THE TUNNEL DIODE — IN THEORY AND PRACTICE, Part 2

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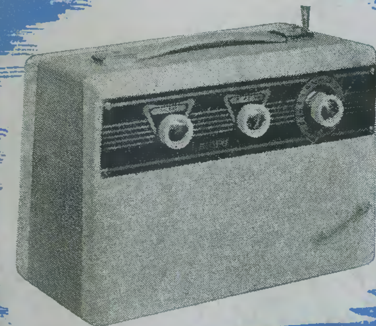
DECEMBER
1960

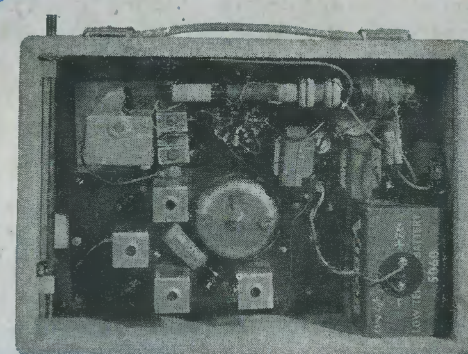
The RADIO Constructor

RADIO · TELEVISION · AUDIO · ELECTRONICS



THE "WAVEMASTER" 7 TRANSISTOR PORTABLE/CAR RADIO

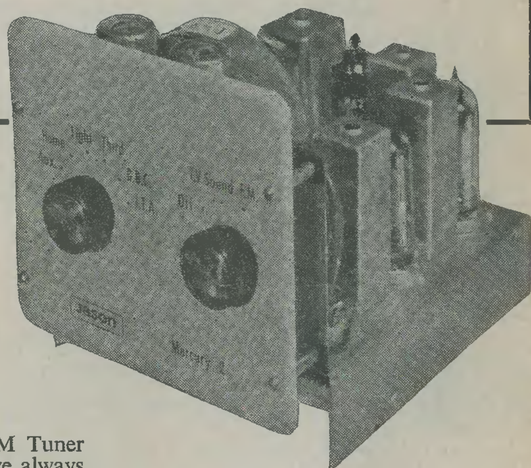
Described by
Alan G. Hepworth



Included in this Issue

DATA Publications 1/9

BUILD A Jason TUNER



Many models Well-presented designs

From the time of the first Jason FM Tuner (FMT.1) the company's activities have always been closely associated with tuner design and production. Jason were first to produce a stable switched FM tuner for reception of B.B.C. transmissions. Jason next pioneered tuners (FM and AM) in various forms which matched with Jason Mono and Stereo Amplifiers, and both ready-built and constructional kits were made available. Yet another outstanding success has been achieved with the introduction of simple-to-operate switched tuners to receive both FM and TV sound transmissions, the latter facility finding ready welcome among both tape recorder and hi-fi enthusiasts. Jason Tuners (which are available from all leading stockists) offer a wide choice of models designed to meet present-day listening requirements and are a delight to build. Full descriptive literature on request.

Tuner Kits

(Valves extra except on Mercury II and JTV/2K Kits with which 2 valves are included)

FMT/1—The original Jason chassis tuner	**£5.19.0**
FMT/2—As above but in shelf mounting case	**£8.15.0**
FMT/3—Variable FM with AFC control (in case)	**£9.19.0**
JTV/2K—Self-powered switched FM/TV sound	**£14.19.0**
Mercury II—Switched FM/TV sound chassis	**10 gns.**
Everest 7 Transistor Portable	**£15.18.9**

JASON TEST EQUIPMENT IN KIT FORM

These highly dependable instruments are supplied in kit form for building oscilloscopes, audio-generators, crystal-controlled calibrators, wobbulators, etc. Excellent instructional literature is included with each model. Details on request.

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Complete resistor kit		7/9
Complete capacitor kit		23/11
Potentiometers		11/6
ECF80	(inc. P.T.)	16/2
6BQ5	(inc. P.T.)	12/4
EZ81	(inc. P.T.)	9/1
Mains Transformer		27/6
Output Transformer		18/9
Valve Holders, B9A (2)		1/6
Valve Holders, with skirt (1)		1/3
Mains plug & socket, Bulgin		3/9
Speaker plug & socket (3-pin) Cinch		7½d.
Power output plug & socket (4-pin) Cinch		9d.
Input plug & socket coaxial		1/-
Mains selector, fused 2A		1/6
Tag strips, 12-way (pair)		1/6
Wire, sleeving, screws, nuts		1/6
Chassis, punched, bronze		10/-
Control panel, gold hammered		10/-
Control knobs, gold insert (3)		3/9
Instructions		1/6
	Total	**£8. 5. 7.**

Inclusive price for complete kit ... £7. 10. 0.
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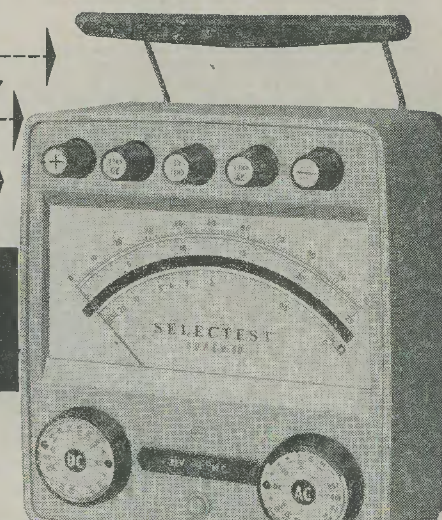

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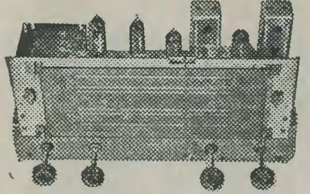

1960 RADIOGRAM CHASSIS

THREE WAVEBANDS — FIVE VALVES
S.W. 16 m.–50 m. — LATEST MULLARD
M.W. 200 m.–550 m. — ECH81, EF89, EBC81,
L.W. 800 m.–2,000 m. — EL84, EZ80

12 month Guarantee. A.C. 200/250V, 4-way switch, Short-Medium-Long-Gram. A.V.C. and negative feedback. 4.2 watts. Chassis 13$\frac{1}{2}$" x 5$\frac{1}{2}$" x 2$\frac{1}{2}$". Glass dial, horizontal or vertical, size 10" x 4$\frac{1}{2}$". 2 pilot lamps. Four knobs, walnut or ivory, aligned and calibrated. Chassis isolated from mains. Leaflet S.A.E.

BRAND NEW £9.10.0 Carr. 4/6

MATCHED SPEAKERS: 8" 17/6. 10" 25/–. 12" 30/–.

LATEST "E.M.I." 4 SPEED SINGLE RECORD PLAYER

Acos 73 Hi-Fi Pick-up for LP, 78 and Stereo 7", 10" and 12" records. Silent motor heavy turntable, auto stop.

Special offer **£6.19.6** post free.

BUILD THIS REPRODUCER BARGAIN

SPECIAL SINGLE PLAYER KIT

COLLARO 4-speed Gram-Pick-up Unit	£3.15.0
Handsome portable case 17$\frac{1}{2}$" x 13$\frac{1}{2}$" x 7" with room to play 12" records	£2. 5.0
Ready built 3-watt, printed circuit, amplifier with two valves and 7"x4" elip. speaker	£3.12.6

or **£9.9.0** complete kit post free

I.F. TRANSFORMERS 7/6 pair
465 kc/s slug tuning miniature can 2$\frac{1}{2}$" x 1" x 1". High Q and good band width. By Pye Radio. Data sheet supplied.

Weyrad Standard Size 465 kc/s 3$\frac{1}{2}$" x 1$\frac{1}{2}$" sq. 12/6 pair

New boxed VALVES 90-day Guarantee

1R5	7/6	6K8G	7/6	EA50	1/6	EZ80	7/6
1S5	7/6	6L6G	10/6	EABC80	8/6	E1148	1/6
1T4	6/–	6N7M	6/6	EB91	6/–	HABC80	12/6
2X2	3/6	6Q7G	8/6	EBC33	8/6	HVR2A	6/6
3S4	7/6	6SA7	6/–	EBC41	8/6	MU14	9/–
3V4	7/6	6SJ7M	6/6	EBF80	10/–	P61	3/6
5U4	7/6	6SN7	6/6	ECC84	9/6	PCC84	9/6
5Y3	7/6	6V6G	6/6	ECF80	9/6	PCF80	9/6
5Z4	9/6	6X4	7/6	ECH42	10/6	PCL82	11/6
6AM6	5/–	6X5	6/6	ECL80	10/6	PEN25	6/6
6B8	5/–	12A6	7 6	ECL82	10/6	PL81	12/6
6BE6	7/6	12AT7	8/–	EF39	5/6	PL82	10/6
6BH6	9/6	12AU7	8/–	EF41	9/6	PY80	7/6
6BW6	9/6	12AX7	8/–	EF50	5/6	PY81	9/6
6D6	6/–	12BE6	8/6	EF80	8/–	PY82	7/6
6F6	7/6	12K7	6/6	EF86	12/6	SP61	3/6
6H6	3/6	12Q7	6/6	EF92	5/6	UBC41	9/6
6J5	5/6	35L6	9/6	EL32	5/6	UCH42	9/6
6J6	5/6	35Z4	7/6	EL41	9/6	UF41	9/6
6J7G	6/6	80	9/6	EL84	8/6	UL41	9/6
6K6GT	6/6	807	5/6	EY51	9/6	UY41	8/–
6K7G	5/–	954	1/6	EZ40	7/6	U22	8/–

DK96, DF96, DAF96, DL96, 8/6 each or 30/– set

B.B.C. Pocket Transistor. M.W. and L.W. Radio Kit 32/6. Phones 7/6 or deaf aid earpiece 15/–.

Our written guarantee with every purchase

C.R.T. BOOSTER TRANSFORMERS

For Cathode Ray Tubes having heater cathode short circuit and for C.R. Tubes with falling emission, full instructions supplied. **Type A.** Low leakage windings. **Optional 25%** and **50%** boost on secondary: 2V, or 4V, or 6.3V, or 10.3V, or 13.3V, with mains primaries, **12/6. Our Latest Superior Product. Mains Input Type A2. High quality low capacity 10-15pF. Optional boost 25% 50% 75%, 16/6** each.
Type B. Mains input. Low capacity. Multi output 2, 4, 6.3, 10 and 13V. Boost 25% and 50%. This transformer is suitable for all TV tubes. **21/–** each.

RESISTORS. Preferred values. 20% 10 ohms to 10 meg. $\frac{1}{4}$W **4d.**, $\frac{1}{2}$W **4d.**, 1W **6d.**, 1$\frac{1}{2}$W **8d.**, 2W **1/–**. **HIGH STABILITY.** $\frac{1}{2}$W 1%, **2/–**. All preferred values 10Ω–10MΩ. Ditto 5% 100Ω–5MΩ, **9d.** each.

WIRE-WOUND RESISTORS
5 watt / 10 watt / 15 watt — 25 ohms–10,000 ohms — 1/3 / 1/6 / 2/–
12.5 kΩ to 50 kΩ 10W. 3/3.

WIRE-WOUND POTS Pre-set min. TV type. Knurled slotted knob. All values 25 ohms to 25k, **3/–** each, 30k, 50k, **4/–**. Ditto $\frac{1}{2}$W Carbon Track 30k to 2 Meg. **3/–**.

3W Lab. Colvern, etc. Standard size Pots, 2$\frac{1}{4}$" Spindle, high grade. All values, 100 ohms to 50k, **6/6**; 100k, **7/6**. W/W EXT. SPEAKER CONTROL 10Ω, **3/–**.

MAINS TRANSFORMERS—200/250 AC

STANDARD 250–0–250, 80mA, 6.3V tapped 4V 4A, Rectifier 6.3V 1A, tapped 5V 2A and 4V 2A	22/6
Ditto 350–0–350	22/6
MINIATURE. 200V 20mA, 6.3V 1A	10/6
MIDGET. 220V 45mA, 6.3V 2A	15/6
SMALL. 220–0–220V 50mA, 6.3V 2A	17/6
STANDARD. 250–0–250 65mA, 6.3V 3.5A	17/6

HEATER TRANS. 6.3V 1$\frac{1}{2}$A **7/6.** Ditto, sec. 6.3V 3A **10/6.** Ditto, tapped sec. 2, 4, 6.3V 1$\frac{1}{2}$A, **8/6.**
Mullard "510" Osram "912" 300–0–300, 120mA, 6.3V 4A c.t., 6.3V 2A tapped 5V **38/6**
General Purpose Low Voltage. Outputs 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30V at 2A **22/6**
Auto. Trans. 150W, 0, 10, 120, 200, 230, 250V **22/6**

O/P TRANSFORMERS. Heavy duty 50mA, **4/6.** Multi-ratio push-pull, **7/6.** Miniature 3V4, etc., **4/6.** Small pentode, **4/6.** Hygrade push-pull 10 watts, **15/6.** Goodmans heavy duty 10/20W 6k or 8k c.t., **30/–.**
L.F. CHOKES 15/10H 60/65mA, **5/–**; 10H, 85mA, **10/6**; 10H 120mA, **12/6**; 10H 150mA, **14/–.**

CRYSTAL MIKE INSERT by Acos **6/6**
Precision engineered. Size only $\frac{7}{8}$" x $\frac{3}{16}$"
ACOS CRYSTAL HAND or DESK MIKE, 25/–

ALADDIN FORMERS and cores. $\frac{1}{4}$" **8d.**, $\frac{3}{8}$" **10d.** **0.3" FORMERS** 5937 or 8 and cans TV1 or 2, $\frac{3}{4}$" sq. x 2$\frac{1}{4}$" or $\frac{3}{4}$" sq. x 1$\frac{1}{4}$", **2/–** with cores.
SLOW MOTION DRIVES. Epicyclic ratio 6-1, **2/3.**
REMPLOY INSTRUMENT IRON, 230V 25W, **17/6.**
MAINS DROPPERS. 3" x 1$\frac{1}{2}$". With adj. sliders, 0.3A, 1,000 ohms, **4/3**; 0.2A 1,000 ohms, **4/3.**
LINE CORD. 0.3A 60 ohms per foot, 0.2A 100 ohms per foot, 2-way, **6d.** per foot; 3-way, **7d.** per foot.
MIKE TRANS. 50:1, **3/9**; 100:1, potted, **10/6.**
LOUDSPEAKERS. P.M. 3 ohm. 5" Rola, **17/6**; 6" x 4" Rola, **18/–**; 4" Hi-Fi Tweeter, **25/–**; 8" Plessey, **19/6**; 6$\frac{1}{2}$" Goodmans, **18/6**; 10" R.A., **30/–**; 12" Plessey, **30/–**; 10" x 6" R.A., **27/6**; 12" Baker 15W 3 ohm or 15 ohm models, **90/–**; Stentorian HF1012 10", **95/–.**
CRYSTAL DIODES. G.E.C., **2/–**; GEX34, **4/–.**
40 CIRCUITS FOR GERMANIUM DIODES, 3/–.
H.R. HEADPHONES 4,000 ohms, brand new, **15/–** pr.
SWITCH CLEANER FLUID, squirt spout, **4/3** tin.
TWIN GANG CONDENSERS. 365pF, miniature. 1$\frac{3}{8}$" x 1$\frac{1}{2}$" x 1$\frac{3}{4}$", **10/–**; 0.0005 standard with trimmers, **9/–**; less trimmers, **8/–**; midget, **7/6**; 50pF single, **2/6.**
SHORT WAVE Single 75pF, 100pF, 160pF, **5/6** each.
TUNING AND REACTION CONDENSERS. 100pF, 300pF, 500pF, **3/6** each, solid dielectric.

HIGH GAIN TV PRE-AMPLIFIERS

BAND I B.B.C.
Tuneable channels 1 to 5. Gain 18dB. ECC84 valve. Kit price **29/6** or **49/6** with power pack. Details **6d.** (PCC84 valves if preferred.)
BAND III I.T.A.—Same prices
Tuneable channels 8 to 13. Gain 17dB. ECC84 valve

Volume Controls

Midget size. Long spindles. Guaranteed 1 year. All values 5,000 ohms to 2 Meg.
No Switch 3/– — D.P. Switch 4/6
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80Ω Coaxial Cable

Semi-air spaced Polythene Ideal Band III **6d. yd.**
Losses cut 50%
FRINGE QUALITY Air spaced Coaxial **1/– yd.**

Coaxial Plugs	1/–	**Lead Socket**	2/–
Panel Sockets	1/–	**Outlet Boxes**	4/6

Balanced Twin Feeder, per yd. **6d.**, 80Ω or 300Ω.
Twin Screened Balanced Feeder, 1/6 yd, 80 ohms.
Trimmers. Ceramic 30, 50, 70pF, **9d.**; 100pF, 150pF, **1/3**; 250pF, **1/6**; 600pF, 750pF, **1/9**; Philips, **1/–** each.
BLACK CRACKLE PAINT. Air drying, **3/–** tin.
P.V.C. CONN. WIRE, 8 colours, single of stranded, **2d.** yd. Sleeving 1, 2mm, **2d.**; 4mm, **3d.**; 6mm, **5d.** yd.
NEON MAINS TESTER SCREWDRIVERS, 5/–.
SOLDER RADIOGRADE, 4d. yd, $\frac{1}{4}$lb **2/6,** 1lb. **9/–.**

Aluminium Chassis. 18 s.w.g. Plain, undrilled, 4 sides, riveted corners, lattice fixing holes, 2$\frac{1}{2}$" sides. 7" x 4", **4/6**; 9" x 7", **5/9**; 11" x 7", **6/9**; 13" x 9", **8/6**; 14" x 11", **10/6**; 15" x 14", **12/6**; 18" x 16" x 3", **16/6.**

Miniature Contact Cooled Rectifiers. 250V 50mA, **7/6**; 250V 85mA, **9/6.** **Selenium Rect.** 300V 85mA, **7/6.**
Coils. Wearite "P" type, **3/–** each. Osmor Midget "Q" type, adj. dust core, from **4/–** each. All ranges.
Teletron D.W.R. L. & Med. T.R.F. with reaction, **3/6.**
Ferrite Rod Aerials. M.W., **8/9**; M. & L., **12/6.**
Ferrite Rods 8" x $\frac{3}{8}$", **2/6** **H.F. Chokes, 2/6.**
T.R.F. Coils A/HF, **7/–** pair. HAX **3/–**, DRR2 **4/–.**
Speaker Fret. Gold cloth, 17" x 25", **5/–**; 25" x 35", **10/–.** **Tygan,** 4' 6" wide, **10/–**; 2' 3" wide, **5/–** ft. Samples, S.A.E. Expanded Metal, Gold, 12"x12" **6/–.**
Condensers. 0.001μF 7kV T.C.C., **5/6**; ditto 20kV, **9/6**; 0.1μF 7kV, **9/6**; 100pF to 500pF Micas, **6d.**; Tubular 500V 0.001 to 0.05, **9d.**; 0.1, **1/–**; 0.25, **1/6**; 0.1/350V, **9d.**; 0.5/500V, **1/9**; 0.01/2,000V, **1/9**; 0.1/2,000V, **3/6.**
Ceramic Condensers. 500V 0.3pF to 0.01μF, **9d.**
Silver Mica. 10% 5pF to 500pF, **1/–**; 600pF to 3,000pF, **1/3**; close tolerance (plus or minus 1pF), 1.5pF to 47pF, **1/6**; ditto 1% 50pF to 815pF, **1/9**; 1,000pF to 5,000pF, **2/–.**

NEW ELECTROLYTICS — FAMOUS MAKES

TUBULAR		TUBULAR		CAN TYPES	
1/350V	2/–	50/350V	5/6	8/600V	9/–
2/350V	2/3	100/25V	3/–	32/350V	4/–
4/450V	2/3	250/25V	3/–	100/270V	5/6
8/450V	2/3	500/12V	3/–	2,500/3V	4/–
8/500V	2/9	8+8/450V	3/6	5,000/6V	5/–
16/450V	3/–	8+8/500V	5/–	32+32/350V	5/–
16/500V	4/–	8+16/450V	3/9	32+32/450V	6/–
32/450V	3/9	8+16/500V	5/6	32+32+32/350V	7/–
25/25V	1/9	16+16/450V	4/3	50+50/350V	7/–
50/25V	2/–	16+16/500V	6/–	64+120/350V	11/6
50/50V	2/–	32+32/350V	4/6	100+200/275V	12/6

Full Wave Bridge Selenium Rectifiers. 2, 6 or 12V 1$\frac{1}{4}$A, **8/9**; 2A, **11/3**; 4A, **17/6.** Free charger circuit.
Charger Transformers. Tapped input 200/250V for charging at 2, 6 or 12V 1$\frac{1}{2}$A, **15/6**; 2A, **17/6**; 4A, **22/6.**

AMERICAN BRAND "FIVE"
FERRO-DYNAMICS RECORDING TAPE

Long Play 7" reel, 1,800ft	35/0	Standard Play—	
5$\frac{3}{4}$" reel, 1,200ft	23/6	7" reel, 1,200ft	25/–
5" reel, 900ft	18/6	5" reel, 600ft	16/–

Spare Plastic Reels all sizes **3/–.** Metal Reels 7" only **2/–.** "Instant" Bulk Tape Eraser and Head Defluxer, 200/250V A.C., **27/6.** Leaflet, S.A.E.

BRAND NEW AND BOXED with template Model UA8 **£6.15.0**
UA14 £7.15.0.

STEREO MODELS
UA8 £7.10.0
UA14 £8.10.0

★ **COLLARO** ★
HI-FI AUTOCHANGER £7.19.6
4 SPEEDS—10 RECORDS
or with Cabinet, Amplifier and Speaker
OUR PRICE £11.19.6 Carr. 5/6

★ **GARRARD 4-SPEED RECORD CHANGERS MODEL 210** ★
With Plug-in Head for Monaural **£10.10.0**
Stereo Heads £2 extra

AUTOCHANGER ACCESSORIES

Suitable player cabinets (uncut boards)	49/6
Amplifier player cabinets with cut boards	63/–
2-valve amplifier and 6$\frac{1}{2}$" speaker for above	79/6
3-valve amplifier and 6$\frac{1}{2}$" speaker for above	95/–

Wired and tested ready for use

★ **GARRARD 4-SPEED SINGLE RECORD PLAYER TA MK. II** ★
£8.8.0 with plug-in GC8 Normal Heads
AUDIO PERFECTION
MODEL 4 HF £18 Stereo wired
Stereo Heads £2 extra

Wavechange Switches. 2 p. 2-way, 3 p. 2-way, short spindle, **2/6**; 5 p. 4-way 2 wafer, long spondle, **6/6**; 2 p. 6-way, 4 p. 2-way, 4 p. 3-way, long spindle, **3/6**; 3 p. 4-way, 1 p. 2-way, long spindle, **3/6**; wavechange "MAKITS", 1 wafer, **8/6**; 2 wafer, **12/6**; 3 wafer, **16/–**; 4 wafer, **19/6**; 5 wafer, **23/–**; 6 wafer, **26/6.**
Toggle Switches, s.p., **2/–**; d.p., **3/6**; d.p.d.t., **4/–.**

JASON FM TUNER COIL SET, 29/–. H.F. coil, aerial coil, oscillator coil, two i.f. transformers 10.7 Mc/s, detector transformer and heater choke. Circuit and component book using four 6AM6, **2/6.** **Complete Jason FMT.1 Kit,** Jason chassis with calibrated dial and 4 valves **£6.5.0.**

Valveholders. Pax. int. oct., **4d.** EA50, EF50, **6d.** B12A, CRT, **1/3.** Eng. and Amer. 4, 5, 6 and 7 pin, **1/–.** MOULDED Mazda and int. oct., **6d.**, B7G, B8A, B8G, B9A, **9d.** B7G with can, **1/6.** B9A with can, **1/9.** **Ceramic,** EF50, B7G, B9A, int. oct., **1/–.** B7G, B9A cans, **1/–** each. **Valve and TV Tube** equivalents, **9/6.** **TV Fault Finding, 5/–.** **Quality Amplifiers, 4/6.** **Radio Valve Guide.** Books 1, 2 or 3, **5/–** each.
TRANSISTORS. Ediswan Audio XB112, **10/–**, R.F. 2 Mc/s XA103, **15/–**; R.F. 4 Mc/s XA104, **18/–.** Red Spot **5/–**; White Spot **7/6**, OC72 **15/–.**
Sub-miniature Electrolytics (15V) 1μF, 2μF, 4μF, 5μF, 8μF, 25μF, 50μF, 100μF, **3/–.**

TELEVISION REPLACEMENT

Line Output Transformers
70/– each, from stock
And Other Time Base Components
Most makes available. S.A.E. with all enquiries

A MERRY CHRISTMAS TO ALL READERS OF RADIO CONSTRUCTOR

RADIO COMPONENT SPECIALISTS

337 WHITEHORSE ROAD WEST CROYDON — *Telephone* **THO 1665**

Buses 133 or 68 pass door. S.R. Stn. Selhurst.

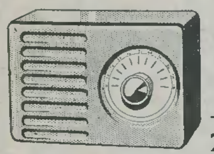
Post and packing charge 1/–, over £2 post free. C.O.D. 1/6 (Export welcome. Send remittance and extra postage

IDEAL XMAS PRESENT!

EASY TO BUILD TWO STAGE TRANSISTOR SET

As described in this issue

The set that looks like a Radio Set.



- Attractive Case
- Mini 0.0005 µF Tuner
- High Q Litz Coil
- Works for months off No. 8 Battery
- Simple to construct in 15 minutes.

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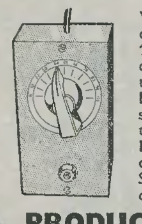

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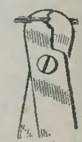

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CONTRIBUTIONS on constructional matters are invited, especially when they describe the construction of particular items of equipment. Articles should be written on one side of the sheet only and should preferably be typewritten, diagrams being on separate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

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TRADE NEWS. Manufacturers, publishers, etc., are invited to submit samples or information of new products for review in this section.

