Paxolin. The moving or rotor vanes of the capacitor should be connected to the aerial input and the stator vanes to the switch wiper of $S_{1(a)}$.

The aerial r.f. voltages are induced into the secondary, or grid, windings L_3 or L_4 (according to which is selected by $S_{1(b)}$) and are tuned by C_2 (Bandset) with C_3 (Bandspread) in parallel. The selected signal is then applied to the grid of $V_{1(a)}$ by way of the grid capacitor C_5 and grid leak R_1. These components have values which ensure that reaction is smooth and free from backlash. Regeneration is applied by positive feedback from the anode of $V_{1(a)}$ via the tertiary windings L_5 and L_6, according to the setting of $S_{1(c)}$, the amount of feedback being controlled by variation of the reaction capacitor C_4.

The inductances L_1, L_3 and L_5 are, of course, all contained on one former whilst L_2, L_4 and L_6 comprise a further component. (See Components List.)

As $V_{1(a)}$ grid and cathode form a diode, detection of the applied signal takes place, the resultant amplified a.f. voltage being applied to the grid of $V_{1(b)}$ by C_6. The resistor R_2 forms the anode load of $V_{1(a)}$ whilst the r.f. choke ensures that no residual r.f. voltages are fed to the grid of $V_{1(b)}$.

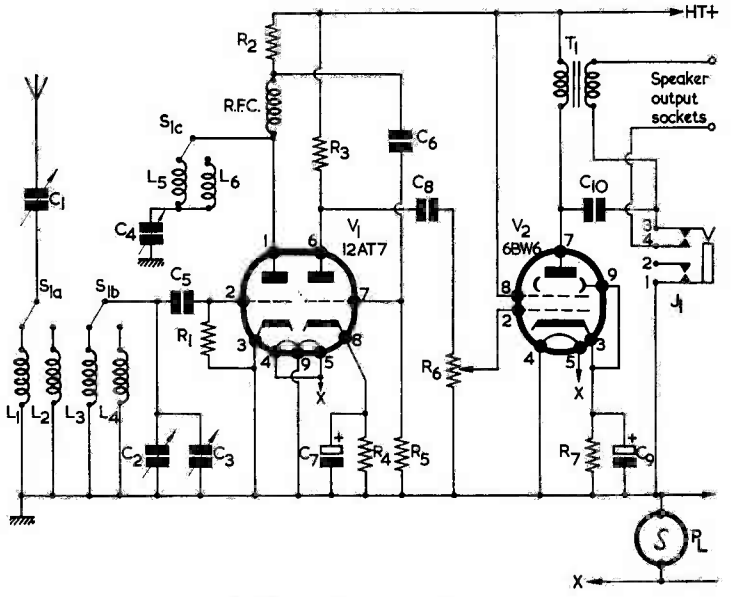

Fig. 1. Circuit of the receiver

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Components List

(Fig. 1)

Resistors
(All ¼ watt except where stated)

R_1	2MΩ
R_2	470kΩ
R_3	47kΩ
R_4	1kΩ
R_5	470kΩ
R_6	500kΩ pot. Log track
R_7	270Ω 1 watt

Capacitors

C_1	25pF variable, Jackson Bros. type C804 (see text)
C_2	140pF variable, Eddystone type 586
C_3	25pF variable, Jackson Bros. type C804
C_4	100pF variable, Eddystone type 585
C_5	200pF silver mica
C_6	0.01μF
C_7	25μF, electrolytic, 12V wkg
C_8	0.01μF
C_9	25μF, electrolytic, 25V wkg
C_{10}	0.02μF

R.F.C.
2.5mH

Phone Jack and Plug
Igranic

Chassis and Panel
H. L. Smith & Co.

Coils
L_1, L_3, L_5 SWQ1 } Osmor
L_2, L_4, L_6 SWQ2 }

Switch
$S_{1(a)}$, (b), (c) 3-pole, 2-way

Speaker
7 x 4in elliptical 3Ω impedance

Output Transformer T_1
Miniature pentode type
Ratio 40:1

Pilot Bulb and Assembly
6.3V, 0.5A

Miscellaneous
B9A valveholders (2), nuts, bolts, grommets, wire, etc.

(Fig. 2)

Capacitors
C_{11}, C_{12} 8+16μF, electrolytic, 350V wkg.

Chassis
6 x 4 x 2in (H. L. Smith & Co.)

Rectifier
EZ41 Mullard

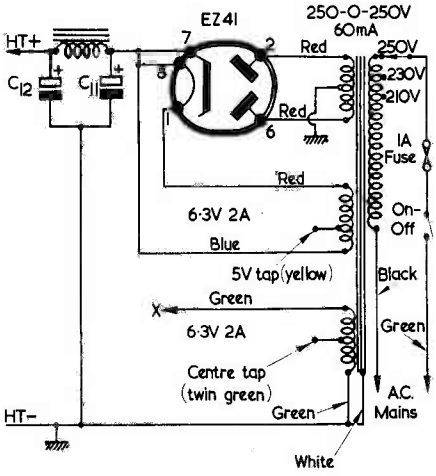

Fig. 2. Power supply circuit

Switch
s.p.s.t. toggle

Mains Transformer
Ellison type MT161

LF Choke
10H, 60mA (H. L. Smith & Co.)

Miscellaneous
Capacitor clip, B8A valveholder, nuts, bolts, wire, etc.

Fuse
Cartridge type with holder, 1A

$V_{1(b)}$ operates as the first a.f. stage, the greatly amplified a.f. signal appearing at its anode being fed to the grid of the following stage via C_8 and R_6. The resistor R_4 and capacitor C_7 provide the requisite bias voltage for $V_{1(b)}$ R_5 provides the grid chassis return for $V_{1(b)}$ whilst R_3 forms the anode load.

The potentiometer R_6 is the audio volume control and the required amount of audio is tapped off by the slider of this component and applied to the grid of V_2.

The resistor R_7 and the electrolytic capacitor C_9 ensure that the correct bias voltage is present at the cathode and the beam forming plates (pin 9) of V_2, whilst the anode load is provided by the primary winding of the output transformer T_1. The screen grid is connected direct to the h.t. line.

The resulting amplified audio signal appears across T_1 and is then fed to the speaker. With the phone plug withdrawn from the phone jack, the circuit to the speaker is completed via the contacts 3 and 4. When the phone plug is inserted into the jack, contacts 3 and 4 are separated, thus cutting out the speaker. At the same time, the phones are connected to the anode of V_2 via C_{10} (contact 3) and to chassis (contact 1), this completing the signal path from anode to chassis and thus operating the headphones.

A suitable power unit for the receiver is shown in Fig. 2, that used by the writer being provided with an octal socket output so that the power unit itself can easily be disconnected from the receiver and used for supplying power to other items of equipment when so desired.

The power unit is constructed around an EZ41 full-wave rectifier simply because this was to hand at the time of construction. The mains transformer employed (Ellison MT161) has a 6V 2A winding tapped at 5V which could, however, be utilised with a rectifier valve such as the 5Y3GT or 5U4, both obtainable on the surplus market at reasonable prices. The EZ41 has a 6V 0.4A heater and this is run from the appropriate tapping as shown in Fig. 2.

A single-pole-single-throw switch is inserted into one mains input lead as the on/off switch, one side of this being connected to the appropriate mains tapping on the primary winding of the transformer, via a 1A fuse. All the colour connections to the mains transformer are shown in Fig. 2.

Construction

The front panel and chassis details are shown in Fig. 3, from which it will be seen that all the controls are mounted on the front panel, the bandspread capacitor C_3 being se-

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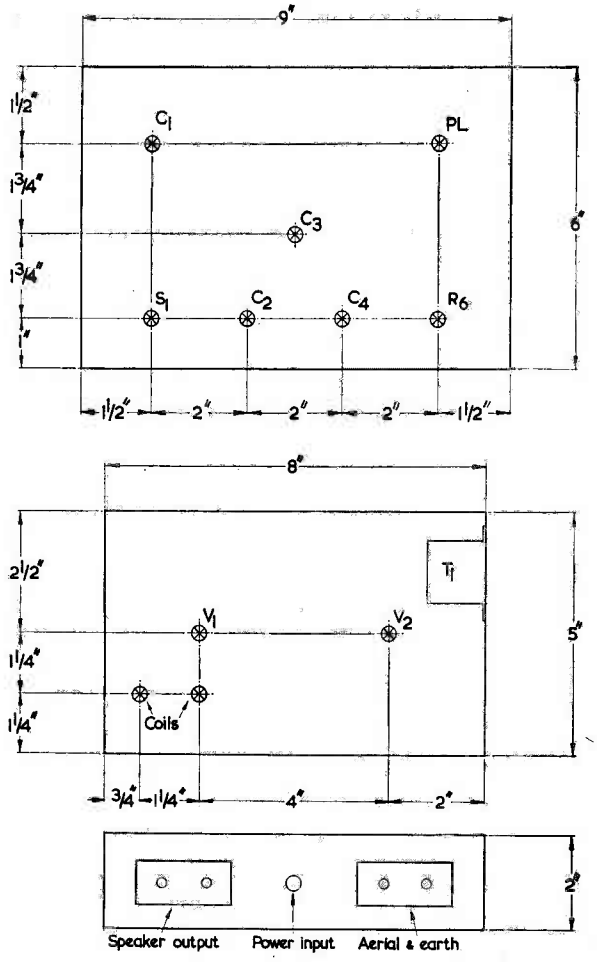

Fig. 3. Panel and chassis details. Both the output transformer T_1 and the two coils are mounted below the chassis

cured to the panel above the chassis. A hole should be drilled in the chassis directly under this capacitor and fitted with a rubber or p.v.c. grommet so that a direct connection may be made from C_3 to the bandset control C_2. Two further holes on the chassis deck, also fitted with grommets, should be made directly under the aerial coupling capacitor C_1. The holes will then be utilised for the connections from the aerial input tag to the rotor plates of C_1 and from the stator plates to the wiper arm connection of the switch $S_{1(a)}$. A further hole, with grommet, is now required on the chassis deck for the 6.3V connection to the pilot bulb assembly, the remaining tag of which should be soldered to an earth tag mounted above the chassis.

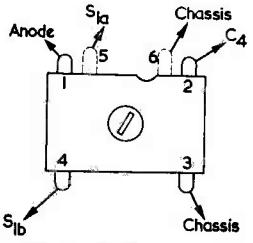

Fig. 4. Coil connections

The two coils should be mounted on the underside of the chassis as near to the switch as possible, the prototype measurements being shown in the chassis drawing. The actual coil connections are shown in Fig. 4 and these are self-explanatory. The speaker is fed from the output sockets located on the rear of the chassis and is mounted in a further separate chassis, the deck of which has been suitably drilled in a geometric pattern and the speaker mounted inside the chassis.

The receiver chassis could be somewhat smaller if desired, that utilised being to hand at the time of construction. The output transformer T_1 is mounted below the chassis.

The front panel should be marked out and suitably drilled in the first instance, this then being used as a template for the required holes in the front of the chassis for the fitting of the controls S_1, C_2, C_4 and R_6. The chassis can now be drilled to take the valveholders, output transformer, coils, the grommets already mentioned, etc. (If not required, C_1 may be omitted altogether or, alternatively, replaced by a fixed value of around 50pF.)

The rear of the chassis is shown at the foot of Fig. 3 and from this it will be noted that two Paxolin output strips are used, that on the left being utilised for the aerial and earth connections whilst the other strip is that for the speaker output. The power input hole at the centre should, of course, be fitted with a grommet.

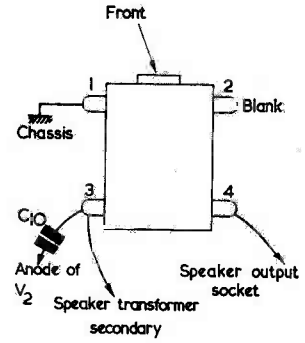

Fig. 5. Headphone jack connections. The tags point away from the reader

All wiring should be as short and direct as possible, especially when dealing with the tuned circuits of $V_{1(a)}$.

The wiring associated with the headphone jack is shown in Fig. 5 and a comparison of this with the appropriate part of Fig. 1 will ensure that no mistakes are made with respect to wiring up this part of the circuit.

Final Details

Once completed, the receiver controls should be fitted with appropriate knobs after having applied Panel-Sign transfers to the front panel. Set No. 1 is that required for the purpose and also for the wording. Set No. 2 will also be required for obtaining the full vision dial (4 x 2¾in approx.) for the bandspread

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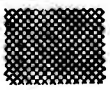
control C_3, two of these dials being contained in this set of transfers. The bandspread control spindle should be fitted with a round fluted knob of suitable size, to which a thin sheet of Perspex material may either be screwed or glued, the Perspex having first been scribed with a sharp instrument in order to obtain a central hair-line indicator mark. This line should then be carefully filled in with indian ink. The panel could, of course, be painted to choice, prior to the application of the transfers.

Once in operation, this receiver will be found to be an ideal unit for use as a standby receiver. For the beginner it will provide endless hours of fun and enjoyment on the short wave bands.

The twenty-sixth in a series of articles which, starting from first principles, discusses the basic theory and practice of radio

part 26

understanding radio



By W. G. MORLEY

IN LAST MONTH'S ARTICLE WE INTRODUCED THE subject of r.f. transformers, pointing out that the majority of these have one or two (occasionally more) tuned windings. We referred, in particular, to r.f. transformers of the type which are suitable for operation at medium wave frequencies, and discussed their performance with or without an iron dust core. We shall now continue to examine these transformers.

Single Tuned Winding Assemblies

We have, up to now, considered r.f. transformers of the type which may be employed on medium waves, since assemblies of this nature offer an excellent example of r.f. transformer design in practice. The transformers we have discussed have been assumed to have single-pie wave-wound tuned windings and coupling windings. A number of r.f. transformers intended for operation at medium wave frequencies may, however, have more than one pie for the tuned winding, and this is especially true when no iron dust core is employed. There is usually little advantage in using more than one pie for the coupling winding.

R.F. transformers intended for operation on the long waveband of, approximately, 300 to 150 kc/s (1,000 to 2,000 metres) will employ a similar construction to the medium wave components we have just discussed. Because of the lower frequencies involved there will be more turns on the long wave tuned winding and, usually, proportionately more turns on the coupling winding. Frequently, the long wave tuned winding will employ single strand wire instead of litz or bunched wire.

In general, it may be stated that the medium wave r.f. transformer construction will be encountered with most single tuned winding r.f. transformers intended for use in radio receivers at frequencies between 50 kc/s and 5 Mc/s or so. There may be variations in dimensions, but the general method of assembly will be the same.

Frequently, a receiver which operates on medium and long waves may employ an r.f. transformer assembly in which both the medium and long wave tuned windings appear on a common former. A typical example is shown in Fig. 160 (*a*), in which diagram we have two tuned windings and two coupling windings. This assembly could be employed in a circuit similar to that illustrated in Fig. 160 (*b*). When the two switches are in the "medium waves" position, the long wave tuned winding and the long wave coupling winding are short-circuited. In consequence, the variable capacitor connects across the medium wave tuned winding only, whereupon the tuned circuit resonates at frequencies within the medium waveband. At the same time, the input

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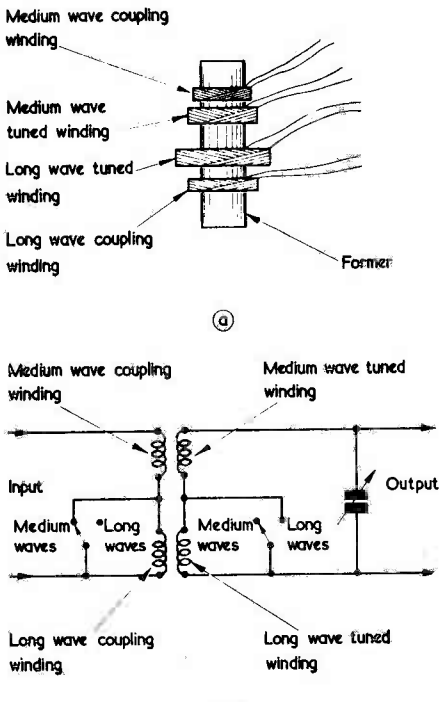

Fig. 160 (a). An r.f. transformer having both medium and long wave tuned and coupling windings (b). The transformer may be connected into circuit as shown here. The two tuned windings are connected so that their inductances are additive (i.e. their fields do not oppose each other). The coupling windings are similarly connected

signal is applied only to the medium wave coupling winding. When the two switches are open (i.e. set to "long waves") the medium and long wave tuned windings are in series, as also are the coupling windings. The resultant circuit is such that the variable capacitor may now tune over frequencies in the long waveband.[1] At the same time, the two coupling windings now couple the input signal to both tuned windings. For convenience, the two switches would be combined together in a single assembly, which then becomes a *wavechange switch*. It will be noted that the technique of short-circuiting the long wave windings when medium waves is required enables the wavechange switch to be of a very simple type. An even simpler wavechange switch is required with the assembly of Fig. 161 (*a*) and (*b*). In this instance there is only one coupling winding, and it becomes necessary to short-circuit the long wave tuned winding only when selecting medium waves. By careful positioning of the common coupling winding, together with a suitable choice of turns, a coupling to both tuned windings is given which is reasonably adequate. The assemblies of Figs. 160 and 161 are frequently encountered in home-constructor applications and have, in the past, been common in commercially manufactured receivers as well.

R.F. transformers intended for operation at frequencies higher than those associated with wave-windings employ single-layer tuned windings. Fig. 162 illustrates two types of coupling windings which may be employed with such transformers. In Fig. 162 (*a*) the coupling winding consists of a second single-layer winding which is positioned a small distance away from the tuned windings. In Fig. 162 (*b*) the coupling winding is interwound with the tuned winding. The coupling offered by the arrangement shown in Fig. 162 (*a*), can be varied by moving the coupling winding closer to or further away from the tuned winding. On the other hand, the coupling provided by the assembly of Fig. 162 (*b*) is fixed, and is, also, very tight. This coupling is, indeed, so tight that, apart from the possibility of damping of the tuned winding due to reflected resistive impedance in the circuit to which the coupling winding connects, it is also possible for *capacitive* or *inductive* reactances from the coupling winding circuit to be reflected into the tuned winding. The latter may cause the tuned circuit to shift from its correct resonant frequency. This effect need not necessarily be serious if the primary circuit impedance remains

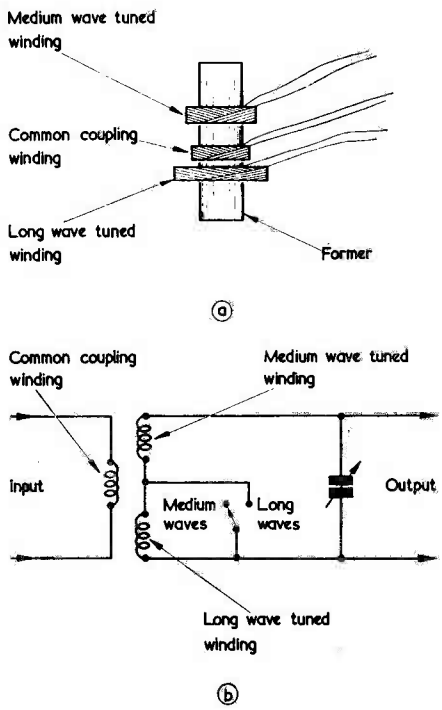

Fig. 161 (a). An alternative construction for a combined medium and long wave assembly (b). Because of the common coupling coil, the wavechange switching circuit becomes extremely simple

[1] The "long wave tuned winding" used in this assembly has, actually, rather less inductance than would be given by the tuned winding of an r.f. transformer intended for long wave operation on its own. Here, additional inductance is provided by the medium wave tuned winding.

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constant, but it can be a nuisance if it varies.[2] The effect can be reduced by employing thin wire (around 36 s.w.g.) for the coupling winding. This increases its effective resistance at r.f. and reduces the coupling between the primary circuit and the tuned circuit.

The coupling method shown in Fig. 162 (*b*) is frequently encountered in the short wave tuned circuits of domestic "all-wave" receivers, where a high level of selectivity is not expected. The transformers will, then, be wound on inexpensive formers made of materials which fall into the Bakelite or Paxolin categories. Where high Q values are required it is more usual to employ a low-loss and/or ribbed former, whereupon the coupling arrangement of Fig. 162 (*a*) is preferable.

As with the wave-wound tuned winding, the tightest possible coupling to a single-layer coil is given by the autotransformer connection shown in Fig. 163. Since the coupling here is tighter than occurs with the coupling winding of Fig. 162 (*b*), the effects of reflected primary impedances are even more pronounced.[3]

Pot Core R.F. Transformers

We have already seen[4] that it is possible to reduce the number of turns on a coil, and obtain a high Q with a small assembly, by employing the pot core method of construction. In this, the coil is enclosed on the outside by iron dust material, whereupon an almost complete magnetic circuit is set up.

[2] As we shall see later, the coupling winding could be connected to an aerial and earth. Different aerial and earth systems will offer different capacitances to the coupling winding, with a consequent shift of resonant frequency.

[3] The same effect is given also with the wave-wound autotransformer

[4] In "Understanding Radio" part 19, March 1963 issue.

