THE

Radio Constructor

RADIO
TELEVISION
AUDIO
ELECTRONICS

VOLUME 17 NUMBER 2
A DATA PUBLICATION
PRICE TWO SHILLINGS

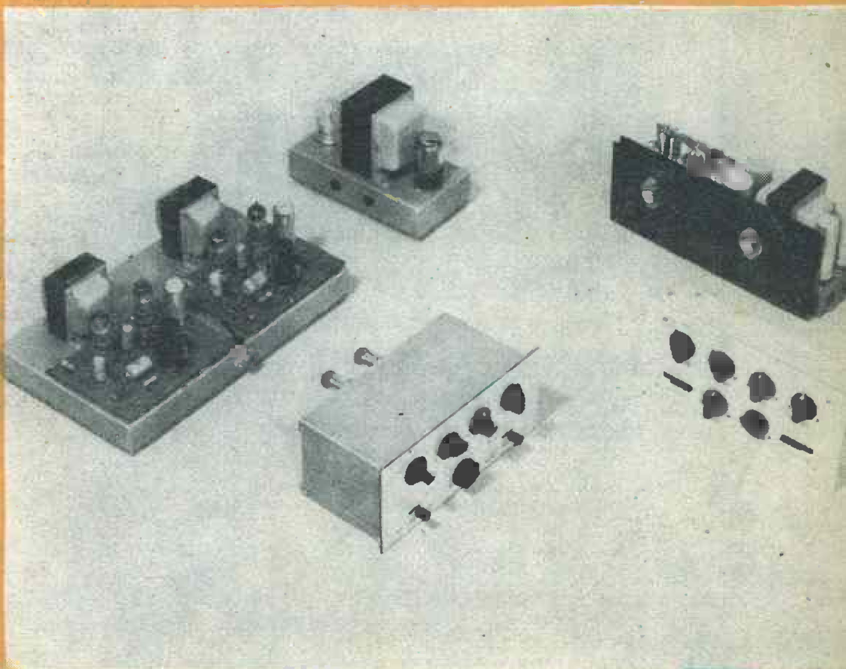
September 1963

Special features include

Stereo on a Shoestring

Battery Burglar Alarm

Electrical Speedometer



LASKY'S RADIO

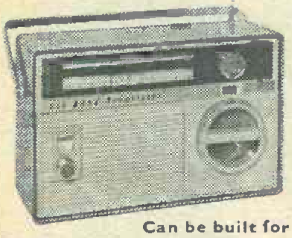
THE FINEST RANGE OF TRANSISTOR RECEIVERS

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



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 **£10.19.6** *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.

Can be built for **£12.19.6** *P. and P. 5/– extra*

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 2¼" 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. ¾" 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 5¼" x 5¼" 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 oustanding 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.

DISTLER MINIATURE MOTORS

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

33 TOTTENHAM COURT ROAD · W1	207 EDGWARE ROAD · W2	152/3 FLEET STREET · EC4
2 mins. Oxford St. Nearest Station: Goodge St. MUSeum 2605	Few yards from Praed St. PADdington 3271/2	FLEet 2833 Open all day Thurs. Closed 1 p.m. Sat.

Tottenham Ct. Rd. & Edgware Rd. addresses open all day Sat. Close 1 Thur. Please address all Mail Orders to Dept. W at above Edgware Road address

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

New Boxed VALVES All Guaranteed

1T4	6/–	ECC83	8/–	PCC84	9/6
1R5	7/6	ECL82	10/6	PCF80	9/6
1S5	7/6	ECL80	10/6	PCL83	12/6
3S4	7/6	EF80	8/–	PCL84	12/6
3V4	7/6	EF86	12/6	PL81	12/6
DAF96	9/–	EL84	8/6	PL82	9/6
DF96	9/–	EY51	9/6	PL83	10/6
DK96	9/–	EY86	10/–	PY32	12/6
DL96	9/–	EZ81	7/6	PY81	9/6
ECC81	8/–	GZ32	12/6	PY82	7/6
ECC82	8/–	EM84	9/6	U25	12/6

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 3d. per yard. ¼lb. 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/–
5¾"	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/–, 5¾" 2/–, 7" 2/3.
PLASTIC REEL CONTAINERS (Casettes): 5" 1/9, 5¾" 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.

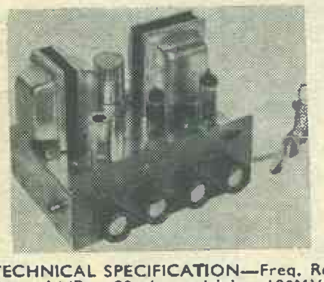
Soldering Irons. Mains 200/220V or 230/250V. Solon 25 watt Inst., 22/6. Spare Elements, 4/6. Bits, 1/– 65 watt, 27/6 etc.

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, WBHF10–12 £4.7.6, Goodmans Axiette £5.5.0, Axiom 10 £6.5.0. Carr. extra

Volume Controls—5K–2 Megohms, 3" Spindles Morganite Midget Type. 1⅛" 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% ¼ and ½W 3d., ¾W 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 ⅛" 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 $\frac{7}{16}$" diam.	5/6
Osc. Coil—$\frac{7}{16}$" 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 HANDBOOK, 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. air spaced)—2–8pF, 1/–; 3–30pF, 1/–.

KNOBS—Modern Continental types: Brown or Ivory with Gold Ring, 1" dia., 9d. each; 1¾", 1/– each; Brown or Ivory with Gold Centre, 1" dia., 10d. each; 1¾", 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.

½ Meg. VOL Controls D.P. Sw. ½" flatted spingle. Famous Mfrs. 4 for 10/– post free.

RECORD PLAYER CABINETS

Contemporary style, rexine covered cabinet in two-tone maroon and cream. Size 17" 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. 6" Speaker and trans. **22/–.** P. & P. 2/–.

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

RCS Est. 1946

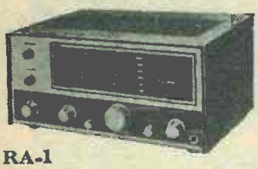
Send for detailed bargain lists, 3d. stamp. We manufacture all types Radio Mains Transf. Chokes, Quality O/P Trans., etc. Enquiries invited for Specials, Prototypes for small production runs. Quotation by return

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 ½ lb 9d., 1 lb., 1/3 3lb., 2/3 5 lb., 2/9 8 lb. 3/6.*

Building Your Own Equipment

Heathkit
DAYSTROM



RA-1

VF-1U

GC-1U

NEW MODEL! AMATEUR BANDS RECEIVER. Model RA-1. To cover all the Amateur Bands from 160–10 metres. Many special features, including: half-lattice crystal filter; 8 valves; signal strength "S" meter; tuned R.F. Amplifier Stage. Full specification sheet available on request. **£39.6.6**

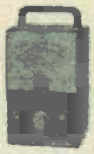
THE "MOHICAN" GENERAL COVERAGE RECEIVER. Model GC-1U. With 4 piezo-electric transfilters, variable tuned B.F.O. and Zener diode stabiliser, this is an excellent fully transistorised general purpose receiver for Amateur and Short wave listeners. Printed circuit boards, telescopic whip antenna, tuning meter and large slide-rule dial, 10 transistors. **£39.17.6**

AMATEUR TRANSMITTER. Model DX-100U. The world's most popular, compact and completely self-contained Amateur Transmitter. Covers all amateur bands: 160–10 m. 150W d.c. input. Careful design has achieved the stability and high performance for which the DX-100U is noted and no less than 35 disc ceramic capacitors reduce TVI to a minimum. **£74.19.0**

VARIABLE FREQUENCY OSCILLATOR. Model VF-1U. Calibrated, 160–10 m. Fundamentals on 160 and 40 m. Ideal for our DX-40U and similar transmitters. **£11.17.6**

Deferred terms available over £10

V-7A



MM-1U

RF-1U

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

MULTIMETER. Model MM-1U. Ranges 0–1.5V to 1,500V A.C. and D.C.; 150μA to 15A D.C.; 0.2Ω to 20MΩ. 4½″ 50μA meter. **£12.10.0**

R.F. SIGNAL GENERATOR. Model RF-1U. Up to 100 Mc/s fundamental and 200 Mc/s on harmonics and up to 100mV output on all bands. **£12.15.6**

AUDIO WATTMETER. Model AW-1U. Up to 25W continuous, 50W intermittent. **£15.15.0**

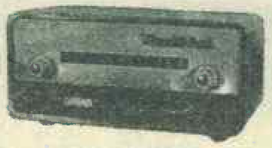
AUDIO VALVE MILLIVOLTMETER. Model AV-3U. 1mV–300V A.C. 10 c/s to 400 kc/s. **£14.17.6**

AUDIO SINE-SQUARE WAVE GENERATOR. Model AO-1U. Covers 20 c/s to 150 kc/s and square waves to 50 kc/s in four ranges. Maximum output 10V, distortion less than 1%. **£13.15.0**

Anyone can build any of these Heathkit models ☆

TA-1S

Truvox D83



FM TUNER

TAPE RECORDING/PLAYBACK AMPLIFIER. Thermometer type recording indicators, press-button speed compensation and input selection. PrintedCircuit Board.
Mono Model TA-1M **£19.2.6** Stereo Model TA-1S **£24.10.0**

HI-FI FM TUNER. Model FM-4U. Also available in two units. R.F. tuning unit (£2.15.0 incl. P.T.) with I.F. output of 10.7 Mc/s, and amplifier unit, with power supply and valves (£12.6.0). Total **£15.1.0**

TRUVOX D83/2 & D83/4 TAPE DECKS. High quality mono/stereo tape decks.
D83/2, 2 track, **£31.10.0** **D83/4,** 4 track, **£29.8.0**

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

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

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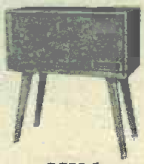
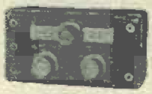
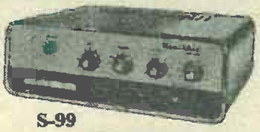


SSU-1



UJR-1



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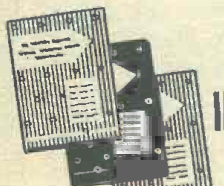

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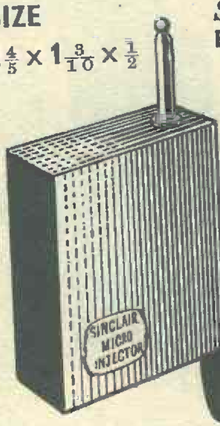

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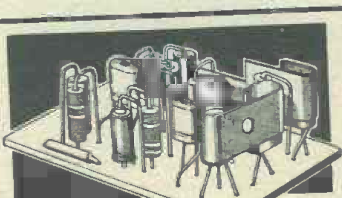

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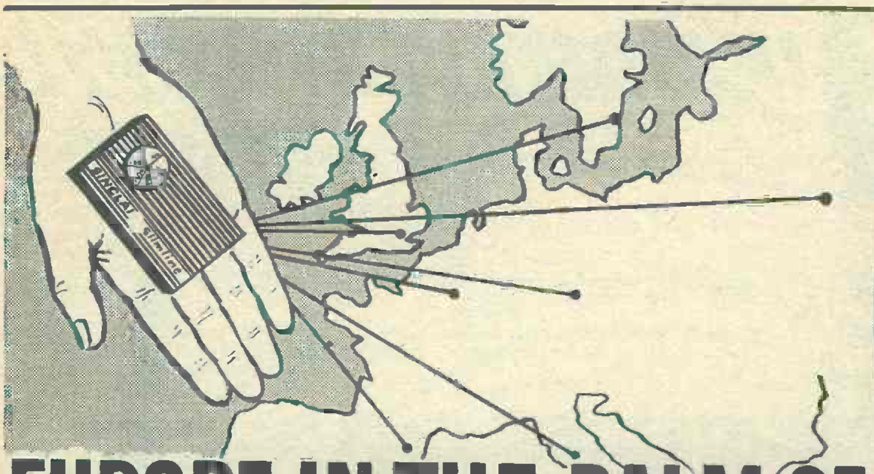

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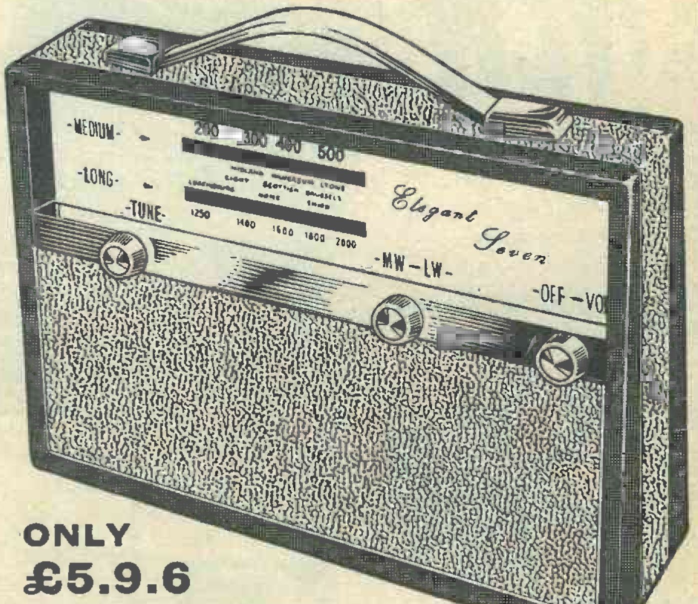

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Cover Illustration

A class AB 10W+10W transistor audio amplifier and transistor pre-amplifier (right) compared with similar valved equipment (left). (Although the designs produced by Mullards are made freely available to equipment manufacturers and, when appropriate, to home constructors, Mullard Ltd. does not make complete amplifiers or kits of parts.)

SEPTEMBER 1963

STEREO ON A SHOESTRING

by J. C. FLIND

THE WRITER HAS LONG HELD THE view that there is a fundamental and often unrecognised difference between monaural and stereophonic listening. Whilst the listener to a single loudspeaker is accustomed to concentrating his attention on the source of sound, with background noise being rejected by a conscious or unconscious effort of will, the stereo listener expects his illusion to be ready-made and complete. Interruptions or extraneous noises are more than just a nuisance to him—they can defeat the whole purpose of stereo, which is the three-dimensional reproduction of the original sound "scene".

Of cardinal importance too is balance which, besides the careful setting of amplifier controls, listeners and furnishings, should, for perfect results, take into account the difference in sensitivity of the two ears of the listener. Failure to appreciate this last point is responsible for many disappointments in the stereo field.

All this leads up to the concept that the ideal instrument for listening to stereophonic sound should terminate not in a pair of loudspeakers, competing with room noises, but in a headphone set with separate amplifiers, each feeding an individual earpiece. The pair of amplifiers for such an installation would have to provide no more than quite a modest degree of gain and power and, if transistorised, could be constructed so as to occupy, complete with batteries, only a few square inches of space.

The opportunity to try out this scheme without undue expense appeared recently, when dealers began to advertise at reasonable cost a pair of lightweight stereo headphones. These are rather like a stethoscope, comfortable to wear and very suitable for working from transistor amplifiers. They are supplied with separate flexible leads to each earpiece, and each lead terminates in a miniature jack-plug.

The Complete Unit

The complete headphone amplifier unit, which has been very successful, is described in this article. It consists of a small flat box containing a battery and a pair of amplifiers, each with its own volume control, together with two pairs of sockets to accommodate two pairs of the special headphones. There is ample power to drive more outlets if desired, but when more than two persons are listening one or more are certain to notice a lack of balance, which will reduce the true stereophonic effect. The gramophone

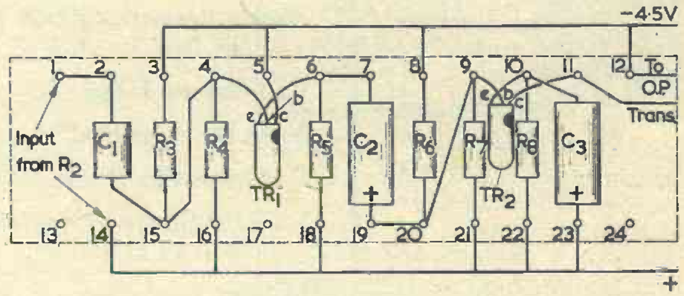


Fig. 2. Suggested layout employing a 24-way tagboard

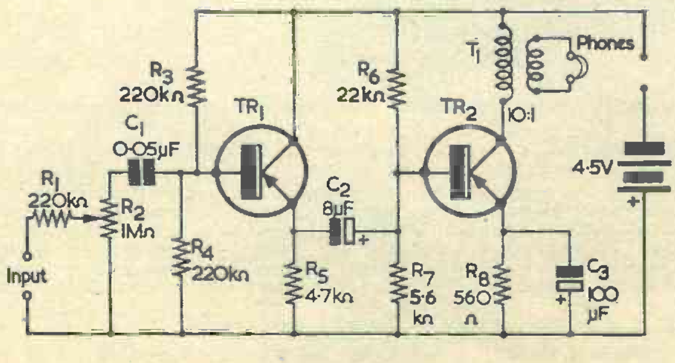


Fig. 1. The circuit of the amplifier used for one channel

Components List

Each of the two amplifiers requires:

Resistors

(All fixed resistors ¼ watt 20%)

- R_1 220kΩ
- R_2 1MΩ miniature volume control (ex-hearing aid)
- R_3 220kΩ
- R_4 220kΩ
- R_5 4.7kΩ
- R_6 22kΩ
- R_7 5.6kΩ
- R_8 560Ω

Capacitors

- C_1 0.05μF
- C_2 8μF electrolytic, 6V wkg.
- C_3 100μF electrolytic, 6V wkg.

Transistors

- $Tr_{1,2}$ OC71, XB112, MAT101 (See text)

Transformer

- T_1 10:1 Ardente type D.262

Tagboard

Miniature, with 12 pairs of tags, 1 x 2½in

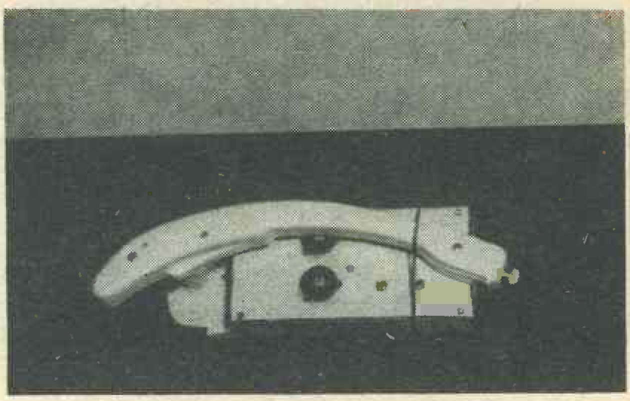
The unit requires:

- 1 Miniature slider s.p.s.t. switch on/off
- 1 Pair "Stereo" headphones, stethoscope type, 2 x 8Ω impedance, (Henry's Radio Ltd.)
- 4 Output sockets, to suit headphones, (Henry's Radio Ltd.)

pick-up is mounted on the unit case, so that the whole self-contained unit can simply be placed on the motor-board of an existing gramophone, the position having, of course, been marked out beforehand so as to ensure correct tracking.

The dimensions of the box used for the prototype are shown in Fig. 3. Its size was governed by the battery to be used, and the choice fell on the familiar three-cell EverReady type 1289. This is conveniently flat in shape and provides a very long life, besides being heavy enough to assist in giving stability. The box, made of strips of thin plywood, is 1in deep and has two compartments, one to take the battery and one to accommodate the two amplifiers. The battery connections consist of two brass drawing-pins, placed so that the battery connections can bear against them and wired to the contacts of a miniature slider-type on/off switch. The latter is mounted in a slot cut in the end wall of the box, as shown. The removable lid, held down by screws, carries the two volume controls (miniature deaf-aid types) and the output sockets. All these are connected to the body of the unit by thin flexible leads so that the lid can be removed for servicing or for battery-changing. As the total consumption is in the neighbourhood of 4mA, battery life can be expected to be many months.

An extension of the base-member of the box provides a mounting for the pick-up pivot. When not in use, the pick-up arm can be turned so that it lies along the top of the box, so occupying the minimum of storage space. A U-shaped rest, made from plastic sheet or from plywood, can be screwed to the end of the box remote from the pivot, so providing a location for the pick-up and protection to the stylus.



The complete unit, stowed for storage

The Circuit

Fig. 1 gives the circuit used for each of the two amplifiers. It will be noticed that the first stage is operated at low current level, so reducing inherent noise.

No originality is claimed for the circuit, which was designed to use OC71 transistors, but has worked well also with XB112's. The new micro-alloy MAT101 transistors which offer high gain at low current levels work well in the circuit.

The amplifiers were built as shown in Fig. 2, the basis for each being a miniature plastic tagboard, with 12 pairs of contacts, measuring 2½ x 1in only. There is plenty of room for ordinary quarter watt resistors, but some care has to be taken in fitting the three capacitors. The output transformers are not mounted on the tagboards, but are glued to the end panel of the box, narrow slots being cut with a penknife in the plywood laminations so as to hold them securely. The transformers specified have quite long flying leads. Of these, the blue and orange leads connect respectively to the negative battery line and to the collectors of the output transistors, while the red and green secondary wires go to the headphone jack sockets. If more than one pair of

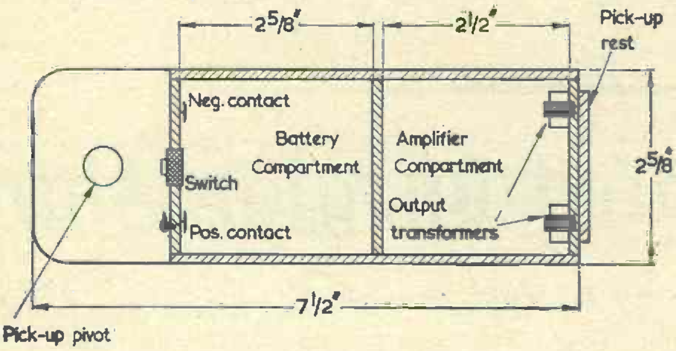
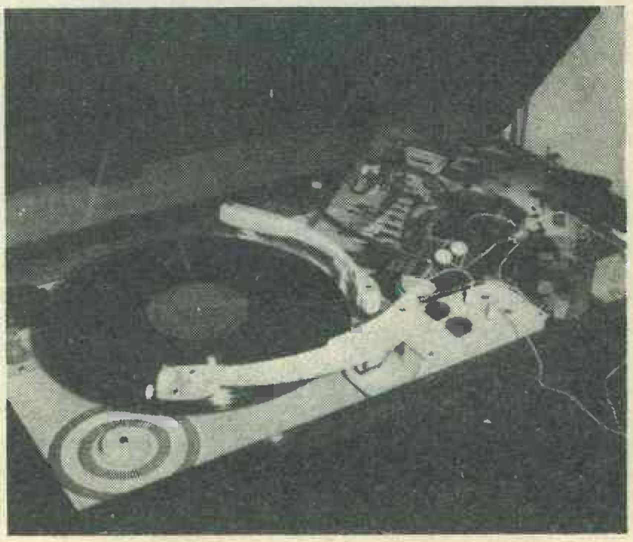


Fig. 3. Layout of the case



The unit in use on a standard motor-board

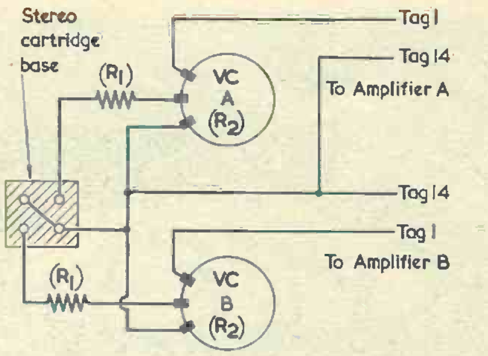


Fig. 4. Illustrating the connections to the volume controls

jacks is fitted some care has to be taken to wire them so that, when the plugs are withdrawn, one jack does not short-circuit its neighbour.

The flexible leads from the volume controls, mounted on the box-lid with contact glue, connect to tags 1 and 14 of the amplifier boards, whilst the thin leads from the pick-up connect to the volume controls as shown in Fig. 4.

Finish

A pleasing finish for the unit is obtained by covering with "Contact", "Fablon" or one of the other brands of self-adhesive plastic sheeting obtainable from "do-it-yourself" stores. The box lid should be covered *before* fitting the output sockets and gluing the volume controls into place.

If the pick-up arm pivot is of the type which projects below the base-board, it will be necessary to cut or drill a suitable hole in the motor-board of the gramophone with which the unit is to be used.

The spatial illusion produced by this unit, once the balance has been correctly adjusted, puts it into quite a different class from conventional stereo equipment. Apart from entertainment value, the construction of the unit has also been well worthwhile for the facilities it has given for studying the effects of quite small variations in balance and the purely psychological processes of "self-deception".

Battery-Operated Burglar Alarm

by A. Vest

As we are all too unhappily aware these days, petty crime and pilfering are on the increase and show no signs of abatement. The householder or shopkeeper has to provide his own precautions against break-in and entry, and this article describes an inexpensive burglar alarm which may be installed by anyone capable of following the simple circuitry involved

HAVING BEEN REQUESTED BY A FRIEND TO PRODUCE a burglar alarm, the circuit described in this article was evolved. No originality is claimed, as the principle is so simple that it must have been used many times before.

Conditions

The following conditions were laid down: (1) the alarm must be cheap; (2) it must be independent of the mains supply; (3) it must "lock on"; and (4) it must be door operated.

In order to satisfy conditions 1 and 2, a quite cheap P.O. 3000 relay was employed, together with a lantern-type 6V dry battery. This relay allowed electrical, instead of mechanical, latching and thereby met condition 3 as well. The fourth condition was easily satisfied by using a door switch of the type which is commonly employed for ringing a bell in small shops. The alarm device was a 4V electric bell.

The relay is the heart of the circuit and must have two pairs of make contacts. The unit available had a 1,000Ω coil, and therefore only 6mA is required to operate it.

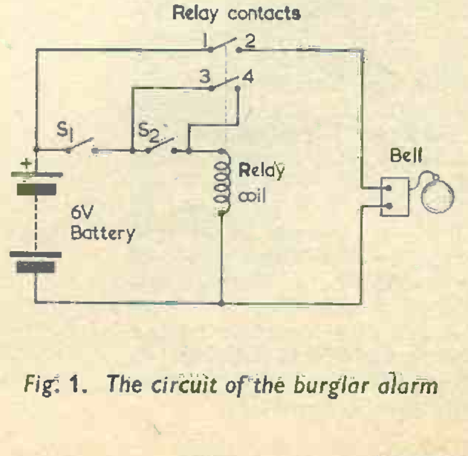


Fig. 1. The circuit of the burglar alarm

The Circuit

The circuit of the alarm is shown in Fig. 1. S_1 is any available single-way switch, and need be only a very small type as it merely has to carry the 6mA required by the relay coil. S_2 is the door switch, and may be of the type shown in Fig. 2. This switch is fitted into the lintel of the door on the hinge side.

To set the device the door is closed, thus breaking S_2. S_1 is made. When the intruder opens the door (by even a tiny fraction) S_2 is made and current flows from the battery through S_1, S_2 and the relay coil. This causes the relay to operate and both sets of contacts to make, whereupon current then flows from the battery through contacts 1 and 2 to the warning bell. The intruder, if he does not panic immediately, may realise that his action in opening the door has caused the bell to ring and he may, therefore, immediately close it again. This has no effect, because the relay coil is now being supplied with current via its contacts 3 and 4, which are directly across S_2, and S_2 offers no further control. The alarm bell will continue to ring until S_1 is opened.

Construction

The writer fitted the relay in an old toffee tin and provided insulated terminals for easy connection to the external circuit. The relay is secured to the lid of the tin by a pair of straps which pass over the relay coil and through slots in the lid, and which are then tightened on the outside. In the original, thin leather straps with buckles were used, but the constructor may easily find alternative materials. The tin was secured to a skirting board in a well-concealed position by means of two woodscrews passed through the bottom of the tin. Switch S_1 is mounted at a convenient point near the relay unit, and the battery is in the same well-hidden position. Obviously, the wiring from the relay unit to the door switch and the bell must be concealed as much as possible.

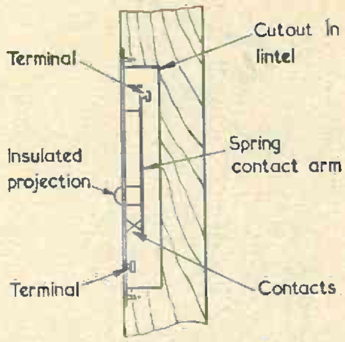


Fig. 2. The door switch employed by the writer. When the door is closed, its edge exerts pressure against the insulated projection, and thereby opens the contacts. The contacts make when the door is opened

A 4V bell was chosen as the alarm bell device to allow for voltage drop on long cable runs.

No difficulty was found with the alarm after construction. It worked perfectly straight away and has been tested frequently over a long period. No intruder has, as yet, proved its efficacy.

EDITOR'S NOTE.—If desired, further switches could be fitted at other points of entry. These should make when the appropriate door or window is opened, and may be connected in parallel with S_2.

An alternative switch to that shown in Fig. 2 would be provided by a micro-switch.

New Surveying Technique Uses Closed-Circuit TV

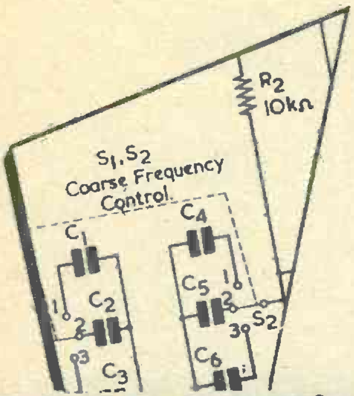
A new technique for borehole inspection using a closed-circuit television camera, which offers several advantages over conventional methods, was demonstrated on the Leeds-Sheffield motorway, seven miles south-west of Wakefield, on Wednesday, 10th July, to local authorities and civil engineers.

Closed-circuit television equipment was supplied by EMI Electronics Ltd., and the demonstration arranged by Drilling and Prospecting International Ltd., a member of the Turriff Group.

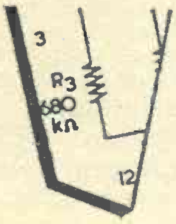
When surveying sites for bridges, cuttings and tunnels, it is essential to ascertain the geological structure of the ground and the positions of any cavities, such as old mineworkings or swallow-holes caused by water seepage. Conventional methods necessitate boring a small hole and dragging out cores of different strata for inspection, but it is obviously impossible to extract specimens of cavities.

When using the television technique, a seven-inch diameter hole is bored and a cylindrical camera in a special housing is inserted, to inspect strata and cavities. A constantly changing picture of the composition of the walls, as the camera is lowered, is shown on a television receiver above ground.

Advantages of the new technique are that visual inspection of the cavities can determine their nature and extent, it can be ascertained exactly where water is seeping in, and the placing of cement grout in old mineworkings can be checked. The television technique can also be used to correlate findings from conventional boring methods.



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. 154 High Quality A. M. Tuner

When it is desired to listen to radio programmes by way of high fidelity equipment it is normal practice to employ an f.m. tuner. Unfortunately, f.m. tuners only offer reception of B.B.C. transmissions, and the limited range of material given does not always meet the requirements of the listener. A very wide range of programme material is available on the medium and long wave bands, and this is capable of excellent entertainment value despite the restricted range of audio frequencies inevitable with broadcast band a.m. reception.