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Suggested Circuits

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

No. 121. A Single Transistor Periodic Switch

A PERIODIC SWITCH WHICH IS CAPABLE OF turning equipment on and off at regular intervals has a number of useful applications. It may, for instance, be employed for continuous timing operations or endurance tests, for switching lamps on and off in shop displays, or for controlling indicator lamps when it is particularly necessary to draw operators' attention. At this time of the year, a periodic switch may have more festive uses, such as the switching on and off of ornamental lights and the like.[1]

In *Suggested Circuits No*. 88 (published in the March 1958 issue of this magazine), the writer described a very simple periodic switching device which employed a relay having a high resistance coil across which was connected a large value electrolytic condenser. When the relay coil was connected to a high voltage source of supply via a series resistor the voltage across the coil rose as its parallel condenser charged. As soon as the voltage across the coil was sufficiently high the relay energised, whereupon one of its contacts broke the circuit to the supply. The voltage across the relay coil dropped slowly, as the parallel condenser discharged, until the relay de-energised. When de-energising occurred the relay contact applied the supply voltage once more, whereupon another cycle commenced. A second pair of contacts on the relay switched the external circuit.

Subsequent correspondence showed that readers were interested in devices of this nature and the writer felt that a transistorised periodic switch would result in a similar amount of interest. Although the transistorised version would require more components, it would have the advantage of working from a much lower supply voltage and would not need a condenser (such as that connected across the relay coil in the earlier design) having as high a capacity and working voltage.

The transistorised periodic switch is that which is described in this month's article.

[1] An alternative method of switching Christmas lamps which uses an entirely different principle is given in "An Auto Switch for Christmas Lights", which also appears in this issue. ED.

The Circuit

The obvious method of producing a transistorised periodic switch consists of using a multivibrator, and of inserting a relay coil in the collector circuit of one of the transistors. However, such a design requires two transistors as well as a diode across the relay coil to prevent the formation of reverse voltage when the relay-energising transistor switches off. In the design described here only one transistor is needed and, since coil current falls at a relatively slow rate before the relay de-energises, there is no necessity for a protective diode across the relay coil.

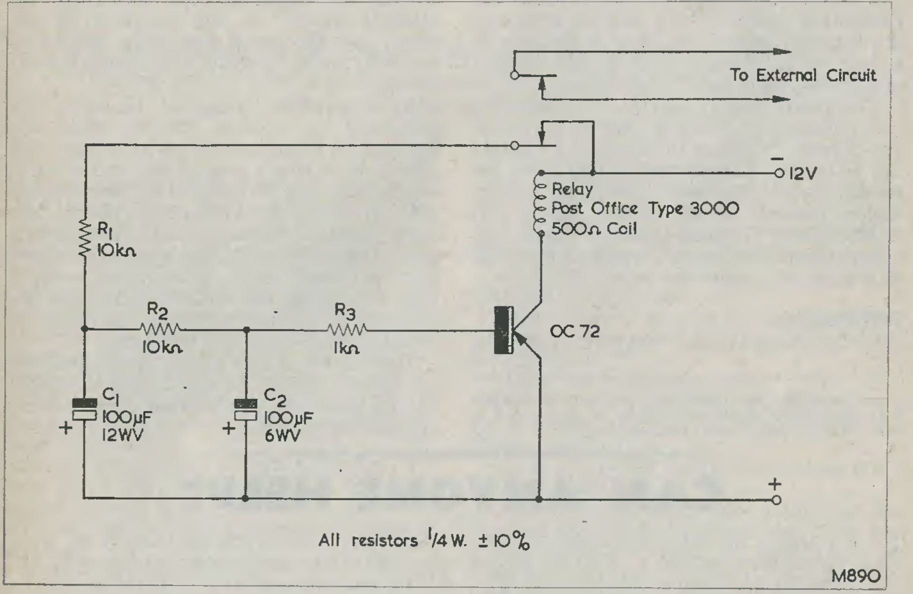
The circuit of the transistorised periodic switch accompanies this article and, as may be seen, it requires few components. The writer had hoped originally to employ even fewer components but, for reasons which are discussed later, this was found to be impracticable. The device operates on the same basic principle as was used in the earlier circuit, this being that a relay energises at a higher coil current than that at which it de-energises.

As soon as the supply voltage is applied to the periodic switch, a current flows from the negative supply line, through the break contact[2] of the relay and R_1 to C_1. C_1 commences to charge. As C_1 charges so also (at a slower rate because of the series resistor R_2) does C_2. During this period the collector current of the transistor is insufficient to energise the relay.

The transistor collector current increases as the potential across C_2 rises. When the latter reaches a sufficiently high level the transistor collector current causes the relay to operate. At once, the break contact of the relay opens, whereupon condensers C_1 and C_2 commence to discharge into the base-emitter circuit of the transistor. As the potential across C_2 drops the collector current flowing through the relay coil decreases. After a period the potential across C_2 is sufficiently low for the relay to de-energise. As soon as this occurs the break contacts of the relay reconnect R_1 to the negative supply line, C_1 and C_2 commence to charge again, and another cycle commences.

A second pair of make contacts on the relay completes the external circuit. As the relay energises and de-energises these complete and break the external circuit accordingly.

[2] The contact which opens, or breaks, when the relay energises.



Design Points

As was mentioned earlier it had been hoped at first to employ fewer components than those shown in the diagram. As originally conceived, R_1 and R_2 would have been combined together as a single 20 kΩ resistor, and a single electrolytic condenser would have been employed in what is now the C_2 position. Although the circuit functioned fairly well when built up in this manner it was found that, after a number of oscillations, it tended to reach a state of equilibrium in which the relay armature became stationary. In this condition the break contacts were held together under very light pressure. The writer assumed that the contacts inserted resistance into the negative feed to the transistor base and that the resultant collector current was just adequate to maintain the very light pressure. It was felt that the difficulty could be overcome by preventing the critical collector current and contact resistance occurring at the same instant during the switching cycle and several methods of accomplishing this were tried out. One method consisted of effectively "slugging" the relay by connecting a high value condenser across the coil, whilst another consisted of connecting a similar condenser (in series with a low-value resistor to prevent sparking) across the break contacts. Both methods were successful but they tended to modify the on-off time ratio of the switch adversely, and it was considered that they were wasteful of components. The final solution consisted of changing from the single 20kΩ resistor to the two 10kΩ resistors shown in the diagram and of inserting the 100μF condenser C_1. Even though this solution introduced two extra components the revised circuit had the advantage that the presence of C_1 enabled a considerably lower value condenser to be used in the C_2 position for the same length of switching cycle.

The 1kΩ resistor R_3 limits the current which flows from C_2 into the base of the transistor. Since C_2 offers a very low impedance and the voltage across its plates varies at a relatively low rate, the maximum collector potential for the transistor may be derived on the assumption of a 1kΩ base resistance.

The relay employed in the prototype is a Post Office type 3000 unit having a 500Ω coil. The reader is strongly advised to employ a relay of this type because it enables maximum use to be made of the energising current available from the transistor. The relay may have a set of make contacts and a set of break contacts as shown in the diagram, or it may have change-over contacts, the unused contacts being ignored.[3] More than two sets of contacts are inadvisable, as these would cause energising current requirements to be increased. On no account should a relay having a coil resistance less than 500kΩ be used.

The transistor is operated fairly close to its maximum dissipation figure. Although in this circuit it is worked within the maximum dissipation figure for use without a cooling fin, it would be good practice to clamp it to a heat sink. Such a sink should have a minimum dimension of 1½in square.

The power supply should be reasonably well-regulated and should offer an output of 12±3 volts. Voltages in excess of 15 should not be applied because they would cause the recommended maximum collector voltage under present circuit conditions to be approached. Voltages below 9 would not allow sufficient collector current to flow and thus reliably operate the relay.

Performance

It was found, after completion of the design, that the prototype gave consistently good results during a test run of several hours. With the component values shown in the diagram the length of a complete switching cycle was approximately 1.75 seconds. The cycle period may be lengthened or shortened by increasing or decreasing the value of C_2. The value of C_1 should not be altered in an attempt to modify the length of the switching cycle or the circuit may fail to operate correctly.

When the relay de-energises a current still flows through its coil, with the result that the armature may not drop to the completely released position. This is no disadvantage, but it is recommended that the external circuit be connected to a pair of make contacts, as shown in the diagram, in order to take fullest advantage of armature movement. If the relay employed is fitted with change-over contacts, only the make pair should be employed for switching the external circuit. In the prototype it was found that the on-off time ratio offered by the relay make contacts was approximately 60:40.

At an applied voltage of 12 the circuit continued to operate reliably when the pressure on the armature was reduced to that offered by a single contact set, and when it was increased to that offered by three contact sets. It continued to operate reliably also when the fixed contact of the break contact set was physically displaced in either direction from its correct position. It may be assumed from these tests that relay requirements are not critical and that there is no necessity for special setting-up of the contacts.

The current drawn by the prototype from the 12 volt supply varied, during the cycle, from 6 to 15mA, the average current being approximately 10mA.

3 A suitable relay, fitted with two sets of change-over contacts, is available from H. L. Smith & Co. Ltd., 287 Edgware Road, London, W.2.

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

R1155, Model 10A.—G. F. Rae, 129 Messingham Road, Scunthorpe, Lincs., would like the service manual, or any information, on this receiver.

Communication Receiver R107T.—D. J. Pratt, 8 Fairfield Avenue, Brown Edge, Stoke on Trent, Staffs., would like to borrow a manual on this 9 valve receiver for a few days (long enough to duplicate).

R1224A Receiver.—C. Stephenson, 10 Plungington Road, Preston, Lancs., wishes to obtain the manual of this receiver. Information is particularly requested on the wiring of the band (Range) switch.

S.T.C. Valve Voltmeter, Type 74101-B.—R. J. Williams, 5 Collingwood Close, Newport, Mon., would like to obtain the service sheet, manual or any information on this instrument, the serial number of which is 41206. Borrow or purchase.

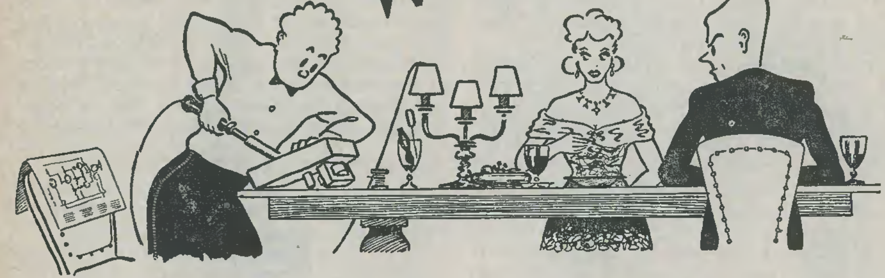
Indicator Unit No. 110QB29.—F. A. Grant, 49 Kirkby Road, Ripon, Yorks, wishes to obtain the circuit diagram and any information on conversion to an oscilloscope.

R1448 and Eddystone 358X.—P. Biddick, 2 Minstead Walk, Woodhouse Park, Manchester 22, urgently requires the service manuals, circuits or any other information available on these receivers.

Marconi Receiver Type CR300/1.—K. F. Gosling, "Melville Cottage", Park View Road, Woldingham, Surrey, requires any information, circuit diagrams, etc., relating to this ex-naval receiver.

Hallicrafters Sky Ranger S39.—F. Reed, 34 Barrs Court Road, Warmley, Bristol, has been vainly trying to obtain a circuit and any other information of the Sky Ranger. Willing to purchase.

IN YOUR WORKSHOP



This month Smithy the Serviceman, aided by his able assistant Dick, tackle the Christmas rush of work with their usual efficiency. And they end, happily, with just the right Christmas spirit

It was Christmas Eve in the Workshop. The snow-bespattered windows, shaken every few minutes by heavy gusts of wind, looked out on a cold winter morning. Inside, Smithy the Serviceman snarled viciously to himself as he jabbed his test prods into a faulty chassis which had, so far, failed to give up its secret. In a corner his assistant Dick, continually chivvied by Smithy, shivered as he attempted to work by the light of a flickering fluorescent tube. Occasionally, he warmed his hands over his soldering iron.

Receivers, serviced or awaiting repair, not only filled the Workshop racks but were strewn around the floor.

There was, suddenly, a loud knocking at the door.

"Who on earth can that be?" snapped Smithy.

"It is probably", said Dick in sepulchral tones, "the ghost of Jacob Marley."

Video Output Coupling

Smithy cast a puzzled look at his assistant as he picked his way across the set-bestrewn floor. Dick had been acting peculiarly since he started work half an hour ago.

A flurry of snow came through the doorway as Smithy opened it, causing him to step back quickly. There was a scrunching noise as his heel caught a knob on a receiver immediately behind him.

"Merry Christmas, sir," said the postman, handing Smithy a letter.

The Serviceman merely grunted shortly in reply, his normal good temper having momentarily evaporated at the thought of the extra work his carelessness had caused.

The postman retreated, and Smithy slammed the door shut.

"Is it a Christmas card?" piped up Dick.

"It is", pronounced Smithy, "our electric light bill."

"Hah," said Dick darkly.

Once more Smithy gave a mystified glance towards his assistant, but Dick made no further comment.

It was impossible for Dick to remain quiet for long, however.

"Smithy," he called out, forgetting his previous attitude for the moment. "I've got a very queer t.v. here. It gives stacks of contrast, but the picture's low in high frequency response. At the same time, the i.f. strip seems to be perfectly O.K., and the a.g.c.'s working fine."

"Try brilliance," suggested the Serviceman.

Dick adjusted the brilliance control knob.

"That seems to be a bit unusual, too," he remarked. "It works O.K. but I can't cut the tube off altogether. The brighter parts of the picture still show up when the control's hard over anticlockwise."

"I should measure the value of the video output anode load resistor," said Smithy. "It may have gone high."

"O.K.", said Dick. He looked at his chassis. "I must admit it *does* look a bit cooked up."

Dick checked the resistor with an ohmmeter and, since its nominal value could not be read directly from the burnt colour-coding, consulted the service manual for the receiver. The resistor had, indeed, gone high in value. Satisfied, he went to the spares cupboard, located a new resistor of the correct value and wattage rating, and soldered it into circuit in place of the faulty component. He switched the receiver on again.

"The set's fine now, Smithy," he called out. "How did you diagnose it so quickly?"

"It was the obvious thing to check," said Smithy, turning round for a moment from his bench. "In practically all t.v. sets the cathode of the c.r.t. gets its voltage direct or indirectly from the anode of the video output stage. In some sets the cathode connects directly to that anode (Fig. 1 (*a*)), and in some others it is connected to a potentiometer which couples to that anode (Fig. 1 (*b*)). Again, you may occasionally find that the cathode is coupled to a cathode-follower whose grid is connected to the video output anode. (Fig. 1 (*c*).) In practically all receivers, therefore, the potential on the c.r.t. cathode is either equal to, or proportional to, that on the video output anode."

"I think", said Dick, "that I'm beginning to understand your diagnosis now."

"It's a pretty simple one," remarked Smithy. "The fact that you couldn't get the brilliance control to cut the tube right off either meant that the range of control voltages offered by the brilliance control slider—which usually, don't forget, connects to the c.r.t. grid—was too positive, or that the tube cathode was too negative. The latter would occur if the video anode resistor had gone high in value. Excessive contrast could also be the result of too high a value in the video output anode resistor, because the changes in anode current due to signal voltages on the grid would result in excessive voltage changes across that resistor. So that's *two* faults which could be caused by a single component."

"What about the poor high frequency response in the picture?"

"To me", replied Smithy, "that was the clinching factor. There are several things which could cause poor h.f. response and one of these is, again, a high value video anode resistor. A correct value video anode resistor prevents stray capacities to chassis from attenuating the higher video frequencies too heavily. If the video anode resistor goes high, the reactances offered by the stray capacities at the higher video frequencies become equal to or even lower than the resistor value itself, with the result that the higher frequencies get attenuated."

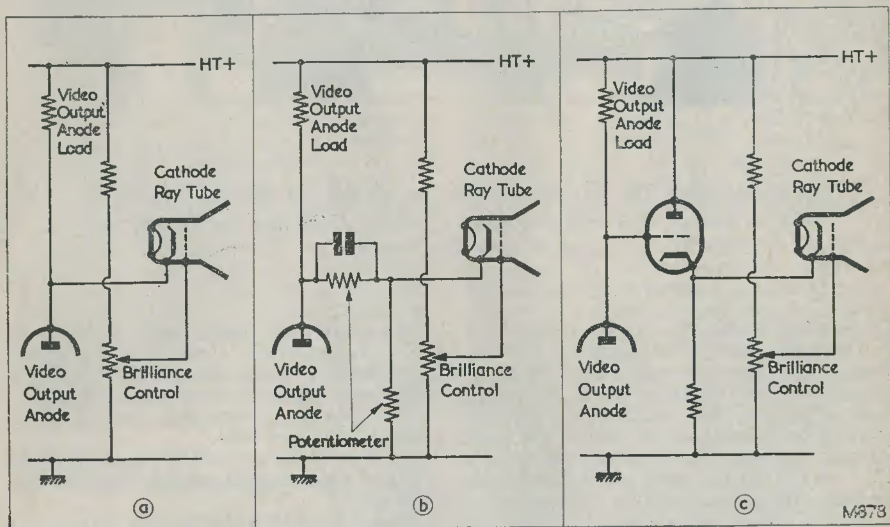


Fig. 1. Three basic methods of coupling the video output anode of a television receiver to the c.r.t. cathode. (In all cases video peaking chokes, series c.r.t. grid resistors, etc., are omitted.) In (a) the c.r.t. cathode is connected direct to the video output anode. In (b) a fixed potentiometer is interposed between the video output anode and the c.r.t. The condenser across the upper resistor of the potentiometer ensures that video frequencies are passed to the c.r.t. cathode. In (c) the video output anode is coupled to the c.r.t. by way of a cathode follower

"Seems pretty conclusive to me," remarked Dick.

"It is," replied Smithy. "But we mustn't do any more nattering just now. We've got a dickens of a lot of sets to repair."

A Peculiar Sound Fault

Something in Smithy's words caused his assistant to revert to his previous manner.

"Hah," said Dick mysteriously.

"Dash it all," protested Smithy. "That's the second time you've said 'Hah'."

"And so I should," said Dick. "Do you know what this place reminds me of today? It reminds me of *A Christmas Carol.*"

"*A Christmas Carol?* What, with Ebenezer Scrooge and all that sort of thing?"

"Exactly! Look at the way things have been going up to now. To begin with, here you are slave-driving me—on Christmas Eve of all days. You haven't got a word of Christmas cheer for anyone. Not even for the poor old postman! And all you've talked about is getting the work out and paying bills."

"Well," said Smithy mildly. "You know we're always rushed off our feet at Christmas time. It's an occupational disease in our business. I don't see why that should cause you to cast yourself in the part of poor old down-trodden Bob Cratchit, though."

Smithy reflected for a moment and an irate glare suddenly came into his eye.

"Are you casting *me*", he continued wrathfully, "as *Scrooge?*"

"Well," said Dick, a little uncomfortably, "I didn't exactly say so. But so far as Bob Cratchit was concerned, you must certainly admit that old Scrooge *did* keep him shivering in his office on Christmas Eve with only a lump of coal in the grate."

A glimmer of understanding came into Smithy's mind. There was always a hard core somewhere at the centre of Dick's grievances.

"Well, I must admit it's a bit nippy in the Workshop this morning," he remarked, "but that's only because the stove hasn't had a chance to get going yet, and this is by far the coldest day we've had this year. Give it another half-hour and we'll be wallowing in our usual Turkish bath atmosphere."

Dick looked a little mollified, and Smithy decided to let the matter rest for the moment.

It was not long, in any case, before Dick ran into difficulties, and had to call for advice once more.

"I'm having trouble with another t.v.", said Dick. "In this case it's the a.f. section. It seems to be completely wrecked! The set had a customer complaint of 'no sound' and, when I switched it on, I found this to be so. The a.f. stages use a single triode-pentode valve and, when I looked inside the set, I found that the screen-grid of the pentode section was nearly white hot. So I switched off smartly. I didn't put another triode-pentode in because I thought that that would suffer the same fate."

Smithy nodded approvingly.

"I suppose", he remarked, "that you found that the anode circuit to the pentode had gone open."

"I did, indeed," replied Dick. "The speaker transformer primary had burnt out. I was just about to replace it when I thought I'd check a few other things as well. The first thing I found was that the cathode bypass electrolytic was short circuited. I nipped this out and, blow me if I didn't then find that one of the two series cathode resistors had gone open circuit! After that I thought I was having hallucinations and I called you over."

"Humph," grunted Smithy. "Try the coupling condenser from the triode anode to the pentode grid for leaks."

Dick hastily applied his test prods across the coupling condenser, and obtained a resistance reading of approximately 10kΩ. Just to make certain that an external short circuit was not causing this low reading, he snipped one of the condenser leads from its tag. His testmeter, connected across the condenser with its one lead now completely disconnected from the receiver, still gave a leakage reading of 10kΩ.

"The coupling condenser's broken down as well," he wailed. "What must have hit this a.f. section—atomic radiation?"

"That condenser was probably the component which started the whole thing," said Smithy. "As you can see, the circuit around the triode-pentode is the sort of thing that's very common in present-day designs (Fig. 2). What probably happened is this. The coupling condenser went leaky, and this caused the pentode to draw more cathode current than it should have done. In consequence, the cathode resistors overheated and one burnt out. As soon as that happened the cathode of the triode-pentode rose to h.t. potential, or nearly so. With the result that the electrolytic cathode bypass condenser broke down, bringing the cathode down to chassis potential. This method of connection, chassis at cathode potential and grid connected to as high a positive potential as grid current would allow, next caused the anode to pass so much current that the speaker transformer primary burnt out. Since this opened the anode circuit, the screen-grid had to take all the dissipation inside the valve; which is why it was glowing red hot when you looked inside the set."

"Phew," commented Dick. "Well, that's

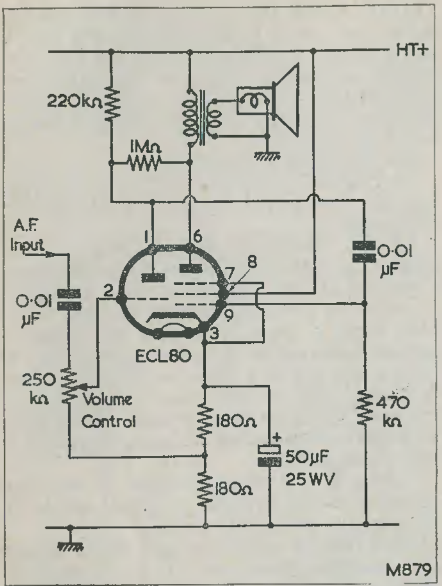


Fig. 2. A triode-pentode a.f. circuit, similar to those employed in the a.f. stages of present-day television receivers. Typical component values are given. The 1MΩ resistor between the two anodes provides a small degree of negative feed-back. In some receivers a condenser (frequently in series with a resistor) may be connected across the speaker transformer primary to provide top cut

a tale of woe if you want one! Don't tell me all that happened instantaneously."

"I don't expect it did," said Smithy. "It more probably took half-an-hour or so. I should imagine that the set had been left unattended for a while. Incidentally, it isn't usual for speaker transformer primaries to burn out under conditions like this, as they can normally stand a pretty sizeable overload. However, the manufacturer may have been using as small a component as he could squeeze into the chassis, or the wire may have been nicked or chafed during winding. In which case, the primary would burn out at a lower current than is usually the case."

"There's certainly a few components to change in this set," said Dick. "A coupling condenser, both the bias resistors—because the remaining one has cooked up almost as much as the one that burnt out—and a new speaker transformer."

"And a new valve," Smithy reminded him. "The old one's had it by now."

"And a new valve," repeated Dick cheerfully.

His cheerfulness emboldened Smithy to return to his previous grievance.

"How do you feel about the ambient temperature now?"

"Well," said Dick a little grudgingly, "I must say that things are a little less Arctic at the moment."

"Thank goodness for that," said Smithy. "Incidentally, where *did* you get all this *Christmas Carol* stuff from, anyway."

"I read it last night in bed," said Dick. "It's a jolly good story, too."

Smithy chuckled to himself. Dick had a habit of modelling his behaviour on any fictional character or to fit any fictional situation which had recently impressed him.

"This reminds me," grinned Smithy, "of the time when those Strand cigarette ads first appeared on the telly. It was ages before I could get you to smoke in company again!"

Dick looked a little selfconscious and forebore to comment.

Striations

Smithy and his assistant returned once more to their labours. A whole half hour passed before Dick's voice became audible again.

"I've got a shocking fault here," he called out.

Dutifully, the Serviceman walked over to Dick's bench.

"Look," said Dick, indicating the screen of the receiver before him.

A number of marked vertical striations were visible on the left hand side of Dick's picture. (Fig. 3.)

"You know what that is?" continued Dick. "It's ringing in the line output stage! Which means I've either got to swap the line output

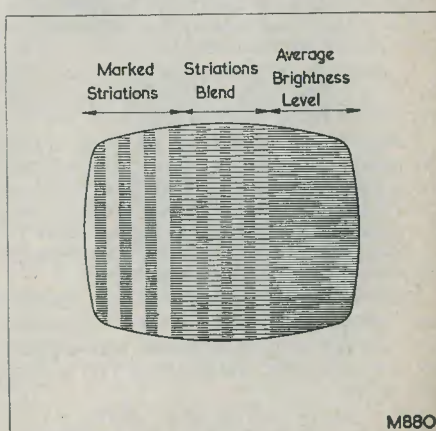


Fig. 3. Striations on the c.r.t. screen caused by ringing in the line output stages

transformer or the deflection yoke."

"Don't jump to conclusions," remarked Smithy. "There are lots of other things which could cause this snag. Explain what has happened up to date."

"Well," said Dick. "The set came in without any picture. I looked around inside, and the first thing I noticed was that there was no e.h.t. The obvious thing to do, then, was to exchange the line output valve. This I did, and I've now got a ding-dong picture. But with striations."

Smithy looked at the back of the chassis and experimentally grasped one of the leads connecting to the c.r.t. base. The striations became even more marked.

"Gosh," said Dick. "You've made it worse."

"Only in order to find out what's wrong."

Smithy removed his hand and the striations reverted to their previous condition.

"You are first of all", pronounced Smithy, "in error if you think that striations are caused only by ringing currents in the line output transformer or deflection yoke. When they *are* caused by these two components it may, even then, be due to a damping resistor connected across the windings or part of the windings having gone open circuit. But there are other components which can also cause ringing currents to flow in the line deflector coils. These are any inductive width or line linearity controls which may be fitted to the receiver. Such controls normally have damping resistors connected across them, and an open circuit in such resistors may also cause striations."

Smithy paused and lit a cigarette.