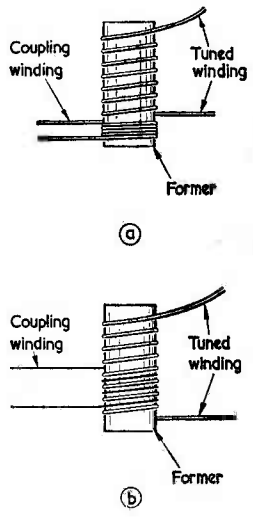

Fig. 162 (a). An r.f. transformer employing single-layer windings. The tuned winding could also be close-wound, as is the coupling winding

(b). In this diagram the coupling winding is interwound with the tuned winding, giving a very tight coupling. It is usual, in assemblies of this nature, to employ thin wire for the coupling winding

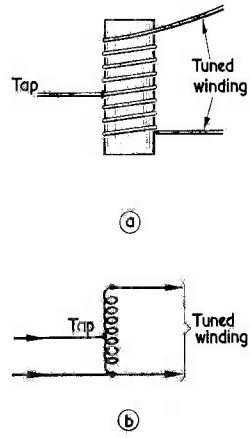

Fig. 163 (a). An r.f. autotransformer having a single-layer tuned winding

(b). The autotransformer may be connected into circuit as shown here

The pot core method of construction is very common with r.f. transformers. The assembly employs the same construction as for the coil described previously, the coupling winding, or windings, being fitted inside the pot core in addition to the tuned winding. The inductance of the tuned winding is then varied by adjusting the iron dust core of the pot core assembly.

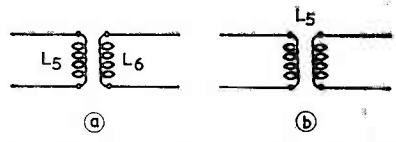

Fig. 164. The manner in which r.f. transformers are identified in circuit diagrams tends to vary. In (a) each winding is designated by a separate suffix number whereas, in (b), the complete transformer is identified by the suffix number

Pot core r.f. transformers are normally employed at the frequencies associated with the medium and long wave bands. They are used mainly in transistor receivers, wherein their small dimensions are of particular advantage.

Alternative R.F. Transformers

We have discussed r.f. transformers from the point of view of components which are employed in radio receivers, since these represent the types which the amateur will most frequently encounter. Also, they demonstrate the principles involved very adequately.

However, r.f. transformers need not necessarily have the relatively small dimensions associated with

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receiver components. In transmitters, for instance, r.f. transformers will be employed which are very much larger. They will, nevertheless, have the same basic design as the transformers we have considered.

Terminology

Whilst dealing with r.f. transformers we have referred to the complete assembly as a "transformer" and, then, to the individual "windings" of that transformer. The terminology generally employed for these components is not, however, so meticulous.

It is very common practice to refer to an r.f. transformer as a "coil", this term embracing both tuned and coupling windings. Thus, an r.f. transformer whose tuned winding resonates at medium wave frequencies, and which is intended to couple to the receiver aerial, may be described as a "medium wave aerial coil". At the same time, the individual windings of the transformer may also be described as "coils"! Loose usage of this nature may be a little mystifying at first to the beginner, but the confusion soon clears with familiarisation.

In circuit diagrams an r.f. transformer may, because of the same association of ideas, be identified in one of two ways. In Fig. 164 (*a*), the two windings of an r.f. transformer are identified by the letters L_5 and L_6 (it being assumed that L_1 to L_4 appear elsewhere in the associated circuit). In Fig. 164 (*b*), the letter L and its suffix figure is intended to apply to the transformer as a whole, whereupon the *transformer* is designated L_5 (again assuming that L_1 to L_4 appear elsewhere). Both methods of identification will be encountered in circuit diagrams.

Next Month

In next month's article we shall introduce the subject of r.f. transformers having two tuned windings.

"Monopoint" Pick-up Arm

By **N. A. BARGERY**

USING A SINGLE DAMPED POINT ON WHICH TO "suspend" a pick-up arm enables an almost frictionless movement in the lateral and vertical planes to be achieved.

This in turn means that, with such an arm, one may use cartridges capable of tracking at 2 grs. and below. Moreover, by slight coiling of one of the conductor leads used with stereo wiring, a tendency to out-swing can be given to the arm. This is, in effect, dynamic balance, a condition which improves reproduction in high quality equipments, and especially with stereo.

Design

In the arm described in this article, a hardwood was used and had the dimensions given in Figs. 1 (*a*) and (*b*). Under the main part of the arm two grooves are cut to carry the conductor wires. The head section is fixed by a bolt at an angle of 27°. This section is fitted above the main part of the arm (see Fig. 4) so that, when the cartridge is in position, the stylus is nearer to the horizontal plane of the pivot. This is a desirable condition which minimises distortion on warped discs.

Dimensions are not critical. A Meccano axle was used for the pivot, since a Meccano bush wheel can then be used to allow vertical adjustments to be made to the arm where necessary. Other similar arrangements could be made to function just as well.

The point of the pivot was ground and polished in an electric drill, and is just a little smaller than a socket recessed in a ¼in steel bolt. This allows for

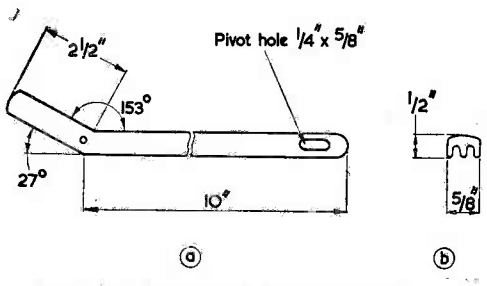

Fig. 1 (a). The general dimensions of the arm (b). A cross-section through the arm, showing the grooves for the connecting wires

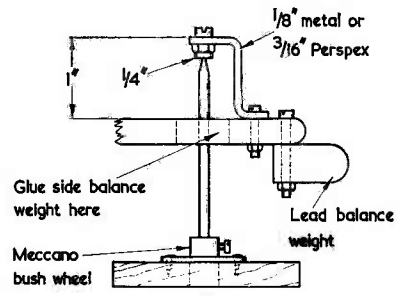

Fig. 2. The pivot balancing assembly

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a little packing of damping grease. See Fig. 2.

The hanging arm is of ⅛in metal, which could be aluminium for ease of working. Alternatively, $\frac{3}{16}$in Perspex could be used. The hanging arm is secured to the main arm by small bolts, or screws. The balance weight is calculated when the chosen cartridge is *in situ*. An overweight is desirable, since it is easier to rasp the lead down to weight than to build it up.

It may be necessary to apply a little side weight, as in Fig. 2, to counteract the pull given by the offset head. The weight may be a suitable small piece of lead secured to the arm with Bostik. Readers may wish to fit a sliding weight and this modification should present no difficulty.

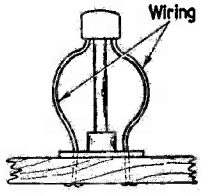

Fig. 3. Detail illustrating the disposition of wiring at the pivot

Fig. 3 illustrates the manner in which the conductor wires are disposed. They pass through a ¼in pedestal block and are soldered to contacts or sockets in the base. Screened leads from these then connect to the amplifier.

Final Balance

To obtain final balance, the necessary down pressure can be given by cementing a small weight to the arm just behind the head section, as shown in Fig. 4. Siting the additional weight here will not upset side balance. If the weight is placed directly over the cartridge stylus, side balancing will need to be adjusted.

It is appreciated that readers will be able to improve on this prototype model; hence it is not proposed to do more than give basic details in this article.

So far as lining up the arm for minimum tracking error is concerned, the writer uses the following procedure. He always "locks" the turntable, after which he places a cardboard disc on the turntable that has a line drawn on it running from the centre to the circumference. It is assumed that the maximum amount of material recorded on a disc never exceeds a 4in wide band from the edge towards the centre, whereupon the writer lines up the cartridge so that it is truly tangential at the inner end of this 4in band, a point that can be marked on the line drawn on the cardboard disc.

The arm should then be "spot on" for tangency at the critical point of discs, i.e. near the run-off. When adjusting the arm for height, ensure that the cartridge has the recommended angle to the disc surface.

Regarding lateral friction assessment, a method devised by Percy Wilson of *The Gramophone* is very simple. A strip, 4in long by ⅜in wide, of good quality notepaper is grasped at one end between finger and thumb, the other end being then pressed against the pick-up arm, which must be in a balanced state and

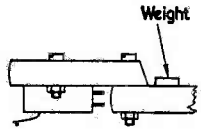

Fig. 4. The cartridge and final balancing weight in position

free-swinging. It should be possible to move the arm by the paper strip without the strip bending. When this happens, the side friction of the arm is near zero, and cartridges of the lowest down-pressures, such as the Decca "Deram" Transcription can be used. The previously mentioned state of dynamic balance still applies, however, when the cartridge is tracking a disc so that, after achieving this near zero movement, attention must be given to incorporating dynamic balance by some stressing of the conductor wires between the arm and the base.

The Radford Dynamic Cartridge

The writer specially recommends the Radford Stereophonic Cartridge for use with this arm, as he feels that it gives superb transient response and a very high signal-to-noise ratio, together with minimum record wear and no hum pick-up.* This cartridge has a response of 30 c/s to 15 kc/s ± 2dB, channel separation better than 22dB, and an output of 7mV. There is a choice of diamond stylus tip radii, and the down pressure is 2.5 to 3 grs.

* The Radford Stereophonic Cartridge is manufactured by Radford Electronics Limited, Ashton Vale Estate, Bristol 3.

NEXT MONTH . . .

- *11-Valve Double Superhet Communications Receiver*
- *Transistorised TV, Part 1*

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A Transistorised Voltmeter

By J. ANDERSON

A simple, easy-to-build, instrument which offers a very high input resistance

WHEN MEASURING POTENTIALS in circuits having a high resistance of their own, it is always essential to see that the resistance of the measuring meter is considerably higher than that of the circuit. Usually, the meter resistance should be at least ten times that of the circuit under consideration. Conventional meters for voltage measurement do not normally have an extremely high resistance, and for this reason the service engineer favours the use of a valve voltmeter which, ideally, draws virtually no appreciable current from the circuit to which it is applied.

However, valve voltmeters have a tendency to be both rather weighty and expensive. On the other hand, a transistor voltmeter can be used instead of the valve voltmeter, giving nearly as high an input resistance and, if constructed carefully, equal accuracy over the available ranges. It also, of course, tends to be smaller and less weighty than the valve equivalent, as well as being cheaper to build and to run.

The voltmeter described in this article has a maximum input resistance in the region of 15MΩ, and averages 150kΩ per volt. The two batteries providing the drive for the unit may, in fact, be soldered into place providing the leakproof type is used. If this is done it must be borne in mind that the soldering iron and the battery terminal must be clean at the point of contact, and that the period of soldering must be as brief as possible.

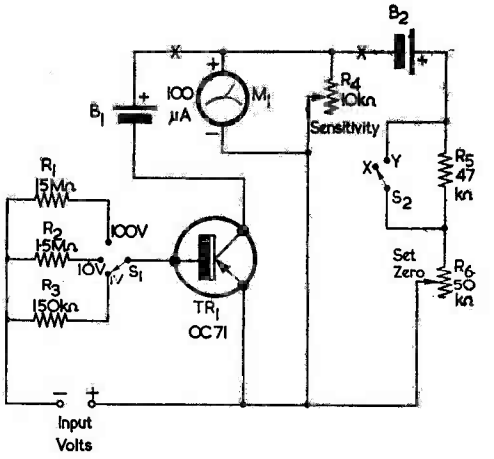

Fig. 1. The circuit of the voltmeter. If desired, a 2-pole 2-way on-off switch may be added, this breaking the circuit at the points marked with crosses

The circuit diagram is shown in Fig. 1. If a potential is applied to the input terminals, a very small current is caused to flow in the input resistance and the accompanying base-emitter circuit. The transistor, in this case an OC71 having a gain of the order of 40, causes a much larger current to flow in the emitter-collector circuit with the result that a reading is given in the microammeter. To take an example, let us assume that the potential to be measured is 1 volt, and that the switch is in the 1 volt range position. The current flowing in the base-emitter circuit (the resistance of the base-emitter component itself being relatively too small to consider) will be of the order of 7µA. Since the transistor gain is 40, the emitter-collector current will then appear as 280µA. The meter in the emitter-collector circuit has a full-scale deflection of 100µA, and an adjustable shunt is placed across it such that 1 volt applied across the input terminals gives a 100µA deflection in the meter. This shunt, R_4, is the sensitivity control.

The purpose of the circuit, R_5, R_6, and B_2, is to provide a reverse current to cancel the effect, in the meter, of the small collector current which will flow even when there is no input voltage.

To set up the meter, the input terminals must be short-circuited and R_6 adjusted until the meter reads zero. If a zero balance cannot be obtained with the switch in position X then move it to position Y, first ensuring that R_6 is at a maximum setting to avoid damage to the meter.* A known voltage is then connected to the input, probably the most easily available form being a Mallory Mercury cell (1.34V), and R_4 is adjusted until the meter reads the appropriate value.

It is important to remember, in the construction, that fairly thick wire should be used, and that all joints should be well soldered to reduce the effects of circuit resistance. The unit may be built into a multimeter, if one is already

* A 15kΩ resistor in series with B_2 will limit the possible back current to 100µA. Also, it may be necessary to select a transistor having a low leakage current at 1.5 volts.—EDITOR.

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available with a 100μA range, or alternatively built into a small shockproof plastic case.

Components List

Resistors

R_1	15MΩ*
R_2	1.5MΩ*
R_3	150kΩ*
R_4	10kΩ potentiometer, pre-set
R_5	47kΩ 10%
R_6	47kΩ potentiometer, pre-set

*Close tolerance, preferably 2%

Transistor

TR_1 OC71

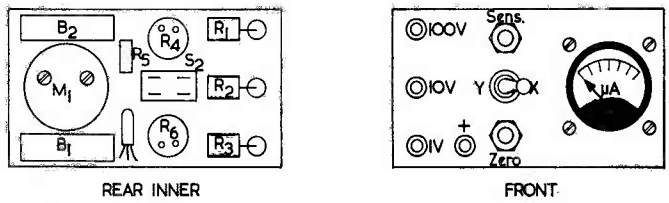

Fig. 2. Layout of the prototype. To reduce size, switch S_1 was omitted here, R_1, R_2 and R_3 connecting to separate sockets

Switches

S_1	1-pole 3-way
S_2	1-pole 1-way

Meter

M_1 100μA f.s.d.

Cells

B_1, B_2 1.5 volt dry cells

Variable Voltage Transistor Power Unit

By **K. BERRY**

THE POWER UNIT DESCRIBED HERE WAS DEVELOPED as a general purpose low voltage power supply for testing and running experimental equipment employing transistors. It can also be used for any other purpose which requires a smooth d.c. supply of up to 12 volts at a current of up to 1 amp.

Performance

Input Voltage: 240 volts r.m.s.
Output Voltage: 0–12 volts d.c.
Output Current: 1 amp maximum
Output Impedance: 0.4 ohms (approx.)
Ripple Voltage: 16 millivolts peak

A change of ±10% in the mains voltage causes a change of ±0.1 volt in the output voltage.

Circuit Description

The circuit of the power unit is given in Fig. 1. The a.c. supply is connected via a double-pole switch (S_1) to the primary of the mains transformer (T_1). The secondary winding is centre-tapped (12–0–12 volts) and feeds two separate full-wave (to be precise, bi-phase half-wave) rectifier circuits using silicon diode rectifiers (MR_{1-4}). Each rectifier circuit is connected to a 3,000μF reservoir capacitor (C_1, C_2). The output of one rectifier circuit is smoothed by a resistance capacitance filter (R_1, C_3) and is fed via a low value decoupling resistor (R_2) to two zener diodes (Z_1, Z_2) connected in series. These diodes provide a stabilised 12 volt (nominal) supply, into which the potentiometer (VR_1) is tapped and supplies base current to the first emitter follower (TR_1). The output of the first emitter follower is fed to the second emitter follower (TR_2) which in turn supplies the output current. The emitters of the two transistors are maintained at the potential of the positive line when VR_1 is set for zero output, by resistors R_3 and R_4. These resistors pass the collector leakage current of the transistors in the absence of a load.*

The output voltage is measured by a moving coil meter (M_2) connected directly across the output terminals, whilst the load current is indicated by a moving coil ammeter (M_1) which is connected in series with the collector of the output transistor. This meter will in fact indicate the load current plus the current flowing through R_4, which latter will amount to a maximum of some 50mA when the output voltage is 12. This error can be eliminated by placing the meter in series with the output lead, but this will increase the output impedance of the power unit by the resistance of the meter.

The choice of a bi-phase half-wave rectifier circuit instead of the more usual bridge rectifier circuit was made to enable two separate supplies to be obtained from the one transformer. Of course, one 12 volt winding could have been used for one supply, and the second 12 volt winding for the other supply, but since this would have involved the use of no less than eight silicon diodes the present arrangement was employed instead. The need to produce two apparently similar d.c. sources is explained by the fact that whilst zener diodes do act as voltage stabilisers, the voltage across them varies con-

* Although TR_1 could be a transistor with a lower maximum collector dissipation than TR_2 the same type transistor has been specified. This was done on the grounds of uniformity and also because, when used at low (relative to Ic max) collector currents, the gain of the transistor is much higher than it is at high currents.

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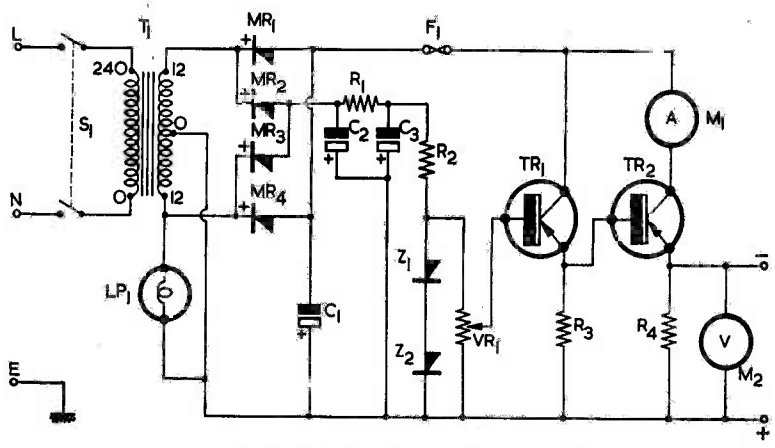

Fig. 1 Circuit of the variable voltage unit

Components List

Resistors

R_1	220Ω ¼ watt
R_2	47Ω ¼ watt
R_3	330Ω 1 watt
R_4	270Ω 1 watt
VR_1	1,000Ω ½ watt variable

Capacitors

C_1, C_2, C_3	3,000μF 25 volt electrolytic

Semiconductors

MR_{1-4}	SJ051-A or SJ052-A or SL051-A } A.E.I.
TR_1, TR_2	OC35 or OC28 } Mullard
Z_1, Z_2	VR625A A.E.I. or OAZ202 Mullard

Miscellaneous

S_1	d.p.s.t. toggle switch
T_1	Mains transformer 240 volt input/12–0–12 volt 1 amp output (Gardners Transformers Ltd., No. ILV860)
F_1	Fuse link 1 amp
LP_1	12 volt M.E.S. lamp
M_1	Ammeter, d.c. moving coil, 0–1 amp
M_2	Voltmeter, d.c. moving coil, 0–12 volts

siderably with the current. To take an example, when the current through an OAZ202 changes from 1mA to 20mA, the voltage changes by 0.6 volts. It is thus necessary to maintain the current through the zener diodes as constant as possible, and the provision of a separate negative supply ensures that this is done.

Possible Modifications

There are a few modifications which can be made to this circuit. The second capacitor smoothing the zener diode supply (C_3) can be omitted, and R_1 and R_2 replaced by a single 270Ω ¼ watt resistor. The only result of this will be to increase the ripple voltage at full load to 28mV, instead of 16mV.

The separate negative supply for the zener diodes can be dispensed with, R_1 being connected to the negative side of C_1. This saves the use of MR_2, MR_3 and C_1, but as explained earlier, results in a higher effective output impedance and is in consequence not to be recommended.

Meters for current and voltage measurements are not essential and they can, if desired, be omitted. If this is done, VR_1 could be calibrated by the use of an external meter or, alternatively, it could be replaced by a series chain of twelve 100Ω ¼ watt resistors, the first ten of which are connected to an 11 position single pole rotary switch, and the remaining two in series to the positive line. This switch will then give an output voltage of 2 to 12 volts in 1 volt steps approximately.

Components and Construction

The construction of this power unit should present no difficulties. The prototype was made

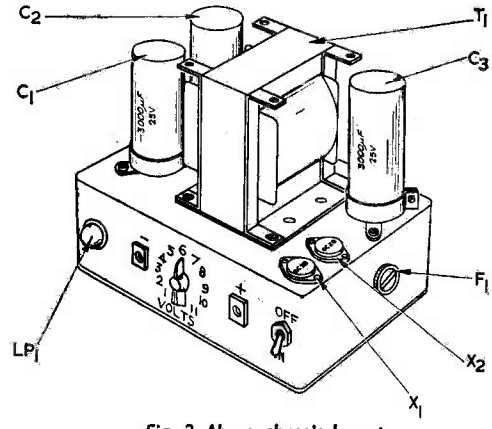

Fig. 2 Above-chassis layout

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without the meters on an Eddystone die-cast case of size 7⅜ x 4⅝ x 2in. The transistors are bolted to the case, which acts as a heat sink, and are insulated from it by means of the mica washer and insulated bushes obtainable with the transistor.

All the rectifiers listed in the component list are suitable for use without a heat sink. The SJO51-A is the least expensive of those listed. The other types are capable of carrying heavier currents (in excess of 1 amp) but are correspondingly more costly.

It must be pointed out here that to ensure that no damage is suffered by the silicon diodes (or, indeed, the transistors) the 1 amp fuse, F_1, must be fitted. Failure to fit this fuse will result in the possible destruction of the diodes and/or the transistors.

Increased Output Current

Although the original design was for a unit capable of supplying a current of up to 1 amp, the design will supply up to 2 amps for output voltages of 6 or more provided certain conditions are met.