This month's article describes a Suggested Circuit for an a.m. tuner in which attention has been paid to ensuring a symmetrical i.f. response. This is an important adjunct of a.m. tuner design, and it is not always realised that disappointing results with such tuners are quite often the result of component skimping in the i.f. amplifier. A further feature is the use of a cathode follower output stage, which enables the tuner to be coupled to any subsequent amplifier input impedance (preferably above 50kΩ) without the risk of introducing an incorrect a.c./d.c. diode load ratio. Another facility, not normally available, allows the a.g.c. circuit to be either delayed or non-delayed, and also provides a panel control which is capable of varying the a.g.c. delay voltage itself. This is an unusual feature, and it offers the advantage that weak signals may be received without a.g.c., the signal level at which a.g.c. takes over being variable as desired. An optional tuning indicator is also included, the type employed being an EM84. Finally, the tuner has its own isolated a.c. mains power supply.

The circuit employs more extensive decoupling than is usual in a tuner of this type. The use of extra components here is considered justified, since the basic function of the unit is to offer an output suitable for application to a high fidelity amplifier, and the additional decoupling obviates the possibility of regenerative effects which might degrade the i.f. response.

Due to the somewhat novel features incorporated, it will be more helpful to describe the basic operation of the circuit first. The more unusual aspects of the circuit will then be discussed afterwards in greater detail.

Basic Operation

In Fig. 1, the aerial signal is applied, by way of $S_{1(a)}$, to the coupling windings of aerial coils L_1 and L_2. $S_{1(b)}$ selects the grid windings, and these are tuned in conventional manner by C_4, which is one section of a two-gang 500pF tuning capacitor. The aerial signal is then applied to the signal grid of the ECH81 frequency changer, V_1.

The triode section of V_1 functions as the oscillator, the appropriate coils being selected by $S_{1(c)}$ and $S_{1(d)}$, and tuned by C_8. The oscillator circuit follows normal practice, feedback being provided by way of the coil windings switched into the anode circuit by $S_{1(d)}$. Capacitors C_{10} and C_{13} are padding components.

All four coils L_1 to L_4 are readily available components which fit comfortably into a circuit of the type described here. They have adjustable iron dust cores for tracking adjustments at the low frequency end of each band.

Switch S_1 has three positions, these being "Medium Wave", "Long Wave", and "Mute". In the "Mute" position the receiver is silenced, $S_{1(d)}$ breaking the h.t. feed to the oscillator anode. At the same time, $S_{1(b)}$ connects the signal grid of the frequency changer to chassis, thereby ensuring that the heptode section still receives its correct value of bias when the tuner is muted.

The intermediate frequency appears at the anode of the heptode section of V_1, and is applied to the primary of the first i.f. transformer. This primary is decoupled from the h.t. line by R_7 and C_{14}.

The secondary of the first i.f. transformer connects to the grid of the i.f. amplifier valve V_2. V_2 is a double-diode-pentode type EBF89, but only the pentode section is employed in the i.f. amplifier. The amplified signal at the pentode anode is fed to the primary of the second i.f. transformer, and this is connected directly to the h.t. line without

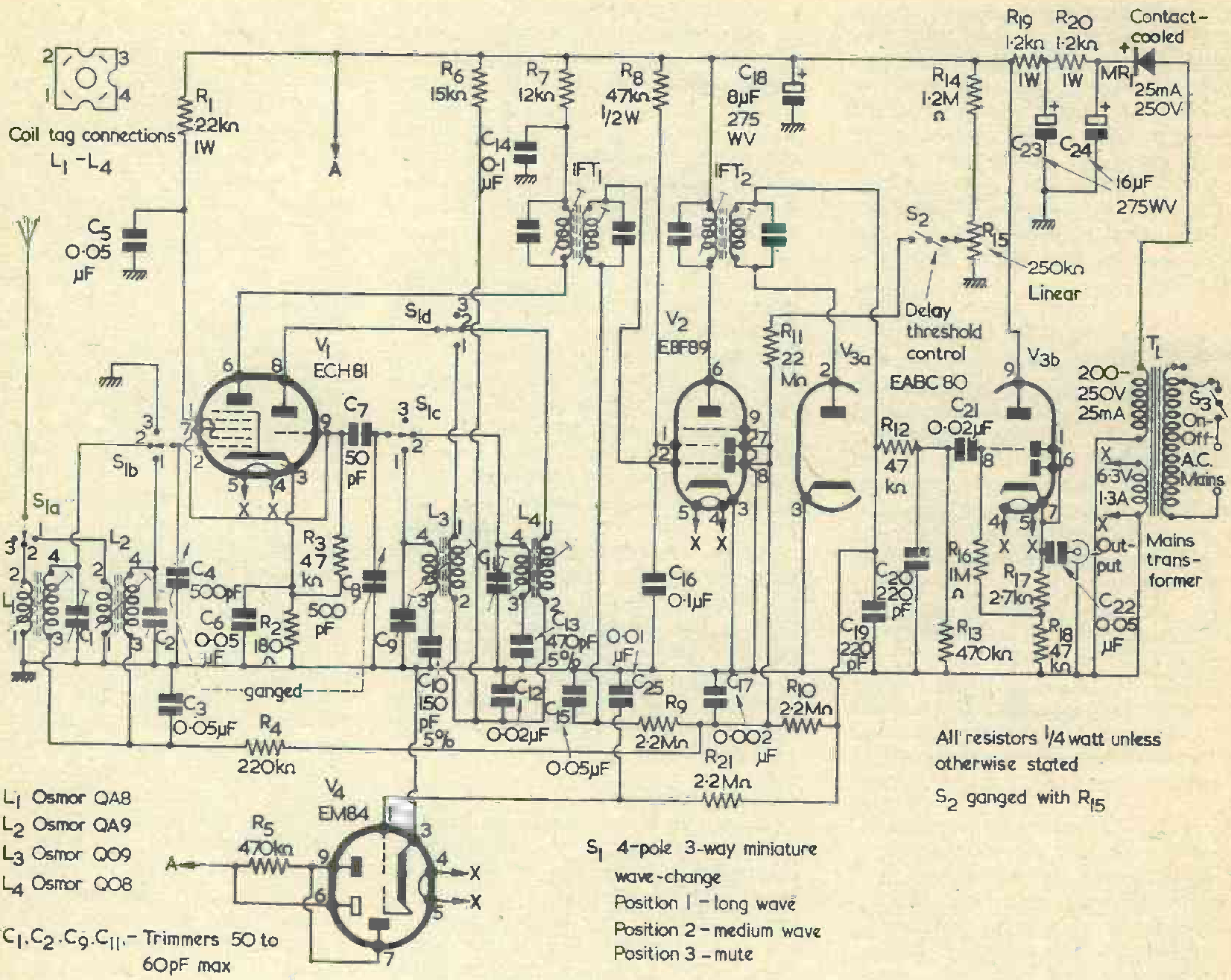


Fig. 1. The circuit of the high quality a.m. tuner unit

decoupling. The secondary feeds into one diode section, $V_{3(a)}$, of a triple-diode-triode type EABC80, the diode load being offered by R_{12} and R_{13} in series. I.F. filtering is provided by C_{19} and C_{20} in conjunction with R_{12}, whereupon the detected a.f. becomes available across R_{13}. This a.f. is applied, via C_{21}, to the grid of the triode section of the EABC80, $V_{3(b)}$, which functions as a cathode follower. The output from the tuner is then taken, by way of C_{22}, from the triode cathode. The remaining two diodes of V_3 are not used, and they are strapped to the triode cathode.

A negative potential proportional to signal strength appears at the junction of C_{19} and R_{12}, and this is employed for a.g.c. When S_2 is open the a.g.c. line functions in conventional manner. The negative potential is applied to the resistors R_{10}, R_9 and R_4, whereupon an a.g.c. potential for V_2 is available at the junction of R_9 and C_{15}, and an a.g.c. potential for V_1 is available at the junction of R_4 and C_3. Capacitor C_{15} bypasses the earthy end of the secondary of the first i.f. transformer, whilst C_3 bypasses the earthy ends of the tuned windings in L_1 and L_2. As will be noted, the a.g.c. circuit has no voltage delay, and all detected voltages appearing at the junction of R_{12} and C_{19} are applied direct to the a.g.c. line.

When S_2 is closed a different state of affairs comes into being, since the two strapped diodes of V_2 now function as an a.g.c. clamp diode. Let us assume that S_2 is closed and that R_{15} is adjusted such that 20 volts positive, with respect to chassis, appears on its slider. This potential of 20 volts will be passed to the clamp diode anode by way of the 22MΩ resistor R_{11}, with the result that the diode becomes conductive and its anode assumes chassis potential. The negative voltage at the junction of R_{12} and C_{19} is also applied to the anode of the clamp diode, and this is passed by way of R_{10} which, it will be noted, has a value that is one-tenth the value of R_{11}. Should the voltage from R_{12} be 2 volts negative of chassis, the clamp diode anode will take up chassis potential, because the negative 2 volts applied to R_{10} then counteracts the positive 20 volts applied to R_{11}. Should the negative potential from R_{12} *exceed* 2 volts the clamp diode anode will go negative of chassis, and the diode will no longer conduct. It follows that, for negative potentials from R_{12} which are below 2 volts, the diode clamp remains conductive and its anode holds the a.g.c. line at chassis potential. As soon as the negative potential from R_{12} exceeds 2 volts the clamp diode ceases to conduct, with the result that the negative voltage is applied to the a.g.c. line, whereupon it controls the bias on V_1 and V_2 in conventional manner. Thus, the clamp diode circuit offers a voltage delay for the a.g.c. system.

The positive voltage applied to the clamp diode anode may be varied by adjusting R_{15}, and this potentiometer offers a control over the negative voltage from R_{12} which is required to make the clamp diode non-conductive. In consequence, R_{15} effectively varies the voltage delay on the a.g.c. system, and it therefore controls the received signal level which brings the a.g.c. line into operation.

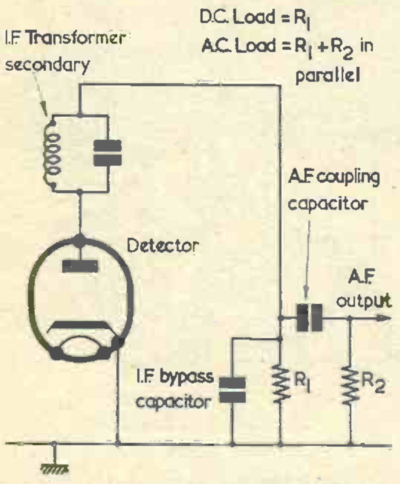


Fig. 2. Illustrating the formation of the a.c. and d.c. diode loads. R_2 may be a volume control or, with a tuner unit, the input resistance of a subsequent a.f. amplifier. The usual i.f. filter capacitor and resistor are omitted here for simplicity

The diagram shows that S_2 is ganged with R_{15}, and this is a convenient method of combining these two components. R_{15} should be wired such that the switch operates when the slider is at the chassis end of the track, since this allows a logical method of using the control. Thus (assuming a conventional potentiometer and switch assembly) S_2 will be open when R_{15} is fully anti-clockwise, and there will be no delay on the a.g.c. system. If R_{15} is turned clockwise sufficiently to operate the switch, S_2 becomes closed, and the clamp diode circuit becomes operative. However, the voltage tapped off by the slider of R_{15} will only be slightly positive of chassis, with the result that the effective voltage delay will be very low. The delay will then increase as R_{15} is adjusted clockwise, being at a maximum when the slider is at the positive end of the track. The overall effect is that clockwise rotation of the potentiometer offers a continually increasing delay, this ranging from zero to maximum as the control is turned.

The tuning indicator, V_4, appears in a conventional circuit, and it obtains its control voltage from the junction of R_{12} and C_{19}. By connecting into this part of the a.g.c. circuit, V_4 is capable of giving indications regardless of whether the a.g.c. delay circuit is selected or not. Resistor R_{21} and capacitor C_{25} prevent i.f. voltages appearing on the wiring to the indicator. These components also ensure that the indicator display does not flicker in sympathy with the a.f. modulation of the received signal. The tuning indicator is optional, and may be omitted (in company with R_{21}, C_{25} and R_5) if desired.

The tuner unit employs its own isolated power pack, and h.t. and heater voltages are provided by an inexpensive mains transformer having a half-wave h.t. secondary winding. A contact-cooled rectifier may be used, and smoothing is provided by R_{19}, R_{20}, C_{18}, C_{23} and C_{24}. The transformer secondary current figures shown in Fig. 1 are minimum requirements. If the tuning indicator is omitted, the heater current requirement drops to 1.05 amps.

Circuit Details

Since the circuit has a number of unusual features, these will now be discussed at some length, bearing in mind the fact that the primary object of the tuner is to provide an a.f. output which, within the limits of a.m. reception, is most suitable for application to a high fidelity amplifier.

The first question to be decided with a unit of this type is whether it should employ transistors or valves. Transistors are certainly more convenient than valves, because there is no necessity for a power supply, no heat is dissipated, and less space is required. On the other hand, it is difficult to obtain the all-important i.f. response with transistor i.f. transformers, most of which are of the single tuned winding type. An excellent response is available with valve i.f. transformers, and this may be achieved quite readily provided a little care is taken in circuit design and in construction. Since the quality of the a.f. output is the most important consideration, it was decided that a valve circuit would be preferable to a transistor version.

The next step was concerned with fitting the i.f. transformers into a circuit which would offer the minimum of regeneration in individual stages or between stages. Such regeneration, even if it is only at a low level, can have a significant effect on the final i.f. response obtained. In the present circuit, extensive h.t. and a.g.c. decoupling is employed to keep any possible regeneration along the associated lines at a minimum.

Another point which has a considerable bearing on the performance of an a.m. tuner is concerned with the a.c./d.c. diode load ratio. In the normal a.m. diode detector configuration, the diode has a resistive load across which both the a.f. and d.c. components of the detected signal appear. See Fig. 2, which shows this load as R_1. The a.f. is then passed to a second resistor (R_2 in Fig. 2) by way of an a.f. coupling capacitor, and this second resistor may be a grid leak or a volume control. With many a.m. tuners, the second resistor is the input resistance of the succeeding amplifier. Thus the diode has two loads: a d.c. load offered by the first resistor on its own, and an a.c. load offered by the first resistor in parallel with the second resistor. It can be shown that if the ratio between these two loads is not close to unity, distortion may result. In practice, quite satisfactory results can be obtained by giving the second resistor a value which is at least four times the value of the first resistor (with a consequent a.c./d.c. load ratio of 0.8). If the diode output is to feed directly into a subsequent a.f. amplifier, the input resistance of the latter governs the maximum value of the d.c. diode load in the tuner. If the input resistance is 500kΩ, the tuner diode load has to be 125kΩ; whilst, if it is 250kΩ (a not uncommon figure), the diode load has to be 63kΩ. Diode load values as low as this offer excessive damping on the secondary of the last i.f. transformer, and are to be avoided.

The solution to this problem in the present design consisted of employing a cathode follower immediately after the diode. The high input impedance of a cathode follower ensures that the a.c. diode load is very close to unity, regardless of the input resistance of the succeeding amplifier. (However, as we shall see shortly, behaviour here is qualified by R_{10}). A secondary advantage is that the output of the cathode follower is at low impedance. In consequence, it is possible to use relatively long interconnecting leads between the tuner unit and the amplifier with less high frequency attenuation than would be given if the output were taken directly from the diode load. With the cathode follower circuit shown here, the succeeding amplifier may have any input resistance above, say, 50kΩ. Also, the signal diode can have a d.c, load with the comfortably high value of 470kΩ.

It was decided to employ a conventional frequency changer and i.f. amplifier pentode to feed the diode. At first sight, an attractive i.f. pentode valve is the EBF89, because this contains two diodes which could be used both for signal and a.g.c. detection. There is, however, a slight tendency towards regeneration (particularly where experimental home-constructor layouts are concerned) with valves of this nature unless great care is taken with wiring and component disposition. It was felt, therefore, that a separate diode would be preferable, and this is conveniently supplied by an EABC80, the triode section of which could operate as the cathode follower. It then becomes possible to obtain an acceptable layout by mounting the second i.f. transformer between the i.f. amplifier valve and the EABC80.

Whilst it was felt that it would be undesirable to employ the diodes of an EBF89 for signal and a.g.c. detection, these diodes become very useful for the a.g.c. clamp circuit. It is permissible to operate the EBF89 with zero cathode bias, whereupon a clamp diode with a chassis-connected cathode is conveniently available. In the circuit, the EBF89 diodes handle the smoothed a.g.c. voltage, and there is negligible risk of feedback.

Turning, now, to the a.g.c. circuit, there are several points here which require a little further explanation. It is, first of all desirable to give R_{10} a high value since, when the clamp diode is not conductive, this resistor appears as a signal diode a.c. load in series with C_{17}. The value of 2.2MΩ shown should be quite satisfactory. The clamp circuit has already been described, and it only needs to be added that the potentials available from R_{15} range from zero to about 40 volts positive for a 250 volt h.t. line. This range of control should be more than adequate, since the highest figure corresponds to an effective delay potential around 4 volts.

R_4, the decoupling a.g.c. resistor for V_1, has a value of 220kΩ, whilst the similar resistor for V_2, R_9, has a value of 2.2MΩ. So far as decoupling is concerned, 220kΩ would be perfectly adequate for both resistors. It is, however, possible to put the tuner unit to "Mute" whilst S_2 is closed and the slider of R_{15} is at the positive end of its track, whereupon the potential on the clamp diode anode would be very slightly positive of chassis. V_2 is operated with its cathode at chassis potential, but it requires a high value of grid resistor to give grid current biasing. Under these conditions, R_9 provides this high value. Another point to mention is that the limiting R_{g-k} for the ECH81 is 3MΩ. R_4, R_{10}, R_{12} and R_{13} in series fall just below this figure.

As has already been mentioned, more decoupling components are employed here than is usual in a conventional a.m. tuner. It was felt desirable to decouple either the frequency changer heptode anode circuit or the i.f. pentode anode circuit from the h.t. line. Since the heptode draws less anode current than the pentode it was felt that the decoupling circuit should, preferably, be in the heptode anode circuit. At the same time, both heptode and pentode screen grids have separate decoupling components, instead of using the frequently encountered common decoupling circuit. The electrolytic capacitor C_{18} bypasses the pentode anode circuit (as well as the V_3 anode circuit) and should be mounted close to the second i.f. transformer.

The "Mute" facility offered by S_1 was considered desirable because tuner unit breakthrough when the subsequent amplifier is switched to another source of signal can sometimes be a nuisance. Miniature 4-pole 3-way wavechange switches are easily available, and these may readily provide the "Mute" function shown in Fig. 1.

Components and Layout

All the components employed are standard types, and it is important to note that all bypass capacitors should be mounted close to the circuits they decouple. Also, R_{10} and R_{21} should be mounted close to R_{12} and C_{19}.

The i.f. transformers need to be a high grade type having a nominal frequency of 465 kc/s. Suitable components would be Denco type 1FT6 or Weyrad type P.30.

Because of the high resistances and low currents associated with the clamp diode circuit, it is advisable to employ a high grade moulded valveholder for V_2. Such a valveholder should keep leakage resistances at a maximum.

If desired, the aerial coils L_1 and L_2 could be replaced by a ferrite frame circuit with bottom-end aerial coupling.*

Layout is not very critical, but it is desirable to avoid excessive crowding of components. The stages should progress along the chassis in the same sequence as they appear in the circuit, with the first i.f. transformer between V_1 and V_2, and the second i.f. transformer between V_2 and V_3.

Alignment

If possible, it would be preferable to align the tuner unit with the aid of a signal generator. The i.f. transformers should be lined up first, with maximum a.g.c. delay applied. Detector output could conveniently be monitored by observing the tuning indicator. The symmetry of the i.f. response curve may be evaluated by rocking the signal generator on either side of central frequency.

The aerial and oscillator circuits may then be aligned in conventional manner, trimming at the high frequency end of the band, and padding (by adjusting the iron dust cores) at the low frequency end of the band.

* See Suggested Circuits No. 152, July 1963 issue.

Whiteness Hamfest and Mobile Rally

The Whiteness Radio Club (Whiteness Manor School for Crippled Boys, Broadstairs, Kent) are holding the above event on Saturday, 14th September from 2 p.m. to 7 p.m. The official opening ceremony will be performed by W. E. Nutton, G6NU (Naughty Uncle) who, with many other local amateurs have greatly assisted the boys with the formation of the Club and the supply of equipment, etc.

Various events will be held throughout the afternoon among these being sack races for Gs, XYLs and SWLs; balloon bursting race; newspaper game; hamfest tin scramble; and the extremely amusing mummy game. Other attractions will include an aerial balloon race; bran tub; treasure hunt; best mobile turnout; longest distance mobile visitor and free ticket table, etc. Radio equipment (listed as prehistoric) will also be on display. The 160 metre talk-in station will be G3PNI/A.

Simple Receiver Circuits for Short Aerials

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

THE RECEIVERS TO BE DESCRIBED can be made in three stages; or, of course, the full circuit of stage 3 can be built straight away. Each stage is a complete receiver in itself but the successive stages include improvements. The first, which is unusually simple, will give results on medium waves superior to those obtained with an orthodox two-valve set. Stage 2 adds a long wave band. Stage 3 provides increased sensitivity, particularly on the long wave band, and is especially recommended for areas where the medium wave Light programme is weak and where a very short aerial is all that is convenient. In each of the different forms the circuits are intended for a simple transportable receiver for use in the garden or bedroom and which provides better quality than is obtained with most small transistor sets. Only one valve is used, this being a multiple affair, type 1D8. It costs only a few shillings.[1] It consumes 0.1A at 1.4V for its filament and, in the circuits described, about 6mA high tension current at 90 volts, for which it will give an output of nearly 200mW. The full circuit shown in Fig. 3 also uses one transistor, but this consumes no extra current as it draws its supplies from the waste high tension current flowing through the valve's bias resistor.

As the title of this article indicates, the circuits are intended for use with a short aerial. With stage 3 a telescopic aerial or even a few feet of wire on the ground will receive in local stations at good strength and, in most parts of the country, the long wave Light programme and probably one or two foreign stations in addition. If a normal aerial is used, many stations will be received—even with stage 1 the prototype picked up 36 at loudspeaker strength in South Devon—but there will be interference on some of these unless wave traps are used for the local stations.

[1] The 1D8 is available from Henry's Radio Ltd.

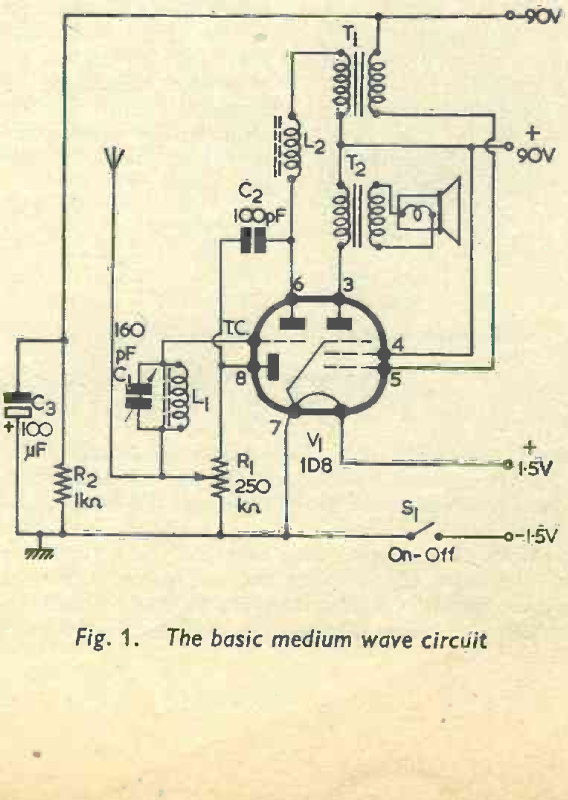


Fig. 1. The basic medium wave circuit

The Basic Circuit

The diode and triode of the valve are used in a simple but effective reflex circuit. The simplicity can be seen from Fig. 1, which shows a complete medium wave receiver circuit. Owing to stray capacitances there are, in effect, capacitors between grid and filament and between anode and filament of the triode. As the aerial is connected to the anode end of L_1 and there are more components connected to the anode than to the grid, the stray capacitances from anode to filament are greater than those from grid to filament. There is, therefore, a capacitive tap into L_1 which is nearer to the anode end than the grid end. The tap is at filament potential and, as a result, reaction effects are introduced.[2] As the aerial is connected to a point on the tuned circuit which is nearer to filament potential than is the grid end, a reasonably loose coupling is provided.

Reaction is controlled by R_1. With the slider at the top end it is clear that there will be oscillation,

[2] The capacitive tap into L_1 causes a Colpitts oscillator circuit to be set up.

Components List

Fig. 1

Resistors

R_1	250kΩ potentiometer, log. (Antilog preferable if available)
R_2	1kΩ

Capacitors

C_1	160pF air-spaced
C_2	100pF
C_3	100μF electrolytic, 12V wkg.

Inductors

T_1	Intervalve transformer (Elstone, type LF38)
T_2	Output transformer, 65:1. (Henry's Radio Ltd., "Standard Pentode Output")
L_1	See text
L_2	See text

Valve

V_1 1D8

Switch

S_1 s.p.s.t. on-off

Speaker

3Ω impedance

Components List

Fig. 2

Resistors

R_3 150kΩ (may need varying for Fig. 3 circuit)

R_4 22kΩ

R_5 270kΩ

Capacitors

C_4 100pF

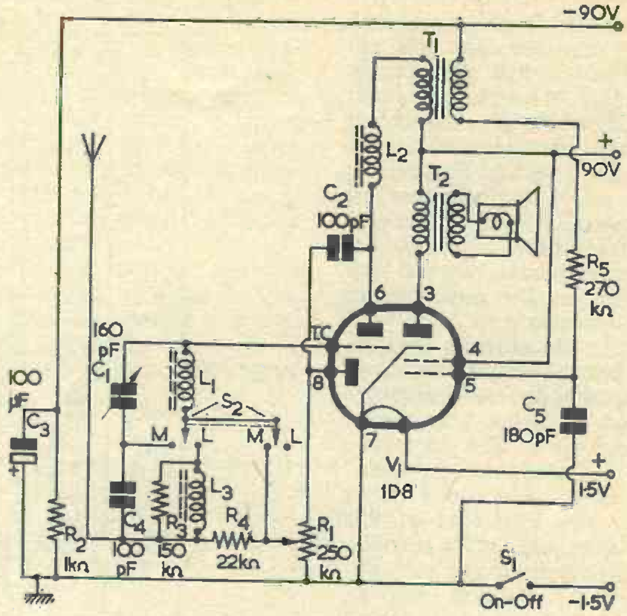
C_5 180pF

Inductor

L_3 See text.

Switch

S_2 d.p.d.t. medium wave–long wave



S_2 - Medium-Long wave switch

Fig. 2. Adding a long wave stage

but stability can be restored by introducing resistance between the anode and L_1. Whatever the position of the slider, the whole of the amplified signal across the choke L_2 is applied to the diode and rectified. There is, therefore, a considerable advantage in the form of high frequency amplification obtained, as compared with a leaky-grid detector which can only provide regenerative high frequency gain.

It will be seen that R_1, in addition to forming a reaction control, is also an audio frequency volume control. It might be thought that the slider would have to be so near to the filament end in order to prevent oscillation that what was gained in high frequency amplification would be lost at audio frequencies. But this is not so. Although at audio frequencies the gain is proportional to the position of the slider, at medium wave frequencies the stray capacitances take charge. In other words the high frequency load is capacitive and R_1 does not act as a potentiometer across it but, using its top section only, as a series resistance between L_1 and L_2. In practice it will be found that with short, careful wiring, about 10kΩ between the slider and the top of the track will stop oscillation at 200 metres and that about 25kΩ will be required at 550 metres. Even at 550 metres there will be a loss of only one tenth of the low frequency signal at the critical reaction point, when a potentiometer of 250kΩ is employed. At lower settings of R_1 correct adjustment of audio frequency amplification takes place. In fact, R_1 will be found to form a smooth control from zero to oscillation point, and is thus vastly superior to the more usual form of reaction control which will not cut a strong signal down to a whisper.

If a straight potentiometer is used it will be found that reaction is fierce. The ideal is a component with anti-log characteristics but these are hard to come by, and the best alternative is to use a log type wired so that reaction increases as it is adjusted in an anti-clockwise direction.

Inductors

It has been pointed out that a considerable gain in amplification is obtained because the valve acts as a true high frequency amplifier in addition to providing regeneration. But further gain can be had as a result of the stray capacitances being smaller than with a conventional circuit. It will be found that the inductance of L_1 can be as high as 500μH and still tune down to 190 metres. C_1 need not be bigger than 160pF to tune L_1 to well above 550 metres. Inductance has been increased by about three times as compared with normal medium wave coils, and capacitance reduced by the same amount. As gain depends on the ratio of inductance to capacitance, an increase of 10 times may be realised. A good short wave tuning capacitor of 160pF capacitance is ideal for C_1. A solid dielectric tuning capacitor should not be used.

L_1 consists of 120 turns of 32 s.w.g. enamelled wire close-wound on a three inch length of $\frac{5}{16}$in ferrite rod. The rod should be covered with a thin paper sleeve before putting the winding on.

L_2, the choke, is made by winding 1,125 turns of 38 s.w.g. enamelled wire in three piles of 375 turns each on a three inch length of $\frac{3}{8}$in ferrite rod. Tedium can be relieved by using a hand drill in a vice as a simple winding machine. About three inches of adhesive plastic with the paper backing left on for the first inch makes an excellent sleeve.

Transformer T_1 must be carefully chosen, as the triode section of V_1 has a high output impedance of over 40kΩ and, unless a transformer with a large primary inductance is used, there will be a serious loss of amplification and no bass. The author recommends the Elstone LF38 for this position but some constructors may have a really good old transformer in their spares box. The Ferranti AF5 will be found excellent, but these huge and magnificent transformers have not been made for many years. If the Elstone LF38 is used, the anode and h.t. positive connections should be made as indicated on the transformer. The grid should be taken to terminal 1 and h.t. negative to terminal 6. Terminals 3 and 4 should be connected together. If the output sounds peaky, or there is low frequency oscillation, a resistor around 0.5MΩ should be connected across the secondary.[3] If that fails, and it is

[3] This measure, and those with reference to T_1, which follow, may become necessary when the long wave band is added, as in Fig. 2.—EDITOR.

only likely to do so if components are unduly cramped, it will be necessary to reverse the connections to the secondary. However, this will reduce amplification, particularly of the higher notes, and the need should be avoided by keeping T_2 and T_1 well apart, and not too close to inductors carrying high frequency currents. If a different transformer is used, experiments should be carried out to find the right way to connect the secondary.

A miniature transformer can be used for T_2 but the circuits described here are not intended for miniature receivers and a larger component will give more bass. The prototype uses a 65:1 "standard pentode" transformer obtainable from Henry's Radio Ltd. The blue lead of this transformer connects to the pentode anode. The red and orange leads are both taken to h.t. positive, and the black and white leads to the loudspeaker.