"Striations caused by ringing currents in the line deflector coil circuit", he continued, "cause *velocity* modulation of the scan. In other words they change the *speed* with which the spot travels across the screen. This change in speed causes changes in brightness level similar to those you've got here."

Dick looked puzzled.

"Regardless of what component is causing the ringing," he said, "I can't see why you made it worse by simply catching hold of one of the wires at the back of the set."

"I was proving", said Smithy, "that, in this case, the striations in the receiver are not caused by velocity modulation of the line scan at all. They're caused by *amplitude* modulation of the *beam*. What's happening is that an otherwise perfectly harmless ringing voltage is present in the line output stage, and that this is being picked up capacitively by the cathode circuit of the c.r.t. The lead I grasped just now is the one which connects from the chassis to this cathode, and the striations got worse because I then increased the stray capacitive coupling."

"Well, we've really got a *fault*," said Dick miserably. "How on earth do I clear capacitive coupling?"

"By the simple process", grinned Smithy, "of replacing over the line output stage the screen you removed to get at the line output valve!"

"Is *that* all that's wrong?"

"That's all," chuckled Smithy.

Cracks and Bangs

He loosened his tie.

"Hot enough now?" he enquired.

"It's much better," confessed Dick. "It's funny how the Workshop had that Charles Dickens atmosphere earlier on."

"That's what comes from reading books in bed late at night. Where did you get this one from, anyway?"

"It's a Christmas present."

"You shouldn't open Christmas presents until Christmas Day," observed Smithy primly.

"Oh, I didn't get it *from* anyone. I'm giving it *to* someone."

Smithy digested this subtle nuance in social behaviour.

"Well, at any rate", he remarked eventually, "it's a good moral story."

"Of course it is," said Dick indignantly. "What sort of Christmas presents do you think I give? Actually there's nothing very much in it, anyway. All that happens is that this geyser Scrooge, who's tighter than watertight, is visited on Christmas Eve by a phalanx of phantoms. These include his old partner in crime, Jacob Marley, and the spirits of Christmas Past, Christmas Present and Christmas Future. Ebby gets the spiel from the shades, and he ends up like he's reformed, man."

"Wasn't there a Tiny Tim?" asked Smithy weakly. "Bob Cratchit's little boy?"

"Of course," said Dick. "You couldn't have a human interest story without a kid!"

Smithy gathered together his shattered memories of Dickens' classic.

"I think I've heard enough for the time being," he remarked truthfully. "Perhaps we'd better get back to the grind."

"Fair enough," said his assistant cheerfully. Dick was now completely back to his usual form.

He selected a television receiver from those lying on the floor and examined the ticket tied to it.

"Well, this is a queer one," he remarked.

"How come?" said Smithy over his shoulder.

"Well, all the ticket says is: 'Set works perfectly but keeps banging'!"

Smithy turned round, an interested expression on his face.

"I've heard of sets with that complaint before," he remarked, "but I've never bumped into one myself. Put it on."

Obligingly, Dick connected the receiver to the mains, plugged in an aerial, and switched on. After warming up, the set produced an excellent picture together with good quality sound. Suddenly, a loud crack like a pistol shot became audible from inside the cabinet. Neither picture nor sound was noticeably affected during the sudden noise, or after it.

"This", said Smithy, pleased, "is quite a rare fault. If my guess is correct, the only thing in the set that can cause a loud crack like that is the sudden discharge of an h.t. electrolytic. Don't forget that h.t. electrolytics in t.v. sets have values around 100μF, and the crack we heard just then is exactly the same sort of sound as you get when you short out an electrolytic of that size."

"How do I set about finding the fault?"

"You possibly won't find it!" beamed Smithy.

burning down their sides between the inside and outside silvering." (Fig. 4 (*a*).)

"Okey-doke," said Dick. "I'll report back."

During the following five minutes Dick removed the chassis of his receiver from its cabinet and carefully examined the h.t. circuit.

"It's no good, Smithy," he called out. "I can't find a thing."

"Not to worry," said Smithy. "How many ceramic feedthroughs did you find directly connected to the h.t. positive rail?"

"Only one. That's the one which carries h.t. positive into the tuner unit."

"Good show," said Smithy. "Just insert a 22Ω ½ watt resistor in series with that feed-through." (Fig. 4 (*b*).)

"But that'll drop the h.t. voltage supplied to the tuner."

"Only by a negligible amount," said

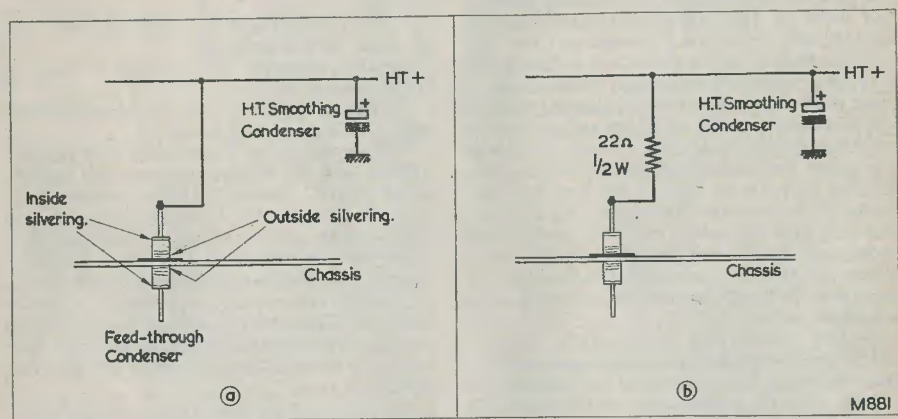


Fig. 4 (a) The "bangs" in a faulty television receiver were caused by sudden discharges of the h.t. smoothing condenser over the outside surface of a feed-through condenser connected directly to it. In common with many feed-through condensers, a little of the inside silvering appears at the top and bottom ends of the ceramic body. The circuit supplied via the feed-through condenser connects to the lower protusion of the centre pin

(b) Smithy's cure for the "bangs" consisted of inserting a 22Ω resistor between the feed-through and the h.t. electrolytic condenser. This method of connection still allows the feed-through condenser to decouple the circuit it supplies

"Shucks, that's a lot of help!"

"I'm quite serious," chuckled Smithy. "Anyway, the first thing you should do is to carry out a visual inspection. Trace the h.t. positive line all round the chassis and see if you can find any evidence of burning to chassis at any point. Look, especially, at any ceramic feedthroughs which connect directly, without any resistors in series, to the h.t. positive rail and, thence, to the h.t. electrolytic itself. Examine these for evidence of

Smithy, "and it should stop all the future bangs."

Dick sat down for a minute.

"Look, Smithy," he said. "I know I'm a bit dim sometimes, but this particular cure has really foxed me. Can you give me a bit more gen on it?"

"Not with any great certainty," admitted Smithy, "but I'll give you the background, anyway. Now, a spark usually occurs between two points because there is ionisation

of the air between them. The spark represents the expenditure of an appreciable amount of energy and, if it travels across the surface of Paxolin or some similar substance, it may cause a breakdown of the chemical constituents of that material. The result is that you may get the start of a 'track' of carbon between the two terminals concerned. With ceramic it's different. If a spark travels over the surface of ceramic it doesn't leave a track because the chemical constituents of the ceramic don't get broken down.

"In the present instance," continued Smithy, "what apparently happens is that ionisation occurs between the inside and outside silvering of the condenser and a spark travels across the surface of the ceramic. It's a very fat and juicy spark because it's got the full weight of a 100μF electrolytic condenser behind it. The spark leaves no trace but it can recur at a later date; maybe as much as a week or a month later."

"How does putting a 22Ω resistor in series clear the trouble?"

"Well, it stops the nerve shattering bangs," said Smithy, "because it prevents the sudden discharge of all the energy stored in the electrolytic condenser. If you short-circuit a charged 100μF condenser via a 22Ω resistor you'll find that you get a very small spark. It may be that the sparks continue after the resistor has been put into circuit, or it may be that it prevents further sparks occurring because it reduces the energy available from the electrolytic. I just don't know. At any rate the 22Ω resistor clears the main trouble, and it seems to effect a permanent cure as well."

"Why should the sparks occur so readily with a ceramic condenser?"

"It may be due to the relative nearness of the two electrodes", replied Smithy, "or it may be due to a moisture film on the surface of the ceramic. Again, I don't know. I understand, however, that the trouble is far less liable to occur if a lacquer is painted over the ceramic, thereby keeping the air from it."

"Bit of a mystery," remarked Dick.

"It is, indeed," said the Serviceman. "Anyway, buck up, Dick, I think we're beginning to see the end of the pile of sets we've got in for repair."

Clearing Up for Christmas

Dick looked around, surprised.

"Why, there's only four or five left to do!"

The pair set to work on the receivers and, in a surprisingly short time, they were able to pronounce them all satisfactorily repaired. Habit then guided Dick's footsteps towards the kettle but Smithy stopped him.

"Not today, Dick," he grinned. "I've brought in a wee bottle of the real stuff!"

The Serviceman and his assistant, both with charged glasses at their elbows, sat down and gazed comfortably at the sets around them. They wore the expressions of those who have finished a good job and know they have done it well.

"You know," the Serviceman said musingly. "Your mention of Christmas Past, Christmas Present and Christmas Future has put me in a reminiscent mood. Christmas Present is what we know now. Christmas Past, from the servicing point of view, was rather the same as it is today. Except that it was all radio in those days. And we *still* had the same old Christmas rush, too!"

"It must have been dead easy," remarked Dick, "just doing radios."

"Funnily enough," replied the Serviceman, "I don't think it was. Radios before the war used to be surprisingly complex and diverse in design. Perhaps the designers who are now fully occupied working on t.v. had time, then, to make simple sets more complicated! You know, it was only around 1938 that the four valve superhet finally became accepted in this country. Before that we used to have all manner of things: t.r.f.s, superhets with reaction in the i.f. stages, reflex sets, and all sorts of weird and odd designs. That was the time, too, when manufacturers went mad with fancy tuning dial gadgets, and when the insides of sets were masses of gears, dial cords and Bowden cables."

Dick removed his coat.

"Gosh, it's sweltering in here, now," he remarked absently.

Smithy drew breath in order to pass comment, and then thought better of it.

"What", continued Dick, sitting down again, "about Christmas Future?"

"Well, *you*", chuckled Smithy, "will probably be a Service Manager by then. I wonder which you'll get first, grey hair or ulcers!"

"Come off it, Smithy! What do you really think?"

"The future," said Smithy pontifically, "may also be fairly similar to what we have today. Most of the things we handle will be transistorised and there will be many more automatically manufactured items. Designs will be more standard, partly because of development and partly because the bigger manufacturers will continue to merge together and concentrate on common chassis. With different cabinets, of course! We will almost certainly have Band IV and, perhaps Band V television as well. This will use the 625 line system. Transistor radios will get smaller and smaller, and we may have to learn quite a few new servicing techniques to deal with them."

"Colour t.v.?"

"Perhaps," nodded Smithy. "I know

they've got colour t.v. in the States but, quite honestly, I doubt whether we'll see it over here for quite a while yet. The receivers are too complex and expensive."

Smithy replenished Dick's glass, then topped up his own.

"Anyway," he said. "Let's get back to here and now. And let me wish you a very Merry Christmas, my lad."

"A very Merry Christmas to you too, Smithy," replied Dick promptly. "And I want to pass on our wishes as well for a very Merry Christmas to all the readers who've put up with our adventures over the last year!"

"Hear, hear!"

Smithy and Dick raised their glasses, touched the rims together, and drank.

"Do you remember how *A Christmas Carol* ended?" asked Dick.

"Not after all these years," Smithy confessed.

Dick held his glass in the air with a flourish.

"'And so, as Tiny Tim observed'," he quoted, "'God Bless Us, Every One!.'"

UNDERSTANDING TELEVISION

PART 35

By **W. G. MORLEY**

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

In last month's article we concluded our consideration of the deflection circuits employed in the television receiver. We shall now carry on to automatic gain control systems.

Automatic Gain Control

The function of an automatic gain control (or a.g.c.) system in a receiver is to ensure that the output voltage varies as little as possible despite variations of input voltage. The output voltage will normally be that applied to the reproducing device (loudspeaker or cathode ray tube) whilst the input voltage will normally be that applied to the aerial terminals of the receiver.

In practical receivers, automatic gain control is achieved by extracting from the signal available at the detector (or at a subsequent amplifier stage) a d.c. control voltage which is negative of chassis and whose amplitude is proportional to that of the signal. This control voltage is then applied, as grid bias, to the control grids in some, or all, of the preceding i.f. and r.f. amplifier stages. A large amplitude signal at the detector causes, therefore, a large negative bias voltage to be applied to the preceding control grids, and the overall sensitivity of the receiver drops accordingly.

If all signal amplitudes appearing at the detector provided a negative automatic gain control voltage, the associated receiver could never achieve maximum amplification. This is because even the weakest of signals would cause the formation of a negative control voltage and a consequent reduction in receiver amplification. Such an effect may be overcome by introducing a *voltage delay* circuit into the a.g.c. system. A voltage delay circuit prevents the formation of a control voltage until the signal amplitude at the detector exceeds a pre-determined level. At all signal levels below that pre-determined level the receiver functions at full gain. Voltage delay circuits are employed in the vision a.g.c. systems of almost all television receivers. Should the designer so desire, all the controlled r.f. and i.f. amplifying valves in the receiver may, then, be operated under maximum current and dissipation conditions, thereby achieving the optimum gain under weak signal conditions of which such valves are capable. Gain requirements for the sound i.f. strips of television receivers are not normally quite as stringent as are those for the vision i.f. strips, with the result that voltage delay circuits are often omitted in television sound a.g.c. systems.

Since automatic gain control circuits tend to maintain the output of the associated receiver at a constant level, despite varying input voltages, they help to overcome varying outputs caused by switching from one channel to another and by fading. In the latter case the *time constant* of the a.g.c. system (the time it takes to adjust itself to a new input signal strength) becomes an important factor, because fading can cause the amplitude of the input signal to vary at high speeds as well as at low speeds.

A.g.c. systems which control the gain of the vision i.f. and r.f. stages of a television receiver and which, as a result, tend to maintain a constant signal amplitude at the modulating electrode of the cathode ray tube, are sometimes called *automatic picture control* (or a.p.c.) systems.

Television A.G.C. Systems

The conventional method of applying automatic gain control in television receivers is illustrated in the block diagram of Fig. 213 (*a*). In this diagram there are two separate a.g.c. systems. One, the vision a.g.c. system, extracts the control voltage from the video amplifier output and applies this to the vision i.f. stages and to the r.f. amplifier, whilst the other, the sound a.g.c. system, extracts a control voltage from the sound detector and applies this to the sound i.f. stages. The "a.g.c. lines" shown in Fig. 213 (*a*) represent the wires which actually carry the negative control voltage. It will be seen from the diagram that the major degree of control is exerted by the vision a.g.c. system, since this, by controlling the gain of the r.f. stage and the common i.f. amplifier, ensures that a fairly constant signal amplitude is applied to the input of the sound i.f. stages before the sound a.g.c. system takes over.

It might, at first sight of Fig. 213 (*a*), be thought that two a.g.c. systems are unnecessary and that a single a.g.c. voltage, derived from either the detected vision or sound signal, could control all the i.f. and r.f. stages in the receiver. This is not entirely desirable, however, because with certain types of fading the sound and vision signals do not fade in sympathy with each other. Also there may be variations in relative output between the vision and sound signals transmitted in different channels. Nevertheless, it is fairly common for receivers employing single valve

sound i.f. amplifiers (following a common sound and vision i.f. amplifier) to have no separate sound a.g.c. system at all, the single sound i.f. valve operating at a fixed bias. In such receivers the sound output is maintained at a relatively constant level (subject to the limitations just mentioned) by the vision a.g.c. voltages applied to the r.f. stage and the common i.f. amplifier. The alternative possibility, that of controlling vision and sound gain by an a.g.c. voltage derived from the sound detector, is never used, because the limitations just stated would give variations in output which would be much

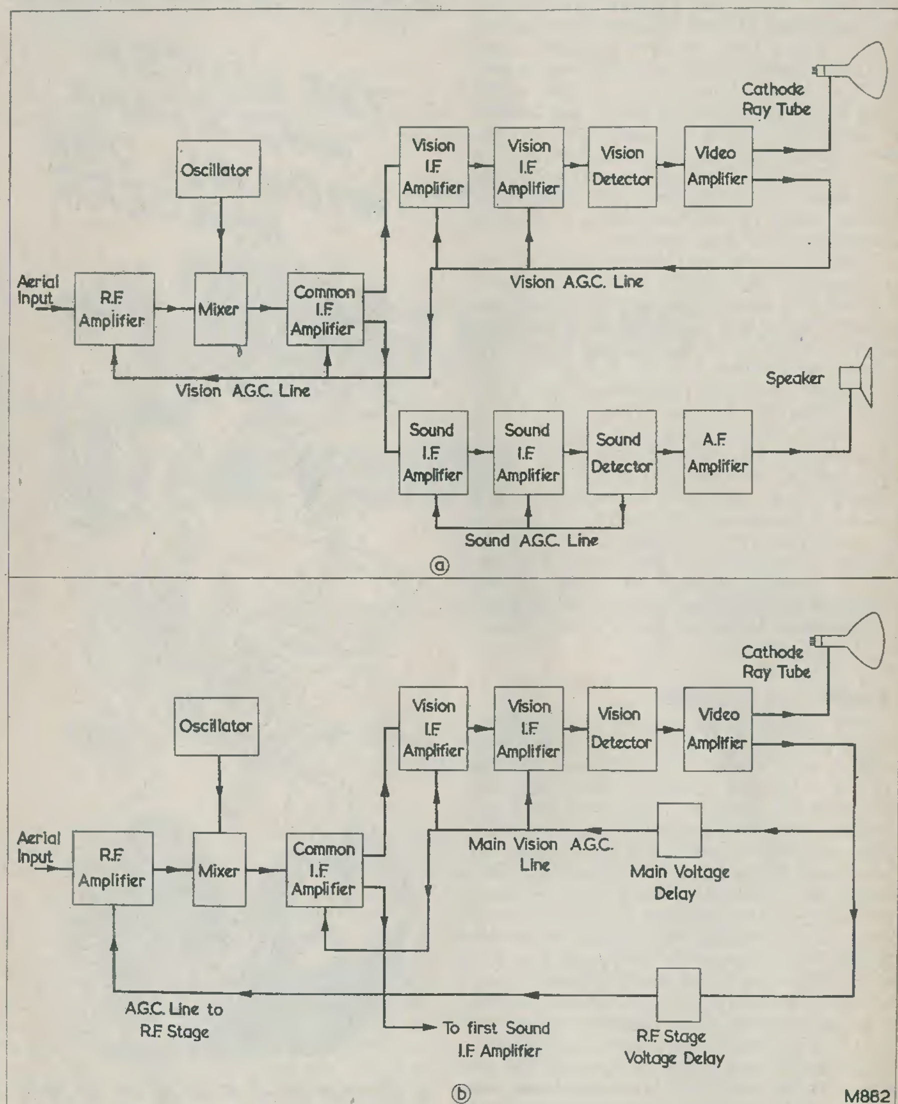


Fig. 213 (*a*). *The vision and sound a.g.c. systems in a typical television receiver.* (*b*). *It is frequent practice to employ two voltage delay circuits in the vision a.g.c. system. The r.f. stage voltage delay prevents the application of a.g.c. voltage to the r.f. amplifier unless signal amplitude is considerably higher than that needed to overcome the main voltage delay*

more objectionable on a reproduced picture than on reproduced sound.

Practical television a.g.c. systems may differ in minor detail from the typical example shown in Fig. 213 (*a*). For instance, when a receiver employs two sound i.f. amplifying stages it is frequent practice to apply the sound a.g.c. voltage to one of these valves (usually the first) only. Similarly, the vision a.g.c. voltage may be applied to only some, instead of all, vision i.f. stages. Again, in some receivers, the vision a.g.c. control voltage may be applied to the grid of the mixer valve (via its grid leak) in order to control the gain of this stage in addition to that of the r.f. and i.f. stages.

As was stated earlier, the vision a.g.c. system in almost all television receivers employs a voltage delay. In addition, it is a common technique in modern receivers to employ a second voltage delay circuit in the a.g.c. line to the r.f. stage, the resultant arrangement being shown in the block diagram of Fig. 213 (*b*). The second delay circuit prevents a.g.c. voltage being passed to the r.f. amplifier unless the applied signal has an amplitude considerably higher than that needed to overcome the main delay. Thus, the r.f. amplifier operates under maximum gain conditions even when the applied signal has sufficient amplitude to overcome the main delay. The reason for having a second a.g.c. delay is that the r.f. amplifier is required to pass a signal to the mixer having sufficient amplitude to override the high noise level generated by the latter. If the r.f. stage were directly controlled by the main a.g.c. line its gain could be sufficiently reduced at moderately high input signal levels for the signal passed to the mixer grid to be low in proportion to mixer noise level. The result would be that background noise, both on picture and on sound, would be unnecessarily high under such conditions.[1] With the arrangement of Fig. 213 (*b*), a.g.c. is applied to the r.f. stage only when the input signal level is sufficiently high to override mixer noise level with reduced r.f. gain.

Sound I.F. A.G.C. Circuits

We briefly discussed sound a.g.c. circuits[2] when we introduced the subject of sound and vision detectors. It was shown, then, that an automatic gain control voltage may be obtained from the sound detector by means of a circuit similar to that shown in Fig. 214 (*a*). In Fig. 214 (*a*) the secondary of the last sound i.f. transformer connects to a load resistor via a diode, with the result that the rectified i.f. voltage appears across this resistor. By connecting the diode load resistor to a subsequent a.f. amplifier via a blocking condenser, C_3 (to remove the d.c. component of the rectified i.f. signal), and a low-pass filter, R_3 C_4 (to remove any remanent i.f. signal)[3], it becomes possible to reproduce the sound modulation of the received signal. At the same time, by connecting a further filter, R_1 C_1 (to remove i.f. *and* a.f. signals), to the load resistor, the average d.c. value of the rectified i.f. signal appears across C_1. It will be noted that the diode is so connected that the upper plate of C_1, which connects to chassis, is positive, and that its lower plate is negative. Since the average value of the rectified i.f. signal is obviously proportional to input signal level, the negative potential on the lower plate of C_1 may be used as an automatic gain control voltage.

An alternative method of connecting the components of Fig. 214 (*a*) is shown in Fig. 214 (*b*). In this diagram the chassis connection is taken to the opposite end of the load resistor. Also, the diode is reversed. Reversing the diode causes the polarity of the voltage across the load resistor to be reversed also, with the result that the average d.c. voltage on the lower plate of C_1 is once more negative with respect to chassis.

Usually, the diode in the sound detector stage of a television receiver is a thermionic valve and it often shares, in a single envelope, the same cathode as a further valve or valves. In consequence, the circuit of Fig. 214 (*b*) is that most frequently employed, since it allows the cathode to be at chassis potential. If a germanium diode is employed, either the circuit of Fig. 214 (*a*) or that of Fig. 214 (*b*) may be used, as the desirability of keeping the diode cathode at chassis potential does not then arise.

A suitable method of providing a voltage delay for the a.g.c. voltage is shown in Fig. 214 (*c*). In this case the diode cathode is returned to a point which is positive of chassis. The diode does not conduct until the peak value of the i.f. voltage applied to its anode exceeds the positive potential on its cathode. The result is that no a.g.c. voltage is provided for i.f. signals lower than the positive potential, and the a.g.c. system is effectively delayed. The positive delay potential could be economically obtained from a cathode bias circuit elsewhere in the receiver and, for the reasons just stated, a germanium diode would normally be employed. Such a diode would be an additional component to that employed for a.f. detection.

[1] Noise appears on the picture as a speckled background, often described as "snow". On sound, it is evident as a background hiss.

[2] In "Understanding Television", part 16, May 1959 issue.

[3] A filter which impedes high frequencies but which allows the passage of low frequencies.

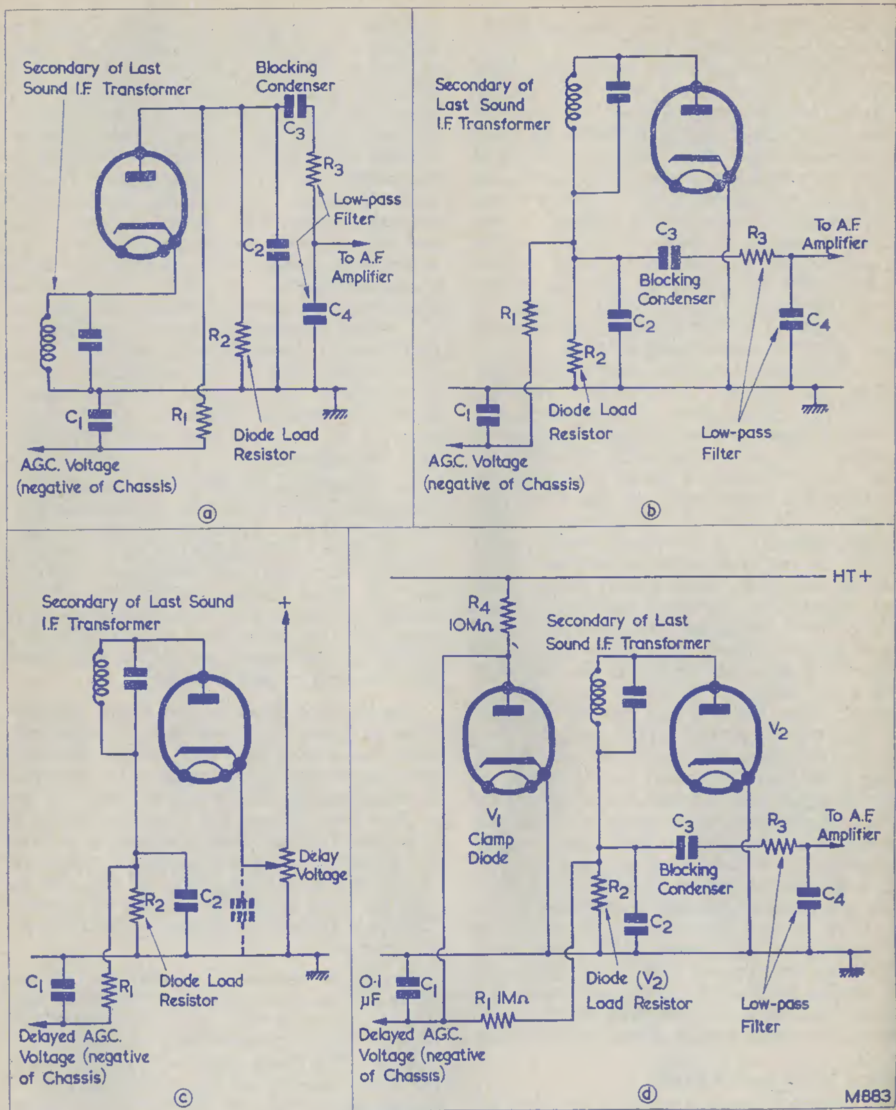


Fig. 214 (*a*). *A combined sound and a.g.c. detector. Resistor and condenser values may vary somewhat widely in individual receivers, but representative values are:* R_1, 1*M*Ω; R_2, 100*k*Ω; R_3, 10*k*Ω; C_1, 0.02μ*F*; C_2, 50*pF*; C_3, 0.01μ*F*; C_4, 50*pF*

(*b*). *A rearrangement of* (*a*) *which enables the cathode of the diode to be held at chassis potential*

(*c*) *A delayed sound a.g.c. detector circuit. An a.g.c. voltage does not appear until the peak value of the i.f. voltage exceeds the delay voltage. Normally, a decoupling condenser (shown in dotted line) would be connected between the source of delay voltage and chassis*

(*d*). *An alternative method of obtaining delayed a.g.c. The values shown for* R_1, R_4 *and* C_1 *are typical*

It is possible to rearrange the components in Fig. 214 (*c*) (in much the same manner as Fig. 214 (*b*) is a rearrangement of Fig. 214 (*a*)), such that a delayed a.g.c. detector is provided using the same basic principle. Circuits of this type can be readily recognised by the fact that the diode is prevented from rectifying under no-signal conditions because of the delay voltage.