(1) The mains transformer must be rated at 12–0–12 volts 2 amps (a suitable type being Gardners Transformers Ltd., No. ILV868).
(2) The two silicon diodes, MR_1, MR_4, must be fitted with cooling fins, 1¾ inches square made of 20 s.w.g. (or thicker) copper. This is not necessary if the SL051-A diode is used.
(3) The fuse, F_1, is increased to 2 amps.
(4) The output transistor, TR_2, must be on an efficient heat sink. Mounting on the Eddystone case as described earlier will suffice, though great care must be taken to ensure that there are no burrs around any of the mounting holes to prevent the transistor from laying flat on the chassis. The application of a smear of silicone grease (or if this is not available, high melting point grease) between the chassis and mica washer and between the transistor and mica washer, is strongly advised.

The power unit, when modified to meet these requirements, will then supply up to 2 amps load current provided that the ambient temperature does not exceed 25°C (77°F). At higher temperatures, the unit must be progressively derated. The unit should not be used at 2 amp output with output voltages lower than 6.

Closed-circuit TV aids Flight Research at Cranfield

A closed-circuit television camera, fitted to the wingtip of a Lancaster bomber, is helping research staff at the College of Aeronautics, Cranfield, to study in flight a swept wing, designed and built by Handley Page Ltd, which has an overall smooth airflow—known as laminar flow—as opposed to the turbulent flow of most present aircraft wings. Such a wing should achieve a considerable reduction in aircraft drag with corresponding substantial gains in payload and fuel economy.

Fitted to the tip of either port or starboard wing and facing inwards towards an experimental laminar aerofoil mounted vertically on the fuselage, the TV camera—a type 8 camera supplied by EMI Electronics Ltd—helps the research in three ways, by transmitting pictures of the aerofoil during flight to a TV receiver in the fuselage.

Firstly, it helps to ensure the safety of the experimental gear temporarily attached to the aerofoil. For instance, a cable or one of the metal pitot combs might break loose, unbeknown to the crew, and cause damage to the test wing. Continuous inspection of the TV screen enables the crew to take preventive action before any serious damage is caused.

Secondly, it checks the proper operation of the traversing gear which samples the state of airflow at different points on the aerofoil.

Thirdly, it monitors the stages of a special chemical technique which shows the areas of smooth and rough airflow on the aerofoil. Caught at the crucial time—a period of 30 seconds which occurs about 25 minutes after take-off—this process is particularly noticeable and can be recorded by a remotely-controlled still camera housed in the opposite wingtip.

The only alternative method of achieving these objectives would be to fly another aircraft alongside. This would be much more expensive than using closed-circuit television and in any case a second aircraft is seldom available on research projects.

Both TV camera and receiver operate on 230V a.c. from a rotary converter which draws power from the aircraft's 24V d.c. supply system. The type 8 camera can also work off batteries.

Purpose of the flight research, which has been proceeding in this country and the United States of America for 13 years, is to keep the airflow within a thin layer close to the surface in a laminar or smooth condition. The flow in this layer is prevented from becoming turbulent by sucking a small portion of the air from the wing surface through fine slits running spanwise along the test aerofoil.

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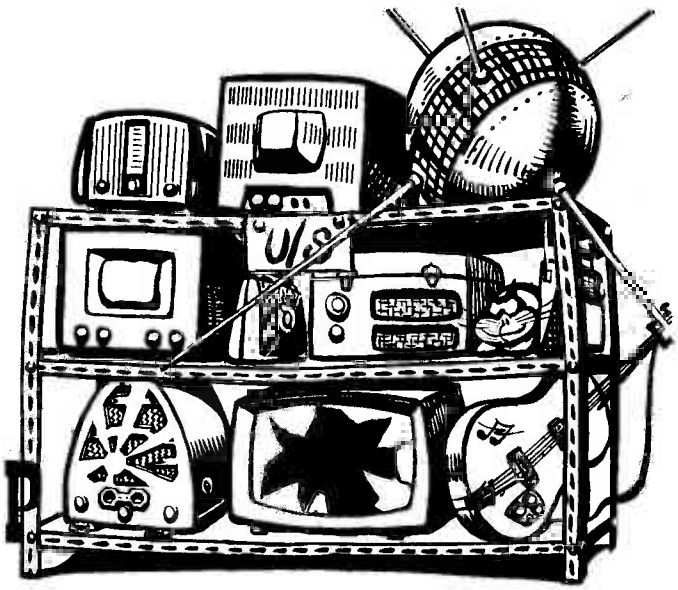
In Your Workshop



This month, Smithy the Serviceman, aided as always by his able assistant Dick, finds himself devoting his lunch-break to a discussion on some of the more intricate points concerning vision i.f. transformers

"THE EVENINGS", SAID DICK chattily, "are drawing in quite noticeably now."

Smithy grunted a response and frowned intently at the Sunday newspaper laid out on this bench.

"It won't be long," remarked Dick in the same conversational vein, "before we start getting on to the old winter weather again."

The preoccupied Serviceman made no reply.

"I don't mind winter all that much," continued Dick, remorselessly. "Coming in out of the cold and wet to a good old fire—there's nothing like it!"

Smithy looked up.

"I want", he announced, "a word of ten letters, starting with 'T'. The clue is: 'A big mix-up to get the muster done'."

"That's easy," responded Dick, airily. "It's probably an anagram of 'muster done'."

"All right then," said Smithy, sarcastically, "what's the word?"

" 'Tremendous'," replied Dick promptly.

Surprised, the Serviceman turned back to his crossword, and checked Dick's answer. It fitted perfectly. With some reluctance, the Serviceman filled it in.

"You know", said Dick critically, "you *are* being a bit anti-social, you know. It's been bad enough getting through Monday morning as it is, but it's even worse when you spend all the Monday lunch-break doing a crossword."

Vision I.F. Detector

"Perhaps you're right," said Smithy, pushing the paper away from him. "What do you want to talk about, anyway?"

"Vision i.f. transformers!"

Smithy hastily pulled the paper back again.

"If", he pronourced, "all you want to do is talk shop, I'm getting on with my crossword!"

"But what I want to talk about is *interesting*," protested Dick. "It's to do with a vision i.f. transformer I had in a set this morning. It was wound with a single-layer primary and a single-layer secondary, and the wires of both windings were laid tight up side by side, and all interleaved."

"May I assume", queried Smithy, "that your graphic description means that the coil was bifilar wound?"

"I suppose you could say that," replied Dick, uncertainly. "At any rate, the windings had the full h.t. voltage between them and they'd broken down."

"That transformer" stated Smithy, "will, of course, be the one which feeds the vision detector."

This time it was Dick's turn to look surprised.

"How did you know that?"

Smithy sighed and pushed away his newspaper once more.

"There's no peace," he remarked, "for the wicked! It looks as though I'll have to give you all the dope on that i.f. tranny if I'm ever going to get back to this crossword."

"Fine," said Dick, enthusiastically, walking over to his bench.

He picked up a service manual, turned to the circuit diagram and laid it out in front of the Serviceman.

"There you are," he said, indicating the circuit around the last vision i.f. transformer (Fig. 1), "that's the circuit the transformer appears in."

"Fair enough," said Smithy, glancing briefly at the diagram. "And I can tell you at once that it is a pretty common circuit in 405 line receivers."

With his pencil, Smithy indicated the components in the circuit which immediately followed the vision i.f. detector.

"Now the first thing you have to remember about a vision detector", said Smithy, "is that it has to feed into a load resistance which is relatively very low in value. Ignoring the chokes for the moment, the load resistor in this circuit has a typical

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value of 4.7kΩ only. It is essential to have a load resistance as low as this because the detected video frequencies go up to 3 Mc/s."

"What you mean," broke in Dick, "is that the stray capacitances across the load have quite low reactances at 3 Mc/s, and if these reactances approach the value of the load resistor, you get heavy attenuation."

"That's about it," agreed Smithy. "When the video signal is developed across a low resistance you get less high frequency attenuation because of stray capacitances than if you develop it across a high resistance. A useful figure to remember is that 5pF has a reactance of approximately 10kΩ at 3MΩ. This gives you an idea of the low capacitive reactances which you're likely to find across the average vision detector load."

"They're certainly very small," commented Dick. "Are the two chokes for peaking purposes?"

"Only the second one is," replied Smithy. "The second choke—the one which connects to the load resistor—is a peaking choke and it will give a boost to the higher video frequencies. In practice, it usually consists of a single wave-winding. The choke immediately following the vision detector will have fewer turns, whereupon it functions as an i.f. filter in conjunction with the two capacitors to chassis on either side. Normally, it will consist of a single-layer winding only."

"Why use a choke?" asked Dick. "Why not use a filter resistor like you do with ordinary a.f. detector circuits?"

"You *can* use a resistor if you like," said Smithy. "But it would need a value around 1kΩ or so to be effective, with the result that you lose a corresponding amount of detected video across it. Most set makers use a choke in that position."

"There's another point I've just thought of," continued Dick. "Why do you put the vision detector diode between the i.f. transformer secondary and the load? Why not have it on the earthy side of the winding, like you do in sound detector circuits?"

"If you have the vision diode in the same position as with sound detector circuits," replied Smithy, scribbling a circuit in the margin of the service manual (Fig. 2), "you will find that you are effectively adding the capacitance between the secondary winding and chassis to all the other stray capacitances which appear across the load. Whereas, if you use the standard vision detector circuit which is employed in that set of yours, those stray capacitances

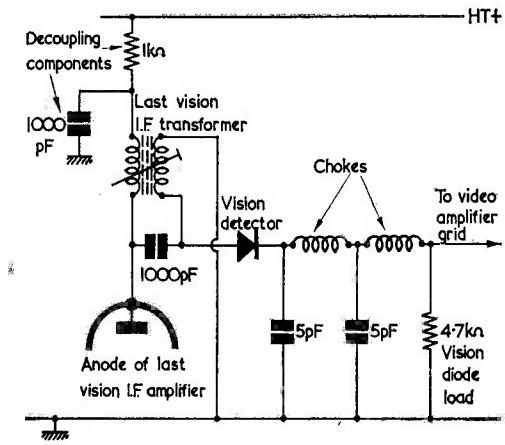

Fig. 1. The circuit around the last vision i.f. transformer in the receiver repaired by Dick

don't appear across the load at all. They are, in fact, isolated from the load by the detector diode itself."

"Does the diode have a self-capacitance?"

"It does," said Smithy shortly. "And, with germanium diodes, it's of the order of a puff or less. Now, let me get back to my crossword!"

Vision I.F. Transformer

"But you haven't," wailed Dick, "even got *round* to the i.f. transformer I asked you about!"

"I am going", said Smithy, resolutely, "to get this crossword finished first if it kills me! I've only got five more words to do."

"All right," said Dick, "give me another clue."

Smithy threw a doubtful glance at his assistant.

"Here you are, then," he said unwillingly, " 'Go too far when toasting'."

"That's easy," replied Dick scornfully. "It's 'scorch'."

"Dash it all," protested Smithy, "I haven't even told you how many letters it has yet!"

"I don't care," said Dick, "I'm quite certain I'm right."

Smithy examined his crossword minutely.

"You are, too," he remarked incredulously. "It fits like a glove!"

"I told you I was right," said Dick complacently. "Now, how about getting back to that i.f. tranny, seeing that I've given you a hand with your crossword?"

"All right," replied Smithy, a tone of unaccustomed respect entering his voice. "How far had we got to?"

"We'd dealt with the vision detector load," replied Dick, "and the fact that it had to have a low value."

"Ah, yes," said Smithy. "Now, because of this, the last vision i.f.

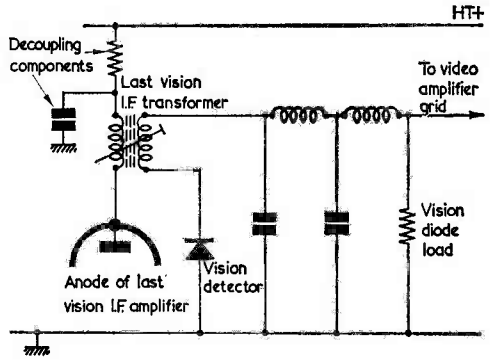

Fig. 2. If the vision detector were inserted on the chassis side of the last i.f. transformer secondary, as shown here, the stray capacitances between the secondary winding and chassis appear across the detected video signal. This circuit corresponds to that of Fig. 1, with the exception that the 1,000pF capacitor bridging the primary and secondary is omitted

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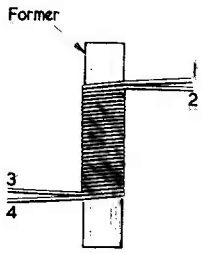

Fig. 3. A layer-wound bifilar transformer winding, of the type employed in the circuit of Fig. 1. The coil wires have a thick covering of tough synthetic enamel. An adjustable iron dust core is fitted inside the former

amplifier valve has to feed quite a pit of power into the vision detector circuit in order to develop a decent voltage across the load. To get that bower into the detector circuit means that the coupling between primary and secondary of the last i.f. transformer has to be good and tight. With the particular transformer you've been working on, it's very tight indeed, because the primary and secondary are interwound in a single layer with all turns touching. (Fig. 3). Furthermore, the two hot ends are bridged over by a 1,000pF capacitor to tighten up the coupling still more."

"Is this the sort of coil," asked Dick, "which you meant just now when you talked about a bifilar winding?"

"That's right," said Smithy. "You see, 'bi' means 'twice', and 'filar' means 'pertaining to wire'. When a coil is wound with two wires at the same time you then refer to it as a bifilar coil, or as being bifilar wound. A bifilar winding doesn't have to be layer-wound, incidentally. You can have a wave-wound bifilar coil as well, this being obtained by feeding two wires to the winding button instead of one. The result looks just the same as an ordinary wave-wound coil but, whereas the ordinary coil has two ends, the bifilar version has four ends."

"All this is very interesting," commented Dick. "There aren't half some ramifications in radio, aren't there?"

"That's it!" shouted Smithy. " 'I, simian factor!' "

The Serviceman scribbled excitedly in his crossword puzzle.

"I've been puzzling away at that one for ages," he remarked happily. " 'Ramifications' is the anagram for 'I, simian factor!' "

"I'm glad I was able to assist," said Dick modestly.

"I've never known you to be so helpful before," replied Smithy. "There are only three words left to do in that puzzle now! Anyway, let's get back to your i.f. transformer. As I said just now, the coupling between the primary and secondary is very tight because of the bifilar winding and because of the 1,000pF capacitor which bridges their hot ends. This coupling is so tight, in fact, that you can almost look upon the two windings as forming a single coil, this being tuned by the output capacitance of the i.f. amplifier valve and the input capacitance of the detector circuit. The coil is heavily damped by the detector circuit, but this is not a disadvantage because you normally want a wide passband in the last vision i.f. transformer, anyway. The assembly is, in fact, very ingenious, since you get the effect of a single coil whilst still enabling the primary to be at h.t. potential—so that it meets the requirements of the i.f. amplifier anode—and the secondary to be at chassis potential—so that it meets the requirements of the vision detector circuit and the following video amplifier."

"I'm afraid", grinned Dick, "that it wasn't so ingenious in the set I was working on! I found, first of all, that the 1kΩ decoupling resistor from h.t. positive to the primary had burnt out, and that there was a dead short between the primary and chassis. It wasn't until I'd checked the 1,000pF decoupling capacitor and the 1,000pF capacitor bridging the windings that I suddenly fell in with the fact that the primary and secondary turns were shorting in the winding itself."

"That does happen occasionally," said Smithy judicially. "The two winding wires are only separated from each other by their enamel coatings. Since the h.t. voltage appears between the two windings, it *is* possible for this enamel insulation to break down occasionally. Breakdowns should be pretty rare, though, because the manufacturers will use winding wires having a thick coating of one of the tough synthetic enamels."

Sound Rejector Circuit

Smithy turned back to his puzzle.

"And that", he pronounced, "is pretty well all there is to say about your i.f. transformer. So let me return to my crossword!"

"What I can't understand", commented Dick, "is why you're doing your Sunday crossword on a Monday. I thought you always got it done on the Sunday itself."

An expression of great bitterness passed over the Serviceman's face.

"It is normally my pleasure", he growled, "to do the crossword on a Sunday. Unhappily, however, you have an uncle."

"Do you mean", asked Dick innocently, "my uncle who is the steward at your club?"

"Who else?"

"What did he do then?"

"When I was in the club the other day," replied Smithy, "he talked me into carrying out what he described as a minor repair on his television set."

Dick grinned.

"Was this pretty late in the evening?"

"The lateness of the evening had nothing to do with it," snorted Smithy. "At any event he dropped the set in at my house, and I tackled it yesterday."

Smithy grimaced with painful recollection.

"Do you know, Dick," he added wearily, "that set had everything wrong with it that it possibly could have had. I was half the morning, all the afternoon, and very nearly all night on it! When I got it finally fixed up, there was nothing left for me to do but drop exhausted into bed. I had a completely wasted Sunday".

"You do get jobs like that every now and again," said Dick sympathetically. "Anyway, if I give you a bit more help with your crossword, will you give me a bit more gen on i.f. transformers?"

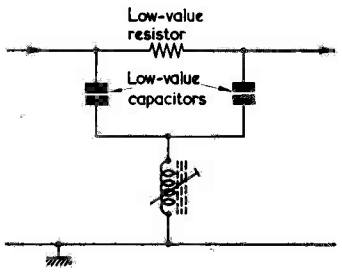

Fig. 4. A bridged-T sound rejector circuit. The two capacitors have the same value and, for 38.15 Mc/s, this normally lies between 2 and 5pF. The resistor value is of the order of 15 to 30Ω. The circuit appears in series with the vision i.f. coils at a convenient point, and the rejection it offers is very high. Frequently, there is no necessity for further sound rejector circuits in the receiver in which it is fitted

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"As you like," said Smithy resignedly. "Let's have a go at the next word, then. This has nine letters, and it starts with 'R' and ends with 'N'. The clue is 'Lessening because of row about editor'."

Dick assumed an expression indicative of intense thought.

"I've got it," he said suddenly, after only three seconds had gone by. "It's 'reduction'! This gives you 'ruction about "ed",' and 'reduction means 'lessening'."

Smithy glanced wonderingly at his assistant.

"I find your sudden brightness almost beyond comprehension," he remarked, filling in Dick's answer in the puzzle.

"I'm a real gone kiddy, you know," replied Dick. "Now, how about some dope on another coil I found in the i.f. strip of this set?"

Dick pointed to a coil assembly appearing between the first and second vision i.f. amplifiers. (Fig. 4.)

"Ah yes," said Smithy, forgetting his vexations for the moment. "That's a bridged-T sound rejector circuit. You can always recognise it by its configuration, and by the fact that it employs two low-value capacitors and a low-value resistor. The capacitors both have the same value and this usually lies between 2 and 5pF according to the set. The resistor is, similarly, somewhere between 15Ω and 30Ω. The circuit appears in series with other i.f. coils and it offers a very high rejection at the sound i.f. Which, for 405 line receivers, is, of course, 38.15 Mc/s."

"Are there any particular points to look out for?"

"Not really," said Smithy. "Provided the rejector circuit is working correctly it gives no trouble at all. It can, however, give trouble if it's out of adjustment. It offers such a high degree of rejection that it can take quite a chunk out of the vision i.f. response if it's tuned too low. Indeed, in receivers which have high internal temperature rises after they've been switched on for some time, manufacturers sometimes employ NPO units for the two capacitors."

"NPO?" queried Dick. "Do you mean ceramic capacitors with zero temperature coefficients?"

"You've got it," confirmed Smithy, "The most frequent ceramic capacitor temperature coefficients you bump into, for low capacitance values, are P100 and N750. P100 means that the capacitor value increases by 100 parts per million for every degree Centigrade rise in temperature, and N750 means that the value decreases by 750 parts per million for every degree Centigrade rise. There's a whole range of temperature - coefficients between P100 and N750 for low value ceramics, and NPO is one of them. So, if you ever swap one of the two capacitors in a bridged-T rejector circuit, you want to ensure that the replacement has the correct temperature coefficient. If it hasn't, the circuit may shift to the wrong frequency after the set's been on for an hour or so."

"What about component tolerances?"

"Well," replied Smithy. "The capacitors and resistor are usually pretty close tolerance, and so any replacement components must, of course, be in the same tolerance. You should try and fit replacement components with the same length of lead as was used by the previous component. So far as the coil itself is concerned there isn't much to go wrong, because it usually consists of just a few turns only. However, you should keep a sharp look-out for dry joints. A joint which introduces only a small amount of resistance into the bridge can sometimes cause it to stop working altogether."

Sound Take-off Circuits

"That seems to clear up bridged-T sound rejector circuits," commented Dick. "What about sound take-off circuits?"

"The next word in this crossword", said Smithy firmly, "has eight letters and the clue reads 'The naughty child pretended to have a collision'."

"'Impacted'," replied Dick promptly.

"How do you do it?" asked Smithy with amazement, as he looked at his puzzle. "I've been struggling over that word for at least ten minutes."

"You've just got to get with it, that's all," said Dick complacently.

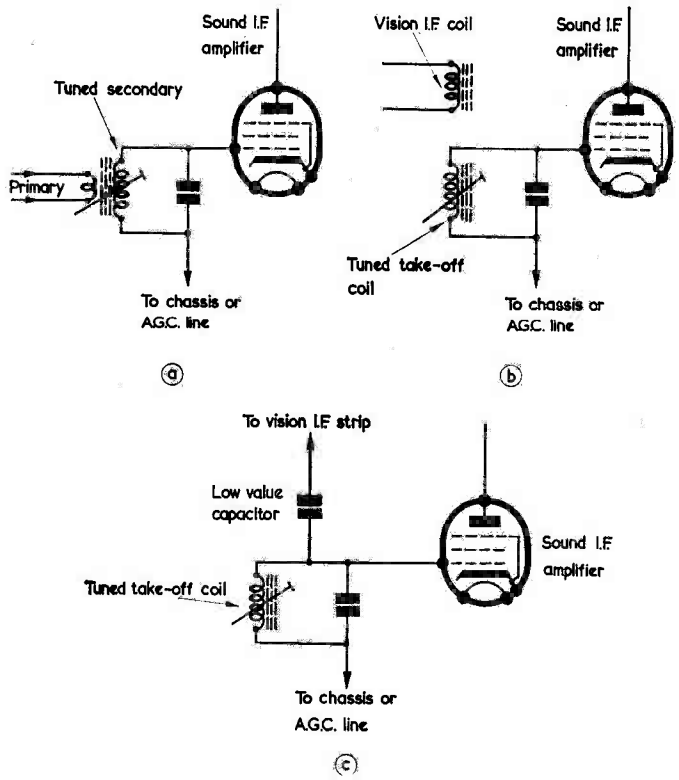

Fig. 5 (a). A typical sound take-off transformer. The primary, which is inserted in series with a vision i.f. transformer circuit, may consist of a single turn only

Fig. 5 (b). Another common sound take-off circuit. The sound take-off coil is in the same can as the vision i.f. coil shown, and is loosely coupled to it inductively

Fig. 5 (c). An extremely simple sound take-off circuit. In this, the take-off coil is coupled to the vision i.f. strip via a low-value capacitor

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'Me, I'm with it!"