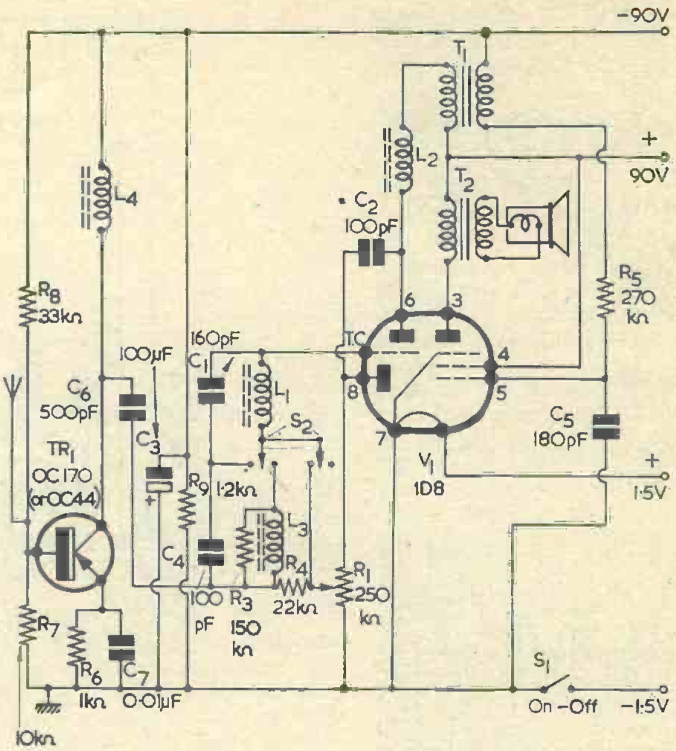


Fig. 3. Incorporating an r.f. amplifier. When an OC170 is used, its shield connection may be taken to the negative filament line

Adding a Long Wave Band

Fig. 2 shows how a long wave band can be added. Inevitably, this introduces a little complication into what is basically a very simple circuit, but gain is good as stray capacitances cause less damping on long waves. In addition, advantage can be taken of the circuit to use a very large inductance of about 10mH for L_3. This is about five times the normal inductance and, in itself, gives an increase in dynamic resistance of about 25 times.

Because of the greater high frequency amplification resulting from the smaller stray capacitances, it is necessary to introduce some damping into the reaction circuit (which does not reduce the obtainable gain) on the long wave band. This is done by R_3 and R_4. If R_3 is omitted or R_4 short circuited it will be found that oscillation starts at such a low setting of the reaction control that there is a loss of audio frequency amplification which cannot be tolerated. R_3 adds artificial damping which has to be overcome by extra reaction. R_4 provides part of the load for the triode, acting as a high frequency amplifier, whilst limiting the feedback to the grid. R_3 has a greater effect at the high wavelength end of the scale, and R_4 at the low wavelength end.

A capacitance of 160pF is too large for C_1 when tuning the large inductance L_3 and, by itself, it causes crowding of stations over half the scale. C_4 is included in series with C_1 when the long wave band is in use. Even with the small resulting capacitance swing of about 60pF there is still a coverage from about 1,100 to about 1,900 metres. On the medium wave band C_4 becomes a series aerial capacitor.

L_3 consists of 500 turns of 38 s.w.g. enamelled wire wound in five piles of 100 turns each on a 3in length of ⅜in ferrite rod.

It will be seen that Fig. 2 adds a filter, R_5 C_5, to the pentode grid circuit. This will be found to be necessary if a long wave band is included, and it prevents spurious oscillation which is probably due to the proximity of the triode and pentode sections in the same glass envelope, and to the large field around L_3. If medium waves only are to be received, as in Fig. 1, and components are not cramped, this filter will not be needed.

An Extra R.F. Stage

The addition of an extra r.f. stage using a transistor, as shown in Fig. 3, is well worth while since no extra current is used and all the components required, including the transistor, cost well under £1. Not only is there a marked increase in sensitivity, but isolation of the aerial from the tuned circuit brings the usual benefits of freedom from hand-capacitance, constancy of reaction effects and avoidance of unintentional annoyance to others through oscillation. No earth connection is needed in the case of the circuit in Fig. 3, which is an advantage with a transportable receiver. An earth connection may be needed with the circuits in Figs. 1 and 2 if hand-capacitance is found troublesome.

There is nothing unusual in the transistor part of the circuit except for the "free" power supply. It is necessary to change R_2, a 1kΩ resistor, to R_9, with 1.2kΩ R_9, in parallel with TR_1, will give about 1kΩ. An OC44 can be used in place of the OC170 but this latter tran-

Components List

Fig. 3

Resistors

R_6 1kΩ
R_7 10kΩ
R_8 33kΩ
R_9 1.2kΩ (replaces R_2)

Capacitors

C_6 500pF
C_7 0.01μF

Inductor

L_4 See text

Transistor

TR_1 OC170 (or OC44). See text

sistor is very efficient, particularly at the low wavelength end of the medium wave band. It may be found necessary to modify the value of R_3 to give satisfactory reaction effects on the long wave band when the output of a transistor, rather than an aerial, is the load on the tuned circuit. In the case of the prototype, 150kΩ was satisfactory for the circuit in Fig. 2, and for Fig. 3 when an OC44 was used; but 75kΩ gave rather better control with the particular specimen of OC170 used.

L_4 is deliberately made differently from L_2 in order to prevent any possibility of interaction between them. With L_4, self-capacitance is less harmful than with L_2, as it will only cause a shifting of the capacittive tap into the tuned circuit and, hence, tend to slightly loosen the coupling. It will not cause a direct loss as would occur with L_2. Therefore L_4 is made by winding one large pile of 1,000 turns of 38 s.w.g. enamelled wire on about $1\frac{1}{2}$ inches of $\frac{3}{8}$in ferrite rod.

It will be noted that, on medium waves, the coupling between the two r.f. stages is by C_6 and C_4 in series, giving 82pF. On long waves C_6, on its own, gives a tighter coupling of 500pF.

Full stabilisation is provided for TR_1 and, in addition, there is a further measure of stabilisation through the action of the valve. If the current taken by TR_1 should tend to rise, the effective bias resistance for V_1 would be reduced in value and the voltage across it would therefore drop. This is, of course, the voltage available for TR_1. The only special care that should be taken is to see that all connections in the grid circuit of V_1 are sound. This is important, in any case, to safeguard the valve. However, an open grid circuit could also cause a dangerous increase in the voltage across TR_1.

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.

Signal Generator RS600.—J. Hewitt, 11 Old Dover Road, Canterbury, Kent, requires the manual for this instrument—made by British Physical Laboratory, London.

* * *

Triplett Signal Generator Model 1632.—E. F. Denning, Grange Road, Albrighton, Staffs, would like to obtain the circuit or manual.

* * *

Dynatron Models FM1 and T99A.—W. H. Rees, 57 Belmont Road, Bushey, Herts, wishes to buy or borrow circuit diagrams or manuals. The FM1 is a switched f.m. tuner and the T99A a 4-waveband superhet tuner.

* * *

Coronet Transistor 6.—W. L. Brunsdon, 56 Greenwood Lane, Wallasey, Cheshire, urgently requires to purchase or borrow the circuit diagrams of the following two receivers—all correspondence acknowledged. Serial No. 11462 or No. 51438, both made by Fidelity Radio.

* * *

G.E.C. All-Wave Receiver Model BG3850.—J. E. V. Henty, 24 Edward Way, Ashford, Middx, requires the loan or purchase of the service sheet for this 5 valve a.c. receiver.

* * *

Long Wave Adaptor.—Dr. Stanley J. Harris, 24 Bentinck Road, Nottingham, wishes to procure, or have made, a long wave adaptor pre-set at 1500 metres, suitable for a car radio.

Cossor Melody Maker.—T. Smith, 6 Kirkby Avenue, Aherton, Manchester, wishes to purchase or borrow the service sheet for this model No. 501UL.

* * *

R1155 Receiver.—W. Barratt, Isabella Cottage, 59 Main Street, Monkton, Ayrshire, would like to obtain the manual or circuit of this receiver—purchase or loan.

* * *

G.E.C. Receiver, Serial No. BC4070.—C. Angell, Bericote, Malvern Wells, Worcs, requires the circuit diagram of the above receiver.

* * *

Valve Type 12E1.—G. Downham, 36 St. Pauls Road, Gloucester, is seeking information on using this valve as an audio or r.f. amplifier.

* * *

BC348N.—1939223 S.A.C. Warwick, Signals Section, R.A.F., Salalah, B.F.P.O. 69, would like to buy or borrow the circuit and any other details of this receiver.

* * *

Supreme Model 89 Valve Tester.—W. J. Cale, 27 Milnes Road, Berea, Durban, Natal, Republic of S. Africa, requires to convert this for testing modern valves. Has any reader any information on this tester or the circuit?

News and Comment

TV Aid to the Blind

Following upon our report last month on a series of experiments for providing hearing aids for *totally* deaf people we now learn of a possible development of television which would enable the blind to "see".

Dr. Allen B. DuMont of the Fairchild Camera and Instrument Corporation of New Jersey at a Television Symposium said "there are outstanding electronic scientists who are firmly convinced that we will be able, eventually, to feed electrical waves directly to the human brain—and to feed them with such precision that, in combination with the human nerves, a blind person will actually enjoy television pictures. In other words, we will electronically bypass the human eye, and yet achieve the same stimuli to the correct parts of the nervous system."

We mentioned in our last issue the use of small transistorised receivers for a simultaneous trans-translating system at the Westminster Theatre. Referring to areas of the world where there are language problems Dr. Du Mont, still referring to TV said, "the transmission of programmes will most certainly employ multilingual sound, so that all persons within viewing areas can understand the language. This will probably be done by multi-plexing on a single-sound carrier or by using frequency modulation multi-sound channels."

Radio for Beginners

Newcomers to the hobby of radio construction are not always sure which constructional projects it is reasonable for them to build in view of their lack of experience.

The new edition of our Data Book, "Short Wave Receivers for the Beginner", is ideal for this purpose. After introducing the factors which make short wave listening such a fascinating pastime, there follows a chapter on soldering, that most important part of radio construction. Then, commencing with a 1 valve battery receiver, detailed constructional details are given of receivers of gradually increasing complexity. 72 pages costing only 6s. make this book wonderful value for the beginner.

Authority v. Authority

The BBC recently lost an appeal against the decision of the Special Commissioners of Income Tax assessing the corporation to income tax under schedule D for the year 1958/59.

The BBC claimed the same immunity from income tax as the Crown because, broadly, it was performing Crown functions. The Crown assumed a monopoly over wireless broadcasts from the earliest days of radio. No station may transmit without a licence and the fees are payable to the Exchequer and the monies for a broadcasting service are voted by Parliament.

It was submitted on behalf of the BBC that it was carrying out a public service financed out of public funds and that it did not receive money directly from members of the public.

The Inland Revenue claimed that the BBC carried on a trade and was thereby prevented from being considered as the Crown, or agent thereof.

The decision means that the Government receives back in income tax part of the excess of its contribution to the corporation over and above the BBC's expenses. To the layman it just seems a question of handing over money from one Government pocket to another.

I.T.A. Report 1962/63

The Independent Television Authority does not receive money from public funds but, if the Television Bill becomes law, it will have to collect rentals from the programme companies not only to cover the authority's costs but also to provide additional revenue for the Exchequer.

Mention is made in the report of "a study which has begun of ways and means by which the guidance (on violence) given to producers could be embodied in . . . a code", and considerable detail is given of expanded rules concerned with the potential effect of advertising on children.

We think Lord Boothby's observations on the subject of children seeing violence on the screen worth repeating again. He said: "Children enjoy seeing cowboys shooting each other in Westerns because they simply don't believe it. What they fear is insecurity. If they see other children or even small animals ill-treated or abandoned on the screen, it really does upset them."

The revised rules for advertisements used in association with programmes intended for children, or which they might see, state that the methods used must not be likely to result in harm to them physically, mentally or morally and must not take advantage of the natural credulity and sense of loyalty of children.

A few of the many examples given are: "children must not be encouraged to go into strange places or converse with strangers in order to collect coupons"; "advertisements must not suggest that unless they buy the product they will be failing in some duty or lacking in loyalty to some person or organisation"; "children seen in advertisements should be reasonably well-mannered and well-behaved".

Unfortunately, given half a chance, children will watch programmes which most parents consider unsuitable. The question of truth in advertisements is a very big thing where children are concerned. Have you ever tried explaining to a child how it is that Mr. X can advertise that he bakes the best bread in the town while Mr. Y, in the same local newspaper, says that his loaves are acknowledged as superior to all others?

Outside TV Aerials

Established readers may remember that a year or two ago we published a photograph of a complete maze of TV aerials situated on the roof of a block of flats near to our editorial offices. The photograph was used to illustrate the advantage of communal TV aerial systems. The ugliness of some aerial arrays is almost as irritating as the loss of peace and quietness which seems to be the price we have to pay for so many technical advances, not least in the radio field.

We were therefore interested when the P.M.G. was asked in the Commons by Mr. Mason, M.P. for Barnsley, what research was being carried out to enable the television transmissions to be received without an outside aerial, and whether legislation could be introduced to abolish them in due course.

In the course of his reply Mr. Bevins made the following interesting remarks.

"An aerial of one sort or another is indispensable for the reception of television by radio; and to get a satisfactory picture it must normally be situated outside on the roof above the level of the surrounding buildings.

(Continued on Page 129)

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

part 25

understanding radio

By W. G. MORLEY

IN LAST MONTH'S ISSUE WE ENDED OUR EXAMINATION of iron-cored transformers, discussing practical applications and magnetic shielding. We then dealt with air-cored and iron-cored chokes, concluding with a description of the swinging choke. We shall now carry on to air-cored transformers.

Air-Cored Transformers

The term "air-cored transformer" applies to transformers which do not have an iron core; although in order that the inductance of one or more of the windings can be varied an adjustable iron dust core, or cores, may be fitted. An iron dust core will vary inductance by entering one of the windings by an adjustable amount, and whilst it may in practice also modify the degree of coupling between windings this is not its primary function. Iron dust cores do not provide a path for a magnetic field which completely enclose the windings, as occurs with an iron core.[1]

Air-cored transformers are almost inevitably employed at radio frequencies, whereupon they are more commonly referred to as *radio frequency transformers*, or as *r.f. transformers*. A special class of r.f. transformer deals with what are known as *intermediate frequencies*, and these are described as *intermediate frequency transformers* or *i.f. transformers*.[2]

[1] An exception is given with pot core assemblies, which will be referred to later.

[2] In one type of receiver, the superhet receiver, amplification of received signals is partly carried out at a particular fixed frequency known as the "intermediate frequency". The intermediate frequency falls within the radio frequency spectrum and is treated in the same way as any other radio frequency. The term "intermediate" results from the manner in which the superhet receiver operates, and it has no other significance.

The majority of r.f. transformers employed in radio have one or more of the windings resonant at the frequency at which the transformer is to work. This is in direct contrast with iron-cored transformer operation where the windings are not normally intended to be resonant. With the r.f. transformer, the resonant winding is usually tuned by a parallel capacitor; whereupon the assembly may consist of one tuned winding and one or more coupling windings, two tuned windings coupled together (with, possibly, one or more coupling windings), or, more infrequently, combinations employing more than two tuned windings. Occasionally, r.f. transformers are encountered which have no resonant windings. These are used for impedance matching in the same manner as an iron-cored transformer, and they will be discussed later.

Single Tuned Winding Assemblies

R.F. transformers having single tuned windings may take up a number of forms, and these will now be dealt with.

Fig. 151 illustrates a typical r.f. transformer of the type which would be employed for tuning over the medium wave band of approximately 1,500 to 500 kc/s (200 to 600 metres).[3] The transformer consists of a single-pie wave-wound tuned winding together with a wave-wound coupling winding. The tuned winding will be required to have a high Q, and it will normally be wound with litz or bunched wire. The coupling winding is not required to have as high a Q, and it may be wound with single-strand

[3] See "Understanding Radio" part 19 (March 1963 issue) in which it was pointed out that a receiver must have at least one tuned circuit resonant at the frequency of the signal it is intended to receive.

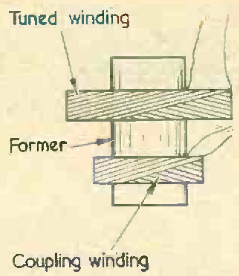


Fig. 151. A typical r.f. transformer, as would be employed for operation at frequencies in the medium wave band

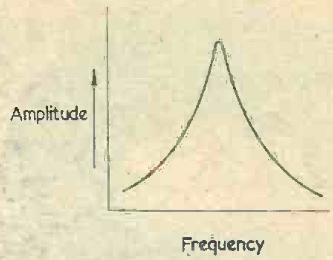


Fig. 153. A response curve, as would be given by the circuit of Fig. 152. Adjusting the variable capacitor will alter the frequency at which the peak of the response appears

wire having a lower diameter than the overall diameter of the wire in the tuned winding. The transformer of Fig. 151 is not provided with an iron dust core.

The transformer under consideration may be connected into a receiver circuit in the manner shown in Fig. 152. In this diagram the two windings are depicted in the same manner as for an iron-cored transformer, but the straight lines between the coils which would indicate the presence of an iron core are omitted. Signals, which may be obtained from the receiver aerial, are applied to the coupling winding and, thence, to the tuned winding. A variable capacitor is connected across the tuned winding and this adjusts the frequency at which the winding is resonant. Since the tuned winding and the capacitor form a parallel tuned circuit, this offers maximum impedance at the resonant frequency. The result is that signals at the resonant frequency are passed on to the succeeding part of the receiver at greater amplitude than all others, and we obtain the response curve which is shown in Fig. 153. By adjusting the variable capacitor we alter the resonant frequency of the tuned circuit and, also, the frequency at which the peak of the response curve appears.

The frequency of the medium wave Light Programme transmitter is 1,214 kc/s (=247 metres) so that, if we adjust the capacitor such that the tuned circuit is resonant at this frequency, the Light Programme signal will appear at the peak of the response curve. We can then say we are *tuned to* (or have "tuned in") the Light Programme signal.

The tuned circuit given by the r.f. transformer will have a high impedance at resonance (its dynamic resistance) and the coupling winding may be employed to match this high impedance to a source of signal having a lower impedance. In such an instance, the coupling winding will have fewer turns than the tuned winding, so that an impedance step-up effect, similar to that given by an iron-cored transformer, is obtained. The degree of coupling between the two windings is, however, very much lower than occurs in an iron-cored transformer, and the simple relationship for turns ratio in the latter cannot be applied with accuracy to the present case. With a coil of the type shown in Fig. 151, it may be generally assumed that an impedance step-up or step-down takes place according to the number of turns in the windings, but the actual impedance presented by the coupling winding may differ widely from the figure which would be expected from a mere consideration of turns ratio.

The degree of coupling between the coupling and tuned winding may be varied by moving the coupling winding closer to, or further away from, the tuned winding. As the coupling winding approaches the tuned winding the coupling becomes *tighter*, and as it moves away from it the coupling becomes *looser*. A very tight coupling is provided in the transformer shown in Fig. 154, where the tuned winding is wound on top of the coupling winding. The tightest possible coupling is given by employing a tap in the tuned winding itself, as shown in Figs. 155 (*a*) and (*b*). In this instance, the coupling winding now becomes part of the tuned winding, whereupon we have an autotransformer.

We said just now that impedance transformations

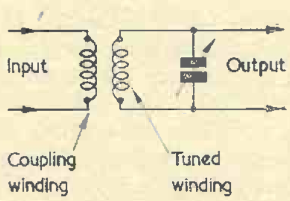


Fig. 152. The r.f. transformer of Fig. 151 may be connected into a receiver circuit in the manner shown here. It will be noted that the circuit symbol for the r.f. transformer is the same as for an iron-cored transformer, with the exception that the straight lines representing the iron core are omitted

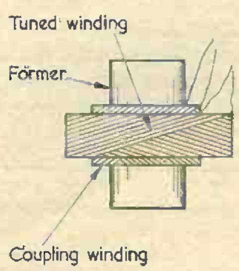


Fig. 154. A tight coupling is provided when the tuned winding is wound on top of the coupling winding

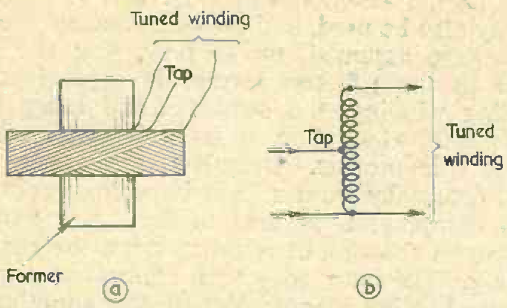


Fig. 155 (a). The tightest possible coupling is given when the coupling winding becomes part of the tuned winding itself, resulting in an autotransformer (b). The circuit symbol for the autotransformer of (a)

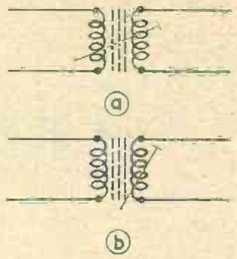


Fig. 157. An r.f. transformer with an adjustable iron dust core may be depicted in a circuit diagram as shown here. The T-symbol (indicating "pre-set") passes through the tuned winding only in (b), and this is the more correct method of presentation. Nevertheless, both versions are employed in practice

in r.f. transformers cannot be accurately evaluated by a consideration of turns ratio. It is worth adding, nevertheless, that the impedance transformation figure offered by the transformer more closely approaches that which would be expected from the turns ratio as coupling becomes tighter.

When we dealt with iron-cored transformers, we saw that the primary may offer an impedance which is "reflected" from a load connected across the secondary.[4] It is similarly possible for a reflected impedance to appear across the secondary when an impedance is connected across the primary. This point is of importance in r.f. transformer design. If the coupling winding is connected to a source of signal having a relatively low impedance, a correspondingly low impedance can be reflected across the tuned winding. If the source impedance is largely resistive (as it usually will be in practical instances) the reflected impedance across the tuned winding becomes similarly resistive, and may be considered as a resistor connected in parallel with the dynamic resistance of the tuned circuit. The total effective resistance across the tuned circuit is then reduced, giving the same result as reduced Q.

[4] See "Understanding Radio", part 23, July 1963 issue.

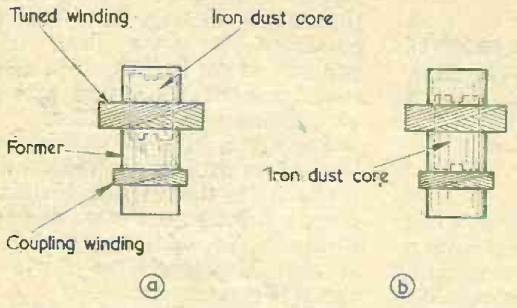


Fig. 156 (a). An r.f. transformer employing a dust iron core
(b). If the core is adjusted to the position shown here, the tuned winding has the same inductance as in (a). However, the coupling between the two windings is tighter

This is usually an undesirable effect, and it can be alleviated by reducing the number of turns on the coupling winding and/or by loosening the coupling.[5]

In passing, it should be mentioned that, when a tuned circuit in an r.f. transformer is caused to act as though it had a reduced Q for the reasons just mentioned, it is described as being *damped.* This term may also be used if the effective Q of a parallel tuned circuit is reduced by connecting a resistive impedance, or a physical resistor, directly across it.

Fig. 156 (*a*) illustrates an r.f. transformer which, like that of Fig. 151, may be employed for tuning over the medium wave band. However, this transformer differs from that of Fig. 151 in that it has an iron dust core, which enables the inductance of the tuned winding to be varied. The associated circuit symbols are shown in Fig. 157. Because an iron dust core is fitted, the transformer may be made smaller in size than the purely air-cored version. A point of interest with the iron dust core transformer is that, if the core is adjusted so that it protrudes towards the coupling winding, as in Fig. 156 (*b*), the coupling between the two windings is tighter than if it protrudes on the other side, as in Fig. 156 (*a*). It is possible to obtain the desired inductance in the tuned winding with either setting of the core, but it is important to note that one setting results in tighter coupling. In some circuits, performance may be degraded by choosing the

[5] As we shall see in more detail next month, the very tight coupling given in the case of the autotransformer of Fig. 155 can give rise to trouble due, also, to reflected inductive or capacitive impedances across the tuned winding.

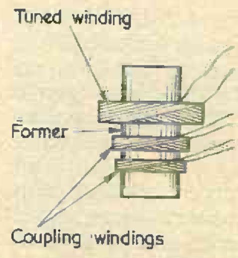


Fig. 158. An r.f. transformer may have more than one coupling winding

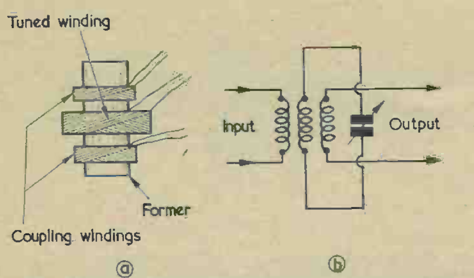


Fig. 159. Occasionally, an input signal is applied to one coupling winding, whilst an output signal is taken from another coupling winding. A suitable transformer construction is shown in (a) and the associated circuit in (b). It is assumed that no iron dust core is fitted

incorrect setting (which may be either that of Fig. 156 (*a*) or Fig. 156 (*b*) according to transformer and circuit design) and some coils are so designed, physically, that the incorrect setting cannot be obtained. This effect is absent when a single-pie tuned winding is wound on top of the coupling winding, or when a single-pie autotransformer design is employed.

Frequently, r.f. transformers of the type we are considering have more than one coupling winding. An additional coupling winding can, for instance, be added as shown in Fig. 158. The additional coupling winding could, also, be fitted on the other side of the tuned winding. Other permutations based on the assemblies of Figs. 151, 154 and 155 (*a*) may also be used, and are often encountered.

We have assumed, up to now, that the input signal to the r.f. transformer is applied to the coupling winding, the output signal being taken from the tuned winding. It is, however, possible to reverse this process. In this instance, the input signal (normally from a high impedance source to avoid damping) is applied to the tuned winding, whereupon the output is taken from the coupling winding. The latter may then connect to a circuit having a low impedance. Yet another combination, which is occasionally met, consists of applying the input signal to one coupling winding and taking an output signal from another coupling winding, as shown in Figs. 159 (*a*) and (*b*). Both the input and the output circuits may then be at low impedance. In an arrangement of this nature the tuned winding (or most of it) would appear physically between the two coupling windings. This method of construction is necessitated by the low degrees of coupling between windings (as compared with an iron-cored transformer). It can then be considered that the input coupling winding couples to the tuned winding and the latter couples, in turn, to the output coupling winding.

Next Month

We shall continue our discussion on r.f. transformers with single tuned windings in next month's issue, after which we shall carry on to transformers having two tuned windings.

Reflexed Single-Valve Television Sound Receiver

By JOHN K. GORDON

By means of an ingenious valve reflex circuit, this inexpensive receiver offers loudspeaker reproduction of the local television sound channel. The design is intended for Band I channels in the service (i.e. non-fringe) area of the transmitter

There are often times when a small, completely self-contained and self-powered television receiver for sound only can prove extremely useful. For certain concert performances, for example, the vision is not always highly important and the domestic set may be tied up with the family on a different channel. It is handy, then, to be able to go into another room and listen to the sound of the channel not voted as the more popular by the rest of the family.

For Tape Recordings

There are, also, those times when a tape recording of the sound accompaniment of a television programme is required. The receiver about to be described is ideal for such an application, and it is interesting to observe that the cost for its construction is less than the cost of a good quality mains isolating transformer, which most ordinary domestic television sets demand before they can be employed to make a recording with adequate safety.

The receiver also has a unique circuit, and for that reason alone it is bound to have a general appeal to the experimenter.

Four Stages

In spite of the modest single valve, the receiver features four distinct stages. These can be picked out from the circuit in Fig. 1. The valve employed is a Mullard triode-pentode of the ECL83 class, and the triode section $V_{1(a)}$, first acts as a grounded-grid r.f. amplifier.

The signal from the coaxial down-lead of an ordinary television aerial is applied to the cathode of the valve section through the matching transformer L_1/L_2, while the grid is held at chassis potential so far as the signal is concerned by C_1.

The triode section is biased by grid current resulting from the use of the 10MΩ grid resistor R_2, which avoids having to break the cathode circuit to introduce a bias resistor and bypass capacitor. Slightly greater gain is also possible by the use of grid current biasing.

Components List

Resistors. Unless otherwise stated, all fixed resistors are ½ watt

R_1 47kΩ
R_2 10MΩ
R_3 47kΩ
R_4 1MΩ log pot, with switch
R_5 280Ω
R_6 1kΩ 3 watt
R_7 15Ω 1 watt

Capacitors

C_1 0.001μF ceramic
C_2 0.001μF ceramic
C_3 Twisted pair (see text)
C_4 0.1μF paper
C_5 0.1μF paper
C_6 0.001μF paper or ceramic
C_7 50μF 12V wkg electrolytic
C_8 16μF 250V wkg electrolytic
C_9 8μF 250V wkg electrolytic

Valve

$V_{1(a),(b)}$ ECL83

Inductors

L_1–L_4 See text
T_1 Speaker transformer. 50:1 for 3Ω speaker
T_2 Mains transformer. Secondaries: 150V at 35mA, 6.3V at 0.6A minimum

Diode

D_1 Germanium diode GEX34

Rectifier

MR_1 Contact-cooled rectifier. Minimum rating 150V input at 35mA

Switch

$S_{1(a),(b)}$ On-off. Ganged with R_4

Miscellaneous

1 B9A valveholder
Chassis
Sockets, etc.

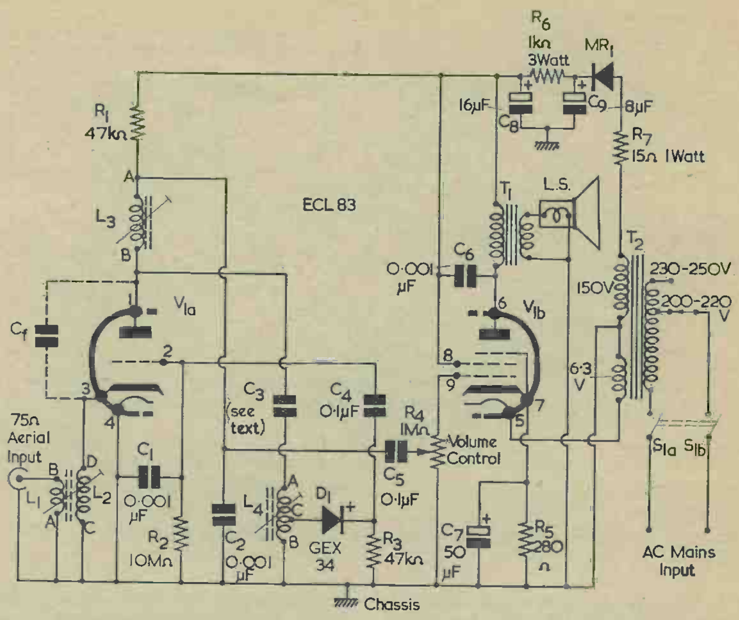


Fig. 1. Complete circuit of the receiver. C3 is formed by a twisted pair

The amplified television sound signal is developed across L_3 in the triode anode circuit, and the low potential (signal-wise) end of this inductor is held at chassis potential by C_2. The signal from L_3 is coupled by C_3 to the tapped inductor L_4 which, together with L_3, forms a kind of bandpass circuit to give the required selectivity, bearing in mind that the selectivity performance must be sufficient to eliminate vision signal breakthrough.