In present-day television receivers delayed a.g.c. detector circuits of the type shown in Fig. 214 (*c*) are not often encountered. Instead, quite a different principle is employed, a typical circuit being given in Fig. 214 (*d*). In this diagram a single diode, V_2, functions as combined sound and a.g.c. detector, with the result that the rectified i.f. signal is applied to the right-hand side of R_1. The left-hand side of R_1 connects to a second diode, V_1, and to C_1 and R_4. In the absence of signal, no rectified voltage is applied to R_1. At the same time the current flowing through R_4 causes diode V_1 to conduct, with the result that (ignoring the very small voltage dropped in the conducting diode) the a.g.c. line assumes chassis potential. In the presence of signal a rectified negative voltage is applied to the right-hand end of R_1. When this voltage is sufficiently negative of chassis, the voltage at the junction of R_1 and R_4 also goes negative of chassis and the diode ceases to conduct. In consequence, a negative a.g.c. voltage becomes available for application to the preceding i.f. amplifier. The circuit of Fig. 214 (*d*) provides, therefore, a form of delayed a.g.c.

It will be noted that, when the delay has been overcome, part of the rectified voltage is dropped across R_1 in the fixed potentiometer given by this resistor and R_4. The relative values of R_1 and R_4 are normally such, however, that the drop across R_1 is relatively small and may be ignored.[4]

The diode V_1 is known as a *clamp diode* (because it provides a "clamp" which prevents the a.g.c. potential from rising above chassis potential). An ingenious circuit device which is occasionally used consists of connecting the junction of R_1 and R_4 to the suppressor grid of one of the sound i.f. amplifier valves, as in Fig. 214 (*e*). At the small currents involved the suppressor grid functions adequately as a diode anode in combination with the cathode and its use thereby eliminates the necessity of the separate clamp diode of Fig. 214 (*d*), giving a consequent reduction in costs.

The component values shown in Fig. 214 (*d*) and (*e*) for R_1, R_4 and C_1 are typical of those encountered in practical receivers. Apart from its function in the potentiometer R_1 R_4, R_1 also forms, in combination with C_1, a low-pass filter which prevents i.f. and a.f. voltages being fed back to the a.g.c. line.

A.G.C. voltages developed by any of the methods discussed up to now may be applied to an i.f. amplifier control grid via a grid leak, as in Fig. 215 (*a*), or via the coil of the grid tuned circuit as in Fig. 215 (*b*). The arrangement of Fig. 215 (*b*) is used most frequently because it is simpler and saves a resistor. Further, the circuit of Fig. 215 (*a*) has the disadvantage that the grid leak may cause slight damping of the grid tuned circuit.

Vision A.G.C.

The process of providing satisfactory vision a.g.c. in a receiver working on a positive modulation signal (as is given by the British 405 line system) involves problems which do not occur in the simple sound a.g.c. circuits discussed up to now. Due to the nature of the modulation it is, also, more difficult to obtain satisfactory vision a.g.c. with the 405 line system than it is with the negative modulation 525 and 625 line systems.

A number of different techniques to provide vision a.g.c. with the 405 line system have been evolved and these will now be dealt with.

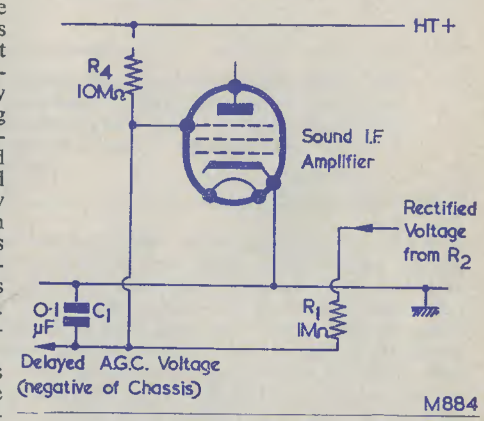


Fig. 214 (*e*). *The clamp diode of* (*d*) *may be obviated by connecting the junction of* R_1 *and* R_4 *to the suppressor grid of a sound i.f. amplifier valve*

Mean Level A.G.C. Circuits

Several lines of a 405 line signal are illustrated in Fig. 216 (*a*). In this diagram we have the line sync pulse tips, which appear at synchronising signal level (0.3% of peak white level); the front and back porches of the line sync pulses, which appear at blanking

[4] There is also a small drop in the *changes* in rectified i.f. voltage. This point will be discussed when we consider mean level picture a.g.c. systems, in which it assumes greater importance.

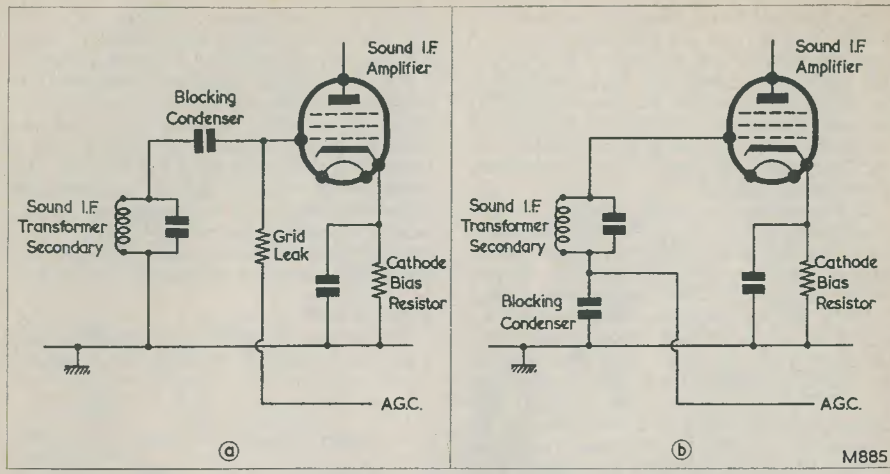


Fig. 215. *Two methods of applying a.g.c. voltage to the grid of a sound i.f. amplifying valve. The blocking condenser in* (*b*) *is mounted close to the i.f. transformer and valve to reduce lead lengths, and would normally have a value around* 1,000*pF. A decoupling resistor may be inserted in the a.g.c. line close to the condenser.*

level (30 ±3% of peak white level); and the picture information, which may have any amplitude lying between black level (5% of peak white amplitude above blanking level) and peak white level. The only parts of the waveform of Fig. 216 (*a*) that have an amplitude which is reliably proportional to the strength of the signal are the front and back porches of the sync pulses.[5] The picture information does not bear a constant relationship to the strength of the signal because it can vary according to the content of the transmitted scene.

Despite this fact, many of the simpler 405 line receivers employ an a.g.c. system in which part of the control voltage is derived from picture information amplitude. The system is known as *mean level a.g.c.*, and the control voltage is obtained from the mean, or average, level of the composite video waveform.

In a mean level a.g.c. circuit, the negative control voltage is obtained from the grid of the sync clipper valve as illustrated in Fig. 216 (*b*), the video waveform of Fig. 216 (*a*) being applied to this grid. The input waveform of Fig. 216 (*b*) has positive-going sync pulses as would be given if (as occurs in conventional receivers) it were obtained from the anode of a video output valve feeding a cathode-modulated cathode ray tube. As we have already seen,[6] leaky-grid action takes place on the grid of the sync clipper with the result that only the sync pulses appear in the anode circuit, picture information falling outside the cut-off point of the valve. Since, in Fig. 216 (*b*), the positive tips of the sync pulses take up a position which is just slightly positive of cathode, it follows that the average potential on the grid will be negative of cathode and that this average potential will be equal to the average potential of the applied composite waveform. The average potential appears on the lower plate of condenser C_1 and, after suitable treatment, may provide the control voltage in a mean level a.g.c. system.

Figs. 216 (*c*) and (*d*) illustrate the fact that the average voltage obtained from the sync clipper grid varies according to the nature of the picture information. In Fig. 216 (*c*) the applied waveform is that given if a completely black scene were transmitted. In this instance the average voltage is slightly positive of black level. Fig. 216 (*d*) shows an applied waveform in which all the picture information is at peak white level. In this case the average level is approximately midway between black and peak white levels. Because of these variations in average voltage

[5] The same cannot be said about the sync pulse tips, because these have an amplitude which corresponds, nearly, to zero transmitter output and could not be relied on to maintain a constant proportion to signal strength. In any event, their amplitude would be much too small for practical use.

[6] When we discussed the operation of the sync separator clipper in "Understanding Television" part 31, August 1960 issue.

level, receivers employing mean level a.g.c. systems exhibit an effect similar to that given by an a.c. coupling in the video amplifier.[7] If the transmitted scene varies from bright to dark, a.g.c. voltage drops and the receiver becomes more sensitive, thereby increasing contrast.[8] Similarly, if the transmitted scene changes from dark to bright, contrast decreases. In practice, variations in transmitted scene brightness are rarely as abrupt as the extreme instances shown in Figs. 216 (*c*) and (*d*), and it is assumed, for most programme material, that the average voltage on the sync clipper grid has a sufficiently constant relationship to signal strength to justify the use of a mean level a.g.c. system.

Two basic methods of treating the average voltage on the sync clipper grid so that an a.g.c. voltage is provided are shown in Fig. 217 with fairly typical component values. In Fig. 217 (*a*) a potentiometer in series with a fixed resistor (to restrict the range of the potentiometer) is connected to the grid, the a.g.c. voltage being taken from its slider. A clamp diode, which carries out the same function as did the clamp diode of Fig. 214 (*d*), provides a voltage delay. Since the potentiometer varies the amount of a.g.c. voltage fed back to the previous amplifier stages, it controls their gain and forms the contrast control for the receiver. Occasion-

[7] A.C. coupling was discussed in "Understanding Television", part 21, October 1959 issue.

[8] Under the same conditions an a.c. coupling would cause the *brightness* level to increase.

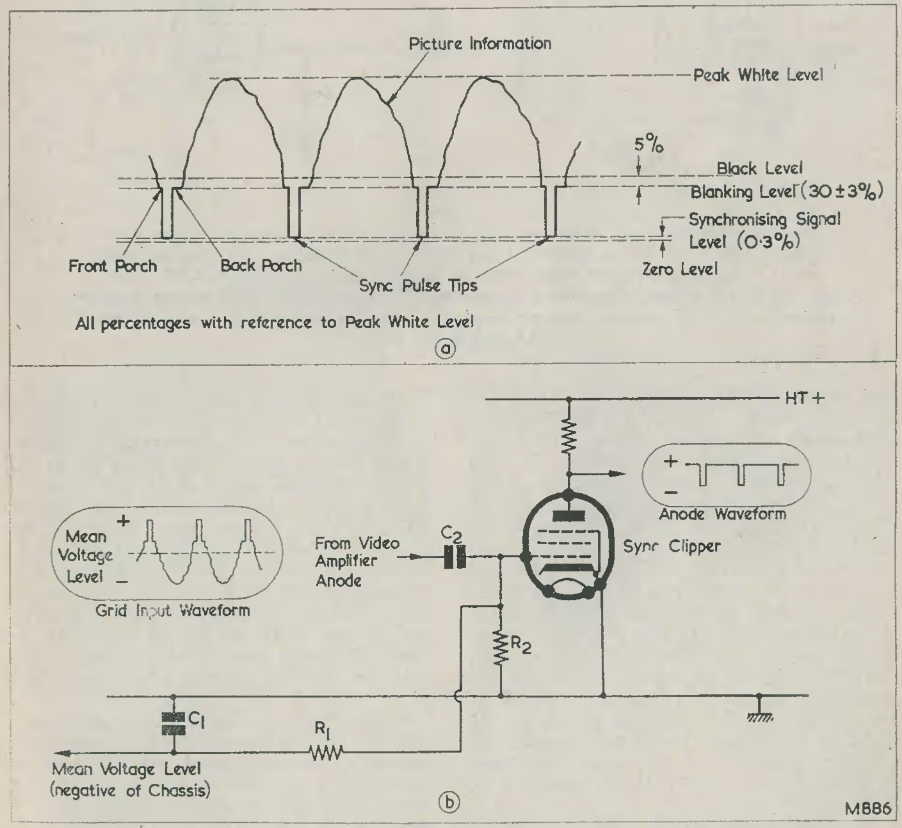


Fig. 216 (*a*). *Several lines of the* 405 *line waveform, showing the levels of the various parts of the signal*

(*b*). *The waveform of* (*a*) *applied, with positive-going sync pulses, to the grid of a sync clipper valve. A negative potential* (*with respect to chassis*) *equal to the mean, or average, level of the waveform appears on the lower plate of* C_1

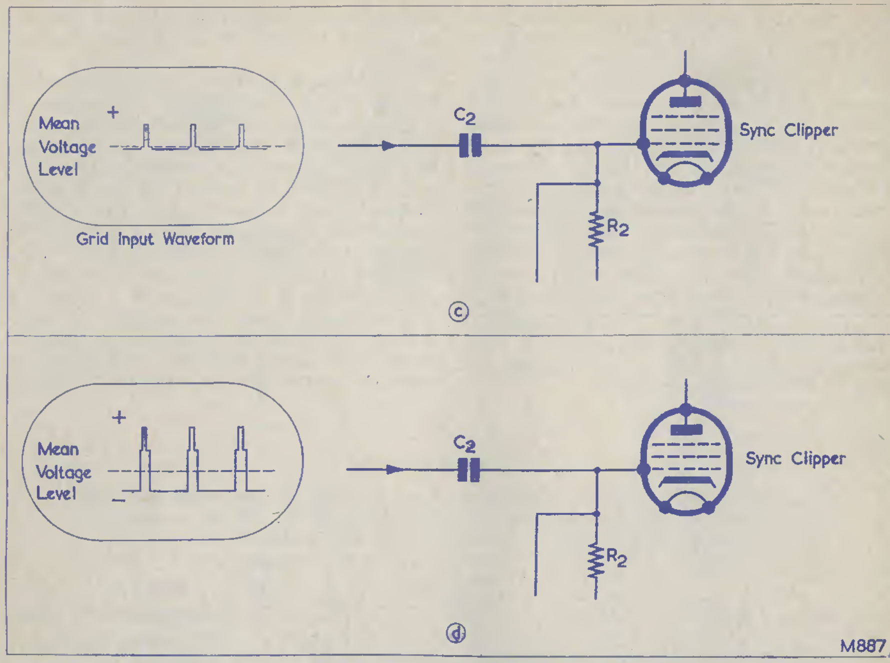


Fig. 216 (c). When a completely black scene is transmitted, the average voltage level on the sync clipper grid is slightly positive of black level
(d). In this diagram, the applied waveform has all the picture information at peak white level. The average voltage level is approximately midway between black and peak white levels

ally, with this circuit, the clamp diode and R_1 are omitted. Fig. 217 (*b*) illustrates an alternative arrangement, again with fairly representative component values. In this instance a fixed potentiometer, R_3, R_2, causes a proportion of the mean voltage on the sync clipper grid to be applied to the anode of a clamp diode, a variable potentiometer, R_1, varying the positive potential applied to the upper end of R_2. Since R_1 varies the positive potential applied to the fixed potentiometer R_3 R_2, it varies the potential on the a.g.c. line and can be used, therefore, as the contrast control for the receiver. Component values for R_3 and R_2 are chosen such that, with all signals having sufficient amplitude to merit the use of a.g.c., the desired setting of R_1 causes the delay provided by the clamp diode circuit to be overcome.

It will be noted that, in both Figs. 217 (*a*) and (*b*), a proportion only of the average voltage present on the sync clipper grid is applied to the preceding amplifier stages as an a.g.c. voltage. This is a necessary feature since the average voltage on the sync clipper grid, under normal reception conditions, will be higher than that which could be accepted as a grid bias control voltage by the preceding amplifier valves. The latter usually consist of high mutual conductance types whose grid cut-off potential may be of the order of 6 volts only. Unfortunately, the resistor network which reduces the average voltage on the sync clipper grid to that applied to the a.g.c. line also reduces the *changes* in average voltage by the same proportion. Thus, the system tends to have somewhat less control than would be given if the voltage changes on the sync clipper grid could be applied directly to the controlled grids.

A disadvantage with the mean level a.g.c. system is that its time constant must be equal, at least, to several frames. If this were not the case, the cessation of picture information during each frame period would cause a drop in a.g.c. voltage, with a consequent increase in receiver gain during, and shortly after (as the appropriate decoupling condensers charged), the frame sync periods. The fairly long time constant required limits the ability of the system to counteract high speed fading.

Blocking

When a very strong signal is suddenly applied to a television receiver employing a mean level a.g.c. system, it is sometimes possible for the latter to lose control. The cause of this loss of control can be described in the following manner. At the instant in which the signal is fed to the receiver the latter is at full sensitivity, and a very high amplitude i.f. signal appears at the grid of the last i.f. amplifier. This valve, being heavily overloaded, passes to the vision detector an i.f. signal of almost constant amplitude. Assuming a conventional receiver (with a cathode-modulated cathode ray tube and a single video amplifier valve) the vision detector then feeds an excessively high positive potential to the grid of the video amplifier, causing this valve to continually pass a maximum or near-maximum anode current. In consequence, very little a.c. information appears at the video amplifier anode for further application to the sync clipper grid. The final result is that only a small negative mean voltage (probably insufficient to overcome the delay) becomes available at the sync clipper grid and the receiver continues to work at maximum gain

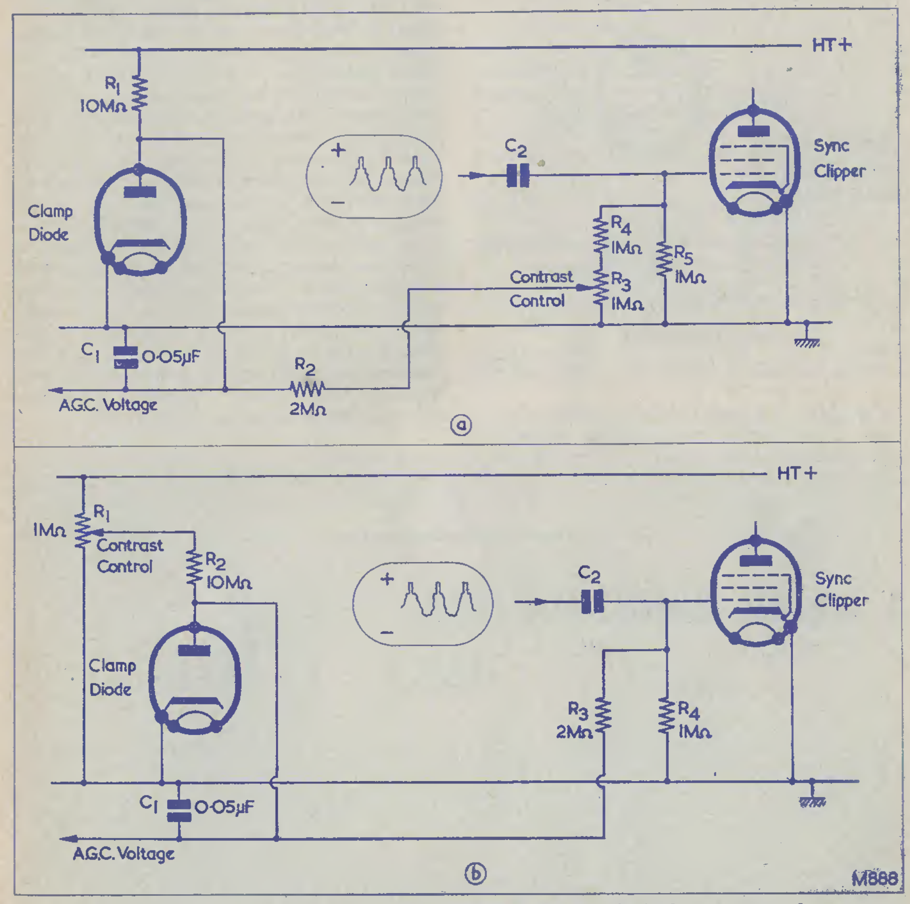


Fig. 217 (a). Illustrating, in basic form, the manner in which the average voltage level on the sync clipper grid may be employed for vision a.g.c. purposes. The component values shown are fairly representative of those encountered in practical versions. Sometimes the clamp diode circuit is omitted, whereupon the slider of R_3 connects direct to the a.g.c. line
(b). An alternative method of obtaining an a.g.c. voltage from the sync clipper grid. Again, component values are representative only

The condition is known as *blocking* of the a.g.c. system.

It should be pointed out that blocking occurs due to the *sudden* application of a very strong signal (as would be given, say, by selecting such a signal on a turret tuner). If the signal were to increase in strength slowly the a.g.c. system would reduce receiver gain correspondingly. Due to its inherent time delay, however, the a.g.c. system cannot operate *instantaneously*.

Damage may occur to components if a receiver is kept in a blocked condition. For instance, both the last i.f. valve and the video amplifier valve are being overrun; also, the vision detector has excess voltage applied to it with the result that, if it is a germanium diode, it may break down.

To guard against blocking it is occasional practice to insert a resistor and condenser in the grid circuit of the last i.f. amplifier valve, as shown in Fig. 218. These two components have a fairly long time constant which may be as great as that of the a.g.c. system. The valve is not coupled to the a.g.c. line. When a very strong signal is suddenly applied to the receiver, the peaks of the positive-going i.f. half-cycles carry the grid of the last i.f. amplifier positive of its cathode. In consequence, a leaky-grid action takes place, the additional series condenser taking up a charge such that the most positive points of the signal on the grid are slightly positive of the cathode. Overloading does not, therefore, occur and a signal possessing a large amount of a.c. information appears on the anode of the video amplifier. A relatively high average voltage is then formed at the grid of the sync clipper, this being sufficiently high to overcome the a.g.c. delay and reduce the gain of the receiver. As gain drops, the voltage across the condenser in the grid circuit of the last i.f. amplifier reduces also, since it discharges into its parallel resistor. Eventually, the voltage on the series condenser drops to zero and the receiver functions normally, with correct automatic gain control.

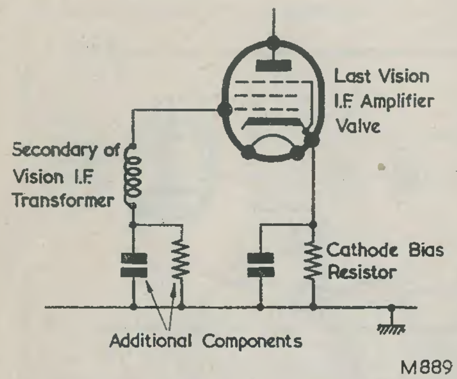


Fig. 218. To guard against blocking of the a.g.c. system an additional resistor and condenser are sometimes inserted in the grid circuit of the last vision i.f. amplifier valve

Next Month

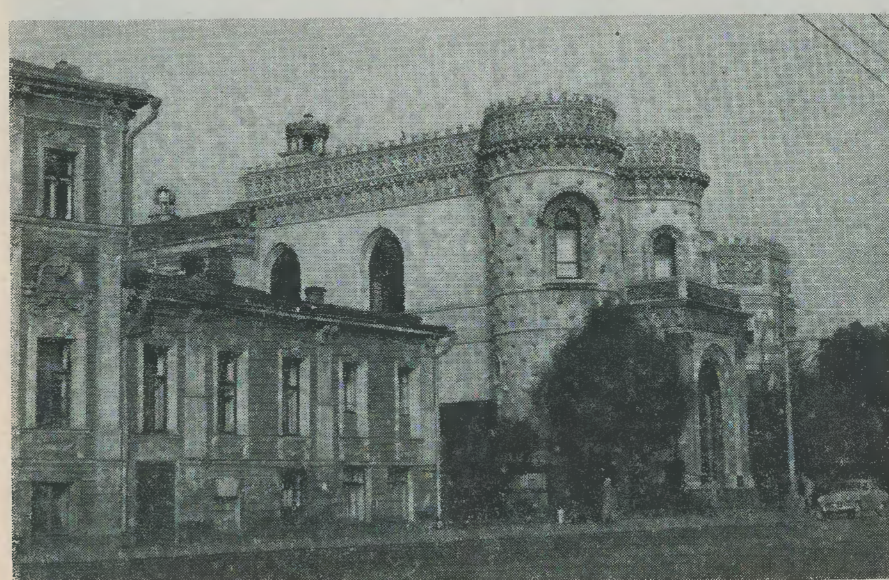
In next month's article we shall carry on to gated a.g.c. systems.