"Well, you're certainly very sharp today," commented the Serviceman. "So perhaps I'd better carry on to sound take-off circuits, as you suggest."

Smithy scribbled a further circuit on the margin of Dick's service manual.

"I should state, first of all," he said, "that there isn't anything at all mysterious in sound take-off circuits. They're all quite easy to understand. The circuit you'll probaly bump into most often consists of a simple transformer arrangement with the secondary tuned to the sound i.f. (Fig. 5 (*a*).) The tuned secondary connects between the grid of the first sound i.f. amplifier valve and the chassis or the a.g.c. line. The primary is of interest because it frequently consists of a single turn of wire only. This turn of wire is inserted in series with the vision i.f. transformer circuit either immediately after the tuner unit, or after the first vision i.f. amplifier. In the latter case the first i.f. amplifier would then be a common vision and sound i.f. amplifier. The tuned secondary of the take-off transformer is designed to have a high Q, and sufficient sound i.f. signal appears across it to be passed into the sound i.f. amplifier despite the low coupling offered by the primary with its single turn. The primary is, indeed, little more than a straight piece of wire, and this fact enables it to be inserted in series with vision i.f. circuits without greatly affecting their basic operation."

Smithy paused for a moment, then sketched out another circuit.

"You'll meet this one quite frequently," he commented, "and it is, again, very simple. (Fig. 5 (*b*).) In this instance, the first sound i.f. tuned circuit is inductively coupled to one of the coils in the vision i.f. system. The coupling is usually very loose, but the coil still picks up sufficient signal to feed the sound i.f. amplifier at adequate strength. The tuned circuit will have a high Q, as in the previous case, and the Q may be enhanced by tapping the sound i.f. amplifier grid a little way down the coil."

"Couldn't that tuned winding also act as a sound rejector?" asked Dick. "It's absorbing energy at the sound i.f. frequency."

"It could do," replied Smithy. "But you will usually find one or more separate sound rejector circuits in the vision i.f. strip in addition. With circuits of this nature you sometimes find that the tuned circuit core setting which causes maximum sound i.f. to be applied to the sound i.f. amplifier is very slightly removed from that which causes maximum sound i.f. attenuation in the vision i.f. strip. I think you'll find that, in most cases, the take-off tuned circuit is coupled very loosely to the vision i.f. coil, so that most of the sound rejection is, in any case, looked after elsewhere."

"I see," said Dick, "are there any other types of sound take-off circuit?"

"There's only one more of any real significance," replied Smithy, "and it's the only other one you'll encounter in the majority of current receivers. This circuit employs a capacitive coupling. (Fig. 5 (*c*).) The sound i.f. take-off coil is, quite simply, hooked into the vision i.f. strip at the most convenient point by way of a capacitor having a value between 2 and 5pF or so according to make and set. And what could you have easier than that?"

I.F. Protection Circuit

"It's certainly very simple," agreed Dick. "Incidentally, there's another thing that's been puzzling me about i.f. amplifiers recently. I've bumped into it in quite a few sets."

Smithy looked at the Workshop clock.

"Do you realise", he remarked, "that there's only five minutes to go before we start work again, and that I've only got one word left in my crossword?"

"Just give me the gen on this single point," pleaded Dick, "and then I'll help you to find that final word."

"You've certainly found the other ones for me quickly enough," commented Smithy. "I've been quite impressed."

Dick grinned in supreme self-satisfaction.

"It *is* possible for the assistant," he remarked patronisingly, "to wear a big halo as well, you know."

"That may be," replied Smithy, "but don't forget that the size of the halo is in proportion to the size of the head it encompasses!"

However, Smithy's words fell harmlessly against the armour of Dick's self-esteem, and he resigned himself to satisfying his assistant's curiosity.

"What has puzzled me," continued Dick, completely unabashed, "has been the fact that the last vision i.f. amplifier is, in some sets, connected up rather like an f.m. limiter valve. The secondary of the i.f. transformer feeding the valve doesn't go direct to the chassis or to the a.g.c. line at all. Instead, it goes to deck via a resistor and capacitor in parallel. (Fig. 6.) I just don't understand the purpose of this circuit."

"It's a protection circuit," replied Smithy, "and to explain its purpose I shall first of all have to explain what it's meant to protect *against*. In the ordinary 405 line TV set having mean-level a.g.c. you get a signal with positive-going picture information passed from the vision detector to the video amplifier grid. (Fig. 7.) At the anode of the video amplifier you then get a signal with negative-going picture and, obviously, positive-going sync pulses. You apply this signal to the sync separator via a grid capacitor and leak, with the result that the tips of the positive-going sync pulses assume chassis potential. In consequence, there is an average negative potential on the sync separator grid which is proportional to signal strength and to picture amplitude, and you use this negative potential for a.g.c. O.K.?"

"Yes," said Dick. "What you've just described is a straightforward mean level a.g.c. system."

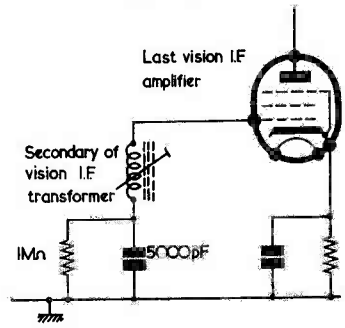

Fig. 6. A circuit which provides protection against a.g.c. blocking. The cathode bias components have normal values. The values shown for the resistor and capacitor between the i.f. transformer secondary and chassis are representative of current practice

"Exactly," confirmed Smithy. "Now let us imagine that a very strong signal is suddenly applied to the receiver. A sudden application of this-type could be caused quite easily by turning the tuner to the station concerned. There is zero a.g.c. voltage when the signal appears and so it belts through the set at very high amplitude. It still has this very high amplitude when it leaves the vision detector, whereupon a very large positive-going signal is applied to the grid of the video amplifier. This valve then becomes saturated, with perhaps only a slight relief during sync pulses. There is, in consequence, very little, if any, a.c. signal appearing at the video amplifier anode. Since there is very

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little a.c. signal at the video amplifier anode, a similarly very small negative voltage appears at the sync separator grid. The result is that, if the a.g.c. line goes negative, it does so by only a very small amount, and the signal continues to grossly overload the receiver."

"Blimey," said Dick. "What you've got here is a set picking up an excessively strong signal. And yet the a.g.c. system is incapable of reducing the receiver's sensitivity!"

"That's right," confirmed Smithy. "The a.g.c. system is, in fact, described as being 'blocked'. You should notice that this effect only occurs when the very strong signal is applied *suddenly*. Had it increased in strength gradually, the a.g.c. system could have controlled sensitivity accordingly."

"Won't the strong signal cause trouble?"

"It will," said Smithy cheerfully. "The video amplifier valve will, for instance, run with very heavy positive grid current. Also, the vision detector will operate with very high peak inverse voltages. If the signal is strong enough, the last i.f. amplifier may also be overloaded, with similarly dire possibilities!"

"How do you get rid of this effect?"

"By adding the little protection circuit you referred to just now," replied Smithy. "You were perfectly right when you said that the last i.f. amplifier looks rather like an f.m. limiter, because this is exactly how it behaves. When a signal of excessive amplitude is applied to its grid, the resistor and capacitor between the i.f. transformer secondary and chassis cause this grid to go negative in just the same way as occurs with the limiter. Or, indeed, with the sync separator. Since the grid of the i.f. amplifier valve goes negative it offers reduced gain, and a signal of smaller amplitude is applied to the video amplifier. The video amplifier valve may still be overloaded, even with the reduced signal, but the overload is now much lower, and an appreciable amount of a.c. signal appears at its anode. This a.c. signal is rectified at the sync separator grid, and an a.g.c. voltage appears. The set then loses further sensitivity, whereupon the a.g.c. system is finally able to take complete charge. Whilst this is happening, the capacitor in the protection circuit discharges into its parallel resistor, and the receiver returns to normal working."

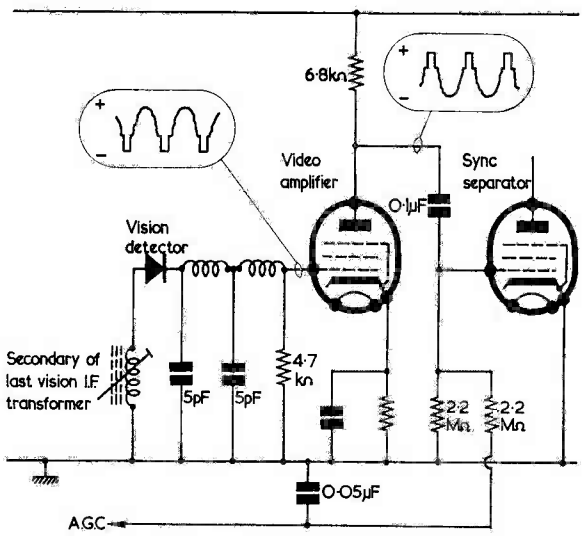

Fig. 7. A skeleton circuit illustrating the operation of a mean level a.g.c. system. Fairly representative component values are shown but this is to indicate their functioning only, since the circuit is of a simplified nature

"Well, I'm dashed," said Dick. "I never expected to find that a little resistor and capacitor had as much influence on performance as that!"

The Last Word

"Little resistors and capacitors," chuckled Smithy, "have been having similar degrees of influence even since radio started. Anyway, I want to finish off this last word in the crossword, now."

"Oh, that," said Dick unguardedly. "It's 'debonair'."

Smithy's mood of good humour evaporated abruptly. He checked the puzzle and found that Dick's answer exactly fitted both the clue and the crossword pattern.

He turned round furiously on his assistant.

"You have", he exploded, "done this crossword before!"

For once, Dick had no reply to offer.

"And here I've been", continued Smithy wrathfully, "praising you up for your smartness, when you knew the answers all the time!"

"It's not *quite* like that, Smithy," stammered Dick, "you see, we had nothing to do yesterday, so we picked up the Sunday paper and . . ."

"We?"

"I called on my uncle. You know, the one who's the steward at your club . . ."

"What do you mean, you had nothing to do?" interrupted Smithy, reverting to Dick's previous remark. "Do you realise that I was going up and down the agony column all day yesterday trying to mend your uncle's set?"

"That's just what I'm trying to explain," replied his flustered assistant. "If you hadn't taken so long fixing the telly, we wouldn't have had to waste all our time doing that dratted crossword!"

The Television Society — Autumn Lectures at the Leicester Centre

All lectures will be held at 7.30 p.m. in the Main Hall, Vaughan College, St. Nicolas Street, Leicester.

October 8th "The World Wide Relaying of Television by Artificial Earth Satellites"
By W. J. Bray, M.Sc.(Eng.), M.I.E.E. Space Communications Branch Post-Office Engineering Dept.

November 12th "Servicing Tape Recorders"
By A. W. Rowe. (Amalgamated Electric Services Ltd.)

December 10th "Television in Retrospect"
By H. J. Barton-Chapple, B.Sc. (Central Rediffusion Services)

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Cover Feature

Electro-magnetic Counters

By J. B. DANCE, M. Sc.

MOST AUTOMATION IN MODERN FACTORIES IS dependent on the ability of the associated electronic equipment to count electrical pulses. In some cases the pulses may be formed when articles on a production line interrupt a beam of light striking a photocell. When a certain number of pulses have been counted and a container has been filled with the articles, the equipment produces a pulse which causes the next container to be moved into position. Counting equipment can also be used for automatic weighing, the control of welding equipment, measuring the rate of flow of liquid in a pipe, measuring the number of turns which have been placed on a reel of wire, and many other purposes. In fact, counting equipment can be used for making almost any kind of measurement automatically. A piece of counting equipment is known as a scaler.

Electrical Counter

The simplest type of electrical counter is the electro-magnetic counter. For many purposes (for example, the counting of nuclear particles) the electro-magnetic counter cannot count quickly enough. Nevertheless if the input pulses are fed into a fast counter which divides them by a factor of ten or a hundred, the output from the fast counter may then be suitable for feeding into an electro-magnetic counter which indicates the remaining digits.

The electro-magnetic counter presents its information in the same manner as the mileage indicator on a car dashboard. The mechanism is very similar to that of a simple relay but, instead of the armature opening or closing contacts when the coil is energised, it operates a pawl and ratchet system which moves the cylinders carrying the digits. See the accompanying photographs. Some types of counters can be reset to zero, but others cannot. The reset on some types of counter is by means of a switch or a lever, whilst other types of counter can be reset by means of a pulse applied to a separate electro-magnet section. The counters are available with various coil impedances. Some are also available with a rectifier for use with an a.c. supply.

The number of digits indicated by the counters can vary from one up to about seven. The counters which have only one digit can be connected in a large variety of ways according to the particular purpose for which they are required[1], and these

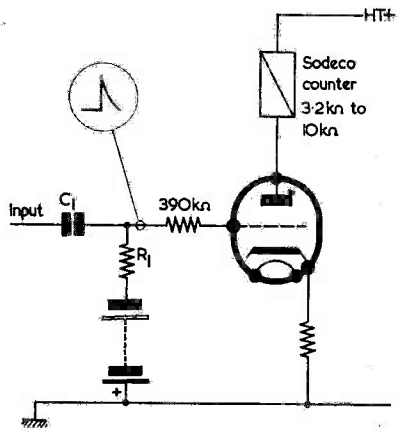

Fig. 1. A circuit for counting long pulses

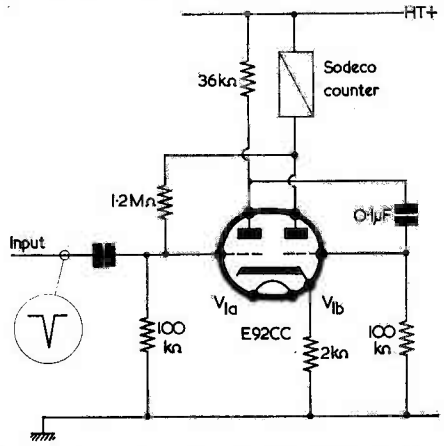

Fig. 2. A circuit for counting long or short pulses

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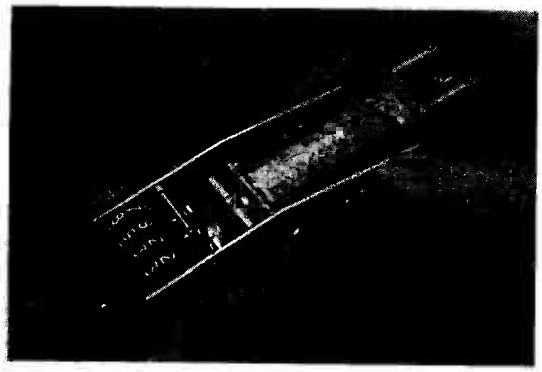

The internal appearance of a Sodeco counter type TCeZ4E

include transmission of information to a distant point, addition or subtraction (reversible counting), etc. Some types of counter even print out the total number of counts onto a sheet of paper.

Some extremely cheap types of Post Office counter are available on the surplus market. They have four digits and cannot be reset. The maximum speed of this type of counter is of the order of ten counts per second and their life is usually limited to about 400,000 counts. Modern electro-magnetic counters have a much longer life, a maximum counting speed which may be of the order of fifty pulses per second and they give a very clear indication of the state of the count. They are, of course, more expensive than the Post Office surplus types.

An appreciable amount of power is required to drive an electro-magnetic counter and the energising coil must normally have an impedance of the same order as the internal impedance of the source of power. A valve or transistor monostable multivibrator circuit is often used so that the counter can be energised for a suitable length of time regardless of the length of the input pulse. The circuit design will, of course, depend on the impedance of the energising coil of the counter.

A typical circuit which can be used to count relatively long positive-going pulses is shown in Fig. 1.[2] The valve is normally cut off by the negative grid potential, but when a positive-going pulse is fed to the capacitor C_1, the valve will conduct for a time which depends on C_1 and R_1. It is assumed that the pulses are long compared with the time constant C_1R_1. If short pulses are fed to this circuit, the coil would not be energised for a sufficient time for a count to be registered.

The grid resistor limits the grid current to a safe value. The cathode resistor should be chosen so that the anode current remains below the maximum permissible value when the grid is earthed. The coil of the electro-magnetic counter should have an impedance between about 3.2kΩ and 10kΩ.

If the pulses which are to be counted are relatively short in duration, the type of circuit shown in Fig. 2 may be used.[2] This is a simple monostable multivibrator. $V_{1(a)}$ is normally conducting, whilst $V_{1(b)}$ is normally cut off by the bias produced by the flow of the $V_{1(a)}$ anode current through the common cathode resistor. When a negative-going pulse is fed to the grid of $V_{1(a)}$ via the input capacitor, $V_{1(a)}$ is momentarily cut off so that the cathode bias drops and $V_{1(b)}$ conducts. The rise of the anode potential of $V_{1(a)}$ is communicated to the grid of $V_{1(b)}$, and this also makes $V_{1(b)}$ conduct. The anode current flowing through $V_{1(b)}$ also flows through the coil of the counter and operates the armature. After a time which is determined by the values of the resistor and capacitor in the grid circuit of $V_{1(b)}$ and the anode resistor of $V_{1(a)}$, the circuit returns to its normal quiescent state in which $V_{1(a)}$ is conducting and $V_{1(b)}$ is cut off. Thus a count is registered. This type of circuit can be used at frequencies of up to about 25 counts per second.

Transistor Circuit

Electro-magnetic counters can be operated by transistors instead of by valves. In the circuit shown in Fig. 3,[3] the OC72 transistor is normally conducting whilst the OC16 (or OC26) is normally cut off, so that no quiescent current flows through the counter coil except for the small transistor leakage current. When a positive-going input pulse of a little over a volt is applied to the circuit, the OC72 transistor is cut off and the voltage across its 220Ω collector resistor disappears. The negative pulse from the collector of the OC72 is fed to the base of the output transistor which therefore conducts.

A double feedback loop is employed so that the current in the coil of the counter reaches its maximum value very quickly. The current through the coil also falls very quickly at the end of the output pulse. The duration of the pulse may be altered by varying the value of the 100μF coupling capacitor or the 390Ω resistor.

Transistors are, of course, ideal for use in low voltage circuits when the energising coil of the counter has a relatively low impedance. They are also very convienient when the driving pulses are obtained from a phototransistor or a photodiode.

Photocell Circuit

An extremely simple method of operating a

The external appearance of Sodeco predetermined counters type TCeZ4PE and TCeF4PE

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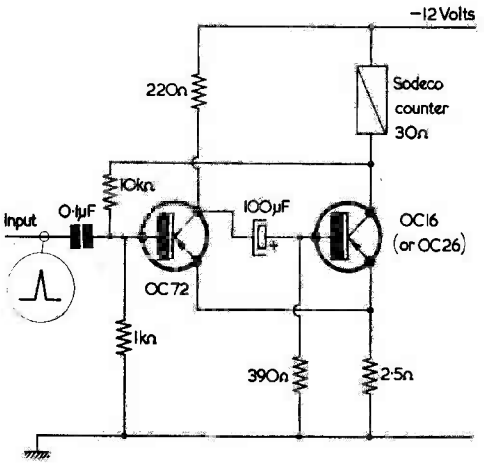
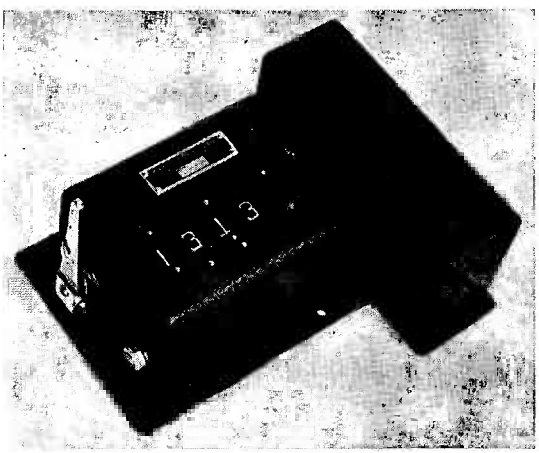


Fig. 3. A transistor electro-magnetic counter circuit

magnetic counter from a photocell is shown in Fig. 4. An alternating potential of about 250 volts r.m.s. is applied to the circuit from the transformer. The photocell will conduct during the part of the mains cycle when its anode is positive if light is falling on its cathode. When the photocell conducts, its anode and the grid of the EN91 thyratron become more negative owing to the flow of the photocell anode current through the 10MΩ resistor. This prevents the thyratron from conducting whilst light is falling on the photocell.

The thyratron will conduct only when its anode is positive and when its first grid is not too negative, i.e. when a positive cycle of the mains voltage is applied to its anode and when no light is falling on the photocell. A capacitor must be placed across the coil of the counter to smooth out the peaks of the thyratron anode current. If this capacitor is too large, the maximum counting speed will be reduced. This very simple type of



An electro-magnetic counter manufactured by B. F. Carter & Co. Ltd.

circuit is not suitable for use at more than a few cycles per second.