Thus, so far explained, the triode section of the valve acts as a fairly conventional grounded-grid r.f. amplifier.

Diode Detector

The amplified and selected signal is applied to the GEX34 germanium diode from a suitable impedance point at tap C on L_4. Tapping down in this way also avoids heavy damping of the tuned circuit by the relatively low impedance of the diode circuit. The diode load is R_3, while the reservoir capacitor is formed by C_4 and C_1 in series.

Across R_3, therefore, appears a low-level audio signal, and this must be amplified before it can possibly be used to drive an output pentode.

Audio Amplification

Audio amplification is also provided by the triode section of the valve, since the a.f. voltage across R_3 is coupled to the grid of the triode through C_4. This has no effect on the r.f. signal as this is adequately bypassed by C_1.

The anode of the triode is further loaded by a resistor R_1, and it is across this that the amplified audio signal is developed, remembering that the amplified r.f. is "grounded" through C_2. The value of R_1 can be increased to give greater audio gain at the expense of r.f. gain, but the value given in the circuit represents a good compromise between r.f. and a.f. gain and also avoids too much treble-cut due to the r.f. filter capacitor requirements in the audio section.

Output Stage

The amplified audio appearing at the anode end of R_1 is fed through C_5 to the slider of the volume control and, since the resistive element of the control is connected between the control grid of the pentode section of the valve and chassis, the required level of audio applied to the pentode can be adjusted in the usual way by the volume control. Applying the signal to the slider avoids a sliding connection actually in the grid circuit of the pentode, and thus ensures a quiet control of volume.

The pentode is cathode biased by R_5 and negative current feedback is prevented by the use of the bypass electrolytic C_7. C_6 eliminates the effects of third harmonic distortion and also provides a degree of tone correction. Its value can be reduced if required (e.g., if improved treble response seems to be needed).

Power Supply

One feature of the receiver is the complete isolation from the mains supply by the use of a double-wound mains transformer T_2 (as distinct from an auto-transformer). This means that the receiver can provide a signal for an audio amplifier or tape recorder with complete safety.

The transformer primary winding should match the local a.c. mains voltage, while the h.t. secondary should give 150 volts r.m.s. at 35mA minimum. The heater winding should be rated at 6.3 volts 0.6A minimum.

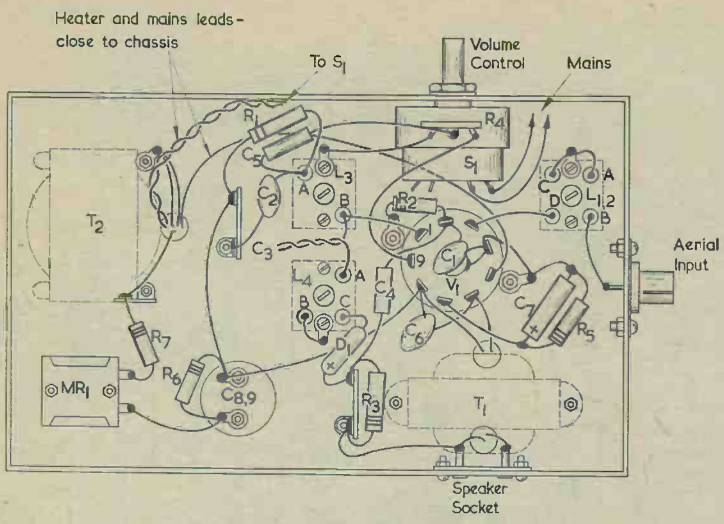


Fig. 2. A suggested layout and point-to-point wiring plan

H.T. is given by a small contact-cooled selenium rectifier fed, preferably, by a surge limiter resistor R_7. A 1kΩ resistor in conjunction with an 8μF reservoir electrolytic (C_9) and a 16μF smoothing electrolytic (C_8) provides adequate smoothing, and the screen grid of the pentode—under these conditions of voltage—can be connected direct to the h.t. line.

A double-pole on-off switch, ganged to the volume control, is included in the mains input circuit. A fuse was not considered warranted in the prototype, but can, of course, easily be included in the mains input circuit if required.

Construction

No hard and fast rules are given for the construction of the receiver, as the ideas of individual enthusiasts can then be incorporated, if desired. However, a suggested layout, showing also the point-to-point wiring in some detail, is given in Fig. 2.

Here a small tray-type chassis is employed having dimensions which fit in comfortably with the mains and speaker transformers. The transformers drawn in broken line are mounted at the top of the chassis, as also, of course, are the tuning coils. Fig. 2, in fact, gives the under-chassis view of the wiring and components.

It should be noted that the number of turns and turns spacing on the coils required to tune a specific channel are influenced to some small amount by the exact layout and wiring routes adopted in proximity to the coils and tuned circuits, and for this reason the information given in the Table should be looked upon essentially as a guide.

Holes to take rubber grommets are drilled below either side of T_1 and below one side of T_2, and through these the transformer lead-out wires are conveyed to the various circuit points. The appropriate mains primary tap is used on T_2 and the unused voltage tap wire is adequately insulated and folded into a loop. The secondary wires of T_1 are connected to the speaker socket, and one side is also connected to a chassis earth point.

The mains and heater leads carrying a.c. should be routed as close as possible to the surface of the chassis so as to avoid undue hum pick-up. These leads should also be kept as far away as possible from the triode and pentode grid circuits. It often pays to use screened cable on the two "live" volume control circuits.

Coils

Basic details for constructing the coils are given in Fig. 3, while winding information is given in the Table. All the coils are wound on Aladdin Bakelite formers Type PP59386, and screened by Aladdin aluminium cans Type D/TV2. The coil lead-out wires can be held firm at the top of the formers if this is considered necessary by Aladdin top plates Type PP5939, but since 18 s.w.g. tinned copper wire was used for this purpose in the prototype adequate stability was automatically achieved.

The coded lead-out wires in Fig. 3 correspond to the letter code adopted both on the circuit diagram and on the under-chassis point-to-point wiring and assembly diagram. Holes of about $\frac{3}{16}$in diameter should be drilled in the chassis at the coil lead-out positions, and care should be taken over this exercise to ensure that, when the coils are properly lined up on the chassis, the lead-out wires protrude through the exact centre of the holes.

All coils are tuned by dust-iron core Type 500/900, and these are best held firmly in the cores by thin elastic.*

Operation

After the finished receiver has been carefully checked for wiring accuracy and freedom from h.t. and l.t. short-circuits, the mains supply can be connected and the receiver switched on. The receiver is designed to operate any 3 to 7Ω loudspeaker system, and a speaker should be connected before turning up the volume control.

A very low level hum will be heard in the speaker when the volume control is turned up, and some sort of sound or vision signal will almost certainly be audible when a television aerial is connected. The core of L_4 should first be adjusted for maximum

* The coils may be wound on the familiar Bakelite formers having an outside diameter of 0.30in and a square base measuring 0.765 by 0.765in. The dust cores, preferably v.h.f. types, have a diameter of 6mm and a length of 12.7mm.—EDITOR.

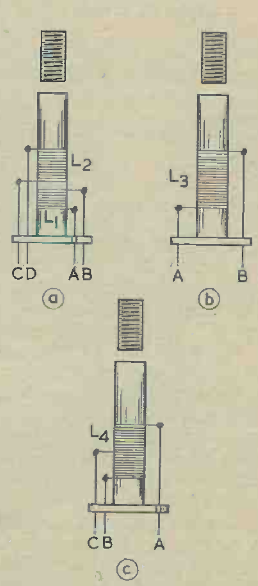


Fig. 3. Details of the coils. See Table. The lead-out wires may be 18 s.w.g. tinned copper

sound output, followed by the core in L_3 and finally that in L_1/L_2. L_4 tuning will be reasonably sharp (but see the following notes on the adjustment of C_3) and L_3 very sharp. L_1/L_2, on the other hand, is very flat indeed.

Adjusting C_3

Capacitance C_3 is formed by four twists of two thin, p.v.c. covered conductors. The resulting value of capacitance generally provides a reasonable balance between gain and selectivity, depending upon the local signal conditions. Should vision breakthrough seriously trouble the required sound signal, however, the value of C_3 may be too large. Alternatively, there may be excessive stray capacitance between the wiring of L_3 and L_4 and/or L_3 and L_4 may not be peaking correctly.

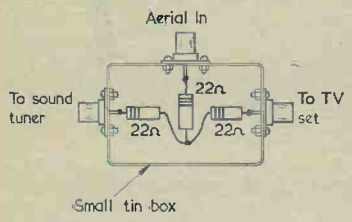


Fig. 4. A network which allows the sound receiver to be operated from the domestic television aerial without affecting normal viewing

The latter possibility should first be checked by ensuring that the coils give a tuning peak when the cores are adjusted just *before* the centre of the windings. If this is not so, then the number of turns and/or the turns spacing should be adjusted accordingly.

For example, the number of turns should be decreased by a small amount if the coil tends just to enter the range of the required sound channel when the core is totally removed from the former. Such a symptom indicates that the coil inductance is too great. The converse will apply if tuning just commences when the core is set to the centre of the winding.

TABLE

Channel	Frequency Mc/s	Number of Turns				
		L_1	L_2	L_3	L_4	L_4 tap from B
1	41.5	4.0	5.5	8.0	7.5	3.5
2	48.25	3.0	4.5	7.0	6.5	3.5
3	53.25	3.0	4.0	5.5	5.0	2.5
4	58.25	2.5	3.5	5.5	5.0	2.5
5	63.25	2.5	3.5	5.0	4.5	2.0

Wire: 22 s.w.g. enamelled-covered all coils.
Winding: Close-wound. Spacing between L_1 and L_2 diameter of wire only.

When it has been established that the coils are tuning correctly and vision breakthrough is still troublesome, one or two twists should be removed from C_3 and L_4 and L_3 readjusted for maximum peak. If there is still excessive breakthrough with C_3 completely untwisted, the wiring in the proximity of the two coils must be rearranged to reduce the high stray capacitance.

To avoid depriving the domestic television receiver of a signal when the sound receiver is being adjusted or used, Fig. 4 shows how two outputs can be obtained from the one downlead over any channel. This device is often called a "star network" for obvious reasons, and by the use of three 22Ω resistors (non-inductive carbon composition type) each socket looks like 70/75Ω when the others are correctly matched to a similar value impedance.

The network can easily be built into a small tin box of the type used to house tobacco and like materials. But it must be remembered that the cost of achieving a correct all-round match is 6dB of aerial signal. That is, each receiver obtains approximately half the signal that is in the aerial downlead.

Final Notes

While the prototype was designed for use on Band I channels, there are no specific reasons why it could not be used on **Band III** channels, provided, of course, there is adequate Band III signal available in the aerial. The receiver is essentially of use in service areas, for a single valve cannot be expected to give fringe area performance no matter how effective the reflexing.

A very strong signal could well cause overloading and make it virtually impossible to eliminate vision signal breakthrough, but this can easily be corrected by the use of a downlead attenuator. The star network described may, in fact, be sufficient to reduce the signal strength to a more suitable level.

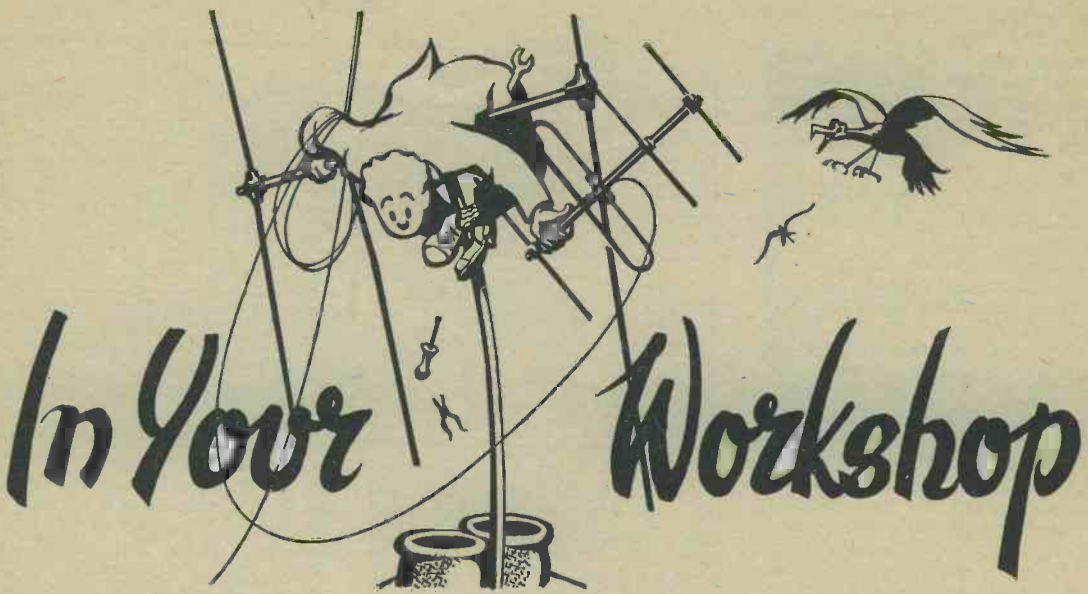
A degree of Q-multiplication can be introduced by connecting a very small value capacitor between the triode anode and cathode, as shown by C_f in Fig. 1. Too much forward coupling of this kind will, however, turn the stage into an oscillator and cut out receivers in the neighbourhood by pattern interference; and this *must* be avoided at all costs. However, just a little coupling, as given by a single twist on two p.v.c. covered conductors (as for C_3) will increase both the selectivity and sensitivity, and can be useful in low signals areas and to enhance vision signal breakthrough.

BBC EXPERIMENTAL STEREO TRANSMISSIONS

In order to assist the manufacturers of stereophonic receiving equipment, the BBC's experimental transmissions using the Zenith-G.E. pilot-tone system were recently increased from one period per week to three per week. The new schedule of transmissions from the Wrotham Third Programme transmitter on 91.3 Mc/s is as follows on Tuesday, Wednesday and Thursday mornings each week: 10.30–11 tone test transmission; 11.15–11.45 programme test transmission.

Both transmissions are preceded by four minutes of tuning signal consisting of two tones of different pitch—the one of lower pitch being on the A (left-hand) channel—followed by one minute with no modulation. At the beginning of the programme period there is a stereophonic announcement for setting-up purposes and the tone transmission is preceded by an explanatory announcement.

The fortnightly experimental transmissions on alternate Saturday mornings, using the television sound channel and the VHF and medium-waveband Network Three frequencies, have been interrupted for the usual summer break, but will be resumed this month.



In Your Workshop

This month Smithy the Serviceman, aided as always by his able assistant Dick, probes the mysteries of vertical and line flyback suppression circuits

"DRAT THESE FLYBACK LINES!" Dick thumped his soldering iron down on its stand, and glared malevolently at the receiver in front of him. This reproduced an excellent picture which was marred only by a succession of sloping white lines whose brightness varied with the overall brightness of the scene being reproduced.

"Drat them!" continued Dick, his voice edged with venom. "Dang them, darn them and drat them!"

"Now, now," said Smithy soothingly, turning round from his bench, "swearing won't make things any better."

"It makes *me* feel better," snorted Dick in reply. "I've spent two hours working on this blistering receiver, and I've already replaced a faulty line output tranny as well as sorting out a stinker of a snag in the tuner unit. I'm getting a perfect picture now, except that I've got these tarnation vertical flyback lines on the screen. What really riles me is that, when I think I've set up the brilliance and contrast controls so that the lines disappear, they come back again when the scene changes."

Line Output Fault

Smithy wandered over and gazed at the offending receiver.

"You aren't", he remarked mildly, "*supposed* to be able to clear vertical flyback lines with the receiver controls. There's a special suppression circuit in the set which should clear them for you."

"Well, it's not" replied Dick, "working for me!"

"Perhaps not," commented Smithy. "Anyway, tell me what you've done up to now."

"As you like," said Dick, his tone becoming somewhat more equable at the prospect of advice from Smithy. "Well, the set came in almost completely kaput. The valves lit up but there was no e.h.t. So I started to do a little fault-finding in my usual masterly manner."

"I see," said Smithy. "Was the line output transformer singing?"

"Very audibly," replied Dick. "Well, the first thing I did . . ."

"And," interrupted Smithy, "did the heater of the e.h.t. rectifier light up?"

"It did," said Dick, "so the first thing . . ."

"Also," broke in Smithy, "was the e.h.t. lead properly plugged into the tube?"

"Yes it was," snorted Dick. "Now, as I was saying . . ."

"I should guess," commented Smithy, "that there was a strong possibility of an open-circuit e.h.t. overwind."

Dick threw an irritated glance at the Serviceman.

"That *was* the snag," he admitted reluctantly. "But I wish you'd let me explain it in my own way! Anyway, I put in a new line output tranny, after which there was stacks of e.h.t. But the screen was now running completely white and there was a very loud hiss from the speaker."

"Instability," commented Smithy. "Possibly in the tuner unit if it was coming through both on sound and vision."

"That's what I thought," said Dick, eagerly embarking on a description of his second fault with the receiver. "Well, I started . . ."

"Did the instability clear when you swung the turret between channels?"

"Yes it did," said Dick. "So what I . . ."

"Swinging the turret between channels," interrupted Smithy, "usually breaks the h.t. supply to the oscillator and the r.f. amplifier valve. So that would confirm that the instability was in the tuner."

"It *was* in the tuner," said Dick irritably. "Now, as I was . . ."

"In which case," continued Smithy imperturbably, "I would check if the tuner used a cascode. If it did, a very likely fault would be an o/c bypass capacitor on the grid of the upper triode."

Dick scowled at the manifestly untroubled Smithy.

"All right then," he remarked eventually, "the tuner *did* have a cascode, and the grid bypass capacitor *was* open-circuit."

"Good," said Smithy briskly, "that brings us up to the present! Let's now have a look at those flyback lines."

The Serviceman peered more closely at the lines on the screen of Dick's receiver. (Fig. 1.) He adjusted the brilliance control experimentally and found that, with a critical setting, he could just render the lines invisible whilst still producing an acceptable picture. However, the brilliance control setting needed to clear the lines had to be altered for scenes of different overall brightness.

"There's nothing very much wrong here," Smithy commented. "The vertical flyback suppression circuit has gone for a burton, that's all."

Dick groaned.

"It *would* be something like that,"

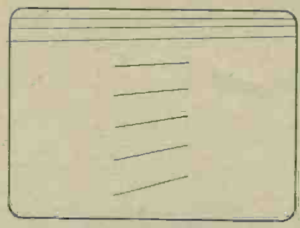


Fig. 1. A typical example of the manner in which vertical flyback lines may become visible on the c.r.t. screen

he grumbled. "Why couldn't it be something nice and easy?"

"Vertical flyback suppression circuits *are* easy," replied Smithy. "They're one of the simplest sections of the receiver."

"They may be simple to you," said Dick aggrievedly, "but they aren't simple to me! I can't even see why you need to suppress the vertical flyback anyway. You shouldn't get anything on the screen because, during flyback, the signal's at blanking level."

Vertical Synchronising Signal

Smithy picked up a stool and drew it alongside Dick's bench.

"I can see," he remarked, sitting down, "that we have stumbled on an arid patch in your general television education. We shall, in consequence, have to start right at the beginning. Hand me over your notebook."

"Here you are," said Dick enthusiastically, forgetting his previous complaints at the prospect of tackling something fresh. "One notebook coming over!"

"Right," said Smithy. "Now, the first thing to do is to take a butcher's at the sort of signal that hits the set when you come to the end of a field. Two fields make up a picture and, because they are interlaced, you get a slightly different signal at the end of each. We'll work with the 405 line system, which is what we're receiving at the time being, although much of what I have to say applies to 625 lines as well. Now, at the end of line number 405 in the transmitted picture you get a vertical synchronising and blanking period, and it looks something like this."

Smithy drew a waveform in Dick's notebook. (Fig. 2 (*a*).)

"On lines 402 and 403," continued Smithy, "you have normal picture

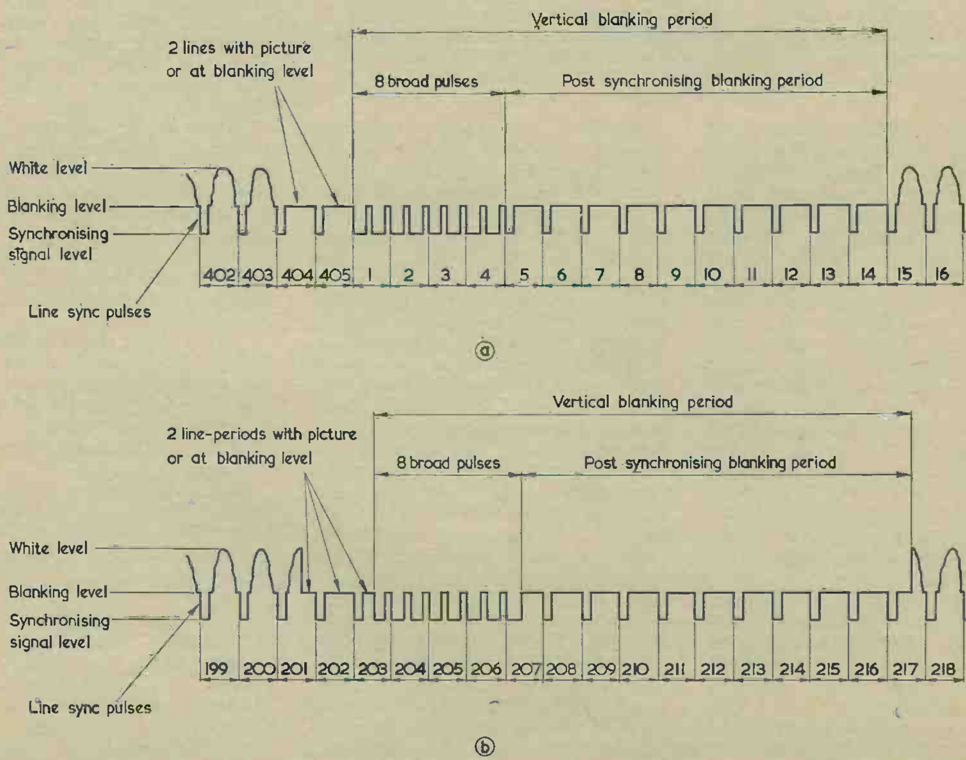


Fig. 2. The vertical synchronising signals for the 405 line system. That at (a) represents even fields, and that at (b) odd fields

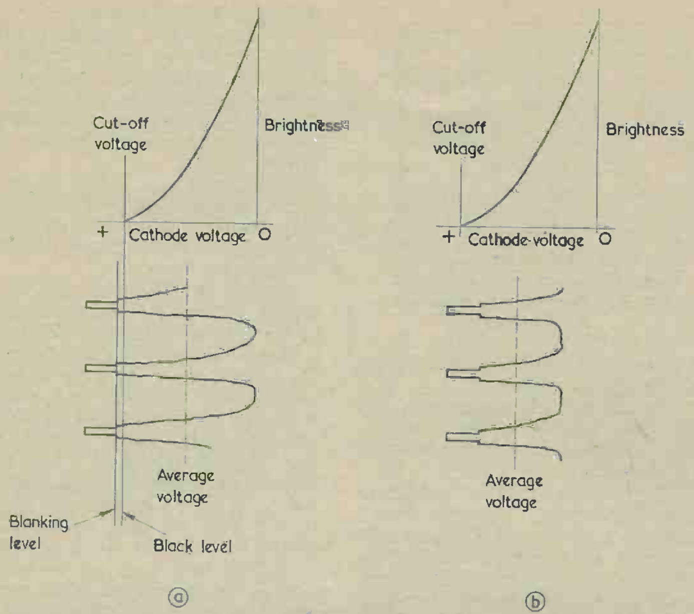


Fig. 3 (a). A typical video signal, as applied to the cathode-voltage/brightness curve of a cathode ray tube. Black level in the signal corresponds to cut-off voltage in the tube, with the result that no signal at blanking level can appear on the screen. (It is assumed that the tube is cathode modulated, whereupon picture information is negative-going)

(b). If a purely a.c. coupling to the tube cathode is employed, the signal takes up a position dictated by its average voltage. In consequence, when video amplitude falls the synchronising section moves to the right, and signals at blanking level become visible on the screen

information. On lines 404 and 405 you may get picture information, or the signal may drop to blanking level, according to what goes on at the transmitter. Whichever happens doesn't worry us here anyway. The standard line sync pulses appear between the lines right up to the start of line 405. After line 405 you get eight broad pulses, and these constitute the vertical synchronising signal. Their function is to trigger the vertical timebase oscillator into flyback, and this usually occurs somewhere between the second and sixth pulses."

"The sync circuits do the triggering for you," broke in Dick. "They may, for instance, integrate the broad pulses and change them to a single big fat pulse which initiates the vertical flyback."

"That's right," agreed Smithy. "Now, after the eight broad pulses have been transmitted, the waveform goes back to normal line sync pulses once more, the signal between pulses being at blanking level. This is the post synchronising period and it continues until line 15, whereupon you're back to picture information again."

Smithy drew Dick's notebook towards him and drew a second waveform. (Fig. 2 (*b*).)

"This," he announced, "is what you get after line 199 in the other field, and I'm including it here for the sake of completeness. As you can see, the waveform is very nearly identical to the previous one, except that the broad pulses start after a half-line instead of a complete line. This time you get picture information until you're half-way along line 201. From this point to half-way along line 203 you may get picture information or blanking level according to how generous they're feeling at the transmitter. Your first broad pulse then starts when line 203 is half-way through. You get your eight broad pulses, followed by the post synchronising period until half-way alone line 217, then you're back to picture information once more. Because you've got a half-line difference, the two waveforms differ slightly at the start of the post synchronising period, but this is of no consequence to us here."

"Do you know," remarked Dick, "you can *see* those half-lines at the top and bottom of the picture if you close the height control up a bit. I've often noticed them!"

"So you will," said Smithy, "provided the set you're using has got decent focus and interlace. Anyway, we now get on to the reason for flyback suppression. As you know, the brilliance control in a television receiver is really a grid bias control. If you have a d.c. coupling from the video output anode to the cathode of the tube and if the set fully retains the d.c. component of the signal, you can then set up the brilliance control so that black level corresponds exactly to tube cut-off. (Fig. 3 (*a*).) Blanking level, with the 405 line system, is 5% of peak amplitude below black level, with the result that none of the signal during the vertical blanking period can possibly appear on the screen."

"Exactly," said Dick triumphantly. "That's *exactly* what I said just now."

"However," remarked Smithy sadly, "we live in an imperfect world, whose many deficiencies include television owners who cannot set up brilliance controls accurately and television manufacturers who do not put d.c. coupling into the video circuits of their receivers. Not only", continued Smithy, unconsciously mounting a favourite hobby-horse, "do the set-makers omit true d.c. coupling, but they also employ mean-level a.g.c. systems whose only advantage is that the sets cost less and more money clatters into the shareholders' pockets."

"Dash it all," protested Dick, "if I had the choice between a mean-level a.g.c. set and a more expensive one with gated a.g.c., I might well think twice before spending the extra money."

"Your choice," pronounced Smithy censorially, "should be governed by consideration of picture quality only."

"What about the set you've got at home?" persisted Dick hotly. "That's just a cheap old commercial model, and I bet it's never even seen a d.c. coupling or gated a.g.c."

"I have", replied Smithy darkly, "*modified* it."

Dick had a mental vision of a receiver bristling with unaccustomed gating pentodes and clamp diodes, and hastily decided to return to the main subject.

Flyback Suppression

"We were", he reminded Smithy, "talking about the vertical blanking period. And how blanking level can appear on the screen."

"Oh yes," said Smithy. "So we were! Well, the point I was going to make is that it's fairly difficult to expect the average viewer to set up a brilliance control such that black level is just at the cut-off point for the c.r.t., and so that blanking level is beyond cut-off. If you don't have full d.c. video coupling it becomes virtually impossible. The worst case occurs with an a.c. coupling to the cathode ray tube, since such a coupling causes the signal to take up the position which corresponds to its average value. If, for example, the signal we considered just now were to be followed by one corresponding to a darker scene, the whole synchronising section moves bodily to the right. (Fig. 3 (*b*).) With the result that signals at blanking level are reproduced by the c.r.t."

"I understand it now," said Dick, light breaking in. "What you've just said explains why the brilliance control setting on the receiver I'm mending has to be continually altered to remove the flyback lines."

"You've got it," confirmed Smithy. "The case of the purely a.c. coupling I've just mentioned represents an extreme instance, but you will get the effect, to a lesser degree, whenever you depart from true d.c. coupling."

"The form that the flyback lines take up," commented Dick, "is rather interesting."

"Yes it is," replied Smithy. "In your case you have a few short lines followed by lines which spread right across the screen. The short lines are given by the short periods at blanking level during the eight broad vertical pulses, whilst the long lines correspond to the full lines at blanking level in the post synchronising period. The number of short lines you get will depend on the particular broad vertical pulse which triggers the time base, and you will obviously get more of these short lines if an early broad pulse does the triggering instead of a late pulse. The fact that the lines are sloping is, of course, due to the fact that the c.r.t. beam is being rapidly deflected upwards during the period when they appear. And the lines are spaced out unevenly because deflection, during flyback, will be pretty non-linear."

Typical Circuits

"Those lines become quite fascinating when you start looking into them," said Dick. "Anyway, what we're supposed to be doing is to be getting rid of them! How can we do that, Smithy?"

"By adding a circuit," replied Smithy, "which blanks out the c.r.t. during vertical flyback. Such a circuit can take up a number of

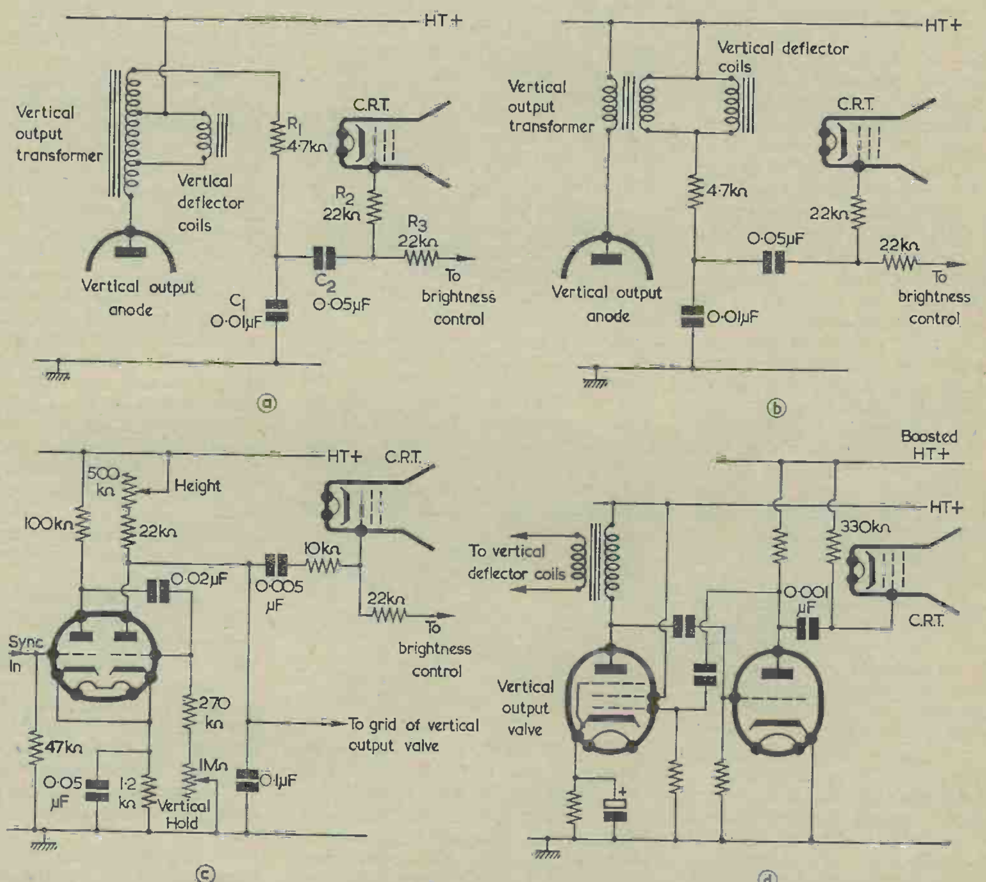


Fig. 4. Four typical vertical flyback suppression circuits, with representative component values as applicable. In (a) the blanking pulse is obtained from an additional winding on the vertical output transformer. In (b) the vertical output transformer secondary is connected such that negative-going pulses are available. Vertical timebase multivibrators provide the blanking pulse in (c) and (d). In (d) the multivibrator is shown in skeleton form, and the pulse is applied to the first anode of the c.r.t. instead of to the grid

simple forms, and they are all perfectly easy to understand. Practically all receivers these days have cathode modulation of the c.r.t., with the result that, if you want vertical flyback suppression, all you need to do is to apply a negative-going pulse to the grid during the flyback."