A RADIO CONSTRUCTOR VISITS *Moscow*

THE PROSPECT OF A VISIT TO MOSCOW SET the writer full of determination to see, if possible, something of amateur radio behind the Iron Curtain and learn to what extent the hobby of radio construction is practiced in the U.S.S.R. Not many visits by radio amateurs have so far been made to the U.S.S.R. One was therefore at a loss to know just how to go about making the necessary contacts. However, an article in the November 1959 *QST*, "A Glimpse of Russian Amateurs", by Dana W. Atchley, W1HKK, contained some useful advice, the best being to write to Box 88 Moscow, telling them of one's proposed visit and asking for a meeting with some Moscow amateurs. This was accordingly done, and in due course a letter was received—in Russian—which when translated, indicated that on arrival in Moscow, one should get the Intourist guide to phone Box 88, when the necessary arrangements would be made. For the help of others who may be contemplating a similar visit, the telephone number is K4–30–70. There are no telephone directories in Moscow!

The journey to Moscow was, for the writer, unique in that it was his first trip in a jet airliner—a Comet. Leaving London Airport in the early hours of the morning, we arrived at Moscow just as dawn was breaking, and the sight of sunrise from 30,000 feet is quite breathtaking. Once we had settled in at the "Ukraine Hotel", I took steps to contact Box 88. The Ukraine hotel is a 29 storey skyscraper in which many visitors to Moscow from overseas are accommodated. The various services provided are extremely useful; besides the usual ones to be found in any hotel of comparable size, there are bureaux for arranging theatre visits and tours of all sorts, entertainments from the Bolshoi Ballet to the Moscow Puppet Show and so on. In fact almost any query the visitor might have can be solved at the appropriate bureau. Producing my letter from Box 88, I asked to be put in touch with its sender. The letter was courteously accepted, carefully studied, and I was politely asked to come back for a reply the next day! This procedure we were to find quite commonplace in most spheres of Russian life. You do not expect—or if you do you will be disappointed—a reply to any question right away. The request must be carefully considered and an answer given later! I began to wonder if I should in fact be allowed to visit Box 88. However, I need not have worried. Next day I was told that representatives of the Central Radio Club of the U.S.S.R. would be very pleased to see me at 16.00 hours at "The House of Friendship", the address of which the Intourist clerk had thoughtfully written down for me in Russian. Armed with this I took my place in a queue for a taxi and was soon whisked away to "The House of Friendship".

This establishment is quite remarkable. Accommodated in a fine old building, which at one time was no doubt the mansion of some wealthy Muscovite, it is used as a meeting place between foreign cultural delegates and their Russian counterparts. I was ushered into a beautifully furnished and elegant room, where Mr. I. Demianov, the General Secretary of the Central Radio Club, "George", UA3FM, "Alexander", UA3BA, and "Jane", awaited me. Jane is the Club's Awards Manager and speaks excellent English, acting as a very able interpreter throughout the interview. George is a Doctor of Medicine, so we felt well at home. They were as interested to see me as I was to see them, I apparently being the first British Radio Amateur to visit the Club. I had fortunately taken some RSGB pennants, some photos of my shack, including the RTTY gear, and QSL cards along with me. My hosts had prepared a nice present for me in the shape of a collection of the very attractive pictorial QSL cards, which the Club provides for the use of members, a selection of various Club badges and some interesting literature—in English—about various aspects of life in the U.S.S.R. After the exchange of these tokens of mutual



The House of Friendship, Moscow

Mr. I. Demianov, "George" UA3FM, "Alexander" UA3BA, and "Jane"

friendship, the formal atmosphere soon dissolved and we were all asking questions and giving answers as fast as Jane could cope with them.

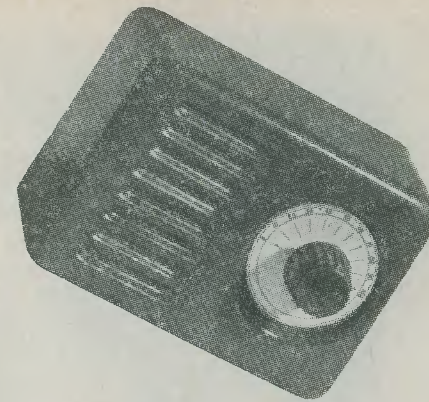
It appears that there are some 30,000 radio amateurs in the U.S.S.R. but it was not clear just how many of these hold transmitting licences. Many are members of a Youth Club or a Hobbies Club wherein amateur radio is one of the club activities and in which they operate the club transmitter. A number of U.S.S.R. amateurs do operate private rigs in their own homes, but one formed the impression that these were in the minority. 20 metres is the most popular band and c.w. being the most used mode by virtue of the inevitable language difficulties. There are five s.s.b. stations and for the record they are: UA3EG; UA3CR; UA3CG, who is a YL operator; UA3FG and UA3DR. Several more are expected on the air soon. Maximum transmitter power is 200 watts and a small licence fee is charged.

We talked of other radio activities in the U.S.S.R. and the picture is much the same as that in this country. Radio control of models has its keen supporters, both model boats and aircraft being extensively built. Hi-fi and audio amplifier construction is popular. The Russian L.P. records ($33\frac{1}{3}$ r.p.m.) have good reproduction and are cheap—average price at English rates of exchange, 7s. 6d.—we naturally brought some home! TV sets are cheap; £30–£60 seeming to be an average price. On the other hand clothes were very expensive. We saw suits at 1,000 roubles and overcoats at 1,250 roubles, which even at the tourist rate of exchange of 28 roubles to the £1, works out pretty expensive! Most of the large towns have a t.v. service and many—like Moscow—have a choice of programmes.

We noticed with interest that radio components were on sale in a number of shops, including the famous G.U.M. store in Moscow. They appeared to be of good quality and much of the same type as their equivalents in this country.

One could write much more about such a unique visit, but space is limited. If one tried to sum it up briefly, one might say that the picture of the average radio constructor in Russia is similar to that here, although he partakes of his hobby more at the Radio Club than we do here. He is just as keen and in a country where scientific accomplishments and technical skills count for a great deal, he gets plenty of encouragement from official sources. Radio is one of the most popular of hobbies in the U.S.S.R. and its importance as a means of self-training is well appreciated in official quarters.

A Christmas Stocking Receiver

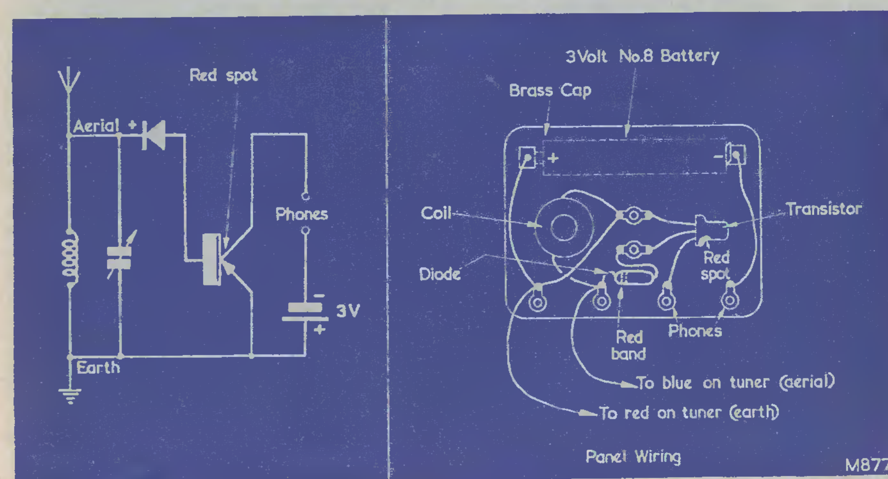


Described by James Sinclair

"CHRISTMAS COMES BUT ONCE A YEAR" —so gaily runs the old adage, but no mention is made of the pre-Yuletide headaches from which harassed parents suffer at this time of the year. What to give Johnny—or Jenny—in the traditional stocking this time? One solution to the problem, for the radio enthusiast, is suggested here. Nothing is more likely to capture the imagination and to delight the youngsters than a *real* radio of their very own. This simple little receiver, inexpensive, easily and quickly constructed, is one which will bring endless hours of fun and enjoyment to the junior members of the family. It requires an earth connection and a short aerial only.

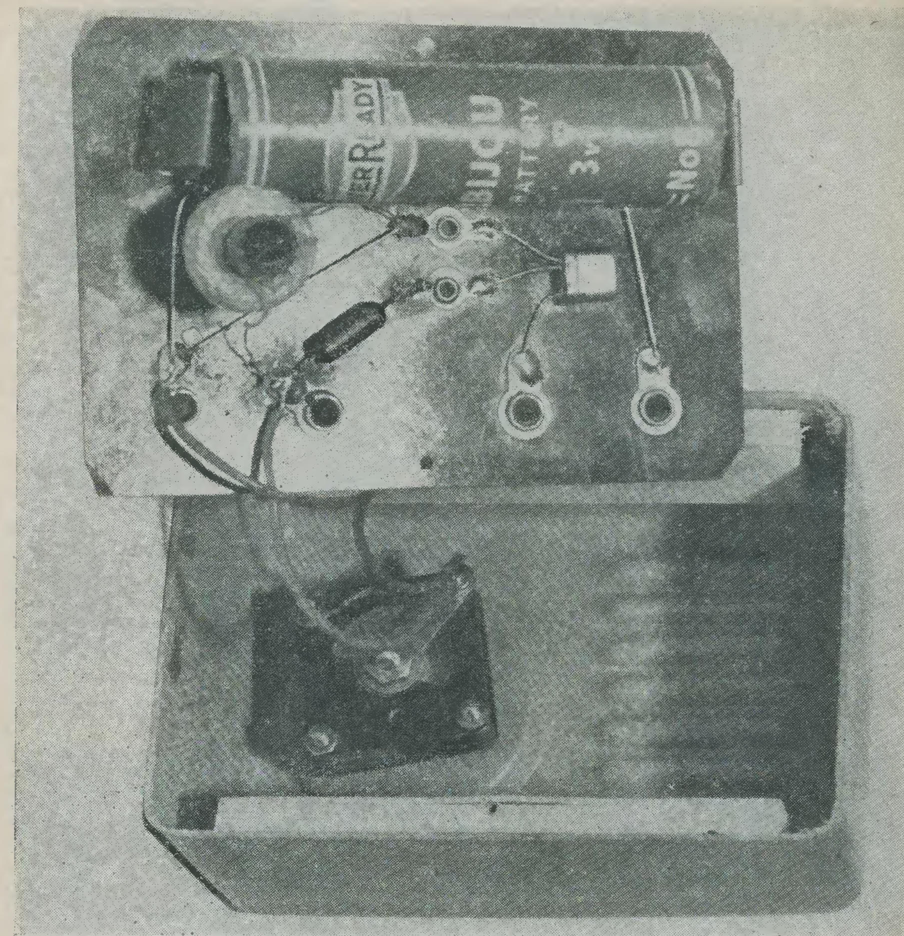
The simple circuit and layout drawing are shown herewith, and these, together with the photographs, make extremely clear the method of construction.

The circuit is that of a germanium crystal diode detector the output of which is fed into the base of a transistor a.f. amplifier. The resultant output of the transistor, powered by a 3 volt EverReady No. 8 battery, is fed into a pair of headphones or, if required, a single headphone. Alternatively, a balanced armature insert could be employed, this being



Components List

Coil (RCS Products (Radio) Ltd.)
Variable condenser (RCS Products (Radio) Ltd.)
Plastic case and knob (RCS Products (Radio) Ltd.)
Paxolin panel (RCS Products (Radio) Ltd.)
Germanium diode.
Transistor (Red Spot a.f. type).
Phones (2,000Ω) (see text).
Battery, 3V EverReady No. 8.



Cabinet and panel showing method of assembly

easily obtainable and inexpensive.

Construction of the receiver is greatly simplified by the use of a Paxolin board on to which the components are mounted and soldered into circuit. As received, the board is already fitted with the two copper battery contact strips and the solder tags.

The variable tuning condenser, a miniature solid dialectric 400pF type, should be mounted to the receiver cabinet panel and soldered into circuit after the main assembly has been completed.

Receiver tuning covers the Medium wave band from 200 to 500 metres, the coil being a litz-wound type.

When completed, the Paxolin board is secured to the receiver cabinet by means of two small wood screws (see photograph). The rear of the board then forms the back covering of the receiver into which the aerial, earth, and the phones are connected by means of ordinary wander plugs.

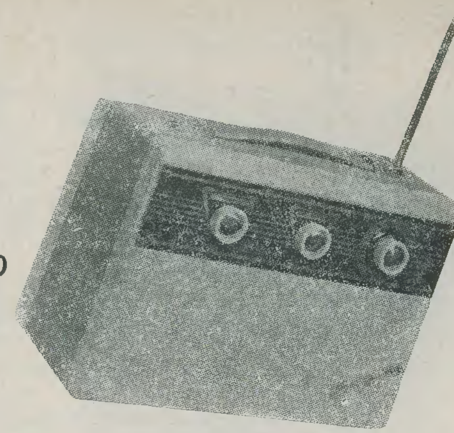
The heading illustration shows the completed receiver (construction time 15 minutes). The red plastic case, with matching knob, is fitted with a white tuning dial, the whole assembly presenting an attractively styled receiver.

The Christmas morning awakening (usually about 5 a.m.!) will almost certainly be followed by repeated requests for father to erect an aerial—so be forewarned and have one ready prior to the Yuletide morning (night?) rumpus!

THE

wavemaster

7-Transistor Portable/Car Radio



Described by
ALAN G. HEPWORTH

Part 1

This receiver has been specially designed and presented for the home constructor wishing to build a transistor receiver of the very latest design. In order to obtain the best possible results, all components used are of the highest quality—the aim throughout being to produce a receiver having an overall performance better than many currently on the market; both with respect to sensitivity and to running costs.

In all stages of this receiver, Seimens-Ediswan "Top Hat" transistors only are employed, the use of sub-standard transistors is not advised.

The receiver as such operates over the Medium and Long wave bands, a ferrite rod aerial, a modern frequency changer and a Permaco oscillator coil being employed. The i.f. transformers are double-tuned to 470 kc/s with specially designed windings tapped to provide perfect matching between stages. In all, six tuned i.f. circuits are employed, imparting a degree of selectivity unobtainable in earlier designs and separation of Medium and Long wave stations which is much better than many commercial receivers.

It will be found that the telescopic aerial improves reception under certain conditions and will prove to be an attractive feature.

The push-pull amplifier is of a special design producing an undistorted output of some 400mW.

Circuit

This is shown in Fig. 1 from which it will be seen that it is a seven transistor design incorporating a ferrite rod aerial L_1, L_{1A}, L_2, together with an alternative car aerial input "X". TR_1, an XA102, performs the function of a frequency changer, TR_2 and TR_3, both XA101 types, act as the i.f. amplifiers, while TR_4, an XB103, is the first a.f. amplifier. TR_5, another XB103, is the driver transistor for the two push-pull output transistors TR_6 and TR_7, these being a matched pair of XC101 types.

The switch S_1, S_2, S_3, acts as the wave-change switch, while S_4 is the on/off control. Medium and Long waves are tuned by the two-ganged condenser VC_1 and VC_2. The output of the frequency changer is applied to the first i.f. transformer IFT_1 and from there to the remainder of the i.f. amplifier. The output from the final i.f. transformer, IFT_3, feeds into the crystal diode D_1, the potentiometer VR_1 being the diode load and also the volume control. The signal passes, via C_{25}, to the first a.f. amplifier, TR_4, the resultant output from this stage being passed, via C_{28}, to the driver transistor TR_5. Both of these latter transistors operate as earthed emitter amplifiers. The output of TR_5 is fed into the primary winding of the a.f. driver transformer T_1. The centre-tapped secondary winding of T_1 is coupled into the bases of the two push-pull output transistors, TR_6 and TR_7, operating in class B. The output of these transistors is then fed, via the output transformer T_2, to the voice coil of the speaker.

Transistor connections are given in the inset to Fig. 1. Particular note should be taken of the numbered eyelet points also shown, these being frequently referred to in the constructional details which follow.

Constructional Notes

The chassis is supplied ready drilled and tagged, brackets being fitted for the aerial rod and ganged condenser. A positive bus-bar is fitted on the chassis, as are the i.f. transformers, trimmers and the interstage

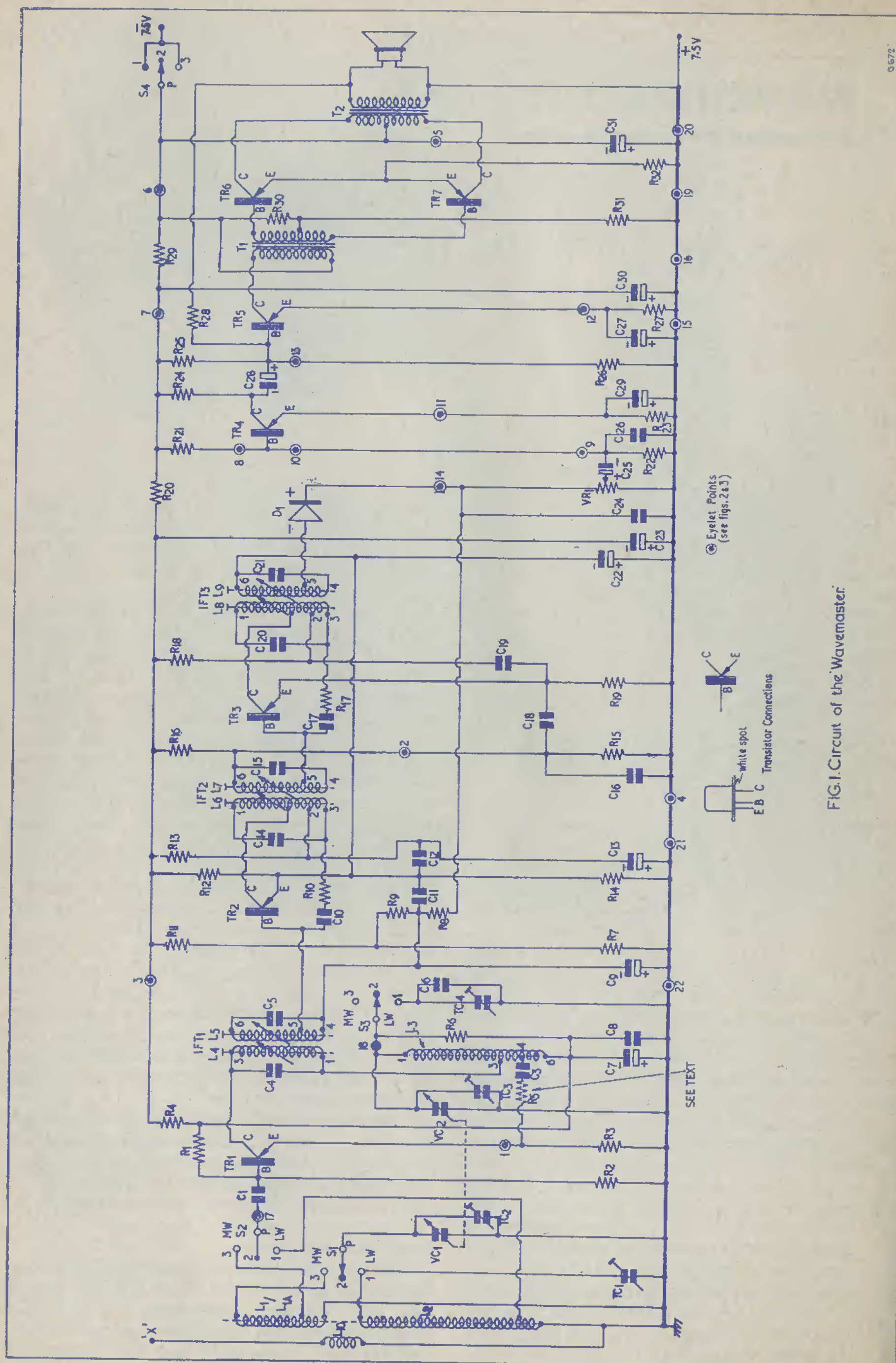


FIG.1.Circuit of the 'Wavemaster'

and output transformers—all this considerably assisting the home constructor in advance.

The various resistors and condensers should be positioned as near as possible to those shown in Figs. 2 and 3. These components must be placed as near to the chassis as possible.

All bare wires must be fitted with insulated sleeving including the lead-outs of all components and transistors.

Electrolytic condensers have coded ends, i.e. **Red** is plus (+) or positive and **Black** is minus (−) or negative. Constructors should remember this when fitting these components and *note the polarity markings* as shown in the wiring diagrams of Figs. 2 and 3.

Transistors

The following instructions apply to all transistors. Do not cut the transistor leads.

First, fit a suitable length of sleeving to each lead of the transistor leaving about $\frac{1}{8}$in of bare wire at the ends of the leads. Coil or loop the leads around a small diameter length of rod, the blade of an average grub screwdriver is ideal for this purpose, forming a loop as shown in the inset to Fig. 3.

Using a pair of pointed pliers, grip each lead in turn near the end to be soldered and join the E (emitter), B (base) and C (collector)

Components List

Resistors

R_1 47kΩ $\frac{1}{8}$ watt
R_2 4.7kΩ $\frac{1}{8}$ watt
R_3 2.2kΩ $\frac{1}{8}$ watt
R_4 1kΩ $\frac{1}{8}$ watt
R_5 See text
R_6 15kΩ $\frac{1}{8}$ watt
R_7 39kΩ $\frac{1}{8}$ watt
R_8 10kΩ $\frac{1}{8}$ watt
R_9 22kΩ $\frac{1}{8}$ watt
R_{10} 1kΩ $\frac{1}{8}$ watt
R_{11} 100kΩ $\frac{1}{8}$ watt
R_{12} 15kΩ $\frac{1}{8}$ watt
R_{13} 470Ω $\frac{1}{8}$ watt
R_{14} 1kΩ $\frac{1}{8}$ watt
R_{15} 22kΩ $\frac{1}{8}$ watt
R_{16} 100kΩ $\frac{1}{8}$ watt
R_{17} 1kΩ $\frac{1}{8}$ watt
R_{18} 470Ω $\frac{1}{8}$ watt
R_{19} 1kΩ $\frac{1}{8}$ watt
R_{20} 150Ω $\frac{1}{8}$ watt
R_{21} 47kΩ $\frac{1}{8}$ watt
R_{22} 15kΩ $\frac{1}{8}$ watt
R_{23} 1.8kΩ $\frac{1}{8}$ watt
R_{24} 5.6kΩ $\frac{1}{8}$ watt
R_{25} 39kΩ $\frac{1}{8}$ watt
R_{26} 22kΩ $\frac{1}{8}$ watt
R_{27} 470Ω $\frac{1}{8}$ watt
R_{28} 100kΩ $\frac{1}{8}$ watt
R_{29} 150Ω $\frac{1}{8}$ watt
R_{30} 3.3kΩ $\frac{1}{8}$ watt
R_{31} 150Ω $\frac{1}{8}$ watt
R_{32} 10Ω $\frac{1}{8}$ watt
VR_1 250kΩ

Condensers

C_1 0.01μF ceramic
C_2 550pF silver mica, ±5%
C_3 0.002μF ceramic
C_4 600pF silver mica
C_5 160pF silver mica
C_6 350pF silver mica
C_7 25μF electrolytic
C_8 0.005μF ceramic
C_9 25μF, electrolytic
C_{10} 47pF silver mica
C_{11} 0.04μF paper
C_{12} 0.002μF ceramic
C_{13} 25μF electrolytic
C_{14} 160pF silver mica
C_{15} 160pF silver mica
C_{16} 1μF paper
C_{17} 47pF silver mica
C_{18} 0.04μF paper
C_{19} 0.002μF ceramic
C_{20} 160pF silver mica
C_{21} 160pF silver mica
C_{22} 25μF electrolytic
C_{23} 25μF electrolytic
C_{24} 0.01μF ceramic
C_{25} 25μF electrolytic
C_{26} 0.01μF ceramic
C_{27} 25μF electrolytic
C_{28} 25μF electrolytic
C_{29} 25μF electrolytic
C_{30} 500μF electrolytic
C_{31} 500μF electrolytic

Transistors

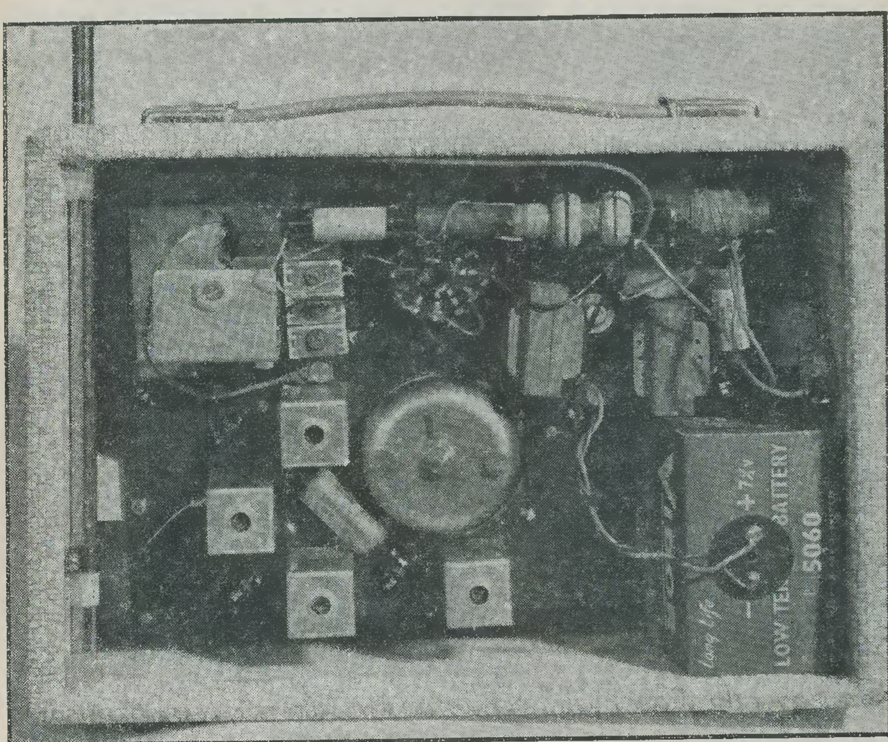
TR_1 XA102
TR_2 XA101
TR_3 XA101
TR_4 XB103
TR_5 XB103
TR_6 XC101 } Matched pair
TR_7 XC101 }

Miscellaneous

D_1 Germanium diode
VC_1/VC_2 500pF twin-gang (slow motion)
S_1, S_2, S_3, S_4 4-pole, 3-way
Battery 7.5V Vidor L5060
2-pin battery plug
Car aerial socket
Cabinet (Clyne Radio Ltd.)
Telescopic aerial (Clyne Radio Ltd.) (7 section)
Knobs, pointers, etc. (Clyne Radio Ltd.)
Chassis assembly with IF's, transformers, trimmers, etc., fitted (Clyne Radio Ltd.)

leads to points as indicated. This method of "shunting" the heat away from the transistor must be followed, otherwise the transistors themselves may suffer permanent damage.