It is essential that the circuit is fed from an a.c. and not a d.c. supply, since a d.c. supply would result in a continuous current passing through the thyratron after the tube had once ignited.

Predetermined Counting

In many industrial operations, such as when articles are being packed in batches, a counter may be used to operate a switch after a certain predetermined number of impulses have been counted. The switch then causes any other desired operation to be performed, such as the movement of a container into position to take the next batch.

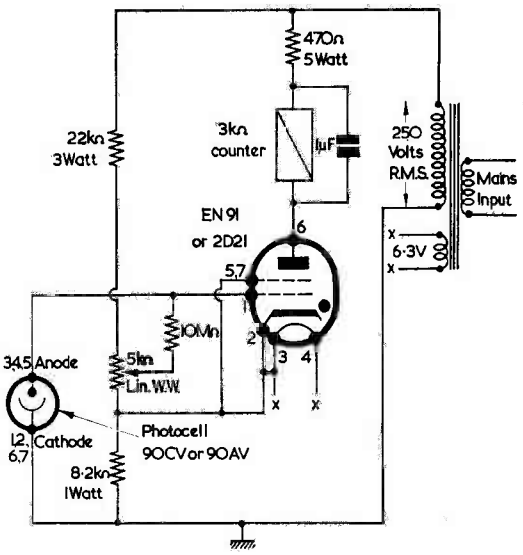


Fig. 4. A simple counter circuit operated by a photocell. The 90AV is particularly sensitive to daylight and to light radiation with a blue predominance, whilst the 90CV is particularly sensitive to incandescent light and to near infra-red radiation

The Sodeco predetermined counter shown in the photograph can be preset to any desired number up to 9,999. This operation is carried out by depressing and turning the knob, opening the hinged cover above the numbers and adjusting the predetermining drums which are found under the cover until the desired digits are shown. Each input pulse applied to the counter reduces the number indicated by one until the zero position is reached. A single-pole double-throw switch inside the counter then operates.

The counters can be reset to the preset number by pressing the knob at the front, but some types of counter can be reset remotely by the application of a suitable pulse to a second electromagnet in the unit. Predetermined counters can be obtained with coils of various impedances, whilst some

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types can be used with pulses derived from an alter natingsupply. The pulses to be counted are often generated by means of simple contacts or a microswitch placed in series with the counter across a suitable supply.

The writer would like to thank the Société des Compteurs de Genève (Sodeco) and their British associates, The Stonebridge Electrical Company Ltd., 6 Queen Anne's Gate, London, S.W.1. for providing technical information and two of the photographs. He would also like to thank Messrs. B. & F. Carter of Albion Works, Bolton for providing the photograph of one of their counters.

Editor's Note

The 90AV has a limiting positive anode voltage of 100, and this is not exceeded in the circuit of Fig. 4. No limiting negative voltage is quoted for this photocell, however, and the negative potential applied in Fig. 4 may exceed 100 volts. The limiting anode voltage for the 90CV is 250.

References and Acknowledgements

(1) Sodeco Technical Information Sheet, E44a.
(2) Sodeco Technical Information Sheet, E28.
(3) Sodeco Technical Information Sheet, E13.

An introduction to . . .

COLOUR TELEVISION

By J. R. DAVIES

PART 5

IN THE ARTICLE WHICH APPEARED LAST MONTH, we discussed the colour television receiver, and examined the r.f. and i.f. stages, the timebases and the video amplifier. We then carried on to the chrominance channel, dealing with IQ receivers and referring briefly to some simple methods of non-IQ colour reclamation.

The XZ System

A non-IQ method of colour reclamation, introduced by R.C.A., is described as the XZ system. In the XZ system, synchronous detection takes place along two vectors on the R-Y and B-Y axes which are so positioned that their outputs can be converted by a simple three-triode matrix into R-Y, B-Y and G-Y signals. Further, the outputs from the matrix are such that they have the proportions needed to overcome the effect of different phosphor sensitivities in the cathode ray tube.

The vectors X and Z are illustrated on the R-Y and B-Y axes in Fig. 18. The outputs from the accompanying three-triode matrix are shown by vectors 1, 2 and 3, and it will be seen that vectors 1 and 2 are very close to the actual R-Y and B-Y axes. Vector 3 is, also, very close to the vector which corresponds to G-Y. The angular differences between the three vectors and the R-Y, B-Y and G-Y quantities is small and the errors in colour rendering which result may be reduced even further by operation of the receiver hue control (which will be discussed later). In consequence, the XZ demodulation process offers excellent results whilst employing simple circuitry and a minimum number of components.[1]

The R.C.A. CTC11 receiver employs XZ demodulation, and it will be helpful if we now examine the system as used in this receiver.[2]

In Fig. 19 (*a*), which shows a simplified version of the XZ demodulator circuit employed in the CTC11 receiver, we may commence at the chrominance take-off coil. This allows the band of chrominance information frequencies available at the anode of the first video amplifier valve to be passed to the grid of the bandpass amplifier. The latter feeds into a bandpass transformer which restricts the range of chrominance signals to that needed for the X and Z demodulators. The output from the bandpass transformer is fed to the *colour saturation control.* This functions as a gain control for the whole chrominance channel. The chrominance

[1] A mathematical analysis of the XZ system is outside the range of the present context. An excellent and fully comprehensive treatment of the XZ system (together with other demodulation systems) is given in *Colour Television—N.T.S.C. System Principles and Practice* (Iliffe Books Ltd.) by P. S. Carnt and G. B. Townsend.

[2] Grateful acknowledgements are due to R.C.A. Great Britain Ltd., who have supplied the author with circuit details of receivers in the CTC11 series.

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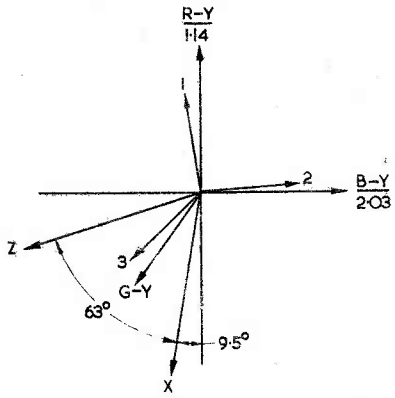

Fig. 18. With the XZ system, demodulation takes place along the X and Z vectors shown here. When the outputs of the X and Z demodulators are combined in a simple three-triode matrix, signals having the angular positions on the R-Y and B-Y axes shown by vectors 1, 2 and 3 are formed

signal voltage tapped off by its slider is then passed to the grids of the X and Z demodulators. These are synchronous detectors, and reference frequencies are fed to their cathodes such that the X demodulator has an output which is proportional to the modulation along the X axis, and the Z demodulator has an output which is proportional to the modulation along the Z axis. The reference frequencies are, of course, obtained from the local oscillator, which is synchronised by the transmitted colour burst.

The X and Z outputs are next passed, via 0.01μF coupling capacitors, to the matrix circuit given by the three triodes illustrated in Fig. 19 (*b*). These three triodes share a common cathode load, and they have anode loads which are approximately equal. The X demodulator output is fed to the upper triode and the Z demodulator output to the lower triode, the centre triode having its grid, so far as the chrominance signal is concerned, at chassis potential. Due to the combination of voltages in the three triodes, the R-Y signal becomes available at the anode of the triode following the X demodulator, and the B-Y signal becomes available at the anode of the triode following the Z demodulator. The centre triode provides the G-Y signal. The three colour-difference signals are finally d.c. coupled to the appropriate grids of the cathode ray tube.[3]

It will be noted that the circuit provides adjustable bias for the cathode ray tube grids, this being offered by the *kine bias*, or *cathode ray tube bias*, control. The kine bias control is coupled into the cathode ray tube grid drive circuits by way of 470kΩ isolating resistors.[4]

[3] Actually the outputs of the three matrix triodes correspond to the vectors, 1, 2, and 3 of Fig. 18. They are, however, referred to as the R-Y, B-Y and G-Y signals, the small angular displacements being ignored.

[4] "Kine" is short for "kinescope", the American term for "cathode ray tube".

Coupled to the three cathodes of the matrix triodes is a *blanker* triode. During each line flyback period the grid of the blanker triode receives, from the line output transformer, a positive-going pulse which causes a negative-going pulse to appear at the anode. The negative-going pulse is applied to the cathodes of all three triodes in the matrix, with the result that they pass a heavy anode current over the duration of the pulse. This heavy anode current causes the cathode ray tube grids to go negative, and the tube to become blanked during the line flyback period. The negative-going pulse also causes the grids of the matrix triodes to pass current, whereupon the diodes formed by each grid and cathode operate as d.c. restorer clamps and ensure that the three 0.01μF grid capacitors become charged to a fixed potential. Between blanking pulses, the three 0.01μF capacitors discharge very slightly, and the clamping action on the subsequent blanking pulse charges them to the desired potential once again. To ensure that the centre triode in the matrix circuit has the same operating conditions as the other two, the 0.01μF capacitor in its grid circuit is returned to h.t. positive. Thus, the 0.01μF capacitor in its grid circuit is subjected to the same clamping action as those in the grid circuits of the other two triodes.

The Reference Frequency Phase Detector

The synchronous detectors in the chrominance channel require reference frequencies having a constant phase relationship with the suppressed subcarrier at the transmitter. These reference frequencies are obtained from a local oscillator which is synchronised in frequency and phase by the transmitted colour burst signal. The most convenient method of achieving synchronism in the local oscillator consists of using circuit techniques similar to those employed for flywheel line sync. The frequency of the local oscillator signal is compared in phase with that of the colour burst, and a control voltage corresponding to phase error is produced thereby. This control voltage is then applied to the grid of a reactance valve, which brings the oscillator back to correct phase relationship. As with line flywheel sync circuits, it is essential that the control voltage in the colour sync circuit be made to undergo a time delay. The control voltage then remains constant over the relatively long period between colour burst signals, as well as remaining reasonably constant if some of the colour burst signals are lost due to interference or noise.

Whilst the principles involved are basically the same as for line flywheel sync, the phase detector circuit which compares the colour burst and local oscillator frequencies may be unfamiliar, and so it shall now be dealt with in some detail.

Fig. 20 illustrates a typical phase detector circuit. The colour burst frequency is applied to a diode anode and a diode cathode by way of a centre-tapped transformer secondary, whilst the local oscillator is fed, from a low impedance source, to the remaining cathode and anode, which are connected together.

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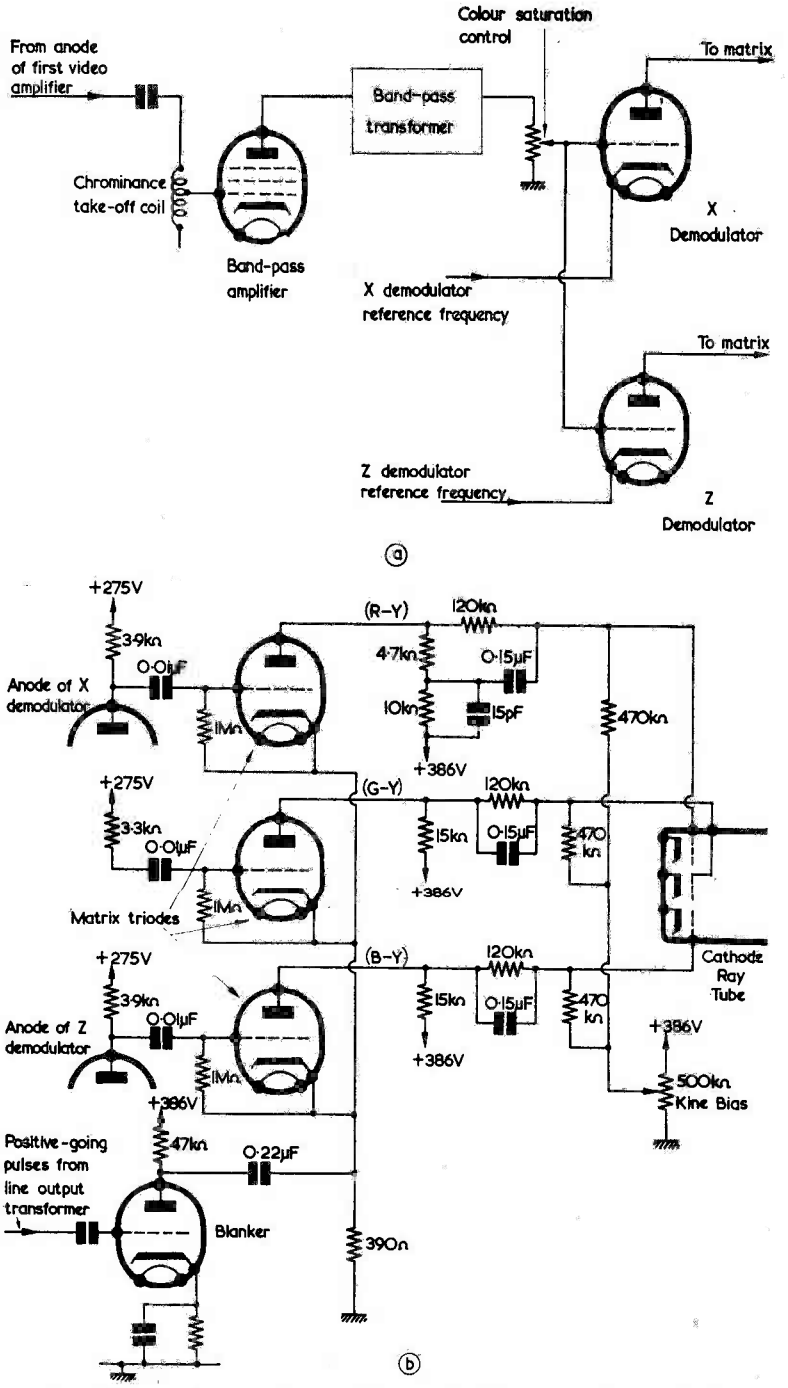

Fig. 19 (a). Simplified diagram illustrating the manner in which the chrominance signal and reference frequencies are applied to the X and Z demodulators in the R.C.A. CTC11 receiver. As will be shown in Fig. 26, the lower end of the chrominance take-off coil is coupled to chassis via a 0.047μF capacitor

(b). The matrix following the X and Z demodulators. The circuit between the matrix triode anodes and cathode ray tube grids is that employed in the CTC11 receiver, whilst the remainder of the circuit is slightly simplified. (Courtesy R.C.A. Great Britain Ltd.)

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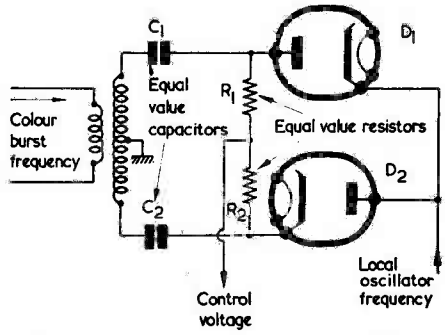

Fig. 20. A typical phase detector circuit. The signal from the local oscillator is at low impedance to chassis

Let us now assume that the desired phase relationship occurs when the local oscillator frequency lags by 90° on the colour burst frequency (as applied to the upper diode). This relationship is shown in Fig. 21 (*a*). Let us, for the moment, also assume that the colour burst frequency is present all the time, and not for short periods during the line cycle.

In Fig. 21 (*a*) we see what occurs in the upper part of the circuit over a cycle of colour burst and local oscillator frequency. The diode conducts and charges C_1 to the maximum forward potential given by the combined waveforms, that is, the potential which causes the diode cathode to be most negative with respect to the left-hand plate of C_1. With the sine wave amplitudes shown in Fig. 21 (*a*), this occurs along line AA′. A negative voltage now appears on the right-hand plate of the charged capacitor C_1. Let us next advance the local oscillator frequency by 90°, as we do in Fig. 21 (*b*), so that it is in phase with the colour burst frequency. Using the waveform amplitudes shown in the diagram, it may be seen that the potential on the left-hand plate of C_1 is at all times equivalent to that on the diode cathode. The diode does not, therefore, conduct, and C_1 receives no charge.

In Fig. 21 (*c*) we retard the local oscillator frequency by 90° instead of advancing it, whereupon it now becomes 180° out of phase with the colour burst frequency. As is obvious from the diagram, the maximum voltage for which the diode will conduct appears along line BB′, and capacitor C_1 becomes charged accordingly. The negative voltage available on the right-hand plate of C_1 is considerably larger than the negative voltage given for the Fig. 21 (*a*) condition.

We have now learned three things. When the local oscillator frequency lags by 90° on the colour burst signal, a negative voltage appears on the right-hand plate of C_1. If we advance the phase of the local oscillator frequency by 90° this voltage (with the waveform amplitudes shown) drops to zero. If, on the other hand, we retard the local oscillator frequency by 90° the negative voltage on the right-hand plate of C_1 increases by a considerable amount. We have chosen large shifts in phase relationship here, but it follows from what we have seen that

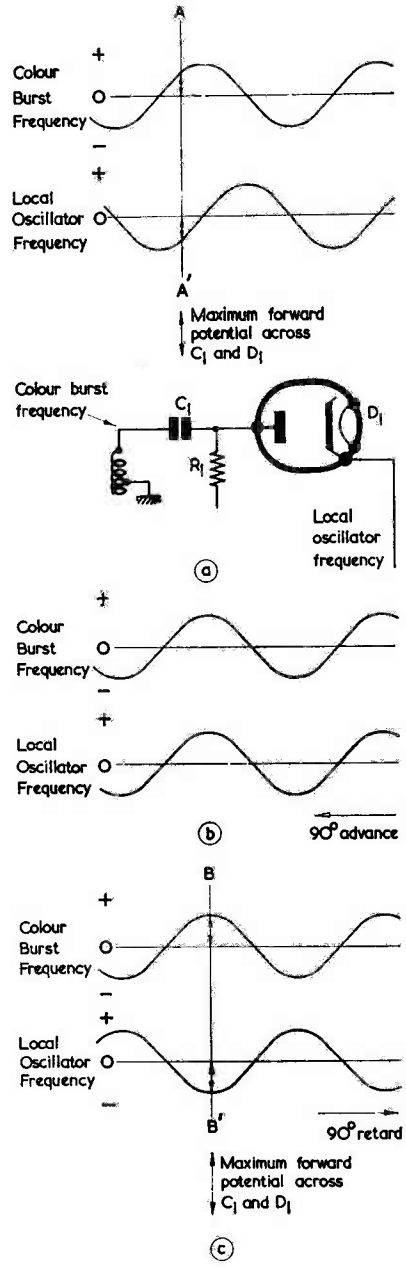

Fig. 21 (a). The waveforms appearing in the upper section of the circuit of Fig. 20 when the local oscillator frequency lags on the colour burst by 90°. It is assumed that both waveforms have the same amplitude

(b). If the local oscillator frequency advances by 90°, the potential across C_1 and D_1 drops to zero

(c). If the local oscillator frequency is retarded by 90°, the maximum forward potential across C_1 and D_1 becomes larger than occurs in (a)

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smaller shifts in phase will cause voltage changes in the same direction. Thus a small advance in local oscillator frequency phase will cause a small decrease in the negative voltage on the right-hand plate of C_1. Similarly, a small retardment in local oscillator frequency phase will cause a small increase in the negative voltage on the right-hand plate of C_1.

Let us next direct our attention to the lower section of the phase detector circuit, as in Fig. 22 (*a*). Because of the centre-tapped transformer secondary, the cathode of the lower diode receives a signal at colour burst frequency which is 180° out of phase with that received by the anode of the upper diode. In consequence, the waveform relationship for the desired 90° lag condition corresponding to Fig. 21 (*a*) appears as shown in Fig. 22 (*a*). The series capacitor, C_2, now charges up to the voltage which causes the diode anode to be most positive relative to the left-hand plate of C_2. With the waveform amplitudes shown, this occurs along line CC'. The right-hand plate of C_2 then acquires a positive voltage. If we advance the local oscillator frequency by 90°, corresponding to Fig. 21 (*b*), we obtain the result shown in Fig. 22 (*b*). The colour burst frequency and local oscillator frequency are now 180° out of phase. The maximum voltage on which the diode conducts appears along line DD' and the positive potential on the right-hand plate of C_2 becomes considerably larger than that resulting from the Fig. 22 (*a*) condition. If we retard the local oscillator frequency by 90°, as in Fig. 22 (*c*), the two frequencies are in phase. Using the waveform amplitude shown, the voltage between the left-hand plate of C_2 and the diode anode is now zero throughout the cycle, with the result that the positive voltage on the right-hand plate of C_2 drops to zero.

Figs. 22 (*a*), (*b*) and (*c*) tell us that, for the preferred 90° phase lag condition, a positive voltage appears at the right-hand plate of C_2. This increases by a considerable amount if the local oscillator frequency is advanced by 90°, and (with the waveform amplitudes shown) it drops to zero when the local oscillator frequency is retarded by 90°. Smaller shifts in local oscillator frequency phase will cause corresponding, but smaller, increases and decreases in the positive voltage on the right-hand plate of C_2.