"Well, that should be easy enough," exclaimed Dick. "You've got a flyback pulse at the vertical output anode already made for you."

"It's not all *that* easy," commented Smithy, "because the flyback pulse at the vertical output anode is positive-going, in just the same way as the flyback pulse at the *line* output anode is positive-going. You have to do a bit of mild jiggery-pokery before you get the required negative-going pulse."

Smithy pulled Dick's notebook towards him once more.

"I'll show you a few typical examples of how the pulse is obtained," he continued. "You'll find that they're all quite simple."

The Serviceman quickly sketched out a circuit.

"Here we are," he said. "The first circuit I'm going to show you is a particularly common arrangement. (Fig. 4 (*a*).) You'll notice that the vertical output tranny is really an autotransformer, and that an extra bit of winding has been stuck on after the h.t. positive tap. During vertical flyback there's a positive-going pulse on the vertical output anode. Since the upper terminal of the autotransformer is on the other side of the h.t. positive tap, you then get a negative-going pulse at this point. The pulse is applied to R_1 and C_1, which will help to give it the desired shape, after which it is passed to the tube grid via C_2 and R_2."

Dick looked at the circuit and frowned.

"There are one or two points I'm not clear about here," he remarked. "For instance, why does the pulse have to be shaped? So long as it blanks out the tube during flyback that's all that's needed, surely?"

"You've got to have a pulse of the right shape applied to the grid," replied Smithy, "to ensure that it blanks out the tube for the correct amount of time. If the pulse is too short it will only blank out the first part of the flyback. If it's too long it will blank out the first few lines of the picture as well. R_1 and C_1 form an integrating circuit which ensures that the pulse on the grid has just the right length."

"I see," said Dick. "What's the series resistor R_2 for? Why can't the grid of the tube connect direct to C_2?"

"You'll find that series grid resistor in lots of TV sets," explained Smithy, "and its usual function is to prevent excessive grid current when you switch off. To begin with, the grid has to be bypassed to chassis by a fairly high value capacitor. When the set is switched off it's possible for the h.t. to drop very quickly, thereby bringing the cathode down to chassis potential at the same speed. The grid bypass capacitor could then discharge into the grid-cathode diode, and cause excessive grid current. In this instance, the series resistor acts as a limiter. It may also act as a grid current limiter for other conditions where there are similar changes in supply voltages. In some receivers it has the further advantage of allowing a line flyback suppression circuit to be incorporated."

"*Line* flyback suppression?" said Dick. "Blimey, I'm still struggling my way through vertical flyback suppression!"

"There's nothing very complex in line flyback suppression," remarked Smithy soothingly. "We'll get on to it in a few minutes."

"Doesn't the series resistor", asked Dick, returning to the previous topic, "cause attenuation of the higher video frequencies?"

"There's certainly a risk of that happening," agreed Smithy. "The signal is applied to the tube cathode and, thence, to the tube grid by the capacitance between them. If the reactance of that capacitance at, say 3 Mc/s is equal to the value of the series resistor, you would expect some attenuation of the 3 Mc/s bars. I don't know what the cathode-grid capacitance of a typical tube would be, because tube manufacturers only quote the capacitances between the cathode and all other electrodes and between the grid and all other electrodes. I would guess, though, that a fairly typical grid-cathode capacitance would be 4pF or so. Which corresponds to a reactance of about—let me see, now—13kΩ at 3 Mc/s."

"Is that all?" exclaimed Dick. "Many of the series grid resistors I've seen are around 22kΩ or so."

"Ah yes," said Smithy. "But don't forget that the grid has a capacitance to chassis which has also to be taken into account. This partly reduces the degeneration given by the cathode-grid capacitance. You'll find, also, that some manufacturers bridge that series resistor with a capacitor of about 100pF or so. This has little effect on voltage changes whilst switching off and so on, and it also ensures that there's negligible loss of the higher video frequencies. Anyway, we're straying away from the subject, which is supposed to be vertical flyback suppression."

"We are, rather," agreed Dick. "Have you any other typical circuits?"

"Here's a common one," replied Smithy, sketching out a further circuit in Dick's notebook. (Fig. 4 (*b*).) "This time the vertical output tranny has a separate secondary winding, and you simply connect one end of this to chassis such that the other end carries the negative-going pulse."

"But you haven't connected it to chassis," objected Dick. "You've connected it to h.t. plus!"

Smithy sighed.

"How on earth", he remarked testily, "am I going to give you any gen on vertical flyback suppression if you keep raising side-issues all the time?"

"But it's true," protested Dick. "You *have* connected that secondary to h.t. plus! Why?"

"It's to keep down the voltage between line and vertical coils in the deflection yoke," said Smithy patiently. "Apart from pulse and scanning voltages, the line coils are at the same potential as the boosted h.t. line. If you keep the vertical coils at chassis potential, you're adding a needless 200 volts to the potential between them and the line coils. By returning the vertical output transformer secondary to h.t. positive, you get the same effect as a chassis connection at vertical deflection frequencies, and you reduce the risk of breakdown between the line and vertical coils in the deflector yoke. O.K.?"

"Fine," said Dick enthusiastically. "Have you got any more typical circuits?"

"A couple more should suffice, I think," said Smithy. "In these, the pulse is derived from the vertical timebase rather than from the vertical output transformer. In this circuit for instance (Fig. 4 (*c*)), you have a cathode-coupled multivibrator driving the vertical output valve. The multivibrator output goes negative during flyback, and so you've got a negative-going pulse all ready for use."

Smithy scribbled a further circuit diagram in Dick's notebook.

"And in this one," he continued, "the vertical timebase comprises a normal multivibrator, of which the vertical output valve forms one half. (Fig. 4 (*d*).) Since the vertical output anode goes positive during flyback, the complementary anode of the pair goes negative. So you've got a negative-going pulse readily available once more."

Smithy stopped and gazed at his assistant. Dick looked up enquiringly.

"No queries?" asked Smithy.

"None at all," replied Dick. "It's all very clear to me."

"Haven't you noticed," continued Smithy, "a little peculiarity about that last circuit?"

"Peculiarity?" queried Dick thoughtfully. "No, I don't think so. It seems perfectly all right to me. Just a minute, though!"

"Yes?"

"I've just spotted it. You aren't putting the pulse into the grid at all!"

"That's right," confirmed Smithy approvingly. "You're putting it into the first anode instead, whereupon it may still blank the tube despite the fact that the control given by the first anode is not so great as that given by the grid. You'll find circuits of this type in sets which have the grid heavily bypassed to chassis, or even at chassis potential itself."

"I'm glad I spotted that first anode connection," said Dick, obviously well pleased with himself. "You know, I'm really on the ball these days. Wait a minute, Smithy, listen to this!"

Smithy groaned. Whenever his assistant was in an elated mood he had a distressing tendency to break out into verse. The concentrated frown on Dick's face showed such a moment was at hand, and the Serviceman feared the worst.

"Here we are, Smithy," said Dick excitedly, his expression clearing. "How about this?

"*At the seaside make careful selection,*
Choose a spot which gives perfect protection,
Find a wall that is high
So, when seagulls fly by,
You'll get vertical flyback suppression!"

Despite himself, Smithy had to chuckle.

"Well," he said, "I must admit you've inflicted far worse than that on me in the past."

"I'm glad you liked it," said Dick modestly. "Any time you want something like that I'm always available."

"We'll let you know," said Smithy, "Don't call us—we'll call you!"

Line Flyback Suppression

But Dick's spirits were not to be damped by Smithy's comments.

"We've had a good stab at vertical flyback suppression," he remarked briskly. "How about the old *line* flyback suppression, then?"

"As you like," said Smithy equably. "To begin with, though, I should mention that, whilst all sets have vertical flyback suppression as standard, only a relatively small proportion have line flyback suppression."

"Why do you want line flyback suppression anyway?"

"Theoretically," remarked Smithy, "you shouldn't need it at all because, during the line flyback period, the signal is either at blanking level or below. It shouldn't, therefore, appear on the screen. But, as we saw with the vertical synchronising signal, this situation doesn't occur in practice, and signals at blanking level *can* appear. Now, at the end of each line the signal drops to blanking level at the front porch of the line sync pulse. (Fig. 5 (*a*).) The front porch is followed by the sync pulse itself, and you then have the back porch. After which your next line starts. The leading edge of the sync pulse triggers off the line timebase and starts the flyback. By the time the pulse comes to an end and the back porch starts, the beam will then be almost certainly more than half-way across the screen."

"I think I see what happens here," interrupted Dick. "When the flyback starts, the signal is at sync pulse tip level whereas, at some point after half-way, it suddenly reverts to blanking level. Signals at blanking level appear on the screen, with the result that the left hand section appears brighter than the right hand section."

"I'm afraid", said Smithy, "that you're barking up the wrong tree there. The process you've just described *can* happen and probably does, but the visible effect on the screen is negligible. This is because the line flyback is so fast that effects of this nature have little influence on screen brightness. Also, even if any changes in brightness do occur, the fast flyback tends to make them relatively gradual so that one blends into the other. But there *is* an effect which can cause a visible result on the screen. If you get overshoot on the trailing edge of the line sync pulse (Fig. 5 (*b*)), you have a short-lived pulse which can give a noticeable result on the screen. This is because, even during the fast flyback, you have a sudden increase in brightness level when the overshoot starts and a sudden reduction when it finishes. The visible effect is that a faint vertical white line appears on the picture. Since there are usually very slight variations in time between the initiation of line flyback and the appearance of the overshoot, the vertical line is not stationary but tends to waggle slightly from side to side. The effect is as though you had a rope hanging downwards and you continually shake it at the top. Indeed, the trouble has, in the past, been referred to as 'rope'."

"Where does the overshoot come from?"

"It could", said Smithy, "originate in the receiver, or it could be present on the transmitted signal. I should add that the visible effect is, usually, only apparent when dark scenes are being presented. The line is quite dim in intensity, but it becomes noticeable and irritating because of the way it waggles about. If it were stationary, it would probably not be half as noticeable."

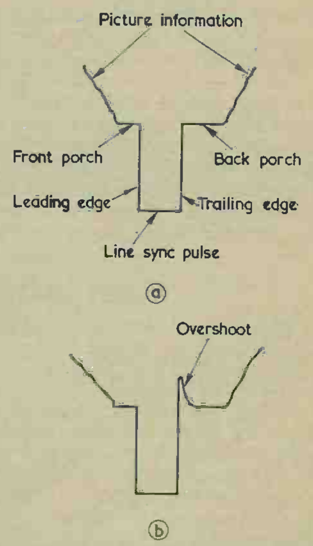


Fig. 5 (a). The line sync pulse. The leading edge initiates line flyback
(b). In some cases it is possible for overshoot to appear on the trailing edge of the sync pulse

"What's the cure this time?"

"It's the same as for vertical flyback suppression," replied Smithy. "Once again you need a negative-going pulse, and once again you apply it to the grid. Since the vertical suppression pulse is usually applied via the series grid resistor we referred to just now, it becomes possible to apply the line suppression pulse to the grid itself. Whereupon the two sets of pulses do their work independently."

"Where", asked Dick, "do you get your negative-going line pulses from?"

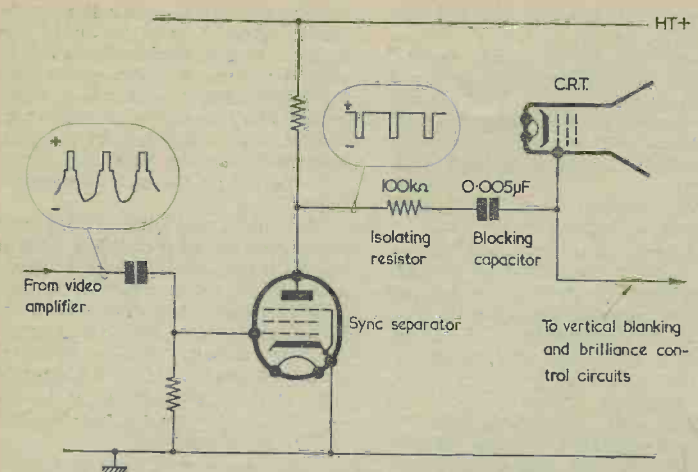


Fig. 6. One method of obtaining line flyback suppression consists of obtaining negative-going pulses from the anode of the sync separator. A second isolating resistor may, in some cases, be interposed between the blocking capacitor and the tube grid

"A good place", said Smithy, "is the line timebase, and this is used in quite a few sets. An alternative idea, which is frequently employed, is to get the pulses from the anode of the sync separator. (Fig. 6.) These pulses are then fed to the grid of the c.r.t. via an isolating resistor and a blocking capacitor. The resistor prevents shorting out the vertical suppression pulses and also avoids their being fed back to the sync separator anode. As you can see, the circuit is really very simple."

"It *is* neat," said Dick. "Do the resistor and capacitor help in shaping the pulse?"

"In this particular circuit", said Smithy, "they won't have a very considerable effect, and the pulse will rather tend to go straight through, after having suffered attenuation due to the presence of the isolating resistor. However, this resistor has rather a high value and some integration is bound to happen. The shape of the pulse isn't all that critical in this instance, since all it has to do is to keep the tube blanked during the overshoot. The only other requirement is that the pulse mustn't be so long as to blank off the beginning of the next line also."

Satiated

Smithy rose from his stool with an air of finality.

"And that," he pronounced heavily, "is that."

"As you like," said Dick agreeably, turning round to his receiver.

Surprised, Smithy returned to his own bench. He suddenly realised, with a sense of unusual achievement, that he had actually satiated Dick's thirst for information on a subject in one single session only.

FIRST INTERNATIONAL TELEMETERING CONFERENCE

Well over 500 engineers and scientists, experts in telemetering, will gather in London from many different parts of the world during the week beginning 23rd September, 1963, for the first International Telemetering Conference.

This event is the result of an initiative by three American societies (the Institute of Electrical and Electronics Engineers, the Instrument Society of America and the American Institute of Aeronautics and Astronautics) who have for the past several years been sponsors of the National Telemetering Conference held annually in the United States. Acting at their invitation as co-sponsors in Britain of the International Conference, are the British Institution of Radio Engineers and the Institution of Electrical Engineers. The Conference sessions will take place in the headquarters of the I.E.E., the "host" institution, at Savoy Place, London, W.C.2. Arrangements are in the hands of joint Committees composed of representatives of all the sponsor societies, headed by Mr. A. L. Gruer in the United States and Dr. J. S. McPetrie, C.B., in the United Kingdom.

Exhibits

Associated with the Conference, an exhibition of telemetering equipment will be held during the same period at the new London Hilton Hotel—one of the first events of this type to be held there. Among the fifty-odd companies exhibiting will be organisations from the Continent of Europe and from Asia, as well as many from the U.S. and the U.K. Equipment complementary to scientific papers being presented at the Conference and historical displays of telemetering devices will also be shown at the I.E.E. headquarters during the week.

International "First"

This will be the first time for a truly international Conference to be held on the subject of telemetering, a comparatively recent science which, in addition to playing a vital role in obtaining and recording previously inaccessible data from space, also accounts for a major part of industrial instrumentation where measurements are made "at a distance". Telemetering techniques have also contributed largely to the advances recently made in such fields as biomedicine and oceanography.

The technical Sessions at Savoy Place will cover all these aspects and it is expected that among those attending and contributing to the discussions will be delegates from the following countries:

Australia	France	South Africa	Syria	U.S.A.
Belgium	Netherlands	Sweden	Tasmania	U.S.S.R.
Canada	Norway	Switzerland	United Kingdom	West Germany
Eire	Poland			

European Tour

A particularly strong contingent is expected from the United States and, largely for their benefit, a post-Conference tour of European telemetering facilities is being arranged to follow the week's activities. Several social functions will take place during the Conference and delegates' wives will have the opportunity of taking part in a special ladies programme.

If this first venture is a success, the sponsors hope to be able to arrange other International Telemetering Conferences, at perhaps two-year intervals, in other parts of the world.

Transistorised Pre-Amplifier Emitter Follower Unit

By JOHN M. TWILLEY

A circuit which offers an extremely flat response

THE AUTHOR HAS FOR SOME TIME BEEN CARRYING out experiments with various forms of hydrophone. During the course of these experiments the need was found for a preamplifier unit having an extremely flat response in the audio band, and which was capable of feeding into a fairly long connecting cable back to the surface. For this requirement the circuit described here was developed.

The original unit was intended for use with a carbon capsule, similar to that in a carbon microphone, feeding at the surface into a transistorised tape recorder. It has since proved a very useful circuit for any application in which it is desired to feed a low impedance transducer into a remotely situated amplifier. One such application has been in a hi-fi reproduction unit, in which case the entire preamplifier, less the power supplies, was mounted into the pick-up arm.

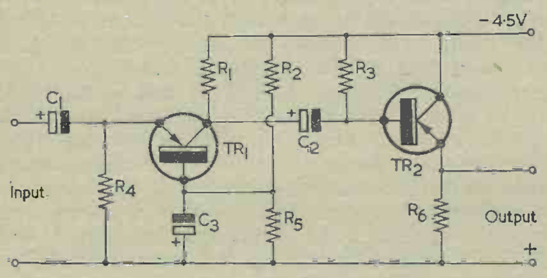


Fig. 1. The circuit of the pre-amplifier unit

Components List

Resistors

R_1	5.6kΩ
R_2	39kΩ
R_3	220Ω
R_4	470Ω
R_5	4.7kΩ
R_6	4.7kΩ

Capacitors

C_1	250μF (see text)
C_2	3μF (see text)
C_3	8μF, 1.5V wkg.

Transistors

TR_1	OC71
TR_2	OC71

Theoretical Circuit

The theoretical circuit is shown in Fig. 1. TR_1 is an OC71 in the grounded base configuration. This is essentially a voltage amplifier, and has a relatively high output impedance. TR_2 is also an OC71, this time in the grounded collector or emitter follower configuration. The latter is analogous to the cathode follower circuit, having a relatively high input impedance and low output impedance. By careful selection of transistors and components, particularly the emitter load of TR_2, it is possible to make the overall voltage gain of the circuit exactly 100 times. For the hydrophone application this was important, since the recordings were later analysed and it was required to know the total gain of the system. If the input and coupling capacitors, C_1 and C_2, are made 250μF and 3μF respectively, the frequency response obtained with a Bruel and Kjoer oscillator and recorder is flat within $\pm\frac{1}{2}$dB from 20 c/s to 20 kc/s. See Fig. 2. If the values of C_1 and C_2 are reduced to 100μF and 0.1μF respectively, the response is 2dB down at 20 c/s, and will be level from approximately 100 c/s upwards.

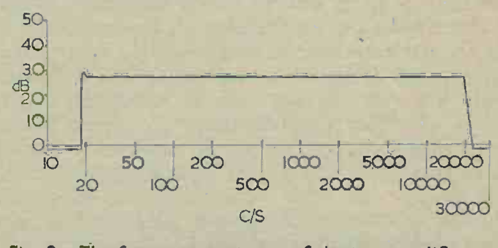


Fig. 2. The frequency response of the pre-amplifier as measured on a Brunel and Kjoer B.F.O. frequency recorder analyser set. (This consists of a b.f.o. having a stable amplitude output driven synchronously with the level recorder, the response being recorded by a pen on a paper scale)

Performance Specification

The complete performance specification of the circuit is as follows:

Overall Gain: 100 times, (40dB voltage.)

Maximum input for no distortion: 20mV peak-to-peak.

Frequency response: $\pm\frac{1}{2}$dB, 20 c/s to 20 kc/s. ($C_1 = 250\mu F$; $C_2 = 3\mu F$).

Phase Distortion: nil.

Input Impedance: in the order of 50Ω, dependent on TR_1.

Output Impedance: in the order of 100Ω.

An introduction to . . .

COLOUR TELEVISION

By J. R. DAVIES

PART 4

In the third article in this series we saw the points at which the N.T.S.C. primary colours appear in the C.I.E. Chromaticity Diagram, noting also the range of colours which they may reproduce by means of additive mixing. We next turned to the modulation of the chrominance sub-carrier, showing the positions the I and Q signals take up in relation to the R-Y and B-Y signals. We then examined the transmitter characteristic and, finally, discussed the colour burst which is superimposed on the back porch of the transmitted line sync pulse. We shall now carry on to the colour receiver.

The Colour Television Receiver

A colour television receiver is, of necessity, considerably more complicated than a monochrome television receiver. Some of the additional complications appear around the presentation device, this being, in domestic receivers, a three-gun cathode ray tube in which each gun corresponds to a particular primary colour. It is necessary to keep the three colour presentations on the screen of the tube in accurate registration, and this is a process that requires deflection components and techniques which are not encountered in monochrome receivers. Further complications are given by the chrominance circuits, whose function is to reclaim the original red, green and blue signals from the modulation on the chrominance subcarrier. Receiver chrominance circuit design has not, unfortunately, become stabilised at the present time, and quite different methods of reclaiming the original primary colours have been developed by various manufacturers. The existence of these different methods can be a source of confusion to the newcomer.

Whether it be intended for monochrome or colour, a television receiver design can always be considered as being proven after it has been in successful mass-production over a period of time. Mass-production ensures that the design is tested for many combinations of component variation within tolerance; also, it enables experience of its performance, both at the factory and in the field, to be gained. At the time of writing, no British domestic colour television receiver has been put into mass-production and we shall, in consequence, refer to a representative American design whenever it is necessary to quote typical aspects of commercial receiver design. The American receiver is the R.C.A. model CTC11, and it incorporates design features which result from the very extensive experience gained by this company, which was the major pioneer in setting up the original N.T.S.C. system.[1]

The R.F. and I.F. Stages

The r.f. and i.f. stages of a colour television receiver are basically similar to those of a monochrome receiver, but they are required to have a response curve which is very nearly constant in amplitude over the range of frequencies handled. The r.f. stages appear in the tuner unit, and the response of this must be reasonably flat-topped over the frequencies between the vision and sound carriers. The relatively large peaks and troughs which are acceptable in tuner units intended for monochrome reception cannot be tolerated in colour television receivers, because they may cause

[1] 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. R.C.A. Great Britain Ltd. state that this information corresponds to the receiver which (at the time of writing) is being offered for modification in England.

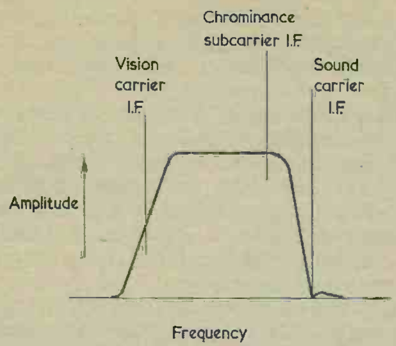


Fig. 11. The i.f. response of a colour television receiver has to be flat-topped, and could take up the form shown here

the chrominance subcarrier sidebands to be excessively accentuated, or attenuated, in relation to the vision carrier and the luminance sidebands.

The American 525 line system uses frequency modulated sound, with the result that 525 line colour television receivers employ standard intercarrier sound circuits. The sound intermediate frequency is passed through the same i.f. amplifier as the vision intermediate frequency, and it is converted to the intercarrier frequency at the vision detector stage. In colour receivers, the response curve of the combined vision and sound i.f. amplifier has to be reasonably flat-topped, and it may take up a form similar to that shown in Fig. 11. It is usually desirable to keep the sound intermediate frequency at a low level in order to reduce the amplitude of any beat signals which may be formed between this frequency and the chrominance subcarrier information. One or more sound i.f. rejectors may be fitted in the i.f. amplifier to achieve this result.

Automatic gain control is essential and this may employ a conventional gating circuit working on sync pulse tips and gated by positive-going pulses from the line output transformer.[2] In the R.C.A. CTC11 receiver, a three-valve i.f. amplifier is employed, a.g.c. being applied effectively to the first two valves.[3] A.G.C. is also applied to the r.f. amplifier in the v.h.f. (Band I–Band III) tuner unit.

In the CTC11 receiver, the intercarrier frequency is taken from the anode circuit of the last i.f. amplifier by way of a separate *sound detector* diode, the 4.5 Mc/s intercarrier frequency being amplified and demodulated to provide the audio signal in conventional manner.

The Timebase Circuits

The line and vertical timebase circuits of a colour television receiver are basically similar to those in a conventional monochrome receiver. They have, however, to generate higher deflection powers than is normal in a monochrome receiver in order to meet the requirements of the three-gun cathode ray tube. Voltages are taken from the timebases, also, for the dynamic convergence circuits, which we will discuss later. Flywheel sync in the line circuits is invariably employed.

The three-gun cathode ray tube requires much higher e.h.t. voltages and currents than are needed by monochrome tubes, and these are of the order of 20 to 27kV at currents which may be as high as 1.5mA. Such voltages and currents are obtained from a line output stage having conventional circuitry, but they necessitate the use of a larger line output valve and line output transformer than would be needed with monochrome receivers. A high degree of e.h.t. voltage regulation is necessary and this may be provided with the aid of a 6BK4 shunt regulator valve, as shown in Fig. 12. The shunt regulator valve is capable of withstanding the e.h.t. voltage between its anode and cathode, and it functions as a regulator by the simple process of drawing more anode current as its grid goes less negative. In Fig. 12 the grid of the regulator valve is coupled to the boosted h.t. line. The voltage on this line reduces (i.e. goes more negative) when e.h.t. current increases. So, also, does the grid of the regulator valve which, in consequence, draws less anode current and allows the e.h.t. voltage to return, or nearly return, to its previous value.

The three-gun cathode ray tube has a focusing

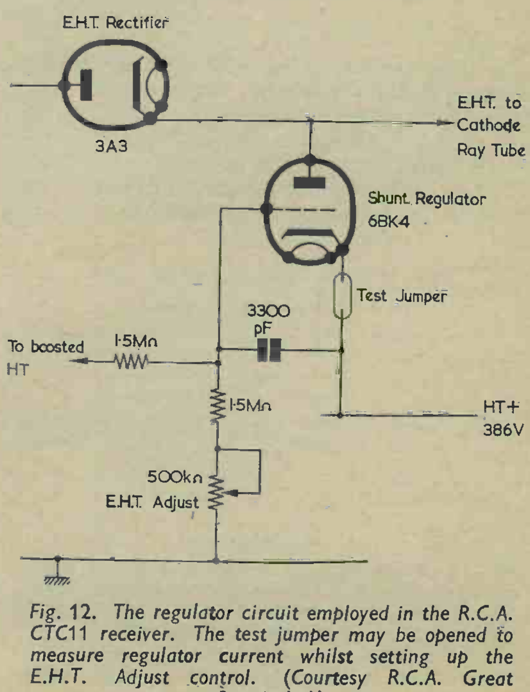


Fig. 12. The regulator circuit employed in the R.C.A. CTC11 receiver. The test jumper may be opened to measure regulator current whilst setting up the E.H.T. Adjust control. (Courtesy R.C.A. Great Britain Ltd.)

[2] Circuits of this type were described in "Understanding Television" part 37, *The Radio Constructor*, February 1961.

[3] These two valves are operated in a "stacked B supply" circuit, in which they are virtually connected in series so far as the h.t. supply is concerned. The actual a.g.c. voltage is applied to the grid of the lower valve (which is the first i.f. amplifier) whereupon it also controls the gain of the upper valve. See "Understanding Television" part 38, *The Radio Constructor*, March 1961.

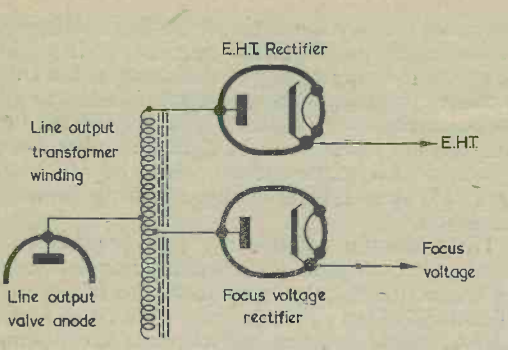


Fig. 13. The colour cathode ray tube requires a focusing potential around 1.2 to 5kV (for current tubes). This voltage is obtained by a second rectifier tapped into the line output transformer winding at a lower potential point than the e.h.t. rectifier

electrode which (for current types) requires voltages ranging from some 1.2 to 5kV. This focusing potential is supplied by a separate high voltage rectifier coupled into the line output transformer winding at a lower potential point than the e.h.t. rectifier. (See Fig. 13.) Some simple means of adjusting the rectified potential for focus control is provided.

The Video Amplifier Stages

The signal appearing immediately after the vision detector consists of the luminance signal and the sync pulses (as would be given in a monochrome receiver), plus the chrominance information and the colour burst. These various signals have to be separated and fed to the appropriate sections of the receiver.

The form taken up by the video amplifier following the vision detector may vary, but a typical arrangement consists of employing the first video amplifier valve to handle all signals obtained from the vision detector. This procedure is followed in the R.C.A. CTC11 receiver, in which the output from the vision detector is fed between grid and cathode of the first

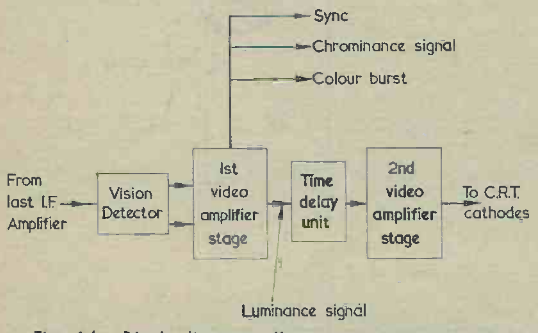


Fig. 14. Block diagram illustrating a typical video amplifier. The sync, chrominance and colour burst signals are taken from the anode of the first video amplifier, and the luminance signal from its cathode. The luminance signal is then fed, via a time delay unit, to the second video amplifier valve, which amplifies the signal in conventional manner

video amplifier valve. The luminance information is then taken from the cathode, whilst sync pulses (for the sync separator and the gated a.g.c. circuit), chrominance information, and the colour burst signal are taken from the anode.