The resistor R_5, shown in dotted line in Fig. 1, is not supplied with the components, it being a variable factor which can only be found by experiment. R_5 may be any value between 22 and 150Ω, it being included when the oscillator circuit shows a tendency towards "squegging" and is only necessary in rare circumstances. Referring to Fig. 3, if R_5 is included, it would have to be fitted between eyelet 1 and C_3 (arranged in series C_3—R_5—eyelet, in that order).



Inside cabinet view of the completed receiver

Construction—Stage 1

Constructors are advised to tick the paragraph numbers as each stage is concluded.

1. Mount the twin-gang tuning condenser VC_1, VC_2, to the bracket already fitted, using three 4BA x ⅛in bolts and tighten securely. Bend up the inside tags that come into contact with the side of the trimmer block. The condenser is fitted from the top of the chassis as shown in Fig. 2, with the spindle on the underside (see Fig. 3).

2. Mount the 4 pole 3 way switch (wave-change combined on/off) shown in Fig. 2 as S_1, S_2, S_3, S_4. Arrange the tags exactly as shown in Fig. 2 and securely tighten the nut.

3. Next, the volume control VR_1 should be fitted into position. Arrange exactly as shown in Fig. 2. Fit the nut and tighten securely.

4. With reference to Fig. 2, the following connections should now be made. Solder a short lead from the earth tag on IFT_1 to eyelet 22 (positive bus-bar).

5. Earth tags already fitted at the bottom of IFT_2 and IFT_3 should now be bent over the edge of the chassis and soldered to the positive bus-bar.

6. Solder C_{16} (1μF) between eyelet 2 and eyelet 4.

7. Fit a short lead between eyelet 14 and the top tag of VR_1.

8. Next, mount C_{25} (25μF electrolytic) between eyelet 9 and the centre tag of VR_1. *Note polarity markings*—**Red** is always the + end.

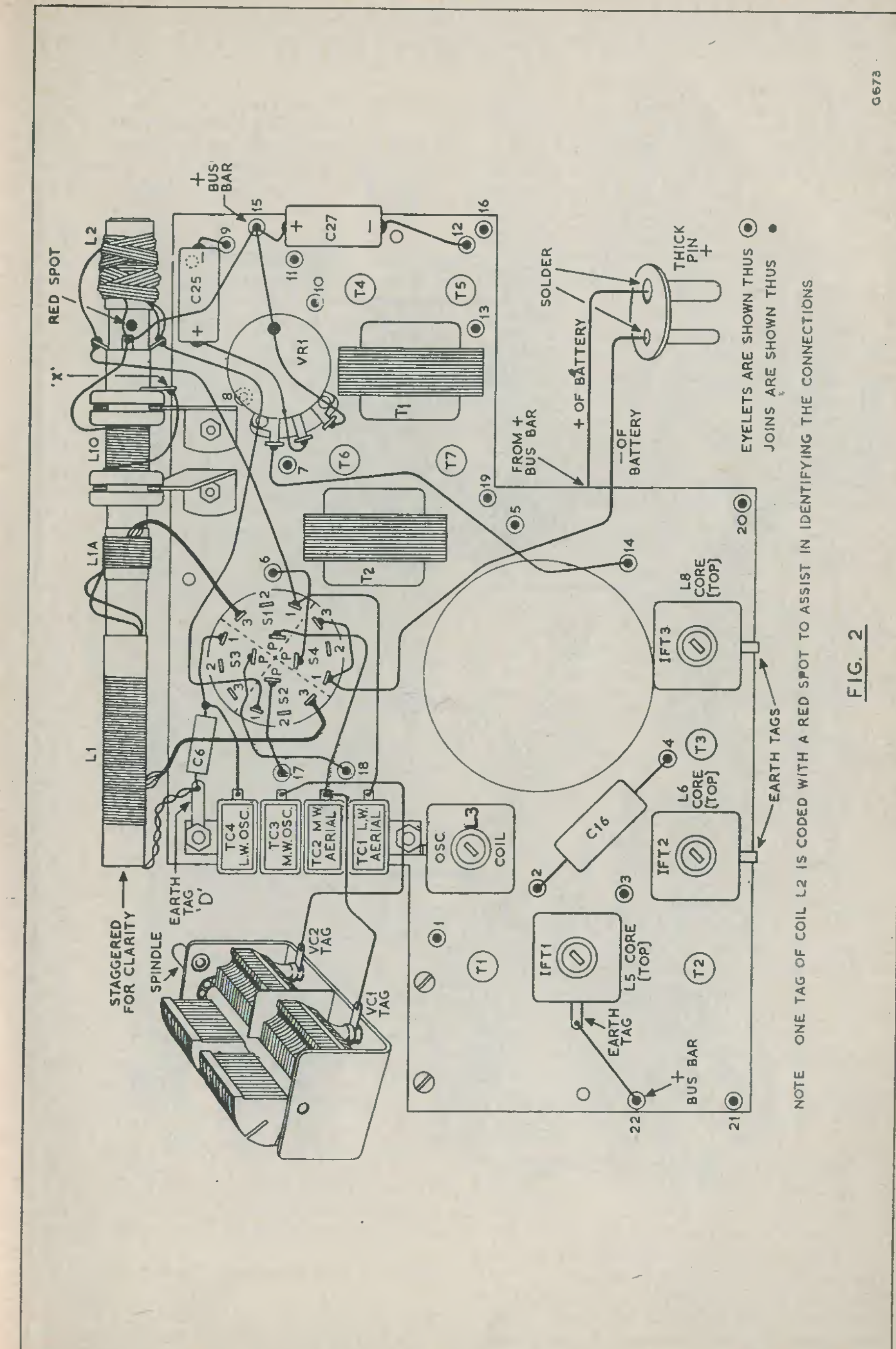


FIG. 2

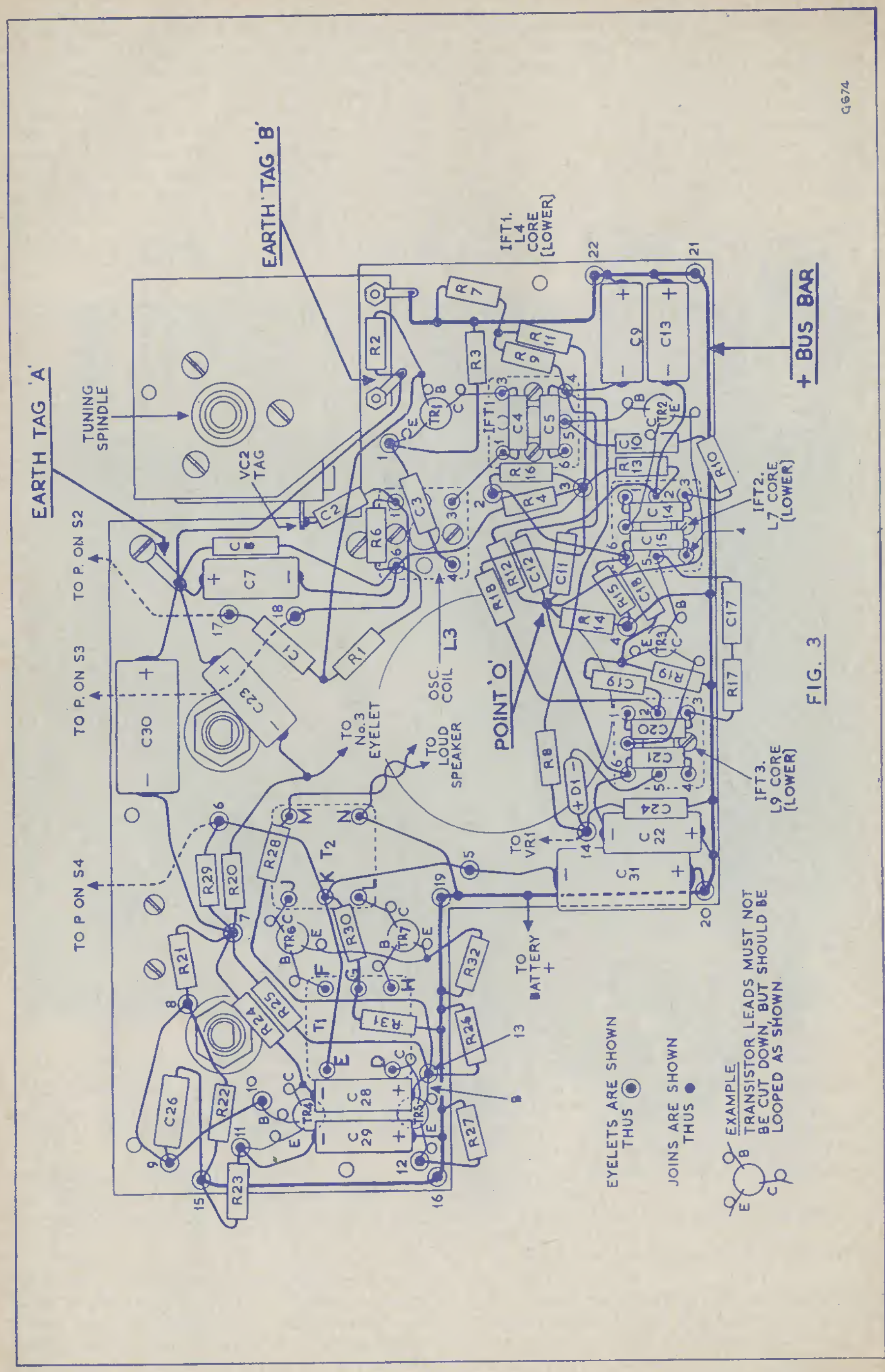


FIG. 3

9. Join a short lead between eyelet 15 and the lower tag of VR_1. Also solder this lead to the metal back cover of VR_1, as shown on the diagram.

10. Fit C_{27} (25μF), *noting polarity markings*, between eyelets 12 and 15.

This completes the wiring on this side of the chassis. The ferrite rod and other leads are fitted later.

Stage 2

With the following connections now to be made, frequent reference should be made to Fig. 3. A great deal of work is to be carried out on this side of the printed circuit board and extra care is therefore necessary.

11. Fit C_2 (550pF) between VC_2 tag and tag 1 on the oscillator coil L_3.

12. R_6 (15kΩ, brown, green, orange) should next be soldered across tags 1 and 6 of the oscillator coil L_3.

13. Solder C_8 (0.005μF) and C_7 (25μF) between tag 6 of the oscillator coil L_3 and the earth tag "A" at the top of the chassis. (*Note polarity of C_7.*)

14. Connect C_3 (0.002μF) between tag 4 of the oscillator coil and eyelet 1.

15. Mount R_3 (2.2kΩ, red, red, red) between eyelet 1 and the positive bus-bar that is round the edge of the board.

16. Fit C_4 (600pF) between tag 1 and tag 3 of IFT_1.

17. C_5 (160pF) is now fitted between tag 6 and tag 4 of IFT_1.

18. R_9 (22kΩ, red, red, orange) and R_7 (39kΩ, orange, white, orange) are joined in series between tag 4 of IFT_1 and the positive bus-bar.

19. To the junction of R_9 and R_7, one end of R_{11} (100kΩ, brown, black, yellow) should now be soldered. The other end of R_{11} is next soldered to eyelet 3.

20. C_9 (25μF), this is fitted between tag 4 of IFT_1 and the positive bus-bar. *Note again the polarity markings.*

21. Solder C_{13} (25μF) between the positive bus-bar and tag 2 of IFT_2, *noting the polarity markings.*

22. R_{13} (470Ω, yellow, violet, brown) should now be soldered between tag 2 of IFT_2 and eyelet 3.

23. Connect C_{14} (160pF) between tags 1 and 3 of IFT_2.

24. Solder C_{15} (160pF) between tags 4 and 6 of IFT_2.

25. Next, join in series R_{10} (1kΩ, brown, black, red) and C_{10} (47pF) and connect the ends between tag 3 of IFT_2 and tag 5 of IFT_1.

26. Fit between tags 3 and 1 of IFT_3 the condenser C_{20} (160pF).

27. The condenser C_{21} (160pF) is now fitted between tag 4 and tag 6 of IFT_3.

28. Join in series C_{19} (0.002μF) and R_{19} (1kΩ, brown, black, red) and connect the ends between tag 2 of IFT_3 and the positive bus-bar.

29. Join in series R_{17} (1kΩ, brown, black, red) and C_{17} (47pF) and connect the ends between tag 3 of IFT_3 and tag 5 of IFT_2.

30. To the junction of C_{19} and R_{19} solder one end of C_{18} (0.04μF), the other end being soldered to tag 6 of IFT_2.

31. Fit R_{15} (22kΩ, red, red, orange) between eyelet 4 and tag 6 of IFT_2.

32. Solder C_{24} (0.01μF) between eyelet 14 and the positive bus-bar.

33. Fit C_{22} (25μF) between the positive bus-bar and tag 6 of IFT_3. *Observe polarity.*

34. Solder D_1 between eyelet 14 and tag 5 of IFT_3. *Note the polarity markings.* The ends of D_1 should be coiled or looped and not cut. Hold the ends of the wires with a pair of pointed nosed pliers in order to conduct some of the excess heat away from the diode when soldering into position.

35. Mount C_{31} (500μF) between the positive bus-bar (eyelet 20) and eyelet 5. *Note the polarity markings.*

36. Fit R_{31} (150Ω, brown, green, brown), one end to the positive bus-bar and the other end to tag G on T_1.

37. To this same tag G, solder one end of R_{30} (3.3kΩ, orange, orange, red), the other end of R_{30} then going to tag K on T_2.

38. Solder R_{26} (22kΩ, red, red, orange) in position, one end to the positive bus-bar and the other end to eyelet 13.

39. R_{27} (470Ω, yellow, violet, brown) is now fitted between eyelet 12 and the positive bus-bar.

40. R_{23} (1.8kΩ, brown, grey, red) is next connected between eyelet 11 and eyelet 15 (positive bus-bar).

41. With a short lead, join eyelet 9 to eyelet 8.

42. Connect C_{26} (0.01μF) between eyelet 9 and eyelet 15 (positive bus-bar).

43. R_{22} (15kΩ, brown, green, orange) should now be soldered between eyelet 8 and eyelet 15 (positive bus-bar).

44. Solder R_{21} (47kΩ, yellow, violet, orange) between eyelet 8 and eyelet 7.

45. Fit R_{29} (150Ω, brown, green, brown) between eyelet 6 and eyelet 7.

46. Dealing with C_{30} (500μF electrolytic) solder between eyelet 7 and earth tag "A". *Note polarity markings.*

47. Join the negative end of C_{23} (25μF) to one end of R_{20} (150Ω, brown, green, brown).

48. Take the positive end of C_{23} to earth tag "A" and the free end of R_{20} to eyelet 7.

49. From the junction of R_{20} and C_{23} a short lead (avoid passing over the large central hole in the chassis) is taken to eyelet 3.

(To be continued)

An Automatic Switch for Christmas Lights

by A. THOMAS

Introductory Note

The diagrams which accompany this article illustrate relays with the "detached" method of presentation. Relay coils are indicated by rectangles containing the coil resistance in ohms, and are designated by a letter over a figure. The figure indicates the number of contacts possessed by the relay. The contacts may appear at any point in the diagram and are shown in the de-energised position. They are designated by a letter and a suffix number. Thus, a rectangle indicated as, say, $\frac{Q}{3}$ refers to the winding of relay Q; the designation also carries the information that there are three sets of contacts. These contacts will be found elsewhere in the diagram designated Q1, Q2 and Q3.—*Editor*.

IT IS OFTEN FOUND THAT COMPONENTS SUCH as relays are one of the few things which are in the spares box but do not have a great many uses.

This article suggests a means of using these and thus providing a novelty for Christmas.

Pulsing Relay

This is an electro-mechanical relaxation oscillator, depending on the charge and discharge of a condenser through a relay coil. The pulsing relay must have two windings, one winding having approximately three times the resistance of the other.

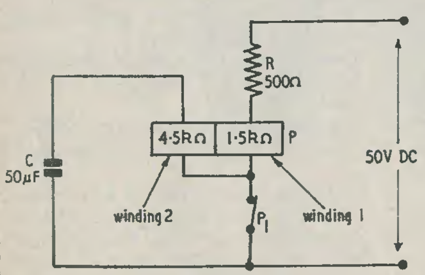


Fig.1
A pulsing relay circuit

There should be one pair of break contacts for use with the oscillator, and as many others as are required by the external function to be carried out. In this case an additional make pair will suffice.

The method of operation is as follows. (Fig. 1.) C is discharged. Current flows through winding 1, relay commences to operate, P_1 contact breaks, and current flows through winding 1, winding 2 and C (C initially looks like a short circuit).

The relay remains operated until C is almost charged, the current through it is then insufficient for the relay to remain operated and it starts to release. P_1 contact remakes and C discharges through winding 2 in opposition to the current through winding 1, whereupon the relay remains released until the standing current through winding 1 overrides the current through winding 2. The relay then re-operates.

The range of frequencies which may be covered by this oscillator extends from 0.05 to 25 c/s depending on the voltage supply and the value of C. R will give a ±10% swing in frequency but should not exceed half of winding 1 resistance. It will have more effect on the ratio between operated and release periods than on speed.

The oscillator shown in Fig. 1 will run at approximately 1 c/s with the values shown.

Switching Circuit

The remainder of the circuit may be varied considerably, but in this instance we will only consider its use as an automatic switch for Christmas tree lights as in Fig. 3, or as an illuminated sign spelling out ME, RR, Y, XM, AS. A suitable circuit is shown in Fig. 2.

The five relays A, B, C, D, E will operate and hold on in sequence on each successive operation and release of the slave relay Q. The relays will light lamps A, B, C, D, E in succession. On the third operation of Q relay, G relay operates and switches off all the lamps. On the fourth release of Q relay, G releases and the lamps relight. The on-off condition continues until F relay operates over the time constant provided by the

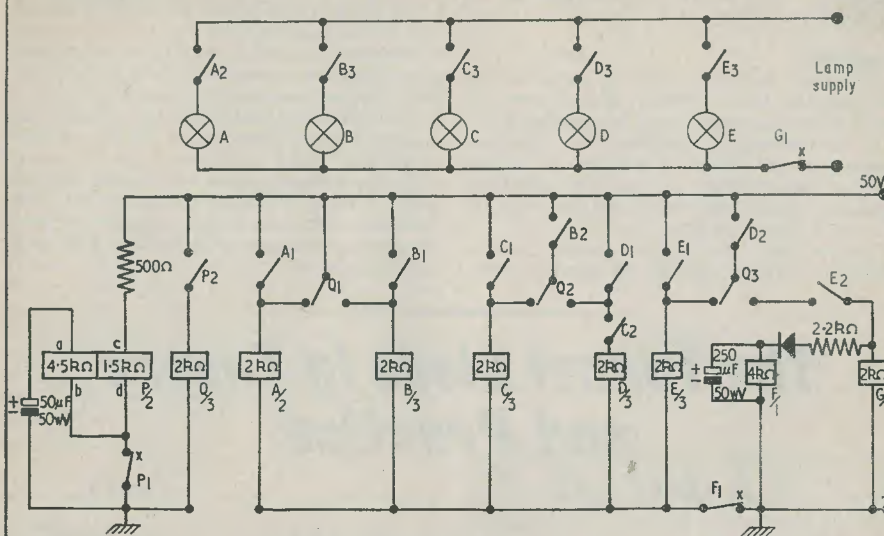


Fig.2
Complete circuit diagram

250µF condenser and the 2.2kΩ resistor. This is in the order of three seconds. (The rectifier in series with F relay prevents the coil resistance of G relay from discharging the 250µF condenser.) When F relay operates, it releases A, B, C, D, E relays. The sequence will then start over again.

The table lists the requirements of each relay. The limiting factor to coil resistance is the current drain from the power supply. Apart from relay P, coil resistances in the table are minimum figures. Coil resistances in Fig. 2 are typical.

Power Supply

The power supply must provide about 50V d.c. at sufficient current to operate all the relays; 1 amp should be satisfactory. Also required is a low voltage to supply the lamps. The smoothing of the 50V supply is not critical and a half wave rectified supply will suffice. If a 50V supply with a greater current capacity is available, then standard Christmas tree lamps may be used, two in series if they are 24V or four in series if they

TABLE
Relay Requirements

Relay	Coil Resistance	Contacts Make	Contacts Break	C/over
A	1kΩ or over	2	—	—
B	1kΩ or over	3	—	—
C	1kΩ or over	3	—	—
D	1kΩ or over	3	—	—
E	1kΩ or over	3	—	—
F	3kΩ or over	—	1	—
G	1kΩ or over	—	1	—
P	1.5+4.5kΩ or similar	1	1	—
Q	1kΩ or over	—	—	3

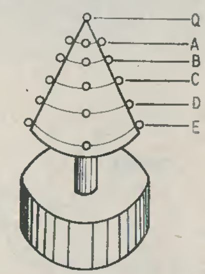


Fig.3
A typical Christmas tree showing lamp layout

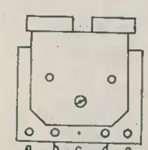


Fig.4
Rear view of relay

E797

are 12V. They may be connected to an unrectified a.c. supply.

Comments

G relay contacts must be suitable for carrying the lamp current; if not, two or more pairs of contacts may be paralleled.

If interference to television is apparent connect a 1μF 50WV condenser in series with a 200Ω resistor across the offending contact. Likely contacts are marked with an X on the circuit diagram.

Ensure that the power supply has a generous current capacity to prevent over-heating during long periods of operation.

Fit fuses to the mains, to the 50V supply and to the lamp supply.

Measure the coil resistance of P relay to ensure correct connections. Fig. 4 shows the relay connections usually employed.

A further contact on Q relay may be used to light a lamp at the top of the tree on each operation. See Fig. 3.

A final point concerns the rectifier in series with F relay. This is not a critical component, and a two-plate copper-oxide or three-plate selenium rectifier would be quite satisfactory.

The Tunnel Diode in Theory and Practice

Part 2

By J. B. DANCE, M.Sc.

Conventional Diode

It is instructive to compare the characteristic curve of the tunnel diode (Fig. 6) with that of a conventional semi-conductor junction diode (Fig. 12); the latter is a junction between moderately doped p and n types of semi-conductor. Energy level theory shows that electron flow occurs from the conduction level of the p type to the conduction level of the n type, but at zero bias the electrons would be required to flow up a hill. A suitable forward bias overcomes this hill, or energy, barrier. If an increasing reverse bias is applied, the breakdown point is reached when the current suddenly increases to a very large value because of the avalanche effect. Increasing the impurity concentration reduces the breakdown voltage as shown in Fig. 12. The tunnel diode may be imagined as a conventional diode in which the impurity concentration is so high that the breakdown voltage is slightly positive. The part of the curve AOB in Fig. 6 is really very similar to the breakdown of a conventional diode. Similarly the part E to F in Fig. 6 is similar to the forward characteristic in Fig. 12. The ordinary diode does not, however, have anything comparable to the part of the Fig. 6 curve from B to D; therefore it cannot amplify.

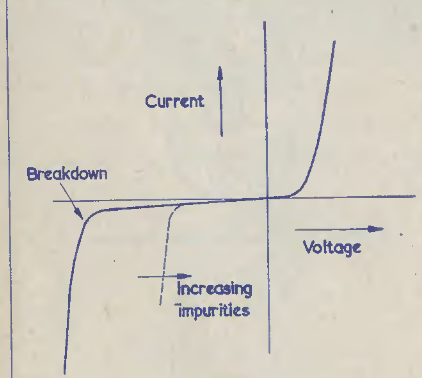


FIG.12

Response of an ordinary semi-conductor diode.

M864

In order for a junction between p and n types of semi-conductor to be operated as a tunnel diode, two requirements must be observed. The junction from the p type to the n type must be very abrupt or the depletion region will be so broad that the probability of tunnelling will be absolutely negligible. In addition both the p type and n type of semi-conductor used must contain so many impurity atoms that they are degenerate (i.e. the Fermi levels must be within the valency band for the p type material and within the conduction band for the n type material). It is very fortunate that degenerate semi-conductor junctions tend to have the narrow barrier region required for operation as tunnel diodes.

The bias voltage applied to the diode is concentrated in the extremely thin barrier region (about a millionth of a cm. thick) and therefore the actual electric field in the barrier region of a typical tunnel diode may be about 500,000 volts per cm., although only a fraction of a volt is actually applied to the diode. The probability of tunnelling across a barrier has been calculated[13] and the results are shown in Table 1 for various electric field strengths. It can be seen that there is an absolutely fantastic increase in tunnelling probability as the field increases from 10,000 volts per cm. to a million volts per cm. It should be appreciated that, for a given applied voltage, doubling the barrier width will halve the electric field strength. If the barrier width is halved, the probability of tunnelling may be increased a thousand times or, under certain field strength conditions, millions of millions of times. This alone could fully explain the difference between tunnel diodes with their narrow depletion region and ordinary semi-conductor diodes in which the probability of tunnelling would be fantastically small—perhaps one electron in a million million years! In addition, however, one has to consider the other requirement which, in effect, states that vacant states in the p type valency band must come opposite occupied states in the n type conduction band before the possibility of tunnelling can be considered. This does not occur in ordinary diodes.

TABLE 1

Probability of tunnelling per second	Electric field (volts/cm)
10^{-100}	10^4
1	10^5
10^{12}	10^6
10^{14}	10^7

The probability of an electron tunnelling through a p–n barrier for various values of electric field strength.

The Backward Diode

Backward diodes are particularly interesting because tunnelling takes place at their barrier. They consist of a p–n junction made from materials which are quite highly doped, but either (or both) of the p or n type materials do not contain enough impurity atoms for the junction to be used as a tunnel diode. The characteristic curve is shown in Fig. 13. The main difference between this curve and the tunnel diode characteristic is that the backward diode shows no negative resistance effect. The reverse part of the backward diode characteristic (from B to A in Fig. 13) is caused by tunnelling in the same way that tunnelling causes the reverse conduction effect in the tunnel diode (O to A in Fig. 6). Owing to the differences in the energy level diagrams, tunnelling does not occur in the backward diode when it is forward biased.