In Fig. 20 the right-hand plates of C_1 and C_2 are coupled together by two equal-value resistors, a control voltage being taken from their junction. For the 90° phase lag condition of Figs. 21 (*a*) and 22 (*a*), the negative voltage on the right-hand plate of C_1 will be equal to the positive voltage on the right-hand plate of C_2, and so the control voltage will be zero (with respect to chassis). If the local oscillator frequency is advanced (Figs. 21 (*b*) and 22 (*b*)) the right-hand plate of C_1 has a lower negative voltage, whilst the right-hand plate of C_2 has a higher positive voltage. The control voltage at the junction of the two equal-value resistors then goes positive. If the local oscillator frequency is retarded in phase (Figs. 21 (*c*) and 22 (*c*)) the negative voltage on the right-hand plate of C_1 increases and the positive voltage on the right-hand plate of C_2 decreases. The control voltage therefore goes negative. Thus, the control voltage takes up a polarity in one direction if the local oscillator frequency advances in phase, and in the other direction if the local oscillator frequency retards in phase. This voltage may, in consequence, be employed to control a reactance valve coupled to the local

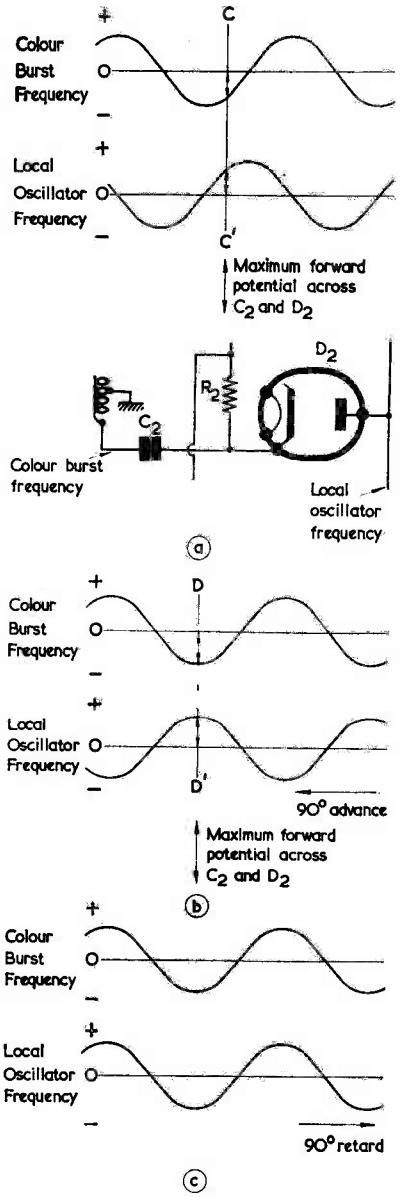

Fig. 22 (a). The waveforms appearing in the lower section of the circuit of Fig. 20. The phase relationships correspond to Fig. 21 (a)
(b). If the local oscillator frequency advances, the maximum forward potential across C_2 and D_2 increases
(c). If the local oscillator frequency is retarded by 90°, the potential across C_2 and D_2 drops to zero

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oscillator, thereby allowing a phase control loop to be set up. In order to obtain a "flywheel" effect, suitable time delay components need to be incorporated between the control voltage take-off point (i.e. the junction of the two equal-value resistors of Fig. 20) and the grid of the reactance valve.

We assumed just now that the preferred phase relationship for the detector circuit was given when the oscillator frequency voltage lagged on the colour burst frequency by 90°. In practice, a usable control voltage would be available if the preferred oscillator frequency phase lag occurred anywhere between nearly lagging by 180° and nearly being in phase with the colour burst frequency. However, the 90° phase difference offers the best results because it causes the control voltage to be zero when the desired phase relationship is achieved. The colour burst signal appears only for a short period during the line cycle and not continually, as we temporarily assumed just now. When the colour burst signal is absent, as it is most of the time, the control voltage will tend to drop to zero. It is, in consequence, desirable that the control voltage given by the colour burst signal should not, itself, be far removed from zero.

Up to now, we have referred to the case where the local oscillator frequency lags on the colour burst frequency by 90°. It must be pointed out that the circuit will similarly provide a control voltage if it is desired to have the local oscillator voltage *lead* on the colour burst frequency by 90°. In this instance, the control voltage will go positive where it previously went negative, and vice versa. Whether the phase lag or phase lead condition is employed depends entirely on the control voltage direction required by the reactance valve for phase correction; and either condition could be employed in a practical colour television circuit.

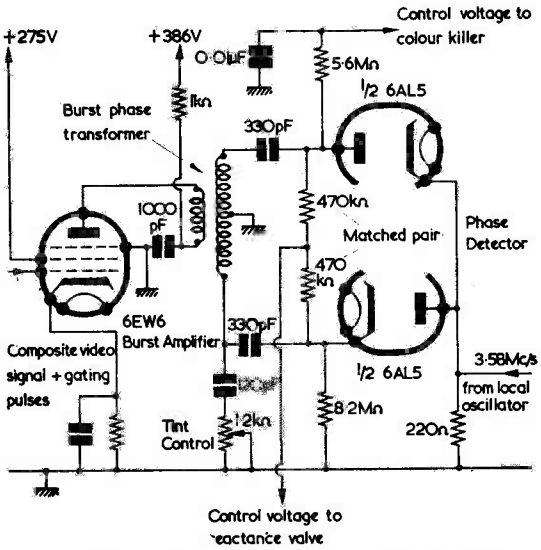

Fig. 23. The phase detector circuit employed in the CTC11 receiver. (Courtesy R.C.A. Great Britain Ltd.)

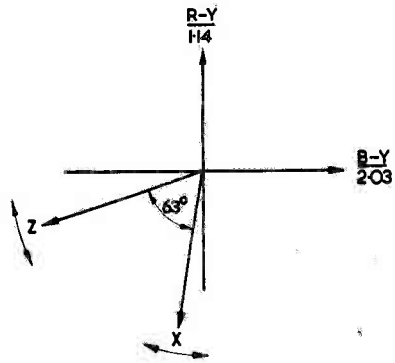

Fig. 24. Adjusting the tint control has the effect of rotating the X and Z vectors about the R-Y and B-Y axes, as shown here

Finally, it should be mentioned that, in Figs. 21 and 22, we used two waveforms of equal amplitude in order to ease the explanation. In practice, a control voltage would still be given if the two waveforms had differing amplitudes.

A Practical Reference Frequency System

The reference frequency circuits employed in the R.C.A. CTC11 receiver are illustrated in Figs. 23 and 25. We shall now consider these in detail, as they offer an excellent example of practical circuit design.

In Fig. 23 the composite signal available on the anode of the first video amplifier is applied to the grid of the burst amplifier pentode. This valve is gated by a positive-going pulse from the line output transformer, which is also applied to the grid, and it amplifies during the back porch period when the colour burst is transmitted. The amplified colour burst is then fed to the primary of the burst phase transformer, the secondary of which connects to the two diodes of a phase detector in the manner we have just discussed. A control voltage is taken from the junction of the two matched 470kΩ resistors.

In Fig. 23 there are two important new points, which we must now examine. The first of these is concerned with the *tint control* which connects to the lower secondary terminal of the burst phase transformer by way of a 120pF capacitor. The tint control is capable of varying the phase relationship between the colour burst frequency and the frequency applied, by the secondary, to the phase detector diodes. Since the reference frequencies for the synchronous detectors maintain a fixed phase relationship with the frequency appearing across the burst phase transformer secondary (because of the phase detector and reactance valve control loop), adjusting the tint control of Fig. 23 causes the reference frequencies to vary in phase relationship with the chrominance subcarrier at the transmitter. The effect given by the tint control is, therefore, to rotate the X and Z vectors on the R-Y and B-Y axes over a range of angles on either side of their theoretically correct position, as illustrated in Fig. 24. As a result, the tint control affects the entire

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colour rendering of the picture.

A tint control, of *hue control*, is available on all N.T.S.C. colour television receivers, and its function is to provide a final colour rendering which agrees, as nearly as possible, with the colour rendering of the scene presented to the transmitter camera. All hue controls function by providing phase adjustment of the reference frequencies employed for demodulating the chrominance information, and they can counteract any small discrepancies in phase which may appear in the overall system.[5] They may also be set up to give what the viewer considers, subjectively, to be optimum colour rendering.

The second additional point in Fig. 23 is given by the inclusion of the 5.6MΩ resistor and the subsequent 0.01μF bypass capacitor connected to the anode of the upper phase detector diode. These components are indicated as supplying a control voltage to the *colour killer*. We shall examine the operation of the colour killer later and, for the moment, shall merely concern ourselves with the voltage applied to the 5.6MΩ resistor.

When a colour transmission is received, the colour burst signals are fed to the phase detector in the manner we have just discussed, whereupon a negative voltage appears on the right-hand plate of the upper 330pF capacitor (corresponding to C_1 in Fig. 20). In the R.C.A. CTC11 receiver, this voltage is normally quite high, at around −46 volts. If a monochrome transmission is being received no colour burst is applied to the phase detector, and the negative voltage drops to zero. The negative voltage is applied to the colour killer and we may note, for the time being, that it has a high value when a colour transmission is being received, and that it drops to zero when a monochrome transmission is being received.

We next turn to Fig. 25, which shows the reactance valve and reference oscillator circuits. The control voltage from the phase detector is applied to the grid of the reactance valve by way of integrating (or time delay) components, and the valve functions as a varying capacitance, the value of capacitance increasing as its grid goes positive. The varying capacitance of the reactance valve is then applied, via the series 220pF capacitor, between grid and cathode of the crystal oscillator, whereupon it offers the required degree of frequency and, hence, phase control.

The crystal oscillator functions in a Pierce configuration, the screen-grid operating as an anode. Oscillator output is taken from the transformer in the anode circuit, the primary connecting, via a 10pF capacitor, to the two diodes of the phase detector of Fig. 23. The secondary connects to the cathode of the X demodulator and, after a phase shift network, to the cathode of the Z demodulator. These demodulators are those of Fig. 19 (*a*). It should be noted that the 820Ω resistor shunted by the 0.01μF and 40μF capacitors provides cathode bias for these demodulators.

[5] This includes the transmitter as well as the receiver.

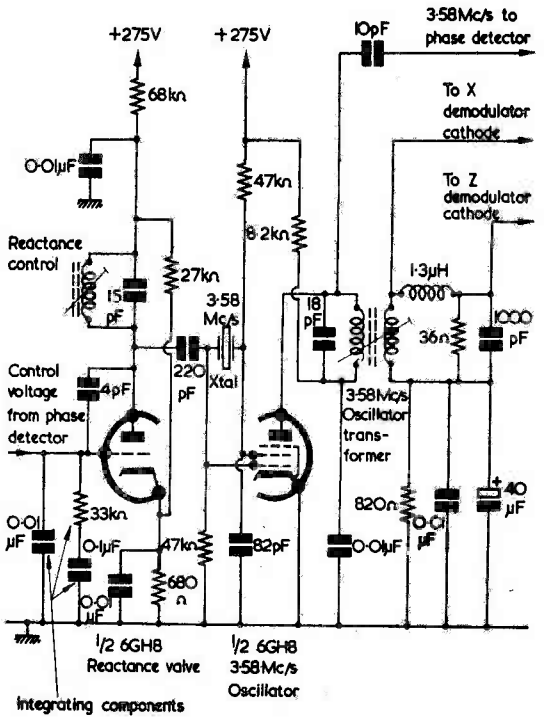

Fig. 25. The reactance valve and 3.58 Mc/s oscillator circuits in the CTC11 receiver. (Courtesy R.C.A. Great Britain Ltd.)

The Colour Killer

When a monochrome transmission is received by an N.T.S.C. colour television receiver, the luminance information it provides is passed to the cathodes of the cathode ray tube. If correctly set up, this tube will then reproduce a black-and-white picture. As there is no chrominance information, no signals are applied to the cathode ray tube grids.

Unfortunately, it is possible, under these circumstances, for bursts of noise and other interference to pass into the chrominance channel, whereupon these may be reproduced on the screen as spots or lines of random colouring. To overcome this effect it is necessary to immobilise the chrominance channel during the reception of monochrome signals, and this task is undertaken by the *colour killer*. The colour killer is a simple device, and we need only concern ourselves here with the representative circuit which is employed in the R.C.A. CTC11 receiver.

The colour killer circuit in this receiver is illustrated, in somewhat simplified form, in Fig. 26. As may be seen, it comprises a triode to whose anode is applied, by way of a capacitor, positive-going pulses from the line output transformer. The grid is coupled to the 5.6MΩ resistor and 0.01μF capacitor of Fig. 23. As we have already noted, these components carry a voltage which, when a colour transmission is being received, has a high negative value and which, when a monochrome

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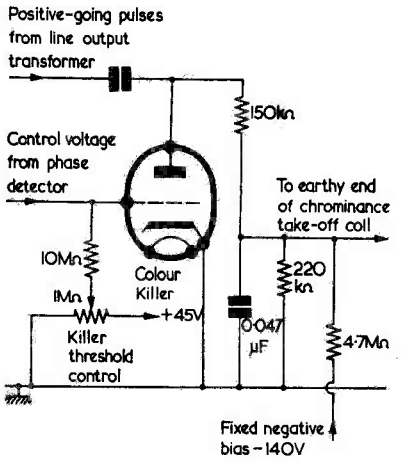

Fig. 26. A partly-simplified circuit of the colour killer stage in the CTC11 receiver. The fixed negative bias of −140V is taken from the grid of the blanker triode (Fig. 19 (b)) which, since it receives positive-going pulses via a capacitor, can offer a convenient average negative potential. The chrominance take-off coil referred to is that shown in Fig. 19 (a). (Courtesy R.C.A. Great Britain Ltd.)

transmission is being received, drops to zero.

During reception of a colour transmission, the grid of the colour killer triode has, therefore, a high negative potential, and it does not conduct when the positive-going pulses from the line output transformer are applied to its anode. The average voltage on the anode then becomes equal to chassis potential. When a monochrome transmission is received the grid of the colour killer triode loses its high negative voltage, and it becomes capable of conducting when the positive-going pulses are applied. The series anode capacitor then becomes charged, and the average voltage on the anode goes negative of chassis. The effect is exactly the same as is given in conventional negative modulation gated a.g.c. circuits.[6]

The anode of the colour killer triode is connected, via a low-pass filter to remove the line output transformer pulses, to the grid circuit of the chrominance band-pass amplifier of Fig. 19 (*a*). The negative voltage given at the colour killer anode when monochrome transmissions are received causes the band-pass amplifier to cut off, whereupon no signals can pass into the chrominance channel. When colour transmissions are being received, the average voltage on the colour killer anode is zero, and the band-pass amplifier functions in normal manner. (The 4.7MΩ and 220kΩ resistors allow the bandpass amplifier to have a small standing bias when the anode of the colour killer is at chassis potential.)

As is shown in Fig. 26 a *killer threshold control* is provided. This is used to adjust the potential on the colour killer grid when monochrome signals are being received and to provide, thereby, the correct operating point for the killer circuit.

(To be continued)

[6] These were described in "Understanding Television" part 37, published in *The Radio Constructor* for February 1961.

New One-Man Device Determines Best Frequency for Long-Range Radio Transmissions

Equipment for continuous rapid determination of the optimum wavelength for long range h.f. radio communication has recently been developed by EMI-Cossor Electronics Ltd, Halifax, Nova Scotia.

Due to the physical structure of the ionosphere, quality of reception of short wave radio transmissions varies considerably between one frequency and another. It is possible to forecast conditions to some extent but if the best possible wavelength is required it can only be ascertained, without the new equipment, by lengthy trial and error methods.

The new device—Ionosonde Model 8000—is compact and easy to operate. It can be carried by a single man and is designed for use with existing transmitter/receivers.

Frequency coverage is 1.8 to 28.8 Mc/s. Assuming it is required to communicate between points A and B, pulse transmissions are commenced at point A and the Ionosonde transmitter frequency is rapidly changed in a series of 128 logarithmic steps to cover the band from 1.8 to 28.8 Mc/s. At point B, the second Ionosonde has a receiver which similarly steps and tunes through the same frequency steps in synchronisation with the first Ionosonde. In this fashion the entire band is covered in just two seconds.

Pulses received at point B are visibly recorded on the face of a cathode ray tube, with long persistence screen, built into the Ionosonde. Traces may be photographed by a Polaroid camera which produces developed prints in less than ten seconds after the frequency band has been covered.

The "ionogram" produced is in the form of a series of fine vertical lines, the "X" axis of the c.r.t. representing the transmission frequency. The pulse is indicated by one or more dots on each vertical sweep. Reception will be best at frequencies where just a single dot occurs—no multipath—and remains visible as the Ionosonde receiver gain is decreased.

In addition to its application in the field of h.f. communication, the Ionosonde can be used for the scientific study of conditions within the ionosphere.

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Kit Review

The Heathkit "OXFORD" Portable Receiver

Model UXR-2

SPECIFICATION

Tuning Range	Medium wave, 555 to 192 metres (540 to 1,560 kc/s) Long wave, 1,800 to 1,000 metres (167 to 300 kc/s)
Loudspeaker	7 x 4in high flux, 3Ω impedance
Power Output	500mW (r.m.s.) at 1 kc/s
Battery	9 volt, Ever Ready PP9 or Drydex DT9 (or equivalent)
Battery Life	300–500 hours
Transistors, Diodes	3—AF117 Mix/Osc and IF amplifier 1—OC71 AF amplifier 1—OC81D driver 2—OC81 audio output (matched pair) 1—AA129 temp. compensating diode 1—OA90 detector diode 1—OA81 AGC diode (or equivalent types to above)

Sensitivity (50mW output 30% modulation):	*Sensitivity*	*Signal to Noise Ratio*
Medium Wave at 1,000 kc/s	19μV/m	3dB
	200μV/m	20dB
Long Wave at 200 kc/s	56μV/m	3dB
	500μV/m	20dB
Selectivity:	*Bandwidth (6dB points)*	*Attenuation (± 9 kc/s)*
Weak Signal	± 3.7 kc/s	44dB
Strong Signal	± 3.0 kc/s	38dB

A.G.C. Range (for 6dB change in audio output)	62dB
Size	11in wide x 8in high x 3⅞in deep
Net Weight	6lb with battery
Shipping Weight	7½lb (less battery)

THE MODEL UXR-2 HAS BEEN SPECIFICALLY designed for those who require a luxury portable transistor receiver for use both in the home as a domestic receiver and in the car where, by virtue of its design and physical dimensions, it is capable of being stowed under the dashboard. For this latter purpose it is fitted with a car aerial input socket and, as may be seen from the illustration herewith, the tuning scale is placed at the top of the cabinet so that, when placed under the dashboard, the tuning scale and controls are facing the user. The stout metal-reinforced leather handle is fitted to the case in such a manner that it may be housed under the receiver, thus positioning the full scale dial at an inclined angle and making the scale clearly visible to the operator.

The UXR-2 may also be used as a personal portable receiver, an output socket for a personal earpiece being one of the features of the design. The slide rule type tuning scale is fitted with a slow motion drive, this considerably assisting with respect to the ease and correct tuning-in of any station. The controls include a combined volume and on/off control, a tuning control, and 3 push buttons for tone, medium and long wave respectively. The cabinet itself is made of real solid leather and the control knobs and dial edging are trimmed with polished brass, giving the whole assembly a most attractive appearance.

In addition to the output sockets previously mentioned, provision has also been made for an output socket for use with a tape recorder.

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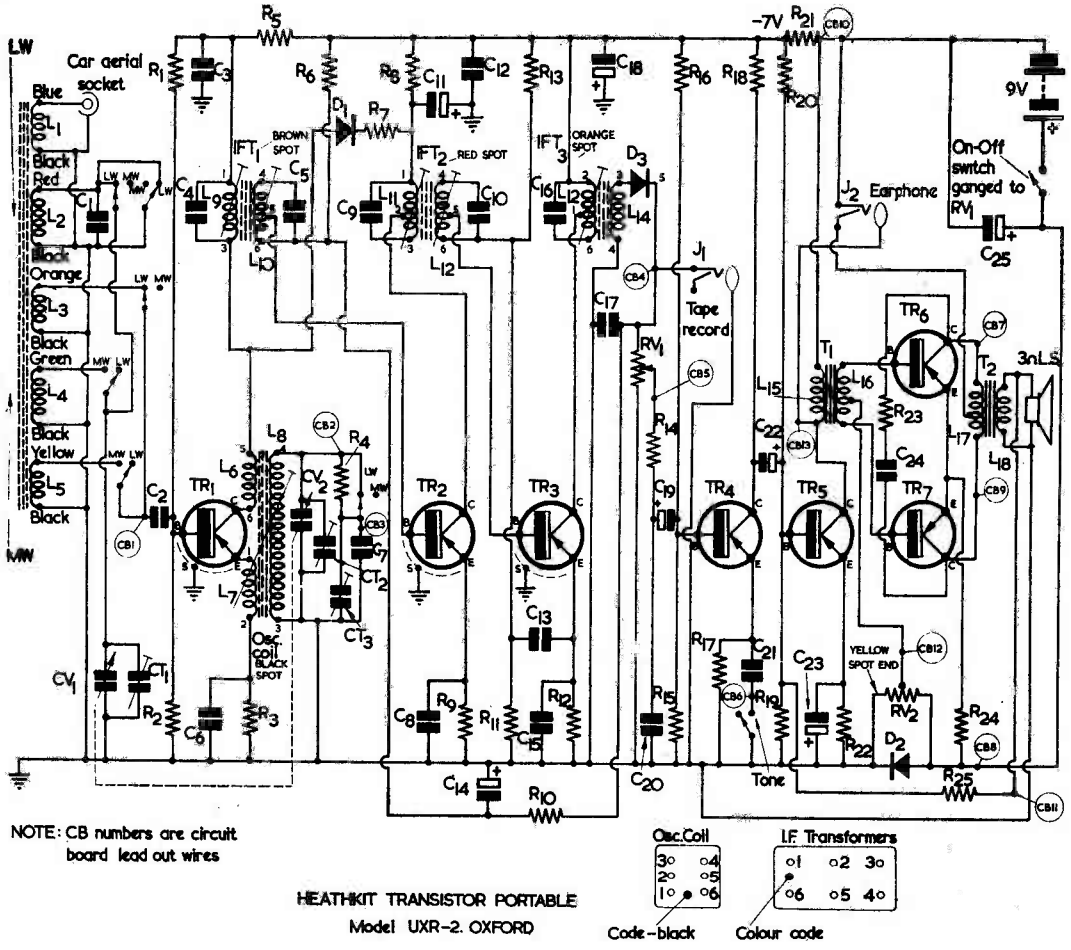

The kit of this receiver is supplied complete with quite the most complete and comprehensive construction manual that we have ever seen. Also included with this well-produced 44 page manual is a 15 x 10in circuit diagram (this being in addition to one included in the manual itself), a component identification chart (8¼ x 11in), five large "exploded" point-to-point diagrams (15 x 11in approx.)—each of the above mentioned sheets being separate from the manual—and a guarantee registration card. The approximate sizes mentioned above are those of the actual diagrams. The manual itself is an absolute mine of information containing colour codes, glossary of radio terms used, servicing information, an introduction to transistors, fault finding chart, operation instructions, and point-to-point disturbance tests. The whole is liberally interspersed with drawings and wiring diagrams, etc.