The luminance signal from the cathode of the first video amplifier valve is fed via a time delay unit to the grid of the second video amplifier valve, as in Fig. 14. This delay unit is necessary because, in the chrominance circuits, the chrominance signals have to pass through one or more filters having relatively narrow bandwidths, a process which incurs a slight time delay. An equivalent time delay has, therefore, to be introduced into the luminance amplifier to ensure that the luminance signal arrives at the cathode ray tube at the same instant as the corresponding chrominance information. Time delays in the luminance channel are of the order of 0.5 to 1μS (according to the design of the chrominance circuits) and may be provided by combinations of inductance and capacitance or similar devices.[4]

In Fig. 14 the luminance signal following the time delay unit is applied to the second video amplifier valve. This valve functions in conventional manner. In the CTC11 receiver, a contrast control is introduced into its cathode circuit, this employing the circuit shown in Fig. 15. As may be seen, there is a varying amount of cathode degeneration, according to the setting of the slider of the control. The luminance signal on the anode of the second video amplifier is finally d.c. coupled to all three cathodes of the three-gun cathode ray tube, following the circuit practice which was shown in Fig. 5 (*b*).[5] The R-Y, B-Y and G-Y signals may then be fed to the respective grids, allowing final colour reclamation to take place in the tube itself. Because the three phosphors in the tube have differing efficiencies, the luminance signal is not applied directly to each cathode. Instead, a simple resistive potentiometer is employed, causing the full luminance signal to be applied to one cathode and smaller proportions to other cathodes. With the CTC11 receiver, the full luminance signal is passed to the cathode of the red gun, variable potentiometers tapping off proportions of this signal for application to the cathodes of the blue and green guns.

In the CTC11 receiver, a positive-going retrace pulse from the vertical output stage is applied to the anode circuit of the second video amplifier. This pulse is, in consequence, fed to the three tube cathodes, and provides blanking during the vertical flyback.

The Chrominance Circuits

The chrominance information obtained after the vision detector is passed to the chrominance circuits, or *chrominance channel*, of the colour television receiver. It is the function of this section of the receiver to convert the information on the chromin-

[4] In some early British experimental colour receivers, the time delay was provided by a short length of coaxial cable.

[5] Published in Part 2 of this series.

ance subcarrier into the R-Y, B-Y and G-Y colour-difference signals, so that these may be applied to the three grids of the cathode ray tube.

A wide range of different circuit techniques have been employed in colour television receivers for extracting the colour-difference signals, and it is not possible to refer to any single technique as representing a method which, with the passage of time, has become standard practice. In consequence, we shall deal here mainly with the principles involved in the basic IQ circuit, and in the current XZ demodulation circuit which was introduced by R.C.A. some years ago.

Before carrying on to the IQ type of chrominance channel we must first briefly consider the *synchronous detector* or *synchronous demodulator*. Two or more synchronous detectors are employed in the receiver for extracting the information carried on the quadrature modulation of the chrominance subcarrier.

In a colour television receiver, the chrominance information may be passed to two synchronous detectors in the manner shown in the block diagram of Fig 16. We know that the information is carried by the I signal and the Q signal, and that the subcarrier is, itself, suppressed. In consequence, we have to reinsert the subcarrier locally, the requisite frequency being obtained from a local oscillator which is maintained in correct phase by synchronising with the colour burst transmitted on the back porch of each line sync pulse. The local oscillator feeds into a fixed phase shift circuit which provides two or more *reference frequencies* for the synchronous detectors. These reference frequencies have exactly the same frequency as the subcarrier at the transmitter but, to meet the requirements of the chrominance channel demodulator circuits, have a fixed phase difference with that subcarrier. A synchronous detector has applied to it both the signal to be detected, or demodulated, and a reference frequency at the same frequency. It then provides an output whose amplitude varies according to the modulation on the signal and its phase relationship with the reference frequency. With practical synchronous detectors, full demodulation can be given for simple phase relationships such as 0° (fully in phase) or 180° (fully out of phase). If, under these conditions, the phase relationship between the signal to be demodulated and the reference signal is 90° or 270°, the output of the synchronous detector is zero.

In Fig. 16 we may obtain demodulation of the I and Q signals by the simple process of applying a reference frequency to one synchronous detector which causes it to offer full demodulation of the I signal, and a reference frequency to the other synchronous detector which causes it to offer full demodulation of the Q signal. Since the I and Q signals are removed by 90° on the R-Y and B-Y axes (as was shown in Fig. 8 (*c*)[6] the reference signals must similarly have a phase difference of 90°.

[6] Published in last month's issue.

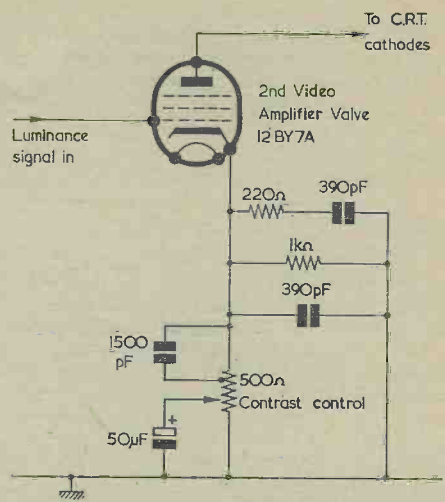


Fig. 15. The contrast control in the cathode circuit of the second video amplifier valve in the R.C.A. CTC11 receiver. The cathode components not immediately associated with the contrast control ensure correct amplifier response. (Courtesy R.C.A. Great Britain Ltd.)

A. synchronous detector has zero output for signals having 90° or 270° phase difference with the preferred frequency, and so the synchronous detector handling the I signal offers zero output for Q signal modulation, and the synchronous detector handling the Q signal offers zero output for I signal modulation.

It is worth staying a little longer with the synchronous detectors of Fig. 16 in order to take note of two further points. Let us say that the I signal synchronous detector is handling a signal whose corresponding vector, on the R-Y and B-Y axes, points in the positive I direction. The detector will then, as it is intended to do, give an output pro-

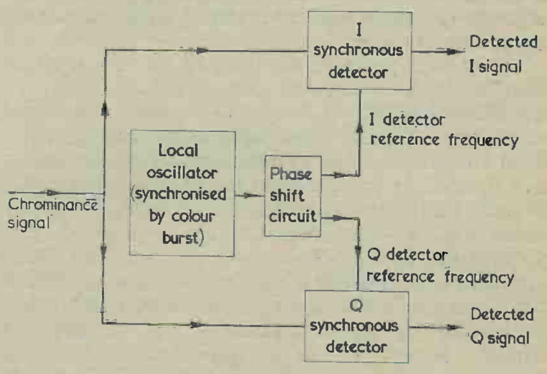


Fig. 16. Employing two synchronous detectors to extract the I and Q modulation from the chrominance information. The I and Q reference frequencies have a phase difference of 90°

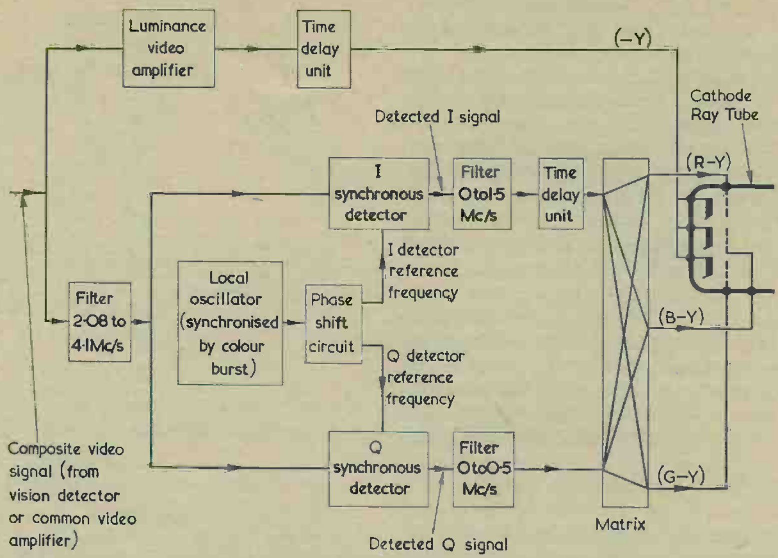


Fig. 17. Block diagram showing the basic elements of an IQ chrominance channel. The time delay unit in the luminance channel could be incorporated in the luminance video amplifier circuit, and need not follow the amplifier, as is shown here. Since the cathodes and grids of the cathode ray tube require voltages of opposing phase to give correct addition, the luminance signal is shown as (—Y), thereby indicating reversed phase

portional to the amplitude of the I signal modulation. Let us next assume that the I signal changes so that its corresponding vector points in the negative I direction. The synchronous detector will still continue to give an output proportional to the I signal modulation amplitude, but the phase of the output will now be reversed. The same applies to the synchronous detector handling the Q signal. This will give an output proportional to the amplitude of the Q signal modulation both when the corresponding vector on the R-Y and B-Y axes points in the positive Q direction or in the negative Q direction, but the output from the detector for negative Q signals will be reversed in phase to that for positive Q signals.

The second point to note has to do with the fact that, as we have already seen, any colour may be represented on the R-Y and B-Y axes in the form of a single resultant vector pointing in any direction from the intersection of the axes. Let us assume that the colour presented to the transmitter camera is such that it corresponds to a resultant vector which lies midway between the positive I and positive Q vectors. This corresponds to an equal length in both positive I and positive Q vectors, and would result in the chrominance subcarrier being modulated by equal positive I and positive Q signals. The outputs of the synchronous detectors of Fig. 16 would then also be equal. If the colour were such that it could be represented by a resultant vector which was closer to the positive I vector than to the positive Q vector, then the chrominance subcarrier would be modulated by a correspondingly stronger positive I signal and a correspondingly weaker positive Q signal. The outputs from the synchronous I and Q detectors of Fig. 16 would be similarly stronger and weaker in consequence. The same state of affairs occurs for any other colour: the position of its resultant vector on the R-Y and B-Y axes corresponds to proportional amplitudes of positive or negative I signal, and of positive or negative Q signal, and these signals then appear at the outputs of the I and Q synchronous detectors of Fig. 16.

IQ Colour Reclamation

We may now turn our attention to the basic operation of a colour television receiver employing IQ circuits in the chrominance channel. In Fig. 17 we see that the output from the vision detector (or common video amplifier) feeds both the luminance video amplifier and the chrominance channel stages. We have already dealt with the luminance video amplifier and we need only note here that it incorporates a time delay unit, the latter causing the luminance signal to arrive at the cathode ray tube at the same instant as the chrominance information (which suffers a time delay due to its passage through relatively narrow-band filters.) In the American 525 line system the chrominance subcarrier sidebands extend upwards to approximately 4.1 Mc/s above the vision carrier and, downwards, to 2.08 Mc/s above the vision carrier. After the vision detector they appear as a band of signals ranging from 2.08 to 4.1 Mc/s and, in Fig. 17, they are taken off the composite video signal by way of a filter which passes this band of frequencies. The chrominance signal is then fed to the I synchronous detector and the Q synchronous detector, these being supplied with reference frequencies (at a phase difference of 90°) which cause the I synchronous detector to give an output proportional to I signal modulation, and the Q synchronous detector to give an output proportional to Q signal modulation. The detected I signal is next passed through a low-pass filter to remove any unwanted signals which may be present above the maximum I frequency of 1.5 Mc/s. For a similar reason, the Q signal is fed through a low-pass filter which removes frequencies above 0.5 Mc/s. Because the Q signal passes through a filter having a narrower bandwidth than the I signal it undergoes a greater time delay. In consequence, a time delay unit is provided after the I signal filter to compensate for this, and to ensure that both signals arrive at the following matrix at the same instant of time.

We have already seen[7] that it is possible to obtain G-Y from R-Y and B-Y by adding together the latter in the requisite proportions in a matrix. G-Y corresponds to a vector on the R-Y and B-Y axes and, because we can obtain this vector from two others by adding in a matrix, it follows that we should be able to obtain, by a similar process, either the R-Y or the B-Y signals, or both, from the detected I and Q signals. Having obtained the R-Y and B-Y signals in this manner, a further matrix could then be used to obtain the G-Y signal.

There is, however, no need to use these successive steps, and it is possible to employ a single matrix which can manipulate the I and Q signals such that all three-colour difference signals are obtained. Furthermore, such a matrix can also remove the $\frac{1}{1.14}$ and $\frac{1}{2.03}$ weighting factors which were applied to the R-Y and B-Y signals at the transmitter. The matrix can even apply new weighting to take up the effect of different sensitivities in the cathode ray tube phosphors.

The matrix of Fig. 17 provides the R-Y, B-Y and G-Y signals in the manner just stated, and it could consist, in practice, of a resistive network with valves for any phase reversal which is required. The matrix provides R-Y, B-Y and G-Y outputs, and these are fed to the three grids of the cathode ray tube. The luminance, Y, signal is fed to the tube cathodes, whereupon the original red, blue and green signals are finally reclaimed.

It is necessary to have some form of gain control in the chrominance channel and, in Fig. 17, this could be provided immediately after the 2.08 to 4.1 Mc/s filter. This gain control would then be capable of adjusting the level of the colours finally reproduced in the cathode ray tube, and would be described as a *saturation control*. For correct results the saturation control would need to be operated in conjunction with the contrast control, which may be fitted at the most convenient point in the Y amplifier.

[7] In Part 2 of this series.

Other Methods of Colour Reclamation

The IQ chrominance channel just discussed offers what is, theoretically, the best possible type of colour receiving technique which can be employed. This is because it reproduces the I signal at its full bandwidth of 1.5 Mc/s and enables full use to be made of the ingenious chrominance bandwidth apportionments which were originally written into the N.T.S.C. specification.

On the other hand, the use of an IQ chrominance channel results in expensive and complicated matrix design, and it appears that this factor has been sufficient to cause most, if not all, American manufacturers to turn to other means of extracting the colour information from the chrominance subcarrier sidebands. In all instances, the alternative methods of operation function by demodulating along vector directions (on the R-Y and B-Y axes) which do *not* correspond to the I and Q vectors. These techniques can offer a considerable simplification and lowering in cost of the matrixing circuits. When such methods are employed, however, it is essential that the maximum bandwidth of all the chrominance signals dealt with be approximately equal to that of the Q signal only. If this point is not satisfied it is possible for the signals applied to the synchronous detectors to interfere with each other and to introduce errors into the colours finally reproduced. The non-IQ systems currently in use handle all chrominance signals at maximum frequencies equal to, or slightly greater than, the 0.5 Mc/s maximum frequency of the Q channel.

It will at once be evident that non-IQ circuits do not take full advantage of the detailed information, at colours to which the eye is most sensitive, that is transmitted by way of the I channel. Because of this, non-IQ receivers offer a picture having less colour detail. On the other hand, non-IQ receivers employ circuits which are much simpler (so far as matrixing is concerned) than are IQ receivers, and they are consequently cheaper, easier to service and more reliable. There are also the facts that the appreciation of a colour television receiver presentation depends partly on subjective standards, and that the transmission and reception of luminance and chrominance information over a restricted bandwidth must inevitably involve compromises at some points along the system. At any event, the question of whether IQ or non-IQ receiving methods should be employed is debatable, and may well be influenced by further developments in the field of colour television.

Turning, now, to the technical aspects of non-IQ receivers, we will first of all refer briefly to several non-IQ techniques which have been used, after which we will carry on to the R.C.A. XZ system.

What is, basically, a very simple method of obtaining colour-difference signals directly from the chrominance subcarrier information consists of detecting along vectors which correspond, on the R-Y and B-Y axes, to the R-Y and B-Y vectors themselves. We can have two synchronous detectors fed with reference frequencies whose phase relationship is such that the outputs of the synchronous detectors are proportional to the R-Y and B-Y signal amplitudes, whereupon the R-Y and B-Y signals become immediately available without the necessity for further matrixing. It is perfectly feasible to extract the R-Y and B-Y signals in this manner (provided that the maximum frequency in the system is no greater than the maximum Q frequency) because all the colours appearing around the R-Y and B-Y axes can be defined in terms of the phase relationship of a simple resultant vector. Having obtained our R-Y and B-Y signals, all that we then require is a simple matrix to give us the G-Y signal, and we have the three colour-difference signals all ready for application to the tube.

Around the R-Y and B-Y axes is a vector which corresponds to G-Y. If we add a third synchronous detector, whose reference frequency phase corresponds to the angular position of the G-Y vector, we may obtain our G-Y signal directly, and there is not then any necessity to have a matrix after the R-Y and B-Y detectors.

A number of schemes similar to the two just mentioned have been introduced. It appears that, in some instances, compromises have had to be made, so far as the phase angle at which detection takes place is concerned, in order to provide a system which is workable in practice.

(To be continued)

Setting Up in Business

By F. WALKER

MANY RADIO AND TELEVISION engineers must have thought to themselves on a quiet Sunday afternoon: "I wonder if I could set up in business on my own account?" The following hints are intended to help the embryo businessman answer this question.

The first requirement is, obviously, to know your job. The newcomer has to be quite sure that he can tackle any kind of job that he may reasonably be asked to do: it may be to repair a TV set, rig an aerial system, fit attenuators or one of a host of other jobs concerned with radios, tape recorders, 'grams, irons, fires, kettles, vac's, spin driers, washing machines, etc.

It is important to remember that there is a great deal of difference between repairing sets at home in the evenings to earn some extra cash, and relying for your total income on your ability as a businessman; especially if you have a young family. For this reason some people go half-way, retaining a part-time occupation whilst they build up experience and capital.

Salesmanship

You must be able to talk. That is, you must be able to sympathise with an aggrieved customer, convince an intending buyer of a new receiver, or whatever it happens to be, that you give better service than anyone else. You must also know when not to talk. Some customers like to think they are *buying* whatever it is you are selling, these types merely need a gentle push now and then to keep them going in the right direction. It is up to the intuition of the salesman to assess the type of customer he is dealing with. A short course in salesmanship at the local technical college could be very helpful. (The beginner usually finds that he is serviceman, salesman, secretary and tea-boy all rolled into one.)

Capital

The question of capital is an important one. Although it is possible to start some types of business with almost sweet nothing-at-all, it is probably true to say that more businesses have failed because of insufficient capital than for any other reason.

The amount needed depends on many factors, financing slow payers, for example, but some of the physical things required are:

(*a*) *Workshop*. Preferably on the ground floor and large enough to accommodate all your equipment and the jobs awaiting repair.

(*b*) *Equipment*. Must be first-class and sufficiently adequate for the work to be carried out. This will obviously include test meter, signal generator, oscilloscope, etc., and a good supply of tools and the more usual components, also service literature.

(*c*) *Motor Van*. Such a vehicle is essential. It has to be big enough to accommodate the largest electric cooker or console television receiver. The Austin A55, the Standard 10 and the Ford Thames 7 cwt., are all very suitable. Some engineers will already own their own van, if not, either buy a new one or a good secondhand one. Nothing looks worse than a battered old wreck, especially if it is of the ex-G.P.O. type!

(*d*) *Telephone*. This again is essential. A telephone employed in conjunction with a regular advertisement in the columns of the local newspaper should bring results.

Trade Associations

It is sensible to become a member of some kind of trade protection society in case there are any bad debts. There are those, unfortunately, who will engage the services of a television engineer without any intention of paying him for his efforts. It is also a good thing to join the local chamber of trade. This organisation will protect a businessman's interests both in local matters and national affairs. Monthly circulars are sent to all members giving news of matters of interest.

The Radio and Television Retailers Association, R.T.R.A., is concerned mainly with the retail trade, but the writer understands that a service workshop proprietor can become a part-member subject to approval. It is most certainly sensible to join if you have retail premises, and you have to have such premises before you can become a full member. The premises have to be of a required standard.

Accounts

A banking account should be opened. Payment by cheque is a considerable convenience and there are many services available to bank customers, for example direct payments to the accounts of hire purchase companies on the due date. The advice of a bank manager can be most helpful in arranging finance and putting you in touch with firms of accountants, solicitors, etc.

The accounts kept do not have to be complicated—it is mainly a question of being methodical. Receipts and payments should be recorded in enough detail for their purpose to be identified. Receipts, etc., should be retained to enable the accountant to be satisfied that payments are genuine and for the purpose stated. The accountant will usually prepare the accounts for the Inland Revenue and agree the income tax liability, if any.

Charges

Put down on your account the date, customer's name and address, and a description of the work done. The minimum rates are usually 15s. per hour for inside work, i.e. in the workshop, plus 15s. per call when using your own transport to a customer's house. When charging for components, insert the purchase tax and the price before tax. Sometimes, when your customer is of limited means, it may not be feasible to charge for all the hours spent on servicing, soak-tests and the like.

A thorny problem is what to do when your charges are not paid. Assuming you are satisfied that your work has been done properly and that the charge is reasonable, send a letter stating that you would be pleased to receive a remittance in settlement of the enclosed account as soon as possible, it now being overdue. If such a letter has no effect after an interval of, say, two weeks, send another more strongly worded letter to the effect that, unless the account is paid within, say, 10 days, you regret that you will have to take further proceedings. If this fails then either put the matter in the hands of a solicitor or the trade protection society, if you have joined one.

Many other matters have to be dealt with—printing of letterheads, business cards and invoices, possible purchase of a typewriter, insurances, negotiation of a lease, and advertising, are some that come to mind.

To be your own boss successfully you must be energetic and conduct your business responsibly and not be wasteful. It must be remembered that ill-health may cause you to give up all that you have worked so hard for, and the family man must particularly bear this in mind.

AN ELECTRICAL SPEEDOMETER

A sensitive low-cost instrument for the cyclist

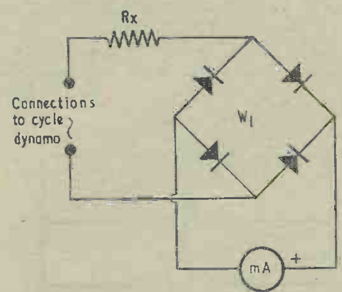
By Gregory J. Powell

MOST OF THE SPEEDOMETERS EMPLOYED FOR bicycles are purely mechanical devices, using a toothed gear assembly on the front wheel. The drive from this to the meter on the handlebars imparts a great deal of friction to the system. Also, the speedometer is rather expensive.

To evade these disadvantages, the circuit shown here was evolved. The meter employed in the prototype was a 2in 6mA ex-Government type, which can be purchased cheaply from radio component stores; although almost any moving-coil type can be used.

The meter movement should preferably be fairly well damped, or the needle will jitter considerably in use.* The voltage produced from the dynamo is applied to a limiter resistor (R_x) and then to a meter bridge rectifier (W_1), giving a voltage sufficient to produce full scale deflection at the maximum speed likely to be reached.

The alternating voltage produced by the dynamo increases very rapidly with speed, giving a corresponding increase in meter deflection. The value of R_x depends on the type of meter and rectifier employed, and that used in the prototype was 5kΩ.



R_x can be made variable and adjusted *in situ*, later being replaced by a fixed component. The meter was recalibrated in m.p.h. with the aid of a friend on a motor-bike.

It is not advisable to use crystal diodes in the bridge rectifier, as their forward resistance tends to vary with temperature. The meter also gives incorrect readings when the lights are on, as they shunt the dynamo.

It might be added that the whole installation is extremely robust, and that the prototype has been in use for well over a year. The instrument is very sensitive, giving an easily readable deflection at a speed of 2 m.p.h.!

* If necessary, external damping could be obtained by connecting a high value electrolytic capacitor across the meter.—EDITOR.

A CALCULATOR

By M. D. Roberts

THIS CALCULATOR WAS DESIGNED TO ACHIEVE, for a minimum amount of effort, a quick and easy way of finding the resultant value of several capacitors in series, or several resistors in parallel. The finished calculator was only 5.5 inches in diameter and could easily be made smaller at the cost of a slight reduction in accuracy. All the spade work concerning calibration of the scales has been carried out by the writer, making the construction of the finished item simple and quick. It is felt that it will be of service to the reader if the train of thought which culminated in the construction of this device was preliminarily described.

The Problem

Let us consider two capacitors in series and two resistors in parallel, as in Fig. 1, and Fig. 2.

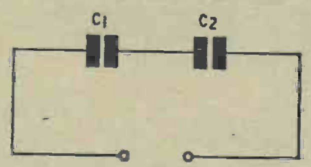


Fig. 1. Two capacitors in series

Now $\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}$ and $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}$

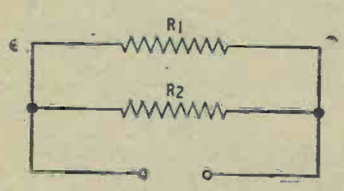


Fig. 2. Two resistors in parallel

On examination of either of these formulae, it is obvious that all that is involved is a number of reciprocals. (For example $\frac{1}{C}$ is a reciprocal.)

We may say, therefore, that the reciprocal of C = the reciprocal of C_1 + the reciprocal of C_2.

Now it is obvious that if we can find the reciprocals of C_1 and C_2, add them together and convert the resulting reciprocal both into a normal quantity, all via a scaled chart, we shall have achieved our aim.

When two quantities are to be added together a linear scale must be used; so that, in order that we may add $\frac{1}{C_1}$ to $\frac{1}{C_2}$ to get $\frac{1}{C}$, we must have a linear reciprocal scale to perform this addition. Such a scale is shown in Fig. 3.

Let us next take a particular case involving two resistors, and work through the procedure which terminates in the use of the scale of Fig. 3. We

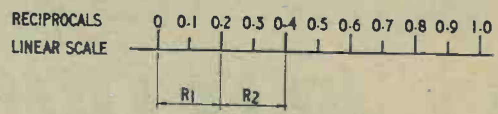


Fig. 3. Linear reciprocal scale

shall do this by finding R when $R_1=R_2=5\Omega$

$$\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}$$

$$\therefore \quad \frac{1}{R}=\frac{1}{5}+\frac{1}{5}=\frac{2}{5}=0.4$$

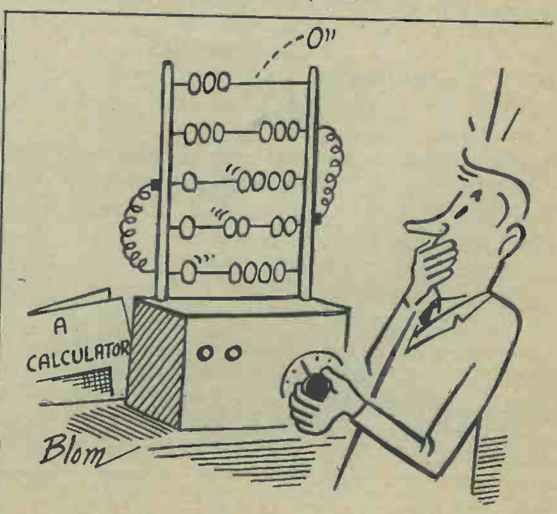
(i.e. reciprocal R=0.4)

and $\frac{R}{1}=\frac{5}{2}=2.5$

Using the scale of Fig. 3 we have:
reciprocal R=reciprocal 5+reciprocal 5.

Since reciprocal $5=\frac{1}{5}=0.2$,

reciprocal R=0.2+0.2.



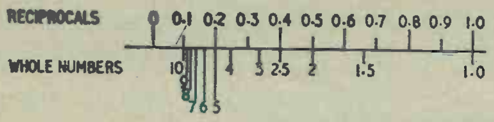
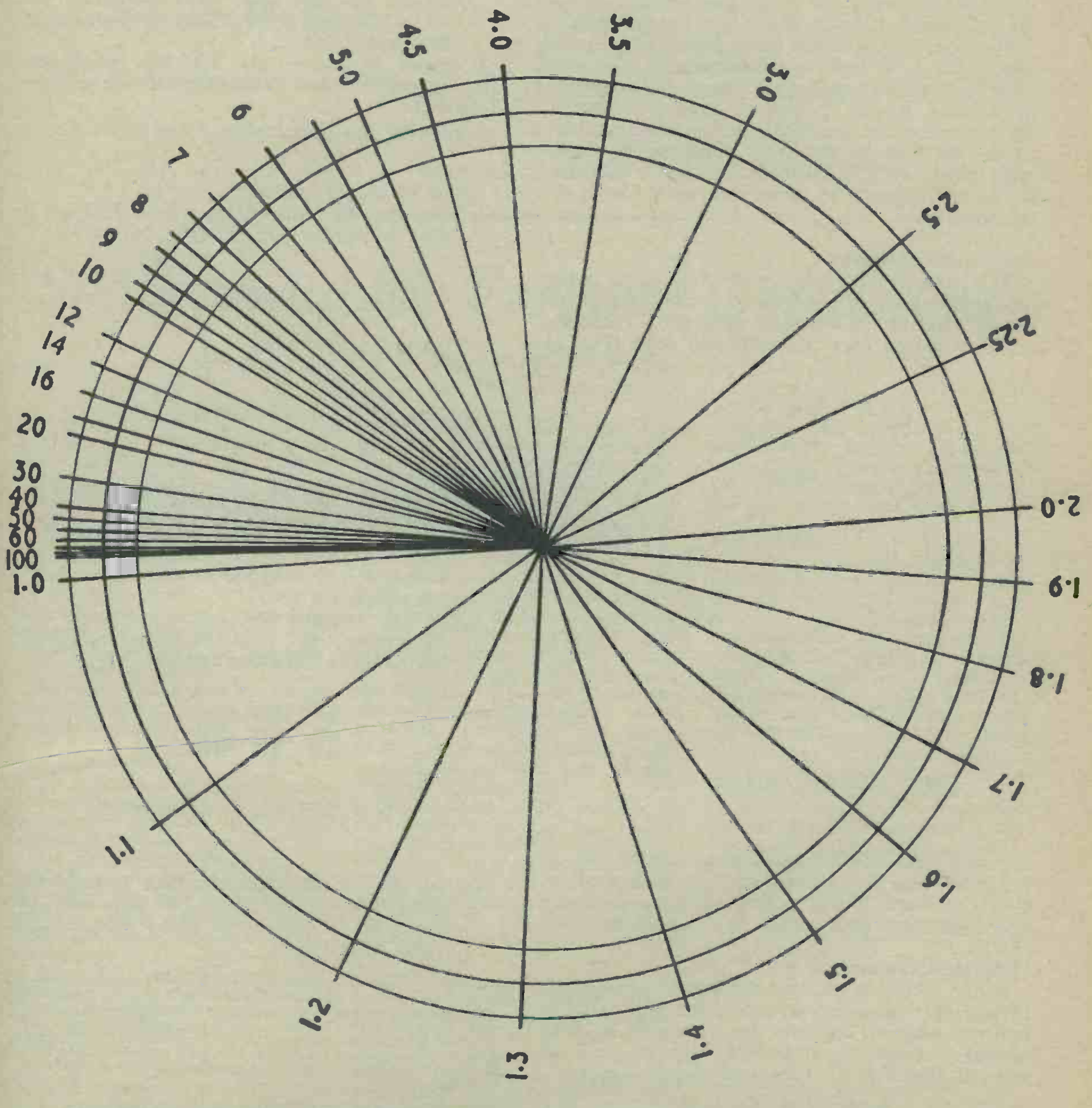


Fig. 4. Whole numbers corresponding to their reciprocals

By adding length reciprocal R_1 (between 0 and 0.2) to length reciprocal R_2 (in this case the same distance) we get the answer of 0.4, which is reciprocal R. So that:

$$\frac{1}{R}=0.4=\frac{4}{10} \quad \therefore R=\frac{10}{4}=2.5 \text{ (as before).}$$

The scale of Fig. 3 is of little help as it stands but,



The calculator scale. (For readers wishing to construct their own scales the angles between each radius and the "1" radius is $\frac{360}{n}$ degrees, where n is the appropriate number.—Editor.)

by eradicating the need of finding the reciprocals of R_1 and R_2, we will be able to improve its usefulness. This is easily carried out by marking on the scale whole numbers in positions which correspond to their reciprocals, as is done in Fig. 4. It can be seen that the whole number scale is not at all linear.