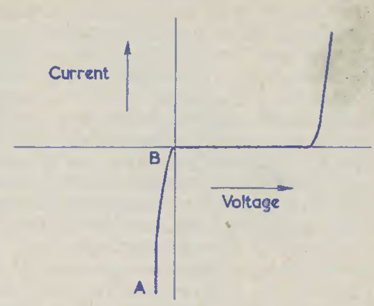


FIG.13

Characteristic of backward diode.

M865

Forward biasing means that the p type material is made positive with respect to the n type material, so that, in a conventional semi-conductor diode, the electrons will flow easily from the n type to the p type. Conventionally we say that the current (not the electrons) flows from the p type to the n type. If the n type material is made positive, an ordinary diode does not conduct easily and only a relatively small current can force its way through the barrier in the reverse or backward direction.

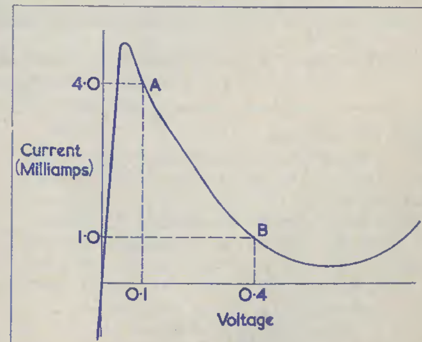


FIG.14

Calculation of negative resistance of tunnel diode

M866

[13] I.R.E. Wescon. Conv. Record, 1959.

In the backward diode, however, conduction occurs much more readily (by tunnelling) when the p type material is made negative with respect to the n type material than when it is biased in the other direction. The backward diode thus conducts more easily "the wrong way round"—hence the name of the device. Nevertheless when the p type material is made positive, the backward diode is still said to be forward biased (by analogy with the conventional semi-conductor diode) although it is in its least conducting state.

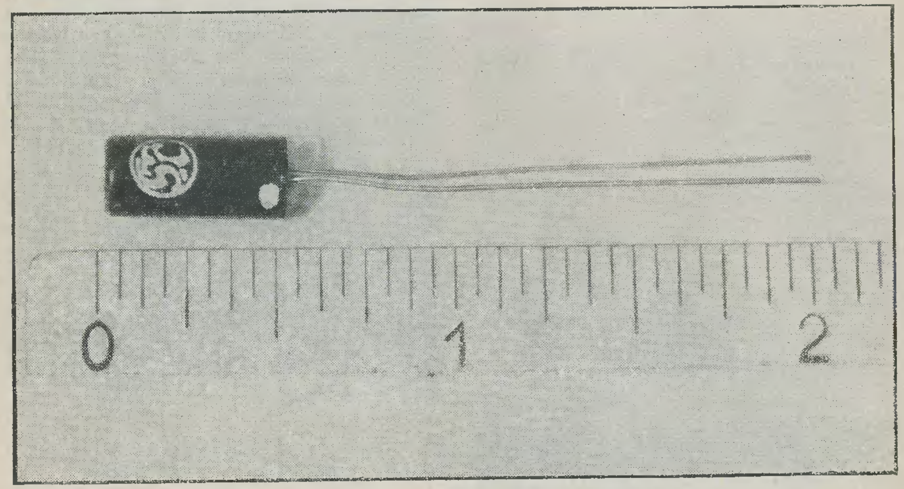
The backward diode is not nearly so important as the tunnel diode, as it cannot amplify or oscillate, but it will have a number of uses in computers, etc. For instance, if a tunnel diode is placed in series with a backward diode, the negative resistance of the tunnel diode is moved into a higher voltage region so that the combination can be used. as a switch for somewhat higher voltages than the tunnel diode.

In any negative resistance device it is actually the a.c. resistance (also called the incremental, dynamic or differential resistance) which is negative. Fig. 14 shows the characteristic curve of a typical tunnel diode and from the curve it is possible to calculate the average a.c. negative resistance between points A and B. The increase in voltage from point A to point B is 0.3 volt. The increase in current between the same two points = −(decrease in current) = −3mA = −0.003A. A.C. Resistance =

$$\left(\frac{\text{Increase in voltage}}{\text{Increase in current}} = \frac{0.3}{-0.003}\right) = -100\Omega.$$

The curve is not exactly linear and therefore the negative resistance will vary somewhat from point to point. In practice, diodes having negative resistances of between about 500Ω and 10Ω will probably be the most useful.

The voltages of the peak (about 60mV)



The small size of and S.T.C. tunnel diode is adequately demonstrated here. (Standard Telephone and Cables Ltd.)

Negative Resistance

It has already been mentioned that in the region from B to D in Fig. 6 the current passing through the tunnel diode decreases as the voltage across it increases. It is usually said that the resistance is negative in this region. This is not absolutely correct, however, because if the d.c. resistance were really negative, a voltage applied in one direction would cause a current to pass in the opposite direction. Energy would then be given out from the device without any energy input—which would be something like the impossible idea of perpetual motion.

and of the valley regions (about 400mV) are similar in all types of tunnel diode and are always less than one volt. The characteristics are therefore usually specified in terms of negative resistance and of peak and valley currents. Sometimes the ratio peak current/valley current is given; values of this ratio between 4:1 and 15:1 are common. There is also a maximum current rating. The equivalent capacity and inductance are important at microwave frequencies.

If the junction area of a tunnel diode is increased, the peak current becomes greater, but the negative resistance becomes so very

low that it may be impossible to match the diode in a practical circuit.

Amplifying devices like the valve and transistor are usually three terminal components. The tunnel diode with its negative resistance has only two terminals and, therefore, special circuitry is necessary to avoid undesired coupling between the input and output circuits. The widespread use of the tunnel diode may well be delayed whilst new circuits are being developed.

The tunnel diode is by no means the first device to be discovered which depends on a negative a.c. resistance for its amplification, although it will almost certainly be the most important and will awaken interest in negative resistance devices. The dynatron negative resistance circuit has been known for many years and can be used as an amplifier, but it is not a convenient one. It is, however, occasionally used as an oscillator. It makes use of the fact that at certain values of screen grid voltage the anode current of a tetrode decreases when the anode voltage is increased owing to secondary emission of electrons from the anode. This gives the circuit a negative a.c. anode resistance. The transitron oscillator is very similar.

It is not difficult to show that a negative resistance effect can be used to obtain oscillation or amplification. If a tunnel diode is put in parallel with a tuned circuit, the positive resistance of the tuned circuit and the negative resistance of the diode can be made to cancel each other and oscillations occur undamped. Naturally appropriate biasing arrangements must be made.

In order to show that a negative resistance can be used to obtain amplification, consider the circuit of Fig. 15. An input voltage E_{in} is applied to a potential divider consisting of the two resistors R_1 and R_2 in series. The output voltage from across R_2 is E_{out} and the current through the resistors i amps, the output current being negligible.

By Ohm's Law: $E_{out} = iR_2$
and $E_{in} = i(R_1 + R_2)$

$$\text{Therefore Gain} = \left(\frac{E_{out}}{E_{in}} = \frac{R_2}{R_1 + R_2}\right)$$

If both R_1 and R_2 are positive, the gain is a fraction. If, however, R_2 is replaced by a suitably biased tunnel diode with, for example, an a.c. resistance of −100Ω,

$$\text{Gain} = \left(\frac{-100}{R_1 - 100}\right)$$

If $R_1 = 50\Omega$, gain = 2
If $R_1 = 80\Omega$, gain = 5
If $R_1 = 99\Omega$, gain = 100

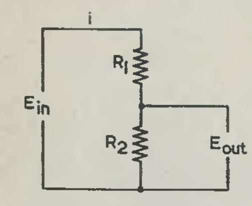


FIG.15
A negative resistance circuit can amplify (see text).

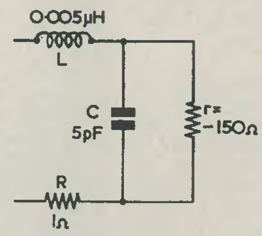


FIG.16
The equivalent circuit of a tunnel diode with typical values.

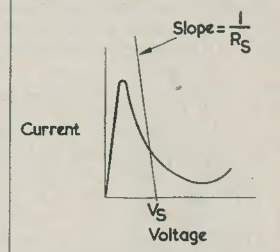


FIG.17
Tunnel diode and load line for use as an amplifier or oscillator.

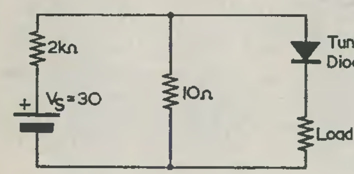


FIG.18
Tunnel diode circuit for amplifier (or oscillator) operation.

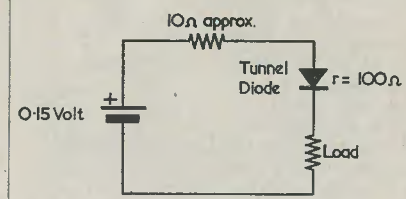


FIG.19
Thévenin equivalent circuit of Fig.18.

M867

Therefore a negative resistance can lead to amplification; but precautions are needed to prevent oscillation.

Equivalent Circuit

The equivalent circuit of a typical tunnel diode is shown in Fig. 16. The diode itself has a negative resistance in parallel with a capacity, but the leads have inductance and resistance.

Operating Conditions

There are two main ways in which tunnel diodes can be operated and in each case the biasing and circuit resistance are most important. One method causes the tunnel diode to operate as a switch whilst the other enables it to amplify, oscillate, etc.

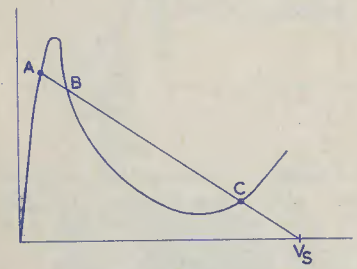


FIG.20
Load line for operation of tunnel diode as switch. M868

Amplifier or Oscillator

Any tunnel diode used as an amplifier or oscillator must be biased so that the operating point is on the negative resistance part of the curve. In addition the equivalent series resistance, R_s, of the circuit must be numerically less than the negative diode resistance, r, or switching will occur. The load line representing R_s (its slope$=1/R_s$) is then steeper than the slope of the diode characteristic (1/r) and consequently the load line can cut the characteristic in only one place (see Fig. 17). The type of circuit used is shown in Fig. 18 with some typical values, and its Thevenin equivalent circuit in Fig. 19. The d.c. resistance of the load must be less than 90Ω when the circuit values shown in Fig. 18 are used no matter whether the diode is used as an oscillator or as an amplifier. The total d.c. resistance must be negative.

The a.c. circuit resistance determines whether the tunnel diode circuit will amplify or oscillate, assuming that the necessary d.c. condition mentioned above has been fulfilled. Oscillation occurs if the total a.c. circuit resistance is negative and amplification if it is positive, but it is most important to note that the total a.c. resistance is the negative resistance of the tunnel diode ($-R_2$) in parallel with the circuit a.c. resistance (R_1). The resulting a.c. resistance is not therefore the series value of R_1–R_2, but the parallel value

$$\left(\frac{-R_1 R_2}{R_1 - R_2}\right)$$

This is positive if R_1 is less than R_2 numerically and is negative if R_1 is numerically greater than R_2. A tunnel diode circuit will therefore oscillate if the negative resistance of the diode is numerically less than the circuit a.c. resistance. In order to avoid oscillation and obtain amplification, however, the numerical resistance of the diode must be greater than the a.c. circuit resistance. This is exactly opposite to the effect which would have been expected.

Another way of looking at the a.c. resistance problem is from the point of view of the load lines. If the load line of Fig. 20 represents the a.c. circuit resistance (dynamic load line), the circuit will oscillate between points A and C. The a.c. circuit resistance is greater than the numerical value of the tunnel diode negative resistance if the dynamic load line cuts the characteristic in more than one place. If the dynamic load line can be represented as in Fig. 17 and cuts the characteristic at a single point, amplification will occur.

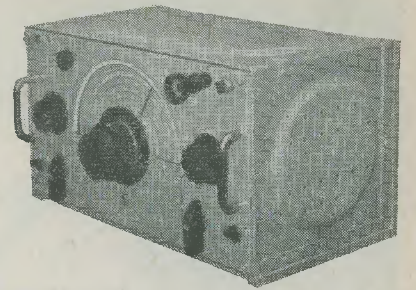
The adjustment of the tunnel diode circuit values is much more difficult for amplifier operation than it is for operation as an oscillator. It must be mentioned that the above discussion assumes that the operating frequency is not high enough for the diode reactances to affect the operation of the circuit.

Switching

A higher series resistance, R_s, is required in a tunnel diode switching circuit so that the slope of the load line is less; the load line can then cut the diode characteristic in three places (see Fig. 20). It is not difficult to see that the point B is unstable. If a minute increase in the voltage across the diode occurs so that B moves down the curve, the current will decrease and this will result in further voltage increase leading to a cumulative effect. Stability will be reached at point C. Alternatively the operating point at B may start to move up the curve and it will not then stop until it reaches A.

The points A and C can both be made stable, so that the tunnel diode forms a useful "flip flop" switch with a switching time as little as a milli-microsecond. This is about 100 times faster than the best transistor. The tunnel diode switching circuit will certainly be useful in computers, etc. *(To be concluded)*

The R1155 as a General Purpose Receiver



By D. Easterling Part 2

Modification Procedure

The first step is to remove all unwanted components, most of this work concerning the d.f. circuits. At first glance the constructor may well assume that the work is going to become very complicated if the removal of wanted parts of the circuit is to be avoided. Actually the process is relatively simple, since unwanted sections are nearly completely independent. Being drastic, therefore, all components below the tuning indicator are removed, including Jones sockets, valveholders, originally taking the two VR99 or VR99A triode hexode d.f. valves, several metal can condensers, various chokes and transformers, and the master switch assembly. One valveholder is refitted later for the rectifier.

The tuning indicator may be temporarily unbolted from the front panel at this stage. It will be refitted later with the new panel.

Next comes the clearance of the front panel with the removal of the following controls: METER BALANCE, FILTER IN, METER AMPLITUDE (to be re-installed later as the new r.f. gain control VR_2), METER DEFLECTION, AURAL SENSE, and SWITCH SPEED. Also to be removed from the front panel is the wiring running in ducts at the top and bottom. Some of this wiring goes to tagstrips leading to components mounted in a screen behind the b.f.o. compartment. These parts, although not used in the modified version, can be left in position, as space here is not essential. Other wiring goes to the valveholder shown in Fig. 5 as V_6. This takes the VR102 double triode valve which is no longer required, the valveholder being used for the 6G6 output stage instead; thus heater leads going to pins 2 and 7 can be retained. Where wiring appears to go into wanted sections of the circuit, it should be left hanging for the time being, as it can be easily identified and linked up later.

With regard to the clearance of unwanted parts to the left, or volume control side of

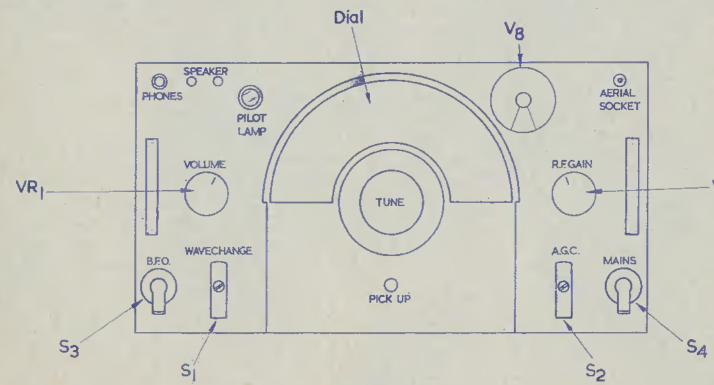
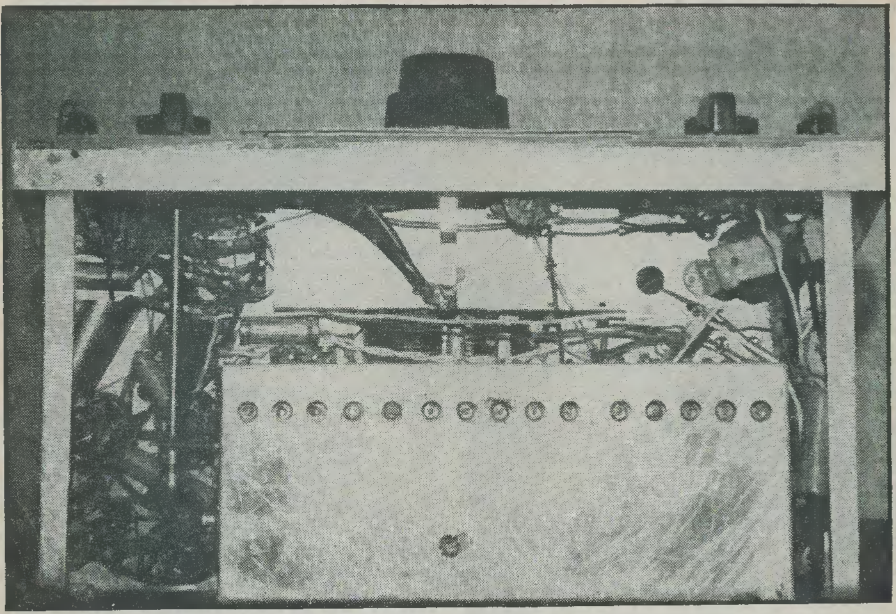


FIG.6
Front View
M835



Under-chassis view of the R1155. Compare with Fig. 7

the receiver, more caution should be exercised. First comes the filter inductor assembly mounted immediately behind the volume control, and associated with the FILTER IN switch. This should be removed complete with attached components, the latter being put carefully on one side, as some will be re-installed later. Last component to be removed is the original output transformer, which is mounted below chassis next to the switched marked HET (S_3 in Fig. 1).

With all the above components removed, space should now be available in between the r.f. transformers associated with the tuning heart and the front panel, on the chassis below the tuning indicator, and below chassis to the side and front of the tuning heart. With regard to the latter position, some receivers are fitted with a single h.f. coil. This is part of a filter circuit connected with the tuning heart, and should, therefore, be retained.

Fitting the New Front Panel

Before proceeding to link up the circuit, the additional major components and new front panel must be installed. First the front panel.

As the existing panel carries all the weight, the new panel which will be fitted on top need not be of heavy material; actually 22 gauge aluminium is adequate. Before it can be mounted, however, the existing front panel has to be cleared of parts such as handles, control labels, and so on. Controls which will remain in the modified version will have to be slipped back on their wiring by releasing the securing nuts. The wavechange spindle is difficult to remove, and should be allowed to remain with the spindle bush slipped back. Also to be temporarily removed are the tuning dial escutcheon, this being accomplished by removal of all perimeter screws and five 4BA bolts visible from the front, and the fixed knob scale (although the tuning knobs themselves can stay put).*

The new front panel must be made to exactly fit the existing one and, as the latter is not necessarily square, it is advisable to cut slightly larger to begin with (say 16⅜ x 8⅝in) and, when the panels are firmly fixed together, remove the surplus with a file. In order to fit the new panel initially, however, a hole for the wavechange switch spindle, and a cut-out for the dial and tuning assembly must be made. The dial cut-out should be marked out on the new panel using the dial escutcheon as a guide. The cut-out is then made ⅜in inside the marking so that the escutcheon covers the join. When the cut-out has been made, the panel will have an appearance similar to a railway tunnel entrance.

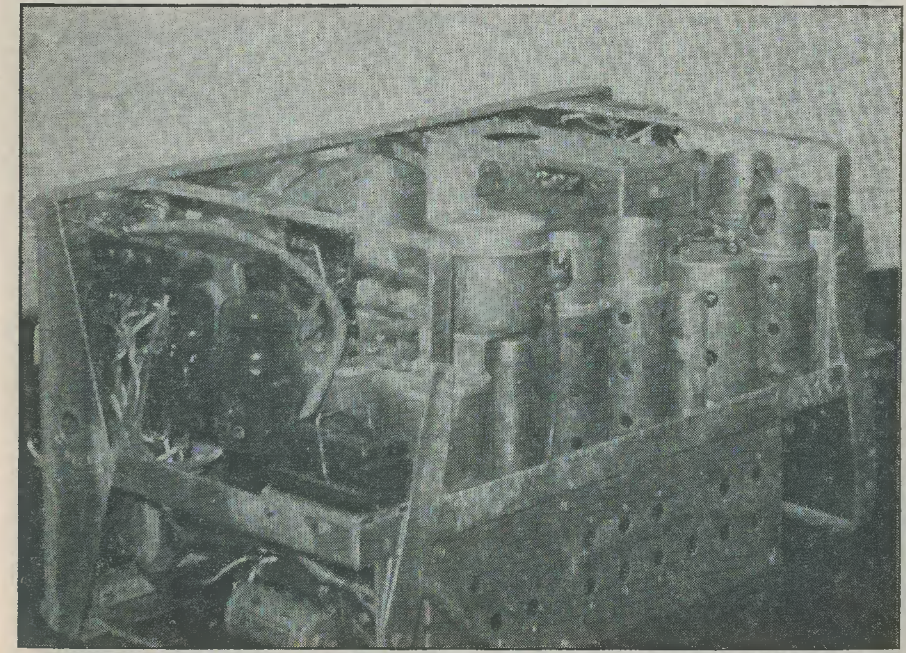
Once the plate has been made to lay flat on the existing front panel, it should be firmly secured, first by the wavechange switch spindle, and then by four 4BA nuts and bolts, which temporarily replace the case securing bolts. To ensure that the holes in the new panel line up with those in the existing one it is recommended that a fine pilot drill be used first, followed by one of the correct size. The latter will guide itself into the correct position.

With the new panel secured, fit the escutcheon plate in place and check that the pointer assembly does not foul. Then, using the same method as suggested for the corner bolts, bore the five 4BA holes used to secure the escutcheon. Next the smaller holes to take the self-tapping screws round the dial perimeter may be drilled. It was found that the original self-tapping screws were not quite long enough, consequently they should be replaced by ⅜in 6BA self tapping screws (obtainable from radio dealers). The original screws may be used later for further strengthening around the panel edge.

Using the pilot drill method, holes may now be drilled for switch S_3 (HET); the volume control, handles, tuning indicator, and original master switch position. The latter will now accommodate the new r.f. gain control. A series of small pilot holes can be used for the tuning indicator hole, these being linked up with a rat-tail file to produce the large cut-out.

New holes are required for the pilot lamp (situated on the side of the tuning scale opposite the tuning indicator), the a.g.c. switch S_2, and mains switch S_4 (situated on the right hand side of the receiver to balance the wavechange switch and b.f.o. switch S_3). Attention should also be given to the connecting arrangements for loudspeaker, phones, aerial, and pick-up. Fig. 6 illustrates where these are positioned in the writer's receiver. Individual constructors, however, may wish to preserve a less cluttered front panel by mounting the sockets either at the side or back of the equipment, in which case special mounting panels will have to be provided and corresponding holes cut in the case. Finally, provision has to be made for the output transformer, which is also mounted on the front panel just above the volume control.

Certain controls, removed from the receiver earlier, are re-installed in new parts of the circuit, and in new positions on the front panel. First the r.f. gain control, VR_2.



General view of the chassis

*This comment applies to R1155,s in which the knobs are coupled direct to the tuning condenser spindle instead of being mounted lower and coupled thereto by slow-motion gearing.—*Editor.*

This was formerly the section of the ganged volume control located furthest from the front panel which is not employed in the modified circuit. The control occupying the METER AMPLITUDE position is now fitted in the VR_2 position. With regard to the mains switch S_4, the switch occupying the old SWITCH SPEED position is re-employed. For the a.v.c. switch S_2, a single pole changeover wafer type is required but, if it is to match the range switch opposite the knob arrangement should be similar. The easiest solution is to dismantle the original master switch and, after shortening the operating spindle and inserting a new stop to provide only two positions of the index (a 6BA self tapping screw may be used for this), reassemble the switch with one wafer only. All controls should now be fitted in the positions indicated in Fig. 6.

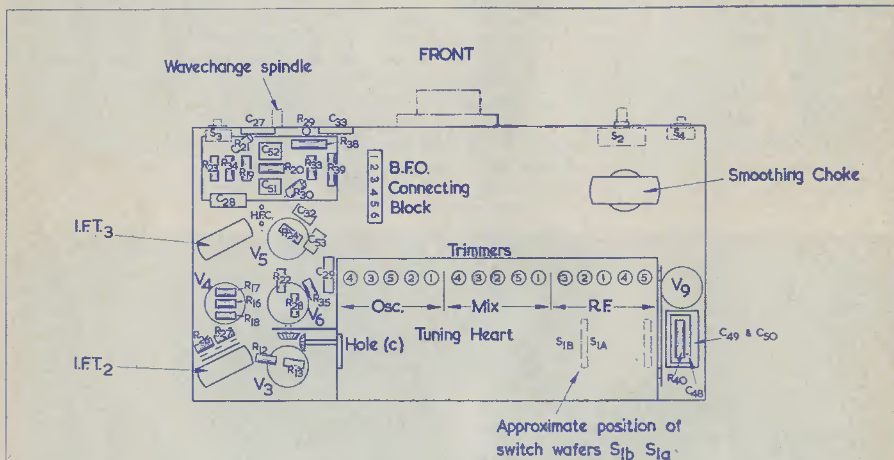


FIG.7
Under-chassis Component Positioning

Now comes the mounting of internal major components, the biggest of these being the mains transformer. The best position for this component is below, and to the right of the tuning indicator. In order to prevent the necessity of large chassis drilling operations a component with upright fixing brackets is preferable to the "drop-through" type. A transformer measuring 7 x 3 x 3in was easily accommodated, although it was necessary to fit the r.f. gain control first.

One of the original d.f. valveholders is used for the rectifier valve, and a two-way fuse bridge can be accommodated in the other valve position. The rectifier valveholder should be minus the screening can base, otherwise the 5Z4G valve cannot be inserted.

The smoothing choke goes below chassis just behind switches S_2 and S_4. Close to the smoothing choke, mounted on the side of the tuning heart, is a tagboard with several small condensers. These are removed and the tag strip is later used to mount components C_{49}, C_{50}, C_{48}, and R_{40}.