Circuit

The latest circuit techniques have been used; and printed circuit board construction, together with the inclusion of pre-aligned double-tuned i.f. transformers for higher sensitivity and 7 transistors plus 3 diodes, make this receiver an outstanding design.

Signals are picked up by the ferrite rod aerial on which are fitted the medium wave coils (L_4 L_5) and the long wave coils (L_2 L_3), wave change being effected by operation of the two push-button switches. The desired station is tuned by one section of the variable capacitor CV_1, the desired signal then being coupled to the base of transistor TR_1.

Variable capacitors CV_1 and CV_2 are ganged and the latter tunes L_8, which appears in the oscillator circuit. The trimmer CT_3, in parallel with C_7, is switched across L_8 during long wave operation, thus lowering the oscillator frequency in order to maintain the 470 kc/s intermediate frequency.

The i.f. of 470 kc/s is selected by the transformers IFT_1, $_2$ and $_3$, and amplified by the transistors TR_2 and TR_3. It is then passed to the detector circuit consisting of the diode D_3, capacitor C_{17} and the volume control RV_1, which forms the diode load. The a.g.c. voltage is filtered by resistor R_{10} and

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Components List

Resistors (all ½ watt 10%)

R_1	33kΩ
R_2	6.8kΩ
R_3	1kΩ
R_4	150kΩ
R_5	100Ω
R_6	56kΩ
R_7	680Ω
R_8	2.2kΩ
R_9	680Ω
R_{10}	8.2kΩ
R_{11}	4.7kΩ
R_{12}	1kΩ
R_{13}	22kΩ
R_{14}	3.9kΩ
R_{15}	15kΩ
R_{16}	82kΩ
R_{17}	1kΩ
R_{18}	3.9kΩ
R_{19}	8.2kΩ
R_{20}	39kΩ
R_{21}	560Ω
R_{22}	1kΩ
R_{23}	100Ω
R_{24}	4.7Ω
R_{25}	39kΩ
RV_1	5kΩ log.
RV_2	200Ω

Capacitors

C_1	47pF
C_2	0.025μF
C_3	0.1μF
*C_4	560pF
*C_5	560pF
C_6	0.025μF
C_7	270pF
C_8	0.1μF
*C_9	270pF
*C_{10}	270pF
C_{11}	2μF
C_{12}	0.05μF
C_{13}	0.025μF
C_{14}	8μF, electrolytic, 12V wkg.
C_{15}	0.025μF
*C_{16}	250pF
*C_{17}	0.01μF
C_{18}	200μF, electrolytic, 16V wkg.
C_{19}	0.5μF, electrolytic, 50V wkg.
C_{20}	0.05μF
C_{21}	0.1μF
C_{22}	0.5μF, electrolytic, 50V wkg.
C_{23}	100μF, electrolytic, 4V wkg.
C_{24}	0.25μF
C_{25}	200μF, electrolytic, 12V wkg.

Variable Capacitors

CV_1	387pF
CV_2	174pF
CT_1	20pF
CT_2	20pF
CT_3	40–110pF

Semiconductors

TR_1	AF117
TR_2	AF117
TR_3	AF117
TR_4	OC71
TR_5	OC81D
TR_6	OC81 } Matched pair
TR_7	OC81 } Matched pair
D_1	OA81
D_2	AA129
*D_3	OA90

* Form part of i.f. transformer assembly.

capacitor C_{14}, and is applied to the base return of the i.f. amplifier TR_2, thus controlling the amplification of this stage over the normal signal levels. Further a.g.c. action is provided by diode D_1, this damping the tuned circuit L_9 in IFT_1 when very strong signals are present. The diode D_1 will only conduct when the voltage at its cathode becomes more negative than the voltage on its anode—this occurring when a very high a.g.c. voltage is apparent.

The rectified audio signal is tapped off from the volume control RV_1 via its slider and is then fed, via R_{14} and C_{19}, to the base of TR_4 the audio amplifier. Fitted in the emitter circuit of this stage is the capacitor C_{21}, which provides treble boost when the Tone push-button is operated.

The signal is now coupled from the collector of TR_4 to the base of TR_5 via C_{22}, TR_5 being the driver stage. At the collector of this stage, signals are passed by the driver transformer T_1 to the bases of TR_6 and TR_7, these providing the output stage. These two transistors are operated in class B for maximum battery economy, the current taken being almost directly proportional to the sound output level.

The output transistors TR_6 and TR_7 are transformer coupled by T_2 to the speaker in order to provide the correct matching, negative feedback being provided by R_{25} which is connected from the secondary winding of the output transformer to the base of the driver stage TR_5. The feedback circuit provides improved frequency response and the reduction of harmonic distortion.

In order to reduce cross-over distortion, it is necessary to provide a small forward bias voltage at the base of the output transistors. In this receiver the bias voltage is stabilised by the junction diode D_2, and is set by the variable resistor RV_2. In order to prevent battery voltage falling on high current peaks, the capacitor C_{25} has been included across the supply. To further ensure stability of operation,

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both C_{18} and R_{21} have been fitted to provide isolation between the output and the other stages.

The receiver power is supplied by a single 9 volt battery, the positive terminal of this being connected to the emitters of the output stage via the on/off switch (integral with RV_1) and the junction of the stabilising components R_{24}, RV_2 and D_2.

By RECORDER

NEW AUDIO AMPLIFYING VALVES are always of interest, and a particularly noteworthy type has appeared on the Continent this year. This new valve is the ECLL800 and it is manufactured by Standard Elektrik Lorenz AG, of Stuttgart. At the time of writing, I haven't heard of an equivalent type being manufactured in (or imported into) the U.K., although such a possibility is quite feasible when the advantages of the valve are considered.

The ECLL800

The Continental valve coding system is very helpful, and it is possible to obtain a good idea of the ECLL800's make-up from its type nomenclature. Thus, the E tells us that it has a 6.3 volt heater, the C that it includes a triode, the two L's that it also includes two output pentodes, and the 8 that it fits into a B9A base. The two 0's at the end of the type number refer to the design or development. We know, therefore, that the ECLL800 is a triode-double-output-pentode.

The purpose of the ECLL800 is to provide a push-pull output stage at high power, and it has the advantage that it contains its own phase reversing triode as well. I am indebted to the June issue of the Dutch magazine *Radio Electronica* for this information, and also for the details of operation which follow. Many of these details are, incidentally, also given in a Standard Elektrik Lorenz advertisement in the July issue of the German amateur radio magazine *Das DL-QTC*.

A typical operating circuit for the ECLL800 appears in Fig. 1. In this diagram, a single-phase a.f. input is applied to the triode section of the valve and is also passed direct to the grid of one of the output pentodes. The signal on the anode of the triode is then passed to the grid of the other output pentode. Since the triode anode signal is 180° out of phase with that at its grid, both pentodes now become capable of operating in push-pull. Their anodes feed, in consequence, into the centre-tapped primary of a push-pull output transformer.

An unusual feature is that the triode does not employ any of the normal phase-splitting circuits. It would appear that it is so designed that it offers a stage gain of unity with the component values shown.

The base pin connections are given in Fig. 2, and I have shown these in a separate diagram, rather than give pin numbers in Fig. 1, because the separate diagram demonstrates very well the ingenious manner in which all the electrode connections are accommodated by nine pins only. Thus, pin 2 carries the connection for the grid of the triode as well as the grid of one of the output pentodes. Similarly, the two screen-grids are brought out at pin 9. Pin 7 takes a really jumbo-sized collection of electrodes, these comprising all the cathodes and both the suppressor grids.

A very popular output valve these days is the EL84, and it can be

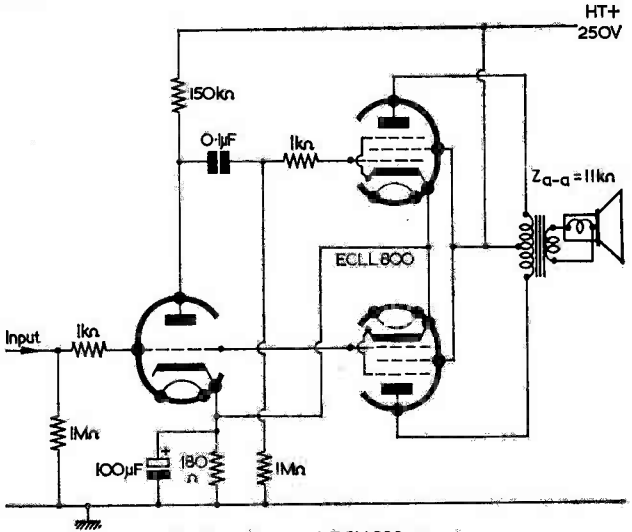

Fig. 1. A typical ECLL800 circuit

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employed, for instance, in the circuit illustrated in Fig. 3. *Radio Electronica* compares the performance of the ECLL800 in the Fig. 1 circuit with that of the EL84 in the Fig. 3 circuit, and the appropriate figures are given in the accompanying Table.

For most parameters, there is little to choose between the two valves. When we come to input voltages and output powers, however, differences begin to show up. For 50mW output the ECLL800 requires 0.5V r.m.s., as against 0.3V r.m.s. with the EL84. The ECLL800 is, therefore, some 4dB or so down on the EL84. On the other hand, at full power the ECLL800 offers 8.5W at 5% distortion, whilst the EL84 offers 5.7W only, at 10% distortion. The corresponding r.m.s. inputs are 8V and 4.3V respectively. So, the ECLL800 is definitely capable of providing higher power at a lower distortion. Total cathode currents

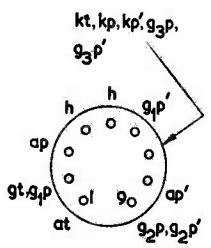

Fig. 2. The pin layout for the ECLL800 shows how the large number of electrodes are accommodated by only nine pins

are fairly similar, that for the ECLL800 ranging from 50.4mA at low input to 70mA at maximum input, and that for the EL84 from 53.5mA at low input to 60.3mA at maximum input.

The cathode currents show that the ECLL800 is working somewhat away from Class A in Fig. 1, and it is interesting to see its distortion curve under these conditions. This is reproduced in Fig. 4. I should add that the ECLL800 appears to have a distortion curve and characteristics which are identical with those for the Brimar ELL80 in Class AB1 at 250 volts.

The ECLL800 is not a hi-fi valve, or at least it isn't in the Fig. 1 circuit. Nevertheless it represents a new departure of considerable interest, and we may well start seeing this valve in radio and record-players in the future. The circuit of Fig. 1 has few more components than the normal EL84 single-valve record

TABLE

Comparison of EL84 and ECLL800

Characteristic	*EL84 (Fig. 3)*		*ECLL800 (Fig. 1)*	
Heater voltage (V)	6.3		6.3	
Heater current (A)	0.76		0.6	
Anode voltage (V)	250		250	
Screen voltage (V)	250		250	
Cathode resistor (Ω)	135		180	
Load impedance (kΩ)	5.2		11	
Input voltage (V r.m.s.)	0.3	4.3	0.5	8
Power output (W)	0.05	5.7	0.05	8.5
Distortion (%)	—	10	—	5
Anode current (mA)	48	49.5	2×21	2×26
Screen current (mA)	5.5	10.8	8.4	18
Total current (mA)	53.5	60.3	50.4	70

player amplifying circuit,* and the new valve looks particularly attractive for this application. The economy of components is, of course, due to the method employed for phase reversal and the use of a common cathode.

Touché

In the July issue, I protested at some length at the infuriating B.B.C. habit of interrupting American space flight sound radio commentaries. What happens is that the American broadcasters are faded out in mid-sentence, to be replaced by B.B.C. commentators who do not appear to have a clue about what is going on and who, between their hesitancies, "ers" and "ahs", do their best to avoid any subject which is even the slightest bit technical.

I have since been taken to task by reader L. J. Pulsford of Huddersfield, who reminds me, quite rightly, that American radio is a commercial enterprise and that the B.B.C. only fades out the programme when the advertisements come on! My thanks are due to Mr. Pulsford for pointing this out, and I must confess that I had completely forgotten this aspect of American broadcasting when I wrote the piece.

However, I cannot help but feel that my complaints are still, to a considerable extent, justified. If it is necessary for B.B.C. commentators to take over space flight broadcasts from time to time, is it not possible to find someone who is more fully *au fait* with what is going on and, further, gives evidence of some interest in the proceedings?

Separate-Luminance Colour System

Just announced by the Research Department of Electrical and Musical Industries Ltd. is a separate-luminance colour system which is stated to represent a breakthrough in colour television design. The separate-luminance system can operate with either the N.T.S.C. or SECAM systems (or any other system employing the colour-difference principle) but requires modifications both at the transmitter and receiver. It functions by employing a four-tube camera and by special

* See, for instance, Suggested Circuits No. 141, "Low-Cost Record Player Amplifier", by G. A. French, in the August 1962 issue.

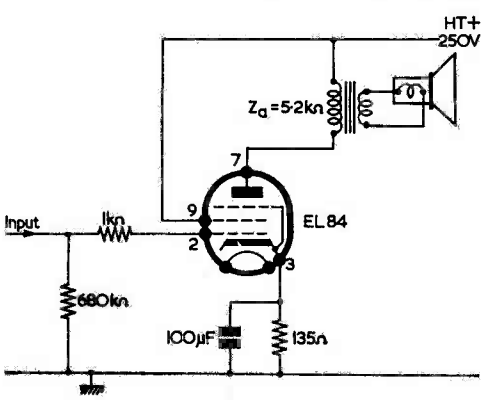

Fig. 3. An EL84 output circuit

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processing of the camera signals before they are converted into the luminance carrier signal and the chrominance subcarrier signal. At the receiver, the luminance and colour signals are reclaimed in the manner applicable to the system, but the green output is incorrect. This green output is then corrected by an additional circuit, whereupon accurate colour signals are fed to the presentation device.

The manner in which the E.M.I. separate-luminance system operates, and the advantages it gives, are a little complex, but I shall endeavour to give a short simplified explanation which should bring out the more important details.

In a conventional colour television camera there are three pick-up tubes corresponding to red, blue and green. The high definition luminance signal is derived from a combination of the outputs of these tubes and, to ensure optimum definition, it is essential that these tubes be positioned such that almost perfect registration is obtained. This can necessitate a positional tolerance, for each tube, of one thousandth of a centimetre in the case of target heights of 3 cms. The maintenance of such positional accuracy places a heavy burden on the transmitting system. There is a further effect which can cause lack of registration, this being due to the fact that the beam in any pick-up tube may not strike its target at exactly the correct point if the target carries a heavy charge. The amount of beam bending in each tube will differ when saturated colours are being scanned.

Another point put forward by E.M.I. is that, after gamma-correction of the red, blue and green signals (gamma being voltage/brightness characteristic) to suit the reproduction devices employed at the receiver, the transmitted luminance signal (Y) does not always have the correct proportions of $0.3R+0.59G+0.11B$. Relatively high discrepancies are given, for instance, by saturated blue scenes or saturated red scenes. The result is that incorrect luminance signals are put out by the transmitter. On a colour television receiver, the incorrect luminance signals are made correct again when all three colours appear at the reproducing device. However, the colour signals which correct the error have to pass through the narrow bandwidth chrominance channel and are therefore applied to the reproducing device at low definition. E.M.I. state that this causes a considerable loss of horizontal resolution in the reproduced *colour* picture.

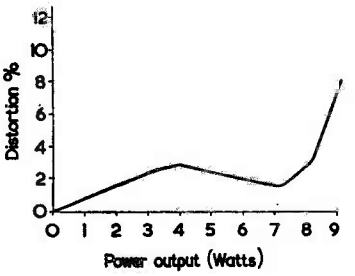

Fig. 4. The distortion/output curve for the ECL800

With the separate-luminance system a camera employing four pick-up tubes is used. In an experimental camera built by E.M.I. one of these is a 4½in image-orthicon tube which provides a 5 Mc/s high definition luminance signal. The remaining three tubes are vidicons which offer red, green and blue outputs respectively at lower definition. The high definition output from the luminance tube then provides the luminance signal which is put out by the transmitter, and this is in every way similar to that put out by a purely monochrome transmitting system. The red and blue camera signals may be fed directly to the system encoding matrix in company with the green signal after the latter has been manipulated to a different form. The output of the matrix then consists of R-Y and B-Y signals, bearing in mind the fact that the green signal has been changed. Other methods of combination may be employed before the Y, R-Y and B-Y signals are finally transmitted. At the receiver the Y, R-Y and B-Y signals are decoded in the normal manner (whether the system be N.T.S.C. or SECAM) after which the modified green signal is reconverted to its original form for application to the reproducing device. E.M.I. state that the additional correcting circuit needed at the receiver to re-convert the green signal could cost less than ten shillings to the customer.

Some of the advantages of the separate-luminance system are as follows:

1. Since there is no registration problem in the generation of the luminance signal at the camera (because it is now provided by one pick-up tube instead of the combined output of three) the monochrome viewer gets as good a picture as in black-and-white practice. Similarly, the colour viewer gets a picture of equivalent luminance resolution.

2. The fact that no luminance information passes through the chrominance channel also ensures better luminance resolution with colour receivers.

3. Errors due to lack of registration between camera pick-up tubes become less important, as the registration between tubes has only to be good enough to satisfy the low bandwidth chrominance circuits. This, in turn, eases positional requirements in the camera.

4. It can be shown, by information theory, that a separate-luminance camera can be made much more efficient optically than a three-tube camera. In consequence, it is possible to obtain good quality colour pictures with the amount of studio illumination which is usually associated with monochrome studios. This is a much lower level of illumination than is normally required for colour working.

EMI's New Range of High-Resolution Scintillation Probes

A range of high-resolution scintillation probes is announced by EMI Electronics Ltd for use in gamma spectrometry work. Three probes are available—types GP3, GP4, and GP5—incorporating different sized sodium iodide phosphors. Both crystal and photo-multiplier are selected to give a high resolution (CO_{60}) of better than 3.5/1.

To obtain this high resolution, a separate signal lead is used, and the collector load (100kΩ) and coupling capacitor (50pF) are integral with the probe. There are, therefore, two connecting leads, one supplying e.h.t. to the photo-multiplier tube and the other carrying the signal back to the amplifier.

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Using the *R1392* without Crystals

By D. F. Warren

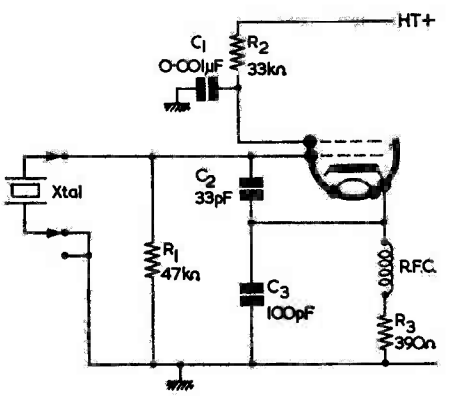
THE INCREASING NUMBER OF REQUESTS FOR information on the v.h.f. receiver type R.1392 by readers of *The Radio Constructor* suggests that it is becoming fairly popular among amateurs.

The R.1392 is a very sensitive receiver intended for use in the 100–156 Mc/s band. Its only major disadvantage is that the local oscillator is crystal controlled. To stock all the 620 crystals required for the available frequencies, where 90 kc/s channel spacing is used, would be out of the question for the amateur.

The plug-in unit to be described here takes the place of the crystals without necessitating any circuit changes in the receiver. In consequence, crystals can still be used when the plug-in unit is removed. The plug-in unit provides continuous tuning over at least the lower half of the band covered by the receiver.

The Receiver Oscillator Circuit

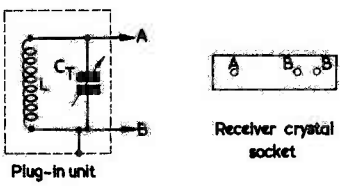
The oscillator circuit in the receiver is as shown in Fig. 1. The valve acts as an electron-coupled oscillator, the screen grid being earthed to r.f. by C_1.



The feedback circuit is of the Colpitts type, the r.f. developed across the crystal being also developed across C_2 and C_3, and applied between the control grid and chassis. The r.f. choke holds the cathode at a high r.f. potential, and R_1 is the grid leak.

The crystal is a form of tuned circuit and it can be replaced by the normal LC tuned circuit. The latter can, of course, be made variable, or tunable.

The circuit of the plug-in unit employed by the writer is given in Fig. 2. The inductor, L, consists of 18 turns of enamelled wire, about 27 s.w.g., wound on a ¼in former, and taking up a ⅜in length on this former. It should also have an adjustable iron dust core. The capacitor is variable up to 100pF. The whole assembly is mounted in a screening can with two short leads protruding to plug into the crystal socket of the receiver.



The capacitor, C_T, may have a dial fitted on its shaft, whereupon the shaft protrudes through the screening can and the dial can be calibrated to facilitate tuning.

Tuning

Tuning is normally carried out by setting the meter switch to the "Tune Osc." position and adjusting the "Tune Osc." control for minimum reading in the meter. The dip should be close to the correct frequency marking on the tuning control. With the plug-in unit (and assuming that C_T is not calibrated) this process has, however, to be reversed. The tuning control is set to the correct marking and C_T in the unit is then tuned to obtain a dip in the meter.

If C_T has been accurately calibrated with the aid of a signal generator, it can be first set to the desired frequency.