We can now dispense with the reciprocals altogether, as we have a reciprocal scale marked off in whole numbers, and by adding together the distance between 0 and R_1 to that between 0 and R_2 we are able to read off the final values directly.

We have, then, a simple scale which is easy to use, and which is the basis of the calculator. The final point is concerned with what shape the calculator must take. It was decided to employ a circular scale as this makes the calculator much less cumbersome. All that remains is to transpose the linear scale on to a set of circular discs, so that a value for R_1 on one disc can be added to a value for R_2 on the other disc.

Making the Calculator

This consists very simply of cutting out three cardboard discs of diameter 5.5, 5.1 and 4.7in, clearly marking the centre of each disc. The discs are then placed over the calibrated scale (Fig. 5)

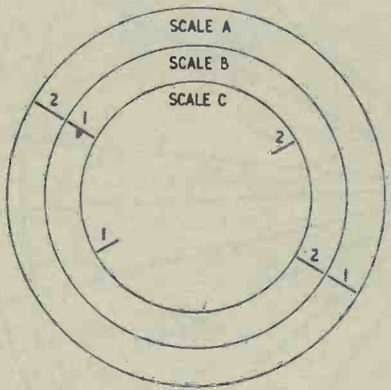


Fig. 6. Illustrating use of the calculator

one at a time, and the graduations marked out on the outer ring. The graduations and rings are then clearly finished in ink before all three discs are fixed together at their centres by a paper clip.

Using the Calculator

If one wishes to discover the overall capacitance of two 2µF capacitors in series, the 1 on scale B is first positioned opposite the 2 on scale A. The answer is then read off scale A opposite the 2 on scale B. (See Fig. 6.) This is, of course, 1.

$$\text{i.e. } \frac{1}{C}=\frac{1}{2}+\frac{1}{2}=\frac{1+1}{2}=\frac{2}{2}$$

$$\therefore C=1\mu F$$ [1]

If an attempt is made to find a solution for several quantities and one of them is below 2 in value, the answer may disappear off the end of the scale and no sensible solution will be otained. Because of this, two elementary laws must be followed when using the calculator.

(1) Numbers from 2 to 10 can be used on the 2 to 10 scale.

(2) If any one of the numbers falls below 2, all the numbers must be converted to the 10 to 100 scale by adjusting the position of the decimal point.

It should be pointed out that the permissible range of numbers for a single calculation is between 2 and 100.[2]

Examples

Let us take some examples.

1. Find the effective resistance of a 2kΩ and a 4kΩ resistor in parallel. (Fig. 7).

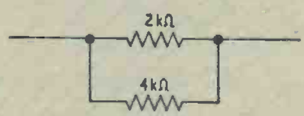


Fig. 7. A 2kΩ and 4kΩ resistor in parallel

(*a*) Place the 1 on the B scale against the 2 on the A scale.

(*b*) Next read off on the A scale the number that is opposite 4 on the B scale. This is 1.3, so that the parallel value of the two resistors is 1.3kΩ.

2. In this example we find the solution for three quantities. Find the total capacitance for the series capacitors shown in Fig. 8.

Fig. 8. Three capacitors in series

(*a*) As one of the capacitors has a numerical value below 2, the 10 to 100 scale must be used. So we first of all add a zero to each value, as in Fig. 9.

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[1] If the reader finds the transference from the linear to the circular scale confusing, it should be pointed out that the process just described is similar to that in Figs. 3 and 4, the quantities being added, as before, from the left hand end of the linear scale. In the circular scale the radius marked 1 is also the radius for infinity (the reciprocal of zero) which appears at the left hand end of the scale in Figs. 3 and 4.—*Editor.*

[2] It is possible, in some instances, to keep the solution on scale whilst one of the numbers is below 2. Thus 1.5 and 10 would give a satisfactory answer, whilst 1.5 and 4 would not. However, ensuring that no number falls below 2 *guarantees* an on-scale answer.—*Editor.*

(*b*) Place the 1 on the B scale against the 10 on the A scale.
(*c*) Find the position of the 20 on the B scale, and place the 1 on the C scale against it.
(*d*) Read off on the A scale the number opposite the 40 on the C scale.

Fig. 9. Adding a zero to each value

This will be 5.6, which means that the solution is 0.56μF.

To check, $\frac{1}{C}=\frac{1}{2}+\frac{1}{1}+\frac{1}{4}=\frac{2+4+1}{4}=\frac{7}{4}$

$\therefore C=\frac{4}{7}=0.57\mu F$

In conclusion it may be stated that, with a little practice, these calculations can be performed at great speed, rendering this calculator a very useful object to have available. Any number of scales can be added by using more discs, making calculations for any number of components easily possible.

The calculator scale (Fig. 5) has been reproduced full-scale. It may therefore be cut out and mounted on cardboard. Editor.

Semiconductor Variable Capacitors

By J. B. DANCE, M.Sc.

A REVERSE BIASED SEMICONDUCTOR junction diode behaves as a capacitor, the value of which varies according to the reverse voltage applied across the p.n. junction. This property is extremely useful at very high frequencies in the microwave region; for example, the diodes can be used as pump elements in parametric amplifiers ("Mavars"). They can, however, also be used in domestic radio receivers for such applications as automatic frequency control and remote tuning.

The devices are known as voltage sensitive capacitors or as capacitor junction diodes.

Theory of Operation

The diodes used as voltage sensitive capacitors consist of a single p.n. junction (Fig. 1). When this junction is formed, holes from the p type material will diffuse into the n type and electrons from the n type will diffuse into the p type. This results in a net positive charge being formed on the n type side of the junction and a net negative charge on the p type side; this charge (and hence the voltage across the junction) will build up until the electrostatic attraction is large enough to prevent further diffusion.

In Fig. 1 the charges which are encircled represent charged atoms held in position by valency forces. The charges which are not encircled are mobile and therefore free to carry current. In the region of the junction itself no free charges (i.e. electrons or holes) are present, but there are charged ions held firmly in position by valency forces. The junction region is known as the depletion region, as it is depleted of mobile charge carriers. (This was discussed in more detail in "The Tunnel Diode—in Theory and Practice" on page 293 of the November 1960 issue of *The Radio Constructor*.)

The depletion region behaves as a very high resistance, since it contains no mobile charges which can carry the current. The high resistance region acts as the dielectric of a capacitor, the plates of which consist of the semiconducting p and n materials on each side of the dielectric depletion region.

The thickness of the dielectric is very small (of the order of 1/10,000 of an inch). It does not necessarily extend into the p and n materials to equal extents, as this depends on the relative numbers of impurity atoms in each of the two kinds of semiconductor materials.

Reverse Bias

If a reverse bias is applied across the junction (i.e. the p type is made negative with respect to the n type), the mobile charged ions are drawn farther away from the junction by electrostatic attraction so that the insulating depletion region becomes thicker. The thicker the dielectric of a capacitor, the smaller its capacitance. Therefore the greater the reverse voltage applied across the semiconductor junction, the less the capacitance. Almost the whole of the applied voltage is present across the high resistance depletion region.

Forward Bias

It has already been stated that an unbiased junction diode has a small standing potential across the p.n. junction. The capacitance of the unbiased diode may be increased somewhat by applying a small forward voltage which is insufficient to overcome the standing potential, as this reduces the thickness of the depletion region. If a higher voltage is applied in the forward direction, however, the electrostatic force is sufficient to attract the mobile charge carriers through the depletion region and the diode will conduct; it will then lose virtually all of its capacitive properties.

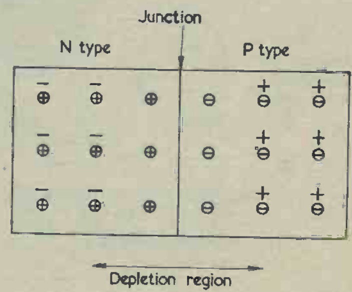

Fig. 1. A p.n. junction

Characteristics

The capacitance of a reversed biased junction diode is given by the equation:

$$C=\frac{K}{(V+P)^n}$$

where K is a constant for any one diode (it is a function of the junction area of the diode and of the number of impurity atoms in each of the two semiconductor materials), and where

V = applied reverse voltage,

P = the contact potential of the p.n. junction when there is no external applied voltage, and

C = the junction capacitance (usually in pF, but by appropriate choice of the value of K, C can be expressed in microfarads or even farads). The index n varies between about 1/3 and 1 according to the carrier gradient at the junction[1].

In most cases over the useful range of the diode the capacitance is approximately inversely proportional to the square root of the applied voltage.

The value of P is about 0.3 volt for germanium at room temperature[2] and about 0.8 volt for silicon at 25°C. decreasing to 0.4 volt at 150°C.[1] Therefore germanium voltage sensitive capacitors are somewhat more voltage sensitive than silicon types.

The type of curve obtained when the capacitance of the semi-conductor junction diode is plotted against the reverse applied voltage is illustrated in Fig. 2. The curve shown is for the germanium diode type GD14, manufactured by Standard Telephones and Cables Ltd.; the shape of the curve for other junction diodes is similar, but the values of capacitance at various reverse voltages will vary from one type of diode to another, as it depends on the amounts of impurities in the p and n materials and on the area of the semiconductor junction (in the same way that the capacitance of a normal capacitor depends on the area of the plates).

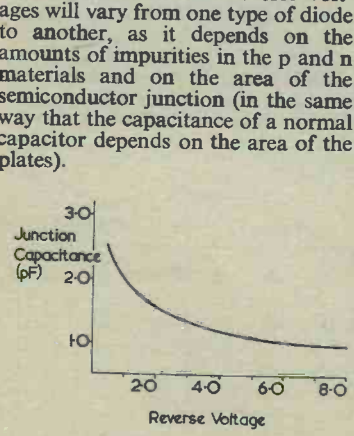

Fig. 2. Characteristics of the S.T.C. GD14

TABLE I

Characteristics at 25°C

	Junction capacitance at −1 volt and 1 Mc/s	Reverse Current
Min.	1.5pF	—
Typical	2.1pF	20μA
Max.	3.0pF	33μA

Ratings

Max. d.c. or mean or recurrent reverse voltage	10V
Max. transient reverse voltage	15V
Maximum storage temperature	75°C

Typical Operating Conditions

Reverse voltage (no signal) ..	−4V
Frequency ..	approx. 90 Mc/s
Total capacitance across tuned circuit ..	approx. 18pF
*Temperature coefficient of padding capacitor	−1,500 parts per million.

* The temperature coefficient will be influenced by the behaviour of other circuit components. The diode should be positioned in the circuit so that its temperature rise is kept to a minimum (e.g. less than 20° C.).

Characteristics and Ratings of the S.T.C. diode type GD14.

Other Variables

The capacitance of a junction diode also varies with temperature, especially at low applied voltages. Generally it increases with temperature owing to the fact that the thermal energy creates more mobile charged particles, which results in a narrower depletion region. The leakage current of the diode and hence the Q of the junction capacitance also varies with temperature.

If the semiconductor materials contain few impurity atoms near the junction, the depletion layer will be narrower for a given applied reverse voltage than if highly doped materials were used. This renders the reverse voltage which can be safely applied to the diode smaller, but on the other hand the junction capacitance is larger.

Types

Some manufacturers classify the devices as diodes and others as capacitors in their lists of products and this can sometimes be confusing. Sometimes special trade names are used.

Manufacturers who produce diodes especially for use as voltage sensitive capacitors usually provide full data showing the variation of the junction capacitance with applied reverse voltage. Many other semiconductor junction diodes not specifically designed for use as variable capacitor diodes may be used for this purpose with some degree of success, but full data about the variation of the junction capacitance is not normally provided in these cases.

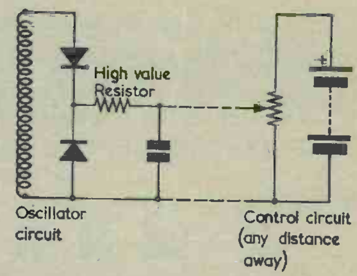

Fig. 3. The two series diode capacitors prevent a flow of current in either direction

One of the most attractive features of these diodes is that many types can be obtained at prices varying from about 2s. to £2 for small quantities. These do not include, however, the special silicon variable capacitance junction diodes for use in parametric amplifiers and frequency multipliers at microwave frequencies, some of which are priced at over £50; they have a capacitance of the order of 1pF, and some can be used at frequencies up to 50,000 Mc/s.

Hughes International Diodes

The characteristics of the HC70 series of silicon capacitors manufactured by Hughes International (U.K.) Ltd. is shown in the table. The minimum reverse bias voltage applied to these diodes is normally zero, but a small forward voltage (up to 0.4 volt) is permissible. At low bias voltages the peaks of signal voltage may exceed the bias voltage and cause conduction and clipping of the signal. This produces distortion and self-biasing due to rectification of the signal. Distortion may be prevented by connecting two capacitors back to back so that no current can flow. When this arrangement is used, capacitance changes of 10 to 1 have been achieved. Hence, frequency ranges comparable with the medium wave broadcast band may be covered using these diodes without any other variable capacitor. This arrangement is very useful for remote tuning of receivers. The type of circuit used is shown in Fig. 3.

The bias circuit may be isolated from the signal circuit by resistors with values up to several megohms. The bias current and therefore the voltage drop across the resistors is negligible.

TABLE II

Type	SPECIFICATION			TYPICAL PERFORMANCE		
	Equiv.	Cap. at −4V d.c. ±20%	Max. d.c. voltage	Cap. Range (0.1V to max. voltage)	Q at 5 Mc/s and max. voltage	Q at 50 Mc/s and max. voltage
HC7001	1N950	35pF	130V	6 to 88pF	360	39
HC7002	1N951	50pF	80V	12 to 120pF	330	36
HC7004	1N952	70pF	60V	20 to 170pF	270	30
HC7005	1N953	100pF	25V	46 to 240pF	200	23
HC7006	1N954	35pF	25V	14 to 88pF	175	20
HC7007	1N955	50pF	25V	22 to 120pF	175	20
HC7008	1N956	70pF	25V	32 to 170pF	175	20

Table showing the HC70 range of silicon capacitor diodes manufactured by Hughes International (U.K.) Ltd.

When the bias voltage contains high frequency components, the biasing networks must be arranged so that it does not load the Q of the r.f. tuned circuit below a usable level. In addition the biasing network looking towards the tuned circuit must not attenuate the desired high frequency components of the bias voltage.

The Hughes HC70 series shown in the table have a typical capacitance variation over the rated temperature range (−65°C to +150°C) of +100 parts per million per °C at a reverse bias of 10 volts.

The capacitance is given by the equation:

$$C = \frac{2.12K}{(V + 0.71 - 0.0022T)^{0.49}}$$

where K = capacitance at −4 volts and 25°C
V = applied reverse voltage
T = temperature in °C

Automatic Frequency Control

One of the most useful applications of junction diode capacitors is in automatic frequency control circuits. They are especially useful for this application at very high frequencies where the use of reactance valves is not very practical.

Tests have been carried out using the Mullard OA11 diode in v.h.f. Band II automatic frequency control circuits[2] and those have shown that the drift could be reduced by a factor of about 60:1. In practice this was found to be excessive, since if the receiver used was tuned from the Light programme (89.1 Mc/s) to the Home Service (93.5 Mc/s), the automatic frequency control held on to the Light programme for so long that the Third programme (91.3 Mc/s) could be missed completely! This effect is easily overcome, however, by increasing the reverse bias so that the change in capacitance of the diode per volt and hence the automatic frequency control efficiency was reduced. Unfortunately the OA11 diode is no longer available, but nevertheless the Mullard report describing these tests contains a great deal of very useful information about the subject.

A practical circuit showing the use of the S.T.C. variable capacitance diode type GD14 to provide automatic frequency control for a v.h.f. receiver is shown in Fig. 4. The junction capacitance of this diode at various voltages is shown in Fig. 2 and other data is given in the table. The necessary automatic frequency control voltage required to operate the oscillator circuit shown in Fig. 4 can be derived from the normal type of ratio detector circuit. The ratio detector is much to be preferred to the Foster-Seeley circuit for this application, as its source impedance is about 5,000 ohms whilst that of the Foster-Seeley circuit is about 100,000 ohms[2].

In Fig. 4 R_1 and R_2 provide the reverse bias for the diode. If the h.t. voltage changes, the diode bias and hence the oscillator frequency will change. Ideally the bias can be derived from a stabilised h.t. supply.

The 47kΩ resistor, R_8, prevents excessive loading of the ratio detector. Capacitor C_{10} prevents audio frequency voltages from reaching the oscillator circuit; any such voltages would act as a negative feedback system and reduce the audio volume by changing the oscillator frequency

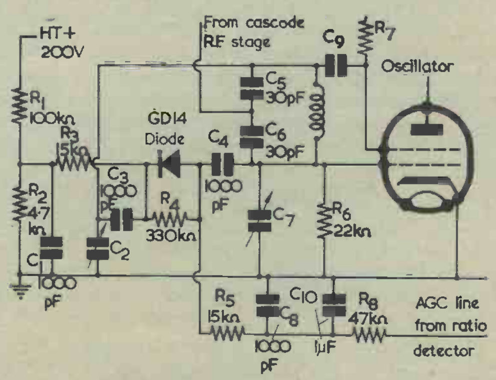

Fig. 4. Recommended oscillator circuit using the S.T.C. GD14 for a.f.c.

at an audio frequency and so reduce the desired frequency modulation of the signal. In fact, if a suitable RC filter were used in the automatic frequency control line, an interesting form of tone control could be formed. C_8, which has a much lower inductance than C_{10}, ensures that no oscillator voltages pass along the automatic frequency control line to the ratio detector and audio stages.

Performance

The factor by which the drift of the oscillator frequency is reduced can be calculated in the following way.

The slope of the GD14 characteristic (Fig. 2) is about 0.16pF per volt at the recommended operating bias of −4 volts. If the total capacitance of the oscillator circuit is 25pF, this value of 0.16pF per volt represents a change of about 1 part in 155 in total capacitance of the oscillator tuned circuit per volt of a.f.c. voltage.

But $f_{osc.} = \frac{1}{2\pi\sqrt{LC}}$ or $f_{osc.} \propto \frac{1}{\sqrt{C}}$

From this it can be shown that a change in capacitance of 1 part in 155 will cause a change in frequency of 1 part in (2 x 155)=310.

If the oscillator frequency is above the signal frequency and the latter is about 90 Mc/s, the oscillator frequency will be about 100 Mc/s, assuming the normal 10.7 Mc/s i.f. is used. A change in frequency of 1 part in 310 at a frequency of 100 Mc/s is 100 x 1/310=approx. 0.32 Mc/s=320 kc/s. This is the frequency change produced by 1 volt of automatic frequency control voltage from the ratio detector.

The voltage output from the ratio detector into the automatic frequency control line of a typical domestic receiver is about 1/10 of a volt for each kilocycle of frequency deviation when the input signal is reasonably good.[2]

The factor by which the drift is reduced will be approximately the product of the number of volts per kilocycle of drift fed into the a.f.c. line by the ratio detector and the number of kilocycles of oscillator frequency change produced by one volt of a.f.c. voltage. In the case given above, this will be 1/10 x 320 =32. This factor is adequate for almost all purposes and is much better than that obtainable from most simple reactance valve circuits (which is of the order of five to ten times).

Acknowledgements

The circuit of Fig. 4 has been designed by Standard Telephones & Cables Ltd. and is published in their GD14 diode data sheets.

References

1 "Semiconductor Junction Capacitors" by C. H. Taylor, *Wireless World*, April 1962.

2 "A.F.C. in Band II F.M. Receivers", based on a report by G. D. Browne, *Mullard Technical Communications*, vol. 4, no. 35.

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"A Voltage Variable Capacitor" by G. F. Straube, *Electronic Industries*, May 1958.

"Taking Advantage of the Voltage Sensitivity of the Silicon Capacitor" by J. G. Hammerslag, *Electrical Manufacturing*, September 1959.

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"Junction Diode A.F.C. Circuit" by G. G. Johnstone, *Wireless World*, August 1956.

High Current Power Packs

by H. N. RUTT

High current, low voltage power packs may raise problems which are not encountered in more conventional units. Our contributor reviews some of the precautions which have to be observed

MOST CONSTRUCTORS ARE FAMILIAR WITH NORMAL power pack circuitry; however, when a power pack is required to supply large currents, perhaps for power transistors, certain problems arise which do not occur, or which are not important, when only a low current supply is needed.

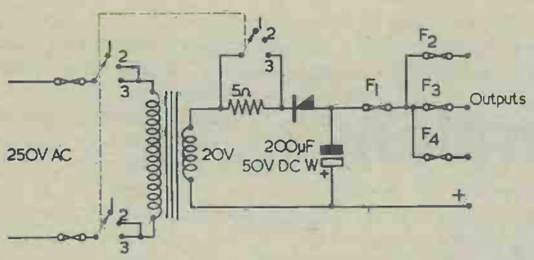
The first problem to be encountered is that of the internal impedance of the power pack. At 100mA load an internal impedance of 10Ω will cause a voltage drop of 1, and this is quite acceptable even in a power pack supplying 20 volts only. However, if the load to be imposed on the power pack is 5 amps, 10Ω will give an excessive voltage drop.

Surge Limiting

In a high current power supply using a silicon rectifier the resistance of the rectifier and transformer is very small and will cause little voltage drop. This low internal impedance can cause a very large current to flow when the unit is switched on and the reservoir capacitor charges, and because of this a surge-limiting resistance, normally of 4 to 5Ω in value, must be included in the circuit to prevent the surge destroying the rectifier. In a low current power supply the surge limiter may be left in the circuit but, at high currents, switching must be included to remove it from the circuit after the capacitor has charged, so that there is no large drop in voltage when a high current is taken. Such a switching circuit is shown in the accompanying diagram. Using this arrangement the surge limiter is automatically replaced in the circuit before the unit is switched on again.[1]

For the same reasons that surge limiters cannot be left in the circuit, resistive smoothing cannot be used. Large value capacitors must be used for

[1] The 3-way switches shown in the diagram should, preferably, be of the make-before-break type in order to prevent a momentary cessation of the supply before the 5Ω limiter resistor is short-circuited.—EDITOR.



A typical low voltage, high current supply. The three switch positions are (1) Off, (2) On, and (3) High-Load

smoothing in the main power pack, and extra smoothing can be included in the individual units, if required.

Output Short-Circuits

With a low power pack internal impedance, a short-circuit of the output will cause a very large current to flow, immediately destroying the rectifier. Thus the unit must be adequately fused, or some other form of short-circuit protection provided.

Suitable rectifiers for high current, low voltage supplies are the ZR23R (8 amps), GEX541 (6 amps) and 1S401 (3 amps).[2]

Two other points should be noted when building a low voltage, high current power pack. Firstly, sub-miniature electrolytic capacitors should not be used as smoothing components, as they may not withstand the ripple current involved. If a capacitor passes too high a ripple current it becomes hot, leaks both electrically and physically, and finally explodes.

Secondly, the rating of switches should be checked. Many small toggle switches are only rated at 2 or 3 amps, and might have their contacts fused by 7 or 8 amps!

[2] Before employing high current rectifiers, always check manufacturers' specifications to ensure that peak inverse voltage, limiting resistance and heat sink requirements are all met adequately.—EDITOR.

RADIO AMATEURS EXAMINATIONS AND MORSE CLASSES

Ilford Literary Institute (High School for Girls, Cranbrook Road, adjacent to Gants Hill Station, Central Line). The following classes have been arranged by the East London R.S.G.B. Group: (1) An eight months course for those intending to take the Examination (Wednesdays 7.15–9.15 p.m.); (2) Morse and Codes of Practice. A six months course in preparation for the G.P.O. Morse Test for an Amateur (Sound) Licence. Arrangements are expected for those who, in the opinion of the instructors, have reached the required speed to be tested at the College by a Post Office representative.

The fees for students living in the Essex County Council area will be 40/– for the R.A.E. Course, 27/– for the Morse and Codes of Practice Course or 50/– for the two courses. Students from other parts of London will be admitted as out-county students provided the Local Authority is informed. Enrolment will take place on 9–12th September from 7–8.30 p.m. but those who intend to enrol are advised to forward their names, etc., together with a s.a.e. to W. G. Hall (G8JM), 48 Hawkdene, N. Chingford, London, E.4. at once so that a place may be assured. Classes commence during the week beginning 23rd September.

City of Portsmouth, Eastney Secondary Modern School for Boys, Reginald Road, Eastney, Southsea, Hampshire. The Radio Amateurs Examination Course commences in September on each Thursday evening at North End Evening Institute, Portsmouth and is supervised by G6NZ. Enquiries are welcomed by The Secretary, Eastney Secondary Modern School for Boys, Reginald Road, Eastney, Southsea, Hampshire.

Grafton Radio Society announce that they have again made arrangements with the Holloway L.C.C. Evening Institutes for official courses in the Radio Amateurs Examination and Morse (both for beginners) to be held this winter at Montem School, Hornsey Road, Holloway, London, N.7. The classes will meet on Mondays, with a repeat lecture on Wednesdays, commencing Monday, 23rd September—R.A.E. at 7–9 p.m. (Instructors: S. H. Iles, G3BWQ, and R. H. Smart, G3MMC), followed by Morse at 9–10 p.m. (Instructor: A. Ralph). The fee for either course will be 25/–, or for the two. Enrolment will be at the school any evening (7–9 p.m.) during the week 16–20th September but application to reserve a place should in the first instance be made to the Grafton Radio Society Hon. Secretary—A. W. H. Wennell (G2CJN), 145 Uxendon Hill, Wembley Park, Middlesex. In the May 1963 City and Guilds examination another 26 passes were obtained, making a grand total of 225 in the ten years that these courses have been running. In addition to the above, the club meet in the same room every Friday evening at 7.30 p.m. for the usual club activity, including three transmitters covering 160 to 2 metres and a monthly "SWL Corner". New members and visitors will be especially welcome when the new session commences on Friday, 6th September next.

Central Evening Institute, Lea Mason Centre, Bell Barn Road, Birmingham. Enrolment during the normal evening school period early September. Classes Monday evenings 7–9.30 p.m., Instructor M. A. Brett, G3HBE. Wednesday evenings 7–9.30 p.m., Instructor H. B. Bligh, G3HBB.

Kit Review

The Sinclair "Slimline" Micro-Radio Receiver

THE MOST POPULAR CONSTRUCTIONAL PROJECT amongst amateurs is the small pocket radio and, as long as there is no loss of performance, the smaller the receiver is the more popular it will be. In the past, the design of really small high performance receivers has been hindered by the lack of sufficiently small components and by the expense of high grade transistors. These problems have been overcome in the "Slimline", which is the result of an intensive effort to produce the smallest possible radio design with full scale performance and still to retain simplicity of construction.

Circuit Description

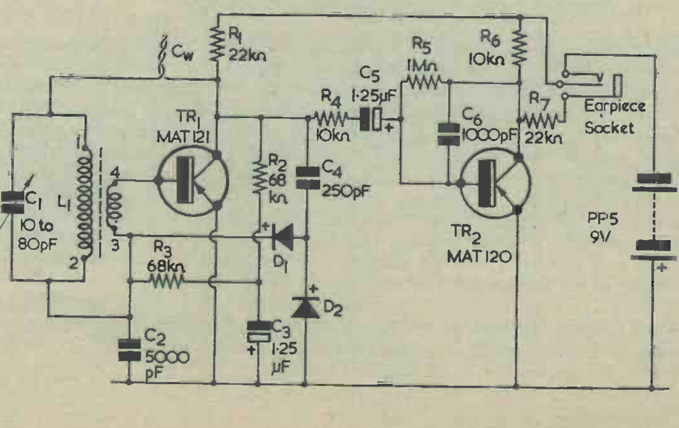
The high performance of the "Slimline" has been made possible by the introduction of Micro-Alloy transistors on to the amateur market. These transistors are the first to combine excellent a.f. performance with cut-off frequencies in the region of 100 Mc/s. The r.f. power gain of a conventional r.f. alloy transistor in a reflex circuit is only about 20dB or 100 times whilst a micro-alloy transistor (MAT) can provide a gain of 40dB or 10,000 times. Furthermore the a.f. gain of a MAT is much higher than that of an ordinary alloy type.

By combining MAT's with careful design it has been found possible to achieve really remarkable performance with only two transistors and relatively few associated components. The sensitivity compares well with that of many superhets and the volume is sufficient to enable the set to be used in a car or train. The "Slimline" is free from noise or distortion and gives excellent fidelity of reproduction.

The "Slimline" circuit is shown in the accompanying diagram. L_1 is a miniature ferrite rod aerial which picks up the signal and, with C_1, tunes to the required station. A secondary winding on L_1 couples the signal to TR_1, MAT 121, which then amplifies at r.f. The r.f. output from TR_1 is fed to a voltage doubling detector via C_4. D_1 and D_2 demodulate the signal and feed an a.f. voltage back to the input of TR_1. Any residual r.f. voltage is removed by C_2.

In addition to detecting the signal, D_1 and D_2 provide an automatic gain control voltage for TR_1. This prevents overloading on strong stations and is an important feature not normally found on simple receivers.

The base bias for TR_1 is provided by resistive feedback from the collector via R_2 and R_3. Taking



Circuit of the "Slimline" transistor receiver the bias from the collector ensures adequate d.c. stabilisation but would normally result in unwanted negative feedback at a.f. This is prevented by decoupling the junction of R_2 and R_3 with C_3, an electrolytic capacitor. The addition of C_3, another novel feature of the circuit, results in a considerable increase in the a.f. gain of the stage.

The r.f. gain of TR_1 is increased by positive feedback or regeneration applied via C_w from the collector to the top of L_1. C_w consists simply of two short lengths of insulated wire twisted together. Its main purpose is to enhance the performance of the radio at the high frequency end of the band, where Radio Luxembourg is situated, thus overcoming the poor sensitivity in this region which is a feature of many reflex sets.

Once the set is constructed C_w does not have to be adjusted because the r.f. gain is automatically controlled by the a.g.c. system.

TR_1 provides about 35dB gain at a.f. and the output is fed to TR_2, and MAT 120, via R_4 and C_5. The circuit around TR_2 is designed to obtain the maximum possible voltage gain from the transistor because the earpiece used, a piezo-electric crystal type, requires a voltage drive for good quality. Crystal earpieces normally give higher sensitivity at high frequencies than they do at low frequencies. This is compensated for by C_6 which provides frequency selective negative feedback from the collector to the base of TR_2.

The total current consumption of the circuit is only 1mA making the battery life several hundred hours with the type specified.

Practical Details

The "Slimline" receiver uses a printed circuit board and the case employed, besides being remarkably small, is both elegant and carefully designed. The case and the dial are both made specially for this receiver.

Particular attention was paid to small details when the layout of the "Slimline" was considered.

This illustration shows the extremely small size of the "Slimline" receiver

For example battery clips are provided making it unnecessary to solder the battery into the circuit. The receiver is automatically switched on when the earpiece plug is inserted and switched off again when the plug is removed. Thus it is virtually impossible to leave the set on unintentionally.

The "Slimline" operates in the vertical position with the dial at the top. The tuning capacitor provided gives full coverage of the Medium wave band and may be detuned slightly to give control over the volume. Alteration of the volume may also be achieved by rotating the receiver, because the aerial is directional.

News and Comment (Continued from page 96)

There is no reason now to suppose that this will cease to be so: indeed, with the introduction of u.h.f. transmissions, the need for outside aerials may well become even more general, though u.h.f. aerials will usually be smaller than the present v.h.f. aerials."

Outside Tx Aerials

Appeals by radio amateurs against decisions by the Ministry of Housing and Local Government refusing them planning permission for aerial arrays, whilst often getting the publicity of a short paragraph in the local newspaper, rarely get the privilege of editorial comment, as happened recently in the pages of the *Eastern Daily Press*, one of East Anglia's foremost "dailies". The interesting thing about this editorial was its very favourable attitude to the activities of radio amateurs and its sympathetic understanding of the amateur concerned.

To quote the *Eastern Daily Press*, "This case is of a kind in which the Radio Society of Great Britain interests itself closely. To many people whose knowledge of radio goes only as far as being aware how to switch on and turn off a TV or "steam" wireless set, it may appear mildly surprising that there are amateurs with aims as wide as this one. . . ." "The authorities, however, do not by any means despise these activities, which during the Second World War often proved of real value and which in these days of complex TV and radio can still be turned to useful account. This far-ranging field of science has developed within the lifetime of many of us. . . ."

"It would be sad if the Ministry decision compelling this devotee to prune drastically his installation meant he and others like him had to consign their activities to oblivion."

RADIO topics

By RECORDER

AMATEUR RADIO CONSTRUCTION must, I feel, be one of the most rewarding pursuits which is available to us. The only basic requirement of any would-be constructor is that he should be able to solder a tinned copper wire to a solder tag. Given this ability, anyone can enter a sphere of activity which is almost entirely limitless in its range of application and in its depth of complexity.

The beginner may commence with simple receivers or amplifiers, whereupon he follows constructional articles of the type which are published in this magazine, or works with the kits which are marketed by our advertisers. Having gained this initial experience, together with the practical knowledge which these first undertakings inevitably bring in their train, the constructor can then proceed to more ambitious projects. The field is wide open, and it includes receivers and amplifiers, together with testmeters, signal generators, oscilloscopes, model control units, electronic timers and other devices, tape recorders, and countless other instruments.

Results Obtained

Apart from the pleasure of building equipment which looks good, the constructor has the secondary advantage of obtaining enjoyment from the results it provides. Lovers of good music can always experience considerable pleasure in true high fidelity reproduction; but that pleasure is increased a hundredfold if the amplifier which provides the reproduction has been built by the listener.

It is always possible to follow the pursuit of home-construction without a great deal of technical knowledge. On the other hand, the enjoyment obtained from the building of equipment is greatly enriched if technical knowledge is allowed to increase hand in hand with advancing mechanical skill and confidence. The articles on "Understanding Radio" by W. G. Morley which appear elsewhere are, I feel, particularly helpful in this respect, because they start right from scratch and assume that the reader is a complete newcomer to the radio scene. W. G. Morley has dealt at some length with the components which we all handle and use, and he has done a great deal to illustrate the fact that there is, here, much detail which has to be taken into account if their functioning is to be fully understood. W. G. Morley has also taken us unscathed through the thorny path of basic a.c. theory and resonant circuits, and these are subjects which are exceptionally difficult to explain without going into an excessive amount of complex detail.

The great advantage, to the amateur, of keeping his technical knowledge in step with his constructional ability is that he can then branch out on his own and make up his own designs. A home-constructor of my acquaintance is particularly adept at this approach, and he usually tackles his projects in three separate steps. His first step is to initially design the circuit and see just exactly what components he requires. He never commences to pay any serious attention to layout until he has all components to hand. However, as his circuits are frequently experimental in one respect or another, he will very often undertake a second step as well before finally settling on layout. In this second step he quickly checks the functioning of a particular part of the circuit about whose practical performance he is doubtful, and he does this by temporarily rigging up this section in the most frightful "bird's nest" assembly one can possibly imagine! Nevertheless, this quick experimental check pays good dividends, because it enables him to find the optimum values for the resistors, capacitors and other components employed, as well as the most efficient circuit configuration in which they may be wired up. Step number three then consists of working out the final layout (bearing in mind any pertinent points resulting from the experimental second step), of bashing out the metalwork, and of fitting and wiring up the components. The result is a beautiful-looking job in which every part is positioned in its right place, and which offers no evidence of last-minute changes because certain sections of the circuit have had to suffer major alterations.

This last approach is, of course, only one of the many that can be applied to radio construction. Perhaps the greatest attraction of the hobby is that you can set about it in any way you darned well please!

Experimental Rectifier Kit

The subject of experimental rigs affords an appropriate introduction to the news that Electro Automat Ltd. have introduced an experimental rectifier kit which enables the amateur and the laboratory engineer to make up rectifier assemblies to meet his exact requirements. The accompanying illustration shows the kit in use, and demonstrates the manner in which a rectifier stack may be built up.

The kit has been carefully planned to give the amateur and professional radio engineer everything he may require to assemble an experimental rectifier stack, and includes three sizes of rectifier plate, Bakelite contact and insulating washers, connecting tags, insulating tubing, mounting spindles, and steel spacing washers and nuts. Also provided are assembly instructions.

The rectifier plates, which are apparently of the selenium type, are available in three sizes at 18mm square, 23mm square, and 30mm square. In half-wave circuits, the 18mm plates can pass a forward current of 60mA, whilst the 30mm plates have a capacity of 300mA. The corresponding currents for full-wave rectification are 125 and 600mA respectively. For rectifier applications, the maximum inverse voltage per plate is 30 volts r.m.s. The rectifiers may also be employed for voltage doubling, d.c. blocking, and magnetic amplifier applications.

The "Standard Kit" (as illustrated) costs £7 7s. complete, and further details may be obtained from Sales Engineering, Electro Automat Ltd., Swinton, Manchester.

Do-it-yourself rectifier assembly. The newly introduced Electro Automat rectifier kit allows the assembly of rectifier stacks to meet exact circuit requirements

Goldbach's Conjecture

Readers who like playing around with numbers may be interested in Goldbach's Conjecture. This states that every even number is the sum of two primes (i.e. numbers which are incapable of being separated into factors).*

To date, nobody has been able to disprove this conjecture, nor to find an exception.

At the same time, nobody has been able to prove it, either!

A Rose Is A Rose Is A Rose

Much to the annoyance of our radio-etymology purists (who take up page after page of *Wireless World* with their complaints about the matter) electronic engineers continue to coin weird and wonderful words to describe objects which have never before appeared on Earth. The present trend is towards words which are made up from initial letters, and a typical example is given by "laser". "Laser" is derived from "Light Amplification by Stimulated Emission of Radiation", and the associated device produces coherent light (i.e. light at a single frequency, as with a radio wave) along a beam whose edges are almost exactly parallel. Materials capable of producing coherent light are few and far between, and a great deal of research is currently in progress to find suitable substances which are easier to handle and more inexpensive than those already discovered. Acceptable materials are those which can be made to "lase", and so we now have a new verb. This is "to lase" and it means "to produce coherent light".

G.P.O. engineers have an ability to create new names from initial letters which are not only fanciful but delightfully macabre as well. Two good examples I've bumped into recently appeared respectively in *Wireless World* for July 1963 and in *The Post Office Electrical Engineers' Journal* for April 1963. The first is "Multiple-Direction Universally Steerable Aerial", and this is referred to as "MEDUSA". The second is "Machine for Automatic Surface Sampling and Automatic Contact-Resistance Evaluation"; which reduces to "MASSACRE".

Before the present-day penchant for devising new words from initial letters came into being, engineers were still capable of producing remarkable terms. Thus, in O. S. Puckle's *Time Bases* (Chapman and Hall) we find a timebase circuit referred to as the "Sanatron". This derives from the Royal Air Force slang term "sanitary", meaning "satisfactory". The sanatron circuit is a development from the "Phantastron", and the name of the latter is due to the fact that, at the time of its invention, its performance was considered fantastic!

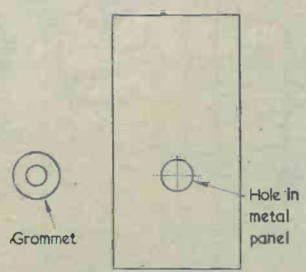


Fig. 1. In production, it is often difficult to insert a grommet into a hole if the grommet is hard and has thick walls

Many more such colourful terms are in use in electronic engineering, and I would like to select a further one before concluding on the subject. It is very often necessary, in receiver production, to fit a rubber or p.v.c. grommet to a round hole in a metal bracket or chassis, as shown in the accompanying Fig. 1. Sometimes, however, the application requires that the grommet be hard and have thick walls, whereupon it becomes extremely difficult to fit it to the hole by hand. The solution is to punch the metal sheet with a hole having the shape shown in Fig. 2. In this case the grommet is inserted in the upper wide-diameter section of the hole, after which it is slid into the narrow-diameter section with little difficulty. And the term given to a hole of this shape? It is described as a "Mae West".

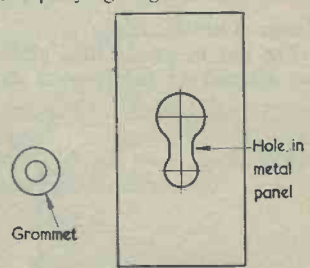


Fig. 2. The solution is to use a hole of this shape. The grommet is inserted into the wide-diameter section, then slid into the narrow-diameter section where it locks into position

* I bumped into this fascinating little item of information in a review by Professor Hyman Levy in *New Scientist* for 4th July, 1963.

The Mighty Midget

A good quality record-player amplifier

By M. J. Pitcher, B.Sc.

WITH THE ACQUISITION OF A RATHER OLD B.S.R. three-speed autochange turntable came a demand from the junior members of the writer's family for a fully working portable record-player. The turntable was in good order but a new pick-up cartridge was wanted and an Acos GP67 was bought as a compromise between quality and economy. The quality produced by the parental Hi-Fi amplifier pleased the youngsters but it became obvious that they could not be left in charge of the volume control knob.

An amplifier giving sufficient volume for one room but small enough to fit into a portable cabinet was clearly called for. At the same time it was felt desirable to produce sound as near to Hi-Fi standards as possible. The resulting amplifier is an economical design with surprisingly good reproduction.

Design Considerations

The use of an a.c./d.c. circuit was discounted on the ground of safety—too many members of the family possess screwdrivers. Transformers can, however, be bulky and expensive components but, since only a small amount of audio power was aimed at, it seemed possible to use a "converter" type of transformer with an output valve such as the EL91 (or 6AM5). These valves are available very cheaply and provide ample power for even large rooms while taking a current of less than 20mA.

The transformer used by the writer is rated at 25mA and the EL91 draws about 19mA, so that the choice of preceding valve for voltage amplification is limited to those taking only a small current. The use of an ECC83 seemed a logical step, but enough gain would be available from one half to fully load the output stage. Rather than allow the other half of the valve to remain unused it was decided to incorporate a Baxandall tone control so that "lift" and "cut" of treble and bass would be given. This eliminated the possibility of applying negative feedback over the whole amplifier but the advantage of wide-range tone control made the sacrifice seem worth while.

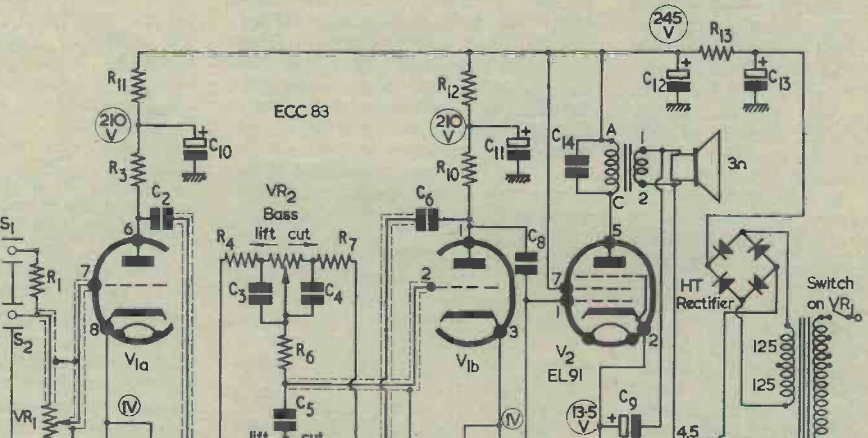


Fig. 1. The circuit of the Mighty Midget. Voltages indicated were obtained with a Weston 772 meter (1,000Ω per volt). The output transformer connections shown are applicable to the Elstone multi-ratio transformer type MR/T

The Power Output Stage

No problems present themselves in designing the output stage providing that the maximum rating for the valve of 250 volts is not exceeded. The cathode bypass capacitor C_9 is returned to chassis through the output transformer secondary, providing some negative feedback. The transformer primary is shunted by C_{14}. The result is a very clean performance in both the bass and the treble regions.

Input Sensitivity

The GP67 crystal cartridge gives a high output and it is possible to use a high resistance in series with it. This improves the performance and makes it unnecessary to employ a higher value than 1MΩ for the volume control in the grid circuit of the first valve. Because of these high values of resistance great care is needed in screening all the leads. An auxiliary output is taken to socket S_2 from the "hot" end of the volume control and this can be used to feed a second amplifier direct from the pick-up. Alternatively it can be used as an input socket to the amplifier. The sensitivity is such that a crystal tuner will produce a reasonable volume from the local B.B.C. stations when plugged into the auxiliary socket, and so turn the unit into a radiogram.

Construction and Layout

It is anticipated that the layout of individual amplifiers will be dictated by the amount of space available inside the record-player cabinet, if, like the writer, a portable case is used. For this reason only a general description of the physical layout is given.

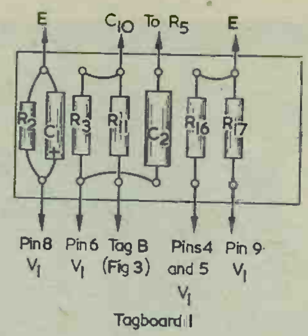


Fig. 2. The components mounted on tagboard 1

The amplifier built by the writer was constructed in a chassis measuring 7 x 4 x 1½in. This chassis was bolted to an aluminium sheet as also were the mains and output transformers. All the screws were countersunk, and self-tapping screws were used to fasten the sheet down to the base of the cabinet.

Two tagboards were used to mount the small resistors and capacitors. It should be noted that R_4, R_5, R_6, R_7, R_8, C_3, C_4 and C_5 are mounted directly on the tone controls VR_2 and VR_3. Connection is made to the tone control circuits via screened cable.

Components List

Resistors (all ¼ watt unless otherwise stated)

R_1	4.7MΩ
R_2	1kΩ
R_3	47kΩ
R_4	100kΩ
R_5	330kΩ
R_6	470kΩ
R_7	100kΩ
R_8	330kΩ
R_9	1kΩ
R_{10}	47kΩ
R_{11}	33kΩ
R_{12}	33kΩ
R_{13}	4.7kΩ 5 watt wirewound
R_{14}	680kΩ
R_{15}	750Ω ½ watt
R_{16}	100Ω
R_{17}	100Ω
VR_1	1MΩ log, with switch
VR_2	1MΩ linear
VR_3	500kΩ lin, with centre tap

Capacitors

C_1	25μF electrolytic, 12V wkg.
C_2	0.1μF
C_3	0.005μF
C_4	0.005μF
C_5	100pF
C_6	0.1μF
C_7	25μF electrolytic, 12V wkg.
C_8	0.05μF
C_9	50μF electrolytic, 25V wkg.
C_{10}, C_{11}	16+16μF insulated electrolytic, 250V wkg. (see text)
C_{12}, C_{13}	40+40μF or 50+50μF electrolytic, 250V wkg., isolated can (see text)

Speaker
3Ω, 7 x 4in

Valves

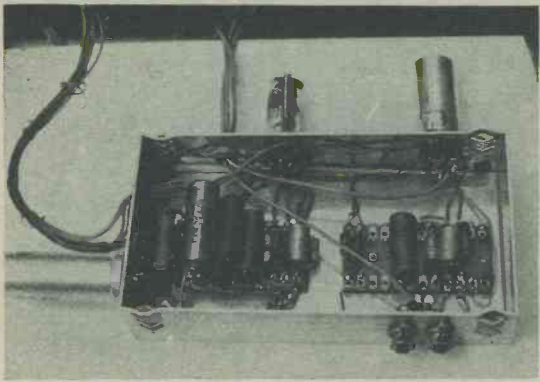
V_1	ECC83 or 12AX7
V_2	EL91 or 6AM5

Mains Transformer
Midget type (Radiospares). Secs: 0–250V, 25mA; 6.3V, 1.2A

Output Transformer
Elstone type MR/T (multi-ratio)

Rectifier
Contact-cooled bridge type, 250V, 25mA minimum

Miscellaneous
One each, 6-way and 12-way miniature tagboards (see Figs. 2 and 3); two coaxial sockets, chassis, etc., to suit space available in cabinet



Interior of the amplifier chassis. The h.t. electrolytic capacitors are mounted on the side

The value of R_1 can be decreased if the output from any particular crystal pick-up is insufficient to fully load the amplifier.

The noise and hum level of the completed amplifier is extremely low and this is due chiefly to very careful screening of the grid leads. One point of interest arises with the volume control used by the writer. A rather nasty high-pitched hum was eradicated by earthing the control spindle. Other points to observe are the mounting of the two transformers with their axes at right angles, and the use of only one earth connection to the chassis. This latter is best situated at a solder tag fixed by one of the securing screws for the input socket.

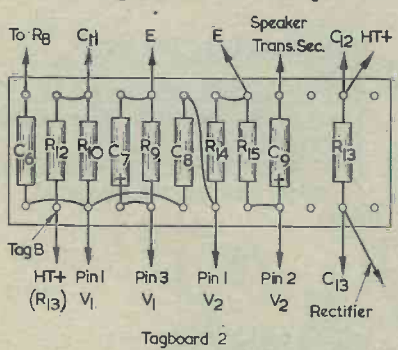


Fig. 3. Wiring to tagboard 2

The h.t. electrolytic capacitor (C_{12}, C_{13}) employed by the writer had an isolated can, and this was also earthed to the common chassis solder tag. Components with non-isolated cans may, of course, be readily insulated from mounting clips by means of tape or a strip of insulating material, thereby allowing the can to be still connected to the common chassis point. The negative terminals of C_{10} and C_{11} are similarly connected to the common chassis point. It was not found necessary to connect the auto-changer chassis to the amplifier chassis, but such a connection could be made if the constructor felt it desirable.

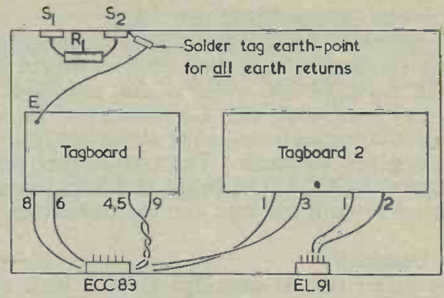
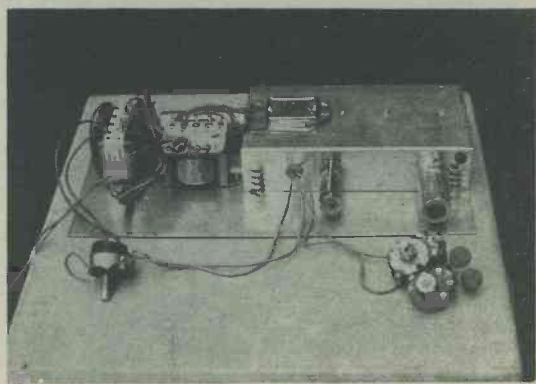


Fig. 4. Illustrating how the tagboards fit into the amplifier chassis

The output transformer specified is large enough to handle the bass frequencies adequately at full power. Alternative transformers with suitable ratios are readily available but "midget" types should be avoided. When connecting the negative feedback leads from chassis and C_9 to the transformer secondary there should be a decrease in volume compared with that available when C_9 is returned to chassis direct. An increase in volume with possibly some instability indicates positive feedback and is an incorrect mode of operation. Correct operating conditions will then be given by reversing the connections to the transformer secondary.

Conclusion

The completed unit was put through its paces with 45 r.p.m. "pop" records for some hours and



The fully assembled amplifier showing the method of mounting the transformers and h.t. rectifier

gave every satisfaction. Then, when the children were safely in bed, it was tried with the Vox record, "This Is High Fidelity". The reduced output at 33 r.p.m. was sufficient to nicely load the output valve, and results were better than expected. The small 7 x 4in loudspeaker was chosen for its cheapness rather than quality, but it has a surprisingly good bass response in the cabinet with the lid down. The tone controls are very effective, but sufficient bass lift is available to produce feedback to the pick-up arm when using the internal speaker.

Handy Signal Generator

By A. G. Dowding

ONE OF THE MOST FREQUENTLY USED TOOLS in the service shop, certainly for the repair of radios, is the signal generator. Many people seem to fight shy of constructing such an instrument, sometimes justifiably so after looking into a precision factory-made unit. The generator described here is, however, of a simple but stable nature, and can be constructed by anyone who understands the principles involved.

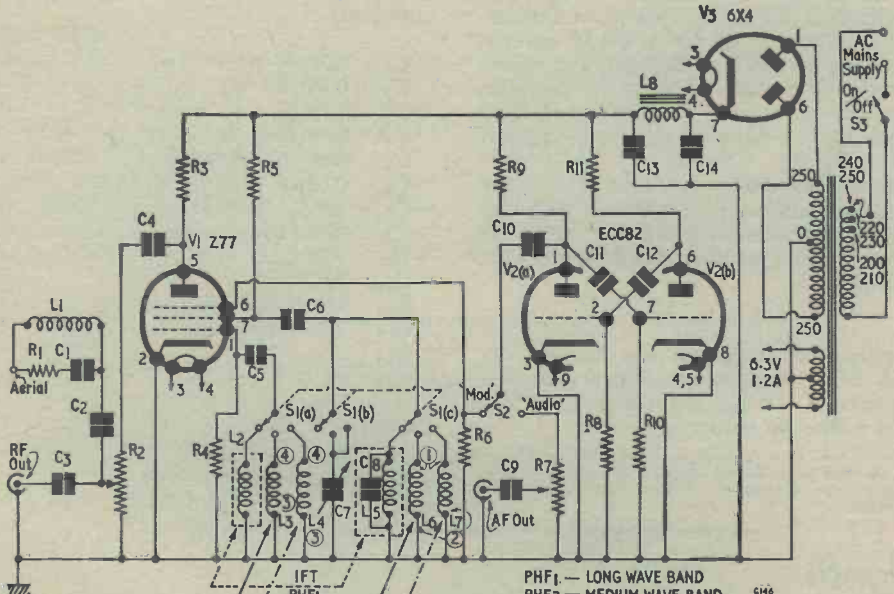
For the repair of domestic broadcast band radios, a signal generator must cover the Long and Medium wavebands, as well as providing an intermediate frequency (465 kc/s) and an audio signal with which it can modulate the other frequencies. The present instrument has these facilities, although by changing the associated coils, frequencies up to 25 Mc/s may be produced.

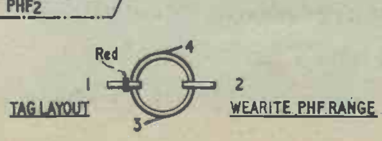
The Circuit

The audio section of the generator consists of a multivibrator circuit using the double-triode V_2. An ECC82 was used in the prototype but a 6SL7, 6SN7, ECC81, or ECC83 may very easily be employed instead. The multivibrator produces an almost true square wave which may be used for audio testing, with or without an oscilloscope.

The frequency of this multivibrator may be adjusted to one's personal taste. The writer finds, personally, that a high pitched note quickly becomes irritating and the components shown in the diagram gave a frequency of 500 c/s in the prototype.[1]

[1] The frequency generated by the multivibrator will vary according to the grid base of the valve employed in the V_2 position. It may be necessary to adjust the values of C_{11} and C_{12} to obtain the desired frequency.—EDITOR.





The radio frequency section employs a Z77, but most r.f. pentodes should suffice. The circuit is quite stable and, provided that construction is carried out carefully with components and wiring fixed rigidly, performance will be very satisfactory.

The coils for the intermediate frequency range, L_2, L_5, are those of an i.f. transformer of the required frequency, one winding of which (L_2) has had its parallel fixed capacitor removed. To tune the i.f. output, the slug of the coil retaining the capacitor must be adjusted. The other slug should be removed.[2]

Extension of the range of radio frequencies and intermediate frequency provided is easily accomplished by switching in the requisite range of coils. If desired, switch S_1 may have an increased number of ways to accommodate such coils.

The r.f. output is provided via a simple attenuator, or by way of the dummy aerial filter $L_1R_1C_1$. The coil L_1 consists of 60 turns of 28 s.w.g. enamelled wire on a ½in diameter former.

Modulation depth is fixed at approximately 30%. Modulation is given when S_2 is switched from "Audio" to "Mod".

It has been considered very necessary, as with all such instruments, to isolate the chassis from the mains with a transformer.

Construction

The whole unit, with associated power pack, can be built on a chassis 9 x 6 x 2in. It is wise with an instrument of this type not to over-crowd components underneath the chassis, as this may lead to complicated wiring or, worse, instability. It is a good idea to use 22 s.w.g. p.v.c. covered tinned copper wire as this is quite rigid. The wiring to the coils must be kept as short as possible, and the coils themselves should be screened from the rest of the unit. This applies also to the dummy aerial components.

The whole unit should be encased in a metal box or cabinet to eliminate interference with any other apparatus. Air vents around ¼in across are allowable, but larger apertures should be backed with a metal grille.

Calibration

Calibration of the prototype was carried out with the aid of a commercial signal generator and radio receiver, but an accurately calibrated receiver could suffice on its own.

[2] If squegging (evident as a violent hiss) occurs, connect across L_2 a resistor whose value, determined experimentally, lies between 5 and 50kΩ.—EDITOR.

Components List

Resistors

R_1	390Ω ¼ watt
R_2	50kΩ pot, log track
R_3	47kΩ ½ watt
R_4	47kΩ ¼ watt
R_5	33kΩ ½ watt
R_6	100kΩ ½ watt
R_7	1MΩ pot, log track
R_8	1MΩ ¼ watt
R_9	47kΩ ½ watt
R_{10}	1MΩ ¼ watt
R_{11}	47kΩ ½ watt

Valves

V_1	Z77 (EF91, 6AM6, 6F12)
V_2	ECC82 (12AU7) (see text)
V_3	6X4 (EZ90)

Inductors

L_1	See text
L_2, L_5	Modified i.f. transformer (see text)
L_3, L_6	Coil type PHF1, Wearite
L_4, L_7	Coil type PHF2, Wearite
L_8	Smoothing choke 10H

Transformer

Mains transformer. Secondaries: 6.3V at 1.2A, 250-0-250V at 20mA

Capacitors

(All fixed values 350V wkg. unless otherwise indicated)

C_1	500pF, 200V wkg.
C_2	0.01μF
C_3	0.01μF
C_4	0.01μF
C_5	50pF, 200V wkg.
C_6	0.01μF
C_7	500pF variable
C_8	fitted to i.f. winding
C_9	0.01μF
C_{10}	0.01μF
C_{11}	100pF (see text)
C_{12}	100pF (see text)
C_{13}, C_{14}	32+16μF, electrolytic

Switches

$S_{1(a),(b),(c)}$	3-pole, 3-way
S_2	1-pole, 2-way
S_3	1-pole, 1-way

Next Month . . .

- **2V Short Wave Receiver**
- **Car Anti-Theft Device**
- **Oscilloscope Double Beam Converter**

★ ★ ★ ★ ★ ★ ★

GOLDEN *Jubilee* OF THE R.S.G.B.

★ ★ ★ ★ ★ ★ ★

Reception at Mullard House

1963 is the Golden Jubilee Year of the Radio Society of Great Britain and one of the events to mark it was an "open house" at the Mullard Electronics Centre, Torrington Place, W.C.1. on July 1st and 2nd.

Here a special programme of demonstrations and films was arranged for members and many distinguished figures in the amateur radio world, including a number from overseas, attended.

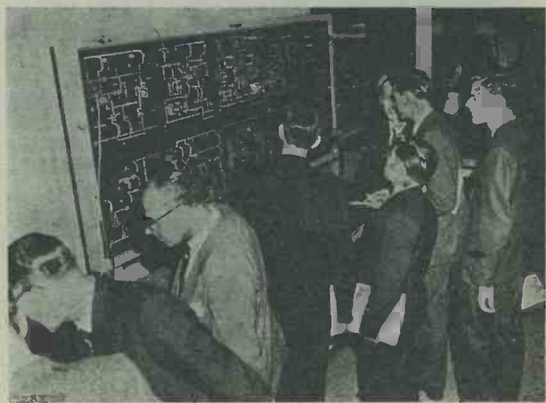
In addition, a reception was held by Mullard Ltd for members of the R.S.G.B. council and their guests at Mullard House on the evening of July 1st.

Among those present were Dr. R. L. Smith-Rose, a member of the society since 1913, the president Mr. N. Caws, F.C.A. and the Mayor of Holborn (Councillor Harold Bright, M.A., M.I.E.E., J.P.) in which borough the headquarters of the society is situated.

In the photograph, visitors are shown listening to an explanation of the latest methods of teaching electronics.

Golden Jubilee Dinner

The Golden Jubilee Dinner was held at the Connaught Rooms, Holborn, on Friday, July 5th and this was the culmination of a week of events in celebration of this milestone in the history of the Society. Some 400 guests representing over a dozen countries attended and the toast to the Society was proposed by Lord Brabazon of Tara who regaled the guests with his early experiences in the many interests he has cultivated. Being nearly 80 years of age, his memories covered the very earliest days of such activities as flying, aerial photography and radio.



Of the numerous presentations made on behalf of various National Radio Societies, the specially designed and made Delft china plate presented by V.E.R.O.N. (Dutch Radio Society), the beautiful pewter vase presented by N.R.R.L. (Norwegian Amateur Radio Society) and cheques for the R.S.G.B.'s Headquarters Building Fund (Swiss and German Radio Societies) were particularly acceptable. Following the formal proceedings, a most pleasant evening was spent by the company renewing old acquaintances, rag-chewing, etc.

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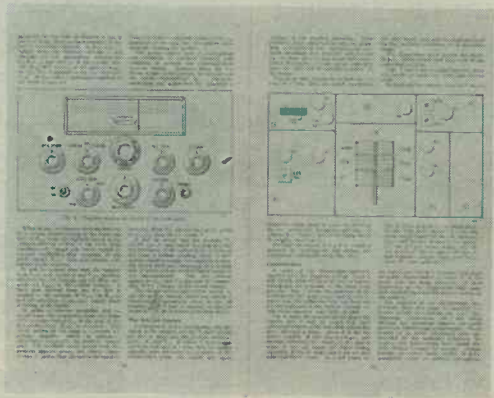

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continued on page 141

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continued from page 139

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continued on page 143

SMALL ADVERTISEMENTS

continued from page 141

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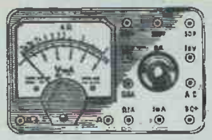

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