R_1 in the receiver is in parallel with the plug-in unit, but it should damp the tuned circuit slightly only. Nevertheless, if the local oscillator refuses to function, it may be necessary to remove R_1. This process should not normally be necessary.

The unit will definitely work over the lower half of the band, and it has been well tested for this application. It is not known if it will work over the upper half without reducing the number of turns on L.

The dust core fitted to L should be set so that the receiver tunes to 100 Mc/s with capacitor C_T fully meshed.

The terminal on the unit which connects to the rotor of C_T should also be connected to the screening can. It should then plug into either of the two crystal sockets which are close together.

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Mains Reflex Circuit with Transformerless Full-Wave Rectification

by

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

This article describes an ingenious two-valve reflex circuit for loudspeaker reception on medium and long waves. Although the chassis is not connected directly to the live side of the mains supply there is still a risk of shock. In consequence, the normal precautions should be observed as for a fully live chassis, these including the housing of the receiver in an insulated cabinet and ensuring that all exposed metal parts are isolated

THE CHIEF PECULIARITY OF THE circuit to be described is that although it is a.c. mains operated by means of full-wave rectification, no mains transformer smoothing choke or heater dropping resistor is used. Also, none of the resistors need be of more than ½ watt rating. The chassis is live, but only at half mains potential, so there is a slight reduction in risk of shock. Even so, half the mains voltage can be dangerous, and the usual precautions have to be taken.

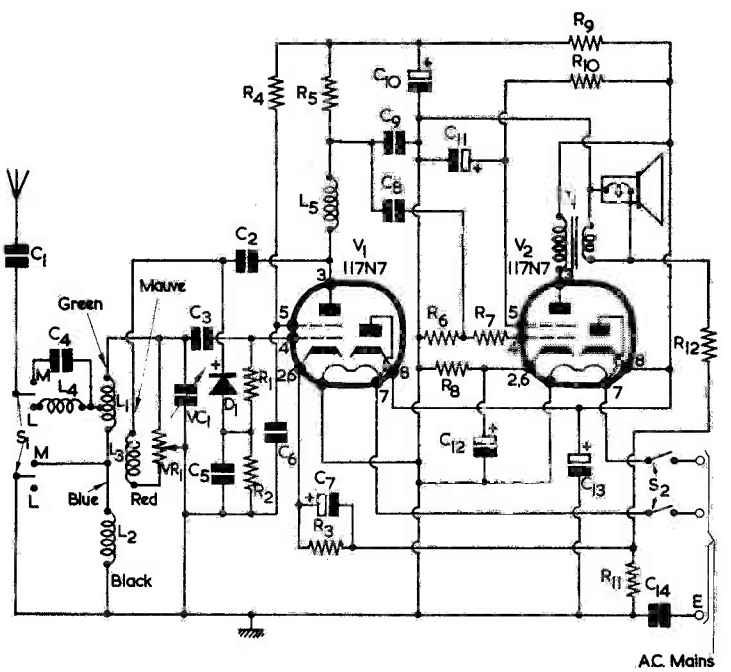
The circuit employs a fairly straightforward reflex arrangement, using an unusual form of reaction-cum-volume control. With two high slope tetrodes there is plenty of sensitivity. The prototype, in South Devon, receives a number of stations, including Luxembourg, at very good volume, using a few feet of wire clipped to a curtain rail for an aerial. About ¾ of a watt output is available.

Two American valves type 117N7 are employed.[1] Each valve contains an output tetrode and a half-wave rectifier within its envelope. The heater takes 117 volts, so that two can be connected in series directly across the mains. The ideal mains voltage is 230, but the slight overload presented by 240 volts will not matter, nor will the under-running from 220 volt mains. At voltages below 220 there will be some loss of efficiency. If 250 volts is used it would be as well to include a 100Ω 1 watt resistor in each lead. The mains must be a.c.

The Circuit

If the accompanying circuit diagram is studied it will be seen that the point at which the two heaters are joined is taken to receiver chassis. The rectifier anodes are internally connected to the heaters, and hence to the mains, and the cathodes externally connected together in normal full-wave rectification manner. With the current of about 43mA taken by the receiver the voltage drops to between 80 and 90. As the valves are rated at a maximum h.t. of 100 volts this is satisfactory, although output is reduced from the rated 1.2 watts for the 117N7. It will be appreciated that the heaters are taking the place of the secondary of a mains transformer with their point of junction as the centre tap. The resistance of the heaters is much greater than that of the secondary of a transformer which accounts for the voltage drop being larger than usual.

Normal precautions against hum should be taken, especially as there is no audio frequency volume control, so that any hum accepted by the grid of V_1 receives maximum amplification. It is necessary, therefore, to keep the leads to the grid of V_1 as short as possible. It is also necessary to use a three pin mains plug so that the receiver chassis is earthed through C_{14}. If this is not done there will be modulation hum as a signal is received. But, provided the receiver is earthed in this manner it will be found that the already



[1] These are obtainable from Henry's Radio Ltd. at the time of writing.

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modest hum level is reduced as a strong carrier is tuned in, since there is a marked a.g.c. effect brought about by D_1. With the prototype there is clearly audible hum when the receiver is tuned to a point on the scale where there is no signal. This is certainly not objectionable when listening to a programme, and becomes inaudible when listening to a local station at a reasonable volume level. Such hum as there is starts at the grid of V_1 and is not due to insufficient smoothing, as can be proved by increasing the values of the smoothing capacitors.

Components List

Resistors

(All fixed resistors ¼ watt)

R_1	100kΩ
R_2	560kΩ
R_3	2.7kΩ
R_4	1.8MΩ
R_5	100kΩ
R_6	470kΩ
R_7	100kΩ
R_8	100Ω
R_9	10kΩ
R_{10}	2.7kΩ
R_{11}	10Ω
R_{12}	100Ω
VR_1	50kΩ linear pot

Capacitors

(Unless otherwise specified, no fixed capacitor need have a working voltage above 150—see text)

C_1	0.01μF 500 wkg
C_2	100pF
C_3	100pF
C_4	100pF
C_5	500pF
C_6	0.01μF
C_7	100μF 12 wkg electrolytic
C_8	0.01μF
C_9	0.01μF
C_{10}	8μF electrolytic
C_{11}	16μF electrolytic
C_{12}	100μF 12 wkg electrolytic
C_{13}	16μF 200 wkg electrolytic
C_{14}	0.1μF 500 wkg
VC_1	500pF tuning

Valves

V_1	117N7
V_2	117N7

Diode

D_1	OA81 or similar

Inductors

$L_{1, 2, 3}$	Repanco Type DRR2
L_4	See text
L_5	See text
T_1	Output transformer 40:1 Primary current 40mA

Switches

S_1	d.p.d.t. wave-change switch
S_2	d.p.s.t. on-off switch

Speaker

Impedance 3Ω

Reflex Amplifier

It will be seen that V_1 acts first as a radio frequency amplifier. The amplified signal appears across the load formed by L_5 in parallel with the series combination of L_3 and part of VR_1. It is rectified by D_1. A small portion of the radio frequency signal is fed back to the tuned circuit to provide reaction. VR_1 combines two functions. It introduces resistance between L_3 and chassis and provides a shunt across the tuned circuit. It thus controls volume from zero to oscillation point.

Although the anode of V_1 is untuned, it will be found that quite a high degree of amplification is obtained, due to the mutual conductance of the valve being 7mA/V. After rectification the signal is again amplified by V_1 and then passed to V_2 which performs as a normal output tetrode.

The purpose of L_4 is to prevent powerful medium wave signals from breaking through on the long wave band. It is made by winding 500 turns of 38 s.w.g. enamelled wire in a single line on about one inch of ¼in diameter rod made of Perspex or some similar non-conducting, non-ferrous material. L_4 will be necessary, in most parts of the country, but not in areas where there is no strong medium wave transmitter in the neighbourhood. L_5 is a standard medium and long wave choke of not less than 20mH inductance. The prototype uses a pre-war Eddystone component. If a new choke has to be bought an Osmor choke type QC1 would be suitable. Alternatively a cheap choke can be made by winding 3 pies of 375 turns each of 38 s.w.g. enamelled wire on a 3in length of ferrite rod, ⅝in in diameter.

The value for C_4 in the components list assumes that a short indoor aerial will be used. If, however, the receiver is to be used on an efficient outside aerial it will almost certainly be necessary to replace the specified capacitor with a 100pF trimmer adjusted for suitable selectivity on the medium wave band. It may also be necessary, in these circumstances, to include a 100pF trimmer between L_4 and S_1 in order to obtain adequate selectivity on the long wave band.

Negative Feedback

Negative feedback is taken from the secondary of T_1 to the cathode of V_1 by means of R_{11} and R_{12}. This produces excellent quality and helps to reduce hum. The correct way round for connection to T_1 must be found by experiment to ensure that feedback is negative. It will make itself understood in no uncertain way if it is positive! There is a considerable degree of feedback and it can be reduced, if insufficient volume is available, by increasing R_{12} in value to, say, 180 or even 270Ω.

With the voltage available for V_2, the anode current is about 40mA and the output impedance, and consequently the optimum load, a little higher than that quoted for normal conditions. It will be found that an output transformer capable of carrying 40mA and matching a load of 5,000Ω will be suitable for T_1. Such transformers are plentiful and cheap.

At first glance the Components List may appear rather formidable for a simple receiver, but in fact the majority of the components are small capacitors and resistors which only cost a few pence each. Also, the reservoir capacitor, C_{13}, need not be above 200 volts working, and the smoothing capacitors need not be rated over 150 volts. The electrolytics are, therefore, cheap.[2] All the components shown in the circuit diagram can be bought for a little over £3, excluding the speaker. The addition of a speaker and materials for a simple cabinet, together with a few odd items such as two international octal valveholders, will not bring the cost to £5, and this is for a complete mains receiver capable of giving good quality and volume from a number of stations off the simplest type of indoor aerial.

Layout

No special care in layout is needed, apart from ensuring short grid wiring for V_1 as already mentioned. Also, D_1 must not be too close to either of the valves. When the prototype was first being tested it was found that reception gradually deteriorated a few minutes after switching on, and that reaction control became spoilt by backlash. Tests showed that D_1 changed its characteristics as it became hot. It was moved a few inches away from V_1, to which it had been rather close, and all was well. The valves give off a fair amount of heat and the design of the cabinet must allow adequate ventilation.

[2] The Components List specifies 150 working volts for all fixed capacitors other than bias capacitors, isolating capacitors and C_{13}. It must be remembered, however, that if one heater burns out, the h.t. potential from its associated and still-hot rectifier cathode could possibly rise above the figures quoted here. Some constructors may, in consequence, prefer to work to a minimum working voltage of 200 instead of 150, with C_{13} at 250V working.—EDITOR.

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continued on page 213

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IH5GT	8/3	9BW6	9/6	DH76	3/9	EM34	8/9	TH233	15/6	volt at ½	
IL4	2/6	10C1	9/6	DK40	18/8	EM71	13/6	TP2620	17/6	amp. No lar-	
ILD5	4/3	10C2	13/–	DK92	6/9	EM80	6/9	TY86F	11/8	ger than a	
ILN5	4/6	10D2	10/6	DK96	6/6	EM81	7/9	U12/14	7/6	shirt button!	
IN5GT	8/6	10F1	10/–	DL68	15/–	EM84	8/3	U16	10/–	8/– each	
IR5	4/9	10LD11	9/–	DL96	6/–	EM85	9/3	U18/20	6/6		
IS4	5/–	10P13	8/6	DLS10	10/6	EM87	15/2	U19	48/6	TRANSIS-	
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IU5	5/3	12AD6	9/6	E83F	24/–	EY83	9/3	U26	7/9	AD140	25/–
2D21	5/6	12AE6	8/–	E88CC	10/–	EY84	10/6	U31	7/–	AF102	27/6
2X2	3/–	12AH8	9/–	E180F	19/6	EY86	6/–	U33	26/2	AF114	11/–
3A4	4/–	12AT6	4/9	EABC80	5/6	EZ40	5/6	U35	16/6	AF115	10/6
3A5	6/9	12AU6	6/6	EAC91	3/6	EZ41	6/–	U37	23/3	AF116	10/–
3B7	5/–	12AV6	6/9	EAF42	7/6	EZ80	4/6	U45	15/6	AF117	5/6
3D6	4/–	12BA6	6/6	EB41	4/9	EZ81	4/3	U76	4/9	AF118	20/–
3Q4	5/6	12BE6	5/–	EB91	2/3	GZ32	7/6	U107	17/6	AF127	12/–
3Q5	7/3	12BH7	7/6	EBC41	7/–	GZ33	17/6	U191	10/–	GD3	5/6
3S4	4/9	12J7GT	7/6	EBC81	6/–	GZ34	11/6	U282	13/–	GD15	8/–
3V4	5/6	12K5	10/–	EBF80	7/–	GZ37	14/6	U301	12/–	GET106	17/6
5R4GY	9/–	12K7GT	3/9	EBF83	7/9	HL2	7/6	U329	9/6	GET873	9/3
5T4	8/–	12K8GT	9/–	EBF89	6/9	HL41DD	8/6	U403	10/–	GET874	9/6
5U4G	4/3	12Q7GT	3/9	EBL21	9/–	HL42DD	8/6	U404	6/–	GEX36	10/–
5V4G	7/6	12SA7	7/–	EC70	12/6	HN309	25/–	U801	17/6	GEX45/1	6/6
5Y3GT	4/3	12SC7	4/–	EC81	27/6	HVR2	9/–	U4020	18/2	GEX64	11/6
5Z3	19/5	12SK7	3/6	EC92	7/6	HVR2A	9/–	UABC80	5/6	GEX66	15/–
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6AG5	2/9	19H1	6/–	ECC35	5/9	KT41	7/6	UBC81	6/3	MAT120	7/9
6AK5	5/–	20D1	13/5	ECC40	7/6	KT44	5/9	UBF80	7/–	MAT121	8/6
6AQ5	6/–	20F2	12/–	ECC81	3/9	KT61	7/6	UBF89	7/3	OA5	6/–
6AT6	4/6	20L1	12/6	ECC82	4/6	KT66	13/6	UC92	7/6	OA10	8/–
6AU6	6/–	20P1	12/6	ECC83	4/6	KT88	28/–	UCC84	9/–	OA70	3/–
6AV6	5/6	20P3	12/6	ECC84	6/–	LP2	9/6	UCC85	6/6	OA73	3/–
6B8G	2/6	20P4	13/9	ECC85	7/–	MHL4	7/6	UCF80	10/3	OA79	3/–
6BA6	5/–	20P5	13/6	ECC88	11/–	MKT4	17/6	UCH21	9/–	OA81	3/–
6BE6	5/3	25A6G	7/6	ECC189	10/6	MU14	5/–	UCH42	7/3	OA85	3/–

We require for prompt cash settlement all types of valves, loose or boxed, but must be new. Send list of types available for offer by return.

6BH6	5/6	25L6GT	6/–	ECF80	6/3	N37	23/3	UCH81	7/3	OA86	4/–
6BJ6	5/6	25Z4G	7/–	ECF82	7/6	N78	26/2	UCL82	8/6	OA91	3/–
6BQ7A	7/6	25Z5	8/–	ECF86	11/6	N108	26/2	UCL83	9/6	OA95	3/6
6BR7	8/6	27SU	23/3	ECH21	11/–	N339	15/–	UF41	6/9	OA210	9/6
6BR8	9/3	28D7	7/–	ECH35	6/6	PC86	10/6	UF42	5/6	OA211	13/6
6BW6	7/6	30C15	9/6	ECH42	7/9	PC88	14/7	UF80	6/6	OC16W	35/–
6BW7	5/–	30F5	6/–	ECH81	6/6	PC95	11/8	UF85	7/–	OC19	25/–
6C5	4/–	30FL1	9/6	ECH83	7/9	PC97	8/3	UF86	8/6	OC22	23/–
6C9	11/–	30FL12	11/–	ECH84	9/6	PCC84	5/9	UF89	6/3	OC23	57/–
6CD6G	21/6	30L15	10/–	ECL80	6/–	PCC85	7/6	UL41	7/–	OC25	12/–
6CH6	5/–	30P4	12/3	ECL82	7/6	PCC88	11/6	UL44	23/3	OC26	25/–
6D3	9/6	30P12	7/6	ECL83	10/–	PCC89	7/6	UL46	9/–	OC28	12/6
6D6	3/–	30P19	12/3	ECL86	9/–	PCC189	10/6	UL84	6/3	OC35	18/–
6E5	6/–	30PL1	9/–	EF22	6/9	PCF80	6/–	UM4	15/2	OC36	21/6
6F1	9/6	30PL13	9/6	EF36	3/3	PCF82	6/6	UM34	16/10	OC41	9/–
6F6G	4/–	30PL14	12/6	EF37A	6/–	PCF84	9/6	UM80	8/6	OC42	9/6
6F13	5/–	35A5	20/9	EF39	3/9	PCF86	7/9	UR1C	7/–	OC43	12/6
6F23	9/6	35L6GT	7/6	EF40	10/–	PCL82	6/9	UU6	9/–	OC44	9/3
6F24	9/6	35W4	8/6	EF41	6/9	PCL83	8/6	UU8	12/6	OC44PM	9/3
6F33	3/6	35Z3	16/4	EF42	5/9	PCL84	4/9	UU9	5/6	OC45	9/–
6J5G	3/–	35Z4GT	4/9	EF73	5/–	PCL85	8/6	UY1N	10/9	OC45PM	9/–
6J6	3/–	35Z5GT	6/6	EF80	4/–	PCL86	9/6	UY21	8/9	OC65	22/6
6J7G	4/9	50C5	7/–	EF83	9/9	PCL88	12/6	UY41	5/–	OC66	25/–
6K7G	1/3	50L6GT	7/–	EF85	4/9	PEN46	4/6	UY85	4/3	OC70	6/6
6K8G	3/9	52KU	14/6	EF86	6/3	PEN383	11/6	VP4	14/6	OC71	6/6
6K25	12/6	72	6/6	EF89	4/3	PL33	16/11	VP4B	20/5	OC72	8/–
6L1	9/6	80	5/6	EF91	3/–	PL36	8/6	VP13C	7/–	OC73	16/–
6L6G	6/6	83	15/–	EF92	2/6	PL38	16/6	VP23	2/6	OC74	8/–
6L7GT	4/6	85A2	9/9	EF97	11/8	PL81	7/3	VP133	10/–	OC75	8/–
6L18	7/6	90AG	67/6	EF98	10/–	PL82	5/6	VR105	5/6	OC76	8/6
6LD20	5/6	90AV	67/6	EFI83	9/–	PL83	5/3	VR150	5/–	OC77	12/–
6N7GT	5/–	90CG	37/6	EFI84	8/9	PL84	6/–	W76	3/9	OC78	8/–
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6R7G	6/–	150B2	16/6	EL33	7/6	PX25	8/6	X61	10/–	OC82	10/–
6SL7	5/9	185BT	34/11	EL34	10/–	PY31	6/6	X65	5/6	OC83	3/6
6SN7	4/6	5763	7/6	EL37	17/6	PY32	8/9	X76M	11/–	OC84	8/6
6U4GT	9/6	AC6PEN	5/–	EL38	12/–	PY33	10/–	X78	26/2	OC140	19/–
6U5G	5/–	AC/TP	19/–	EL41	7/6	PY80	5/6	X79	21/–	OC170	9/6
6V6G	3/9	AZ1	6/6	EL42	7/9	PY81	5/6	XD(1.5)	6/6	OC171	10/6
6V6GT	6/–	AZ31	7/–	EL81	8/9	PY82	5/3	XFY23	6/6	OCP71	17/6
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SMALL ADVERTISEMENTS

continued from page 211

TRADE—*continued*

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continued on page 215

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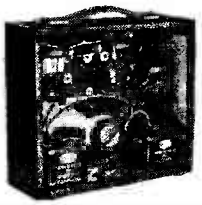

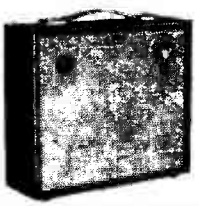

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continued from page 213

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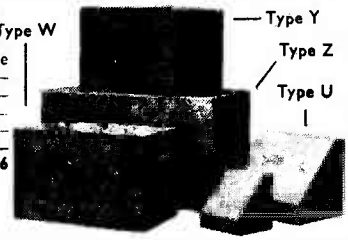

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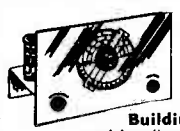

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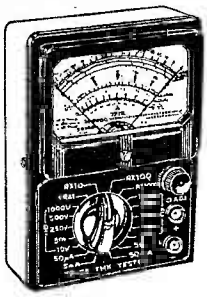

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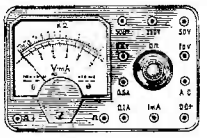

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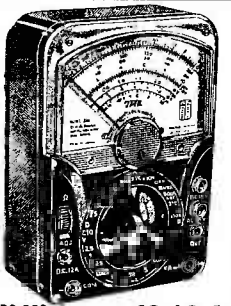

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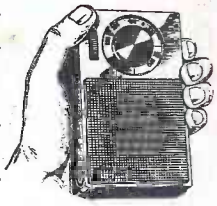

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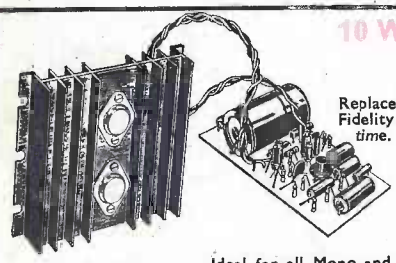

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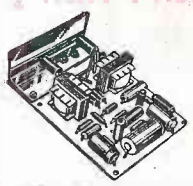

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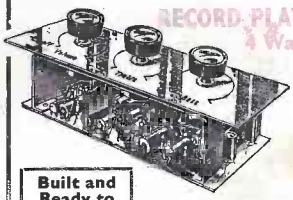

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