Above chassis, between the tuning condenser and the mains transformer, should be mounted a small tagstrip to hold condensers C_1 and C_2. This can be fabricated from parts previously removed from the receiver. A further pair of tags are required on the inside of the front panel adjacent to switch S_3 for securing resistor R_{21} and condenser C_{27}. Finally to complete the metal work, a $\frac{5}{8}$in hole should be drilled in the rear of the case in order to admit the mains lead adjacent to the power unit.

With the above work completed, a suitable stage is reached for the painting process. A Valspar battleship grey was used by the writer. Also painted was the whole case exterior. No attempt was made to remove the previous black crackle finish, which was is fairly good condition; and the crackle effect came through the grey to enhance the finish.

Wiring Up

When wiring a completely new piece of equipment it is wise to follow through the circuits in a logical fashion; starting with the power unit and heater supplies first, then proceeding through the circuit one stage at a time. In the case of an extensive modification process, as in this instance, similar techniques are best followed. Before commencing, however, it is useful to know the simple wiring colour code adopted, which is as follows: Red—h.t. positive; Blue—l.t. positive; Yellow—h.t. negative; Black—earth; Green—grids.

Starting at the mains lead, the neutral connection is taken direct to one side of the mains transformer primary, while the live lead goes via S_4 and the mains fuse carrier to the transformer adjuster strip. Note that the switch used is actually a changeover type; thus it can only be used to break one lead.

The l.t. secondaries are next, with the 5V winding taken to pins 8 and 2 of V_9, while the 6.3V heater chain goes, via a twisted pair, to pins 2 and 7 of V_6. From here the remaining valve heater chain may be traced through the various stages until it disappears through the hole marked (*c*) in Fig. 7. As the interior of the tuning heart has not been touched, it may be assumed to be in order.

Now the h.t. wiring, with the ends of the mains secondary going to pins 4 and 6 of V_9, while the centre tap is taken to a convenient tag on the strip mounted on the side of the tuning heart near the smoothing choke. Components C_{48}, C_{49}, C_{50}, and R_{40} may now be fitted in place. Next the h.t. line is completed from pin 8 on V_9 to C_{50}, thence to the smoothing choke, and from the other side to C_{49}; continuing to the inner tag on R_{39}, then to the pole of switch S_3.

At this stage it would perhaps be best to trace the circuit through from the aerial terminal. A screened lead is fitted from the aerial socket to condensers C_1 and C_2 mounted on the tagstrip to the front of the r.f. transformers. From the other side of C_1 and C_2 connection is made to the leads protruding through the hole marked (*b*) in Fig. 5. If necessary, these leads can be traced to the relevant switch wafers as illustrated in Fig. 7 and Fig. 1.

While the tuning heart is opened for the above investigation, an ideal opportunity arises to remove unwanted leads originating from this unit at their source. Leads appearing at hole (*c*) in Fig. 7 and hole (*a*) in Fig. 5 should be left connected however. At this point the tuning heart may be closed.

The lead originating through hole (*a*) in Fig. 5 is the gain control line, and may be connected to the wiper of switch S_2.

Four leads emerge through hole (*c*) in Fig. 7. The brown lead should already be connected to the earthing tag on V_3, while the blue carries the heater supply, connecting to pin 7 of V_6. One yellow lead carries the bias supply, and goes to the outer tag of R_{26} (see Fig. 7); while the other carries h.t. from a centre tag on i.f.t.2. Following this lead through further it will be noticed that R_{12} and R_{13} feed the screen of V_3 (the anode decoupling resistor R_{14} is inside i.f.t.2); while the h.t. lead continues to pin 1 on V_4, where resistors R_{16} and R_{18} are supplied. From this pin, the h.t. lead reconnects to pin 4 of V_6, and from here joins up with the main h.t. connection at R_{39}.

The signal wiring between V_3 and V_4 i.f. stages is straightforward and should not have been disturbed, but it may be checked by reference to the diagrams.

The a.f. signal emerges from i.f.t.3 and is taken to the filter network of which R_{19} is a part; then to the coupling condenser C_{27} and through the chassis to the top of VR_1 volume control, which is the section nearest the front panel. From the wiper of VR_1, a screened lead is taken to the grid cap of V_5; and from the bottom connection, a lead is taken to the junction of C_{28} and R_{24}.

Referring now to V_5, a check should be made to ensure that C_{53} is still connected to pin 3. Resistor R_{22} should now be inserted along with condenser C_{29}. Resistor R_{22} takes its h.t. from pin 4 of V_6, while the other side of C_{29} takes the a.f. signal to the grid of V_6 (pin 5). The bottom connection of the grid leak R_{28}, along with the cathode bias network C_{30}, R_{35}, is taken to the negative bias line at pin 6 of V_5.

Connection to the output transformer primary (made by a twisted pair from pins 3 and 4 of V_6), and output connections from the secondary winding, complete the a.f. wiring.

The a.g.c. and biasing network comes next, starting from pin 6 of V_5, where a lead is taken to the bottom end of the r.f. gain control VR_2, and thence to the junction of R_{40}, C_{48}, C_{49}, and C_{50}. From pin 6 of V_5 also check connections to R_{23}, R_{24}, and R_{34}. From the other side of R_{34}, the intermediate bias line connects to R_{33} and R_{27}, and should also be linked to the top end of VR_2. The slider of VR_2 goes to one of the contacts on switch S_2; the other contact being taken to the a.g.c. line which is picked up at the junction of R_{30} and C_{33}.

Now the tuning indicator and pilot lamp can be connected, with the l.t. voltage for both being taken from the 6.3V heater winding on the mains transformer. The h.t. connection to V_8 runs direct to C_{49} and the smoothing choke, with R_{41} wired to the valve holder as before. The cathode connection is made direct to the top end of VR_2, and finally the grid is connected to the a.g.c. contact on S_2.

If the pick-up jack facility is required, screened leads should be used to connect it to R_{21} and C_{27}, as illustrated in Fig. 4, where it will be seen that the insertion of the jack plug disconnects the receiver signal automatically. Some breakthrough may be experienced, but can be overcome by setting S_2 to OFF and VR_2 to minimum signal.

PART 2

A Comprehensive Pre-Amplifier Design

By **Peter J. L. Binns, M.Sc.**

(The author wishes to acknowledge with grateful thanks information received from the General Electric Co. Ltd., Tannoy Ltd., and Electrical & Musical Industries Ltd.)

In the first article of this series we considered recording characteristics in some detail, and arrived at a comprehensive correction circuit, together with two simpler alternatives. It remains to consider the rest of the pre-amplifier circuit, bearing in mind the basic requirements laid down in Part I of this series.

Bass and Treble Boost

Let us consider first the bass and treble boost circuits. These may be quite simple, and component values are not unduly critical. The circuit adopted is shown in Fig. 7.

If a simpler pre-amplifier is required, in which the steep cut filter is omitted, variable treble attenuation may be required. This is easily arranged by fitting a two-way switch at point X, this breaking the connection between the 100pF condenser and the 10kΩ resistor, and connecting this latter to a 1,000pF (or larger) condenser with its other end earthed.

Steep Cut Filter

The steep cut filter is rather a difficult proposition for, whichever circuit is chosen, special components are required. A circuit using only resistors and condensers was given by Williamson, and another in *The Art and Science of Sound Reproduction* by F. H. Britten. Both these circuits require high stability close tolerance components. A simpler circuit, requiring a choke, is given in Fig. 8.

This circuit has been used in a monophonic pre-amplifier by Pamphonic. The four switch positions are (1) Out (2) 12 kc/s, (3) 7 kc/s and (4) 4 kc/s. A somewhat similar circuit has been described in *Wireless World* (November 1956) incorporating a "slope" control.

Another approach, which the writer has used successfully, is to use an alloy cored filter choke—the Sound Sales Rho Metal Filter Choke, type C/SF. This, when tuned by its own self capacity, gives a steep cut centred on 10 kc/s, with turnover frequency about 9 kc/s, and considerable recovery above the cut frequency, making it very valuable for the removal of heterodyne whistle. The circuit is shown in Fig. 9.

Condenser C_1 enables the turnover frequency to be lowered, and additional capacity at C_2 or C_3 deepens the cut and reduces the recovery above it. By judicious use of these condensers, an entirely satisfactory performance is obtained. A practical circuit is given in Fig. 10.

With the values shown, the switch positions correspond approximately to (1) Out, (2) 9 kc/s, (3) 8 kc/s, (4) 7 kc/s, (5) 6 kc/s, (6) 5 kc/s. The second position uses only the self capacity of the choke, and gives a steep cut centred on 10 kc/s or a little higher, depending on capacity of wiring, etc. There is some considerable recovery above this frequency, but the response is still several dB down at 15 kc/s, so no trouble is caused from this. In all subsequent positions, the recovery above the null is removed by condenser C_1. The lowering of turnover frequency to 8 kc/s is caused by additional switch and wiring capacity, and in other positions additional capacity is switched across the choke. In order to avoid lowering the maximum working frequency, it is important that the leads to the choke be separately screened, this preventing capacity between them.

Complete Circuit

Having now dealt with the outstanding design features, a complete circuit diagram is given (Fig. 11). The circuits for record compensation, as detailed in Part I of this series, are inserted at points X, as previously explained. If for any reason a very high gain is required (e.g. for a microphone), points X

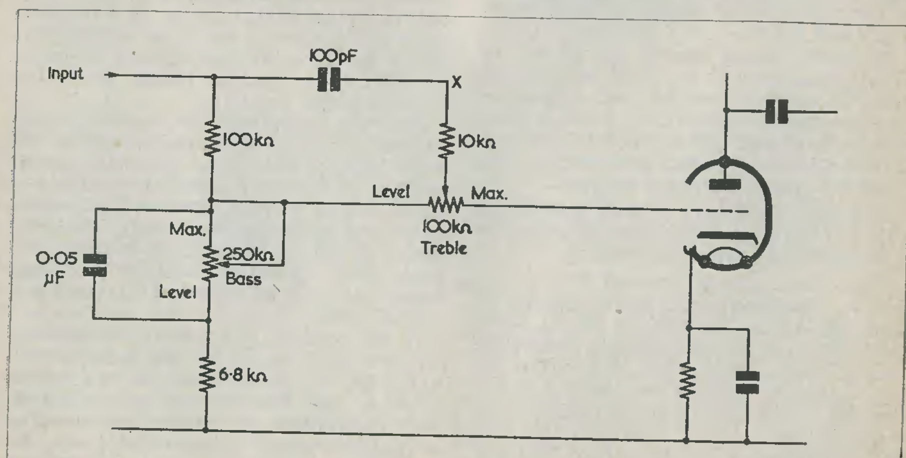


FIG.7

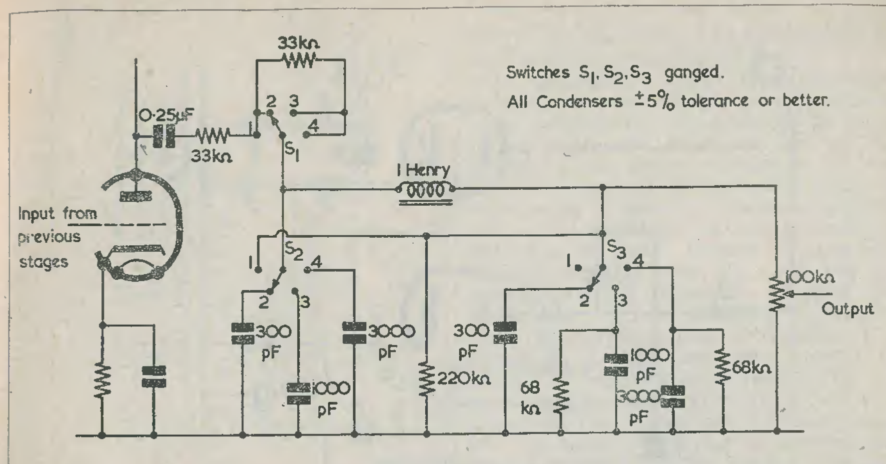


FIG.8

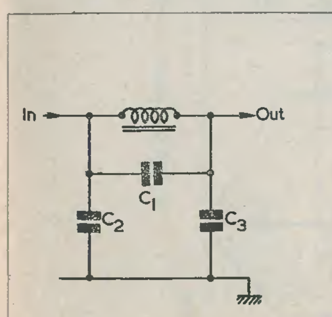


FIG.9

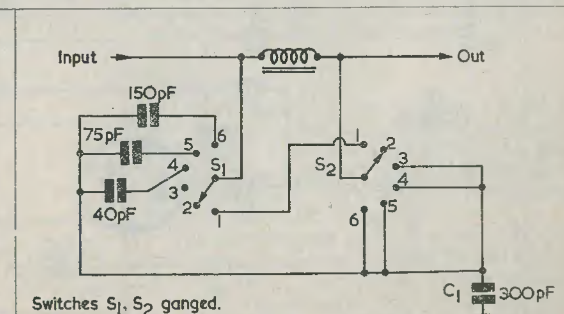
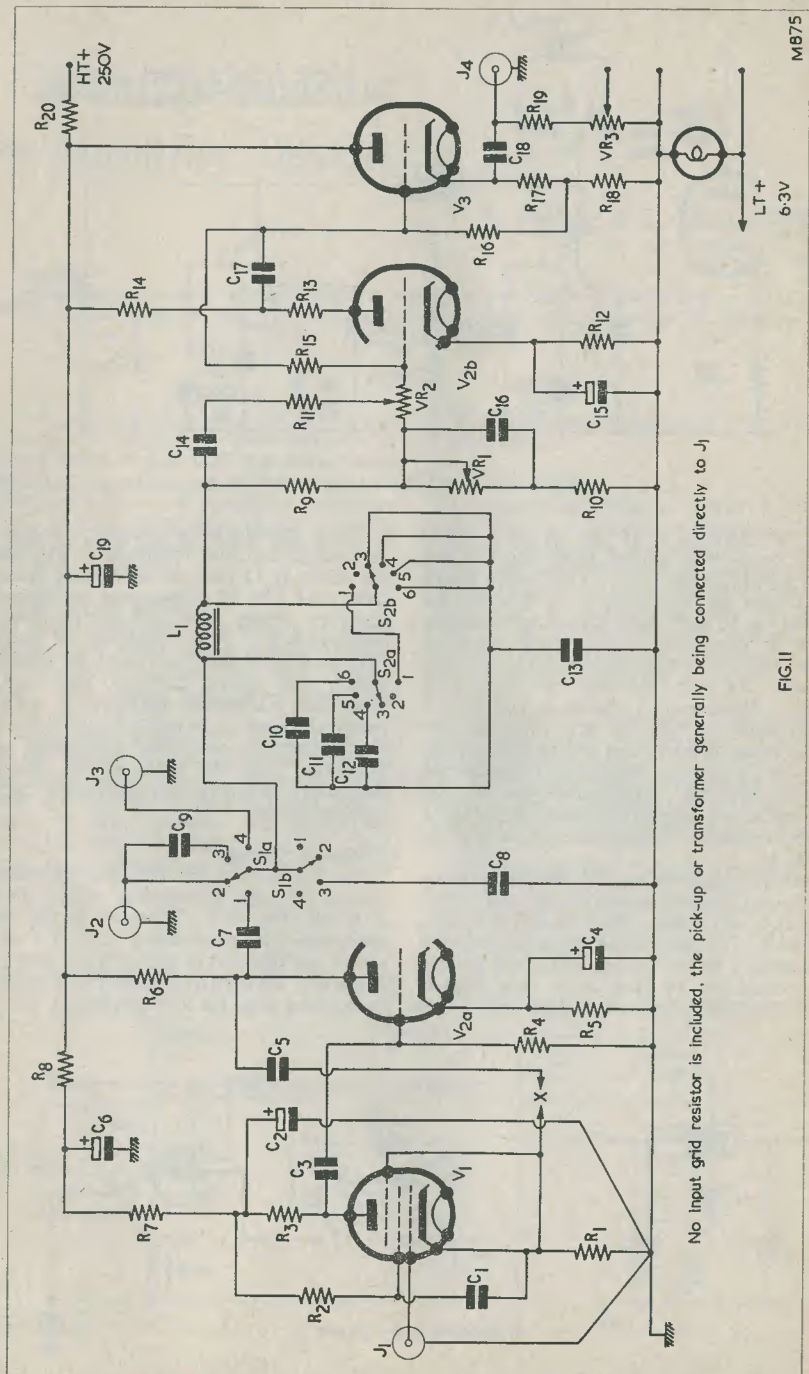


FIG.10



No input grid resistor is included, the pick-up or transformer generally being connected directly to J_1

FIG.11

Components List

(Set out for easy reference to Fig. 11)

Resistors

R_1	1kΩ
R_2	330kΩ
R_3	100kΩ
R_4	1MΩ
R_5	2.2kΩ
R_6	47kΩ
R_7	39kΩ ±10%
R_8	22kΩ
R_9	100kΩ
R_{10}	6.8kΩ
R_{11}	10kΩ
R_{12}	2.2kΩ
R_{13}	33kΩ
R_{14}	47kΩ
R_{15}	2.2MΩ (see text)
R_{16}	47kΩ
R_{17}	2.2kΩ
R_{18}	47kΩ
R_{19}	330kΩ (see text)
R_{20}	6kΩ 2 watt (see text)
	(All ½ watt except R_{20})
VR_1	250kΩ
VR_2	100kΩ
VR_3	100kΩ wirewound (see text)

Condensers

C_1	0.25μF, paper
C_2	32μF, electrolytic
C_3	0.02μF, paper
C_4	50μF, electrolytic
C_5	0.1μF, paper
C_6	8μF, electrolytic
C_7	0.1μF, paper
C_8	0.002μF, mica
C_9	0.001μF, mica
C_{10}	150pF, ±5%, mica or ceramic
C_{11}	75pF, ±5%, mica or ceramic
C_{12}	40pF, ±5%, mica or ceramic
C_{13}	300pF, ±10%, mica or ceramic
C_{14}	100pF, mica or ceramic
C_{15}	20μF, electrolytic
C_{16}	0.05μF, paper
C_{17}	0.1μF, paper
C_{18}	0.5μF, paper
C_{19}	16μF, electrolytic
L_1	Metal filter choke, type C/SF (Sound Sales)

Valves
See text

may be left disconnected, or disconnected by the record compensation switch.

All components except those otherwise designated are not critical, ±20% tolerance being satisfactory. In addition to those already mentioned, there are one or two features which deserve comment. It was found that the gain was more than adequate when using a variable reluctance pick-up with a coil impedance of 1.6kΩ connected directly to the input. Resistor R_{15} provides negative feedback over V_{2b}, but may be omitted without materially affecting the performance, thereby increasing the overall gain. If maximum gain is required, R_{19} should be omitted, and VR_3 charged to 250kΩ. By including R_{19}, however, VR_3 can be reduced to 100kΩ, allowing the use of a wirewound component with indefinitely long life. An on/off switch may be incorporated here to control either the supply to the pre-amplifier or to the main amplifier. R_{20} is correct for an h.t. supply of 250 volts which, in the writer's case, was obtained from a separate small power pack also supplying the radio tuner. If power is to be taken from the main amplifier, a further resistance and decoupling condenser are preferable to merely increasing the value of R_{20}.

Valve types are not critical. V_1 should be a low noise audio pentode. An EF40 was used in the prototype design, but no doubt the more recent EF86 would be much better. The 6J7 or EF37A should also prove satisfactory, or any equivalents of the above types: the high degree of feedback makes the circuit almost independent of valve characteristics. V_2 is a high mμ double triode of the 6SL7 type, and the ECC35 or 12AT7 are alternatives. V_3 is any general purpose triode (L63, 6J5, etc.). J_2 is the radio input jack, and in addition to the normal position of S_1 for f.m. there is a second position giving bass cut (C_9) and treble cut (C_8), intended for a.m. broadcasts of speech only. If this facility is not required, S_1 may be a simple three position switch. J_3 is an additional input for tape recorder, etc. J_4 is an auxiliary output socket for feeding a tape recorder.

Construction

The exact form of the equipment is left to the individual, but some general notes may be helpful. It is advantageous to use a long narrow chassis with all controls placed along the front, and valves placed horizontally towards the back. (Fig. 12.)

The gramophone input is at the left, and the layout continues logically to the output at the right. The power supply is also brought in at the right, but kept spaced from the output leads. The valve heater supply is earthed only at the point where the leads enter the chassis, and both leads are twisted

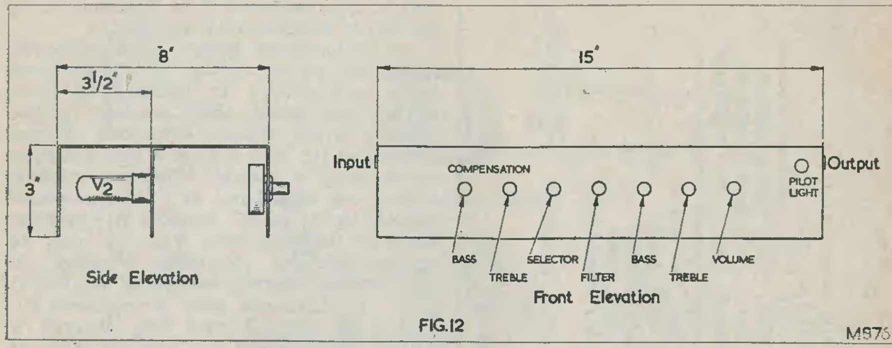


FIG.12

Characteristic	*Bass Comp. Switch*	*Treble Comp. Switch*
A.E.S.	A.E.S.	12
R.I.A.A.	R.I.A.A.	14
N.A.B.	A.E.S.	16
R.C.A. Orthophonic	R.I.A.A.	14
Orthacoustic	A.E.S.	16

TABLE OF RECORD COMPENSATIONS

(1) *Recognised recording and playback characteristics*

33⅓ *r.p.m.*			78 *r.p.m.*		
Make	*Bass Comp.*	*Treble Comp.*	*Make*	*Bass Comp.*	*Treble Comp.*
Decca	A.E.S.	10 or 12	Decca ffrr	ffrr	Disconnected
H.M.V.	R.I.A.A.	14	H.M.V.	E.M.I. 78	,,
Columbia	R.I.A.A.	14	Columbia	E.M.I. 78	,,
Nixa	A.E.S.	14	Parlophone	E.M.I. 78	,,
Westminster	{R.I.A.A.	16	Brunswick	E.M.I. 78	,,
	A.E.S.	12	Telefunken	E.M.I. 78	,,
D.G.G.	Col.	14	Decca (U.S.)	R.C.A.	12
Vox	Col.	16	Capitol	R.C.A.	12
Philips	R.I.A.A.	16	R.C.A. Victor	R.C.A.	14
Argo	R.I.A.A.	16	Columbia (U.S.)	R.C.A.	16
Capitol	A.E.S.	12			
R.C.A. Victor	A.E.S.	14		45 *r.p.m.*	
Columbia (U.S.)	Col.	16	Columbia	R.I.A.A.	16
Oisean-Lyre	A.E.S.	12	Decca	A.E.S.	12
Telefunken	A.E.S.	12			
Parlophone	Col.	16			
Mercury (recent)	R.I.A.A.	14			
E.M.I. (pre-1954)	R.I.A.A.	16			
Brunswick	A.E.S.	12			

(2) *Compensation for various makes of records before* 1955

together and run to the valveholders, to minimise a.c. radiation. Screened lead (preferably coaxial cable) is used for all "hot" connections longer than about an inch, and an earth busbar runs along at the front below the controls. All earth connections are made to this, except for those of the first stage, which are made to a tag fixed at the valve-holder. By observing these precautions, hum and noise were reduced so much in the prototype pre-amplifier as to be quite inaudible at normal listening volume, even with the ear close to the loudspeaker.

Conclusion

It will be clear from the foregoing notes that the complete pre-amplifier is a very versatile design, meeting the most exacting requirements. The prototype has been in use for many months, and has proved entirely reliable.

As indicated previously, possible simplifications include (*a*) simpler record compensation, as discussed in Part 1, and (*b*) omission of the steep cut filter, with modification to the treble control, as detailed at the beginning of this article. If the connection to the main amplifier is by means of a short cable (not more than 2ft) it is permissible to dispense with the cathode follower output. In this event, referring back to Fig. 11. C_{17} and R_{15} will go directly to the top of R_{19}. This simplification is not recommended, as the number of components saved, apart from the valve itself, is small.

Addendum

Since the preparation of these articles, it has been pointed out that a list of recording characteristics which have been used by the major recording companies would be desirable. The writer therefore includes a list of the corrections to be used with the comprehensive circuit described herewith. Not all the makes listed, however, have been available for test purposes, information about many of these has been merely deduced from other sources. All the figures should be used only as a basis for listening.

radio topics

BY RECORDER

A LITTLE OF THE ESSENTIAL COSINESS seems to have gone out of science fiction these days. When, some ten years ago, we read tales about space flight, life on planets other than Earth, and the gradual conquest of Man by the Machine, we were able to shiver pleasurably and comfort ourselves with the thought that such things belonged to a never-never land situated far, far in the future.

Nowadays, we are not quite so sure.

The End of the B.E.M.

I think many of us will agree (I, myself, am quite certain) that space travel will be a practicable thing not so many years from now. There are still problems of fantastic complexity to overcome but the project is, nevertheless, *feasible*. Science-fiction reflects this, and much of the present output of S-F writers concerns itself, not with the mechanics of becoming space-borne, but with the sociological problems which will appear when space travel is an accepted reality. So far as the conquest of Man by Machine is concerned, many writers in the S-F stable have written tales which deal with this subject; although the Machine envisaged tends to be bureaucratic rather than mechanical. It is interesting to note how authors as disparate as Ray Bradbury and George Orwell tend to enter the same category here. The main point of similarity between "Fahrenheit 451" and "Nineteen Eighty-Four" is that both writers are preoccupied with exactly the same thing: the vision of a future society which can only be kept in existence by a deliberate and enforced lowering of standards.

There are still a few science-fiction stories being produced which merit the term "space-opera", and whose characters meet, on their adventures, the proverbial B.E.M. (or Bug-Eyed Monster). But their numbers are diminishing. Science-fact is rapidly superseding this type of science-fiction.

I said just now that I was certain that space travel will become a practicable thing. I must confess that my view is prompted somewhat by wishful thinking. Man is, by his very nature, a restless and adventurous creature who must always seek new fields of exploration. There is little space left on our planet which can support the pioneer, as we understand the word in its pre-twentieth century context; and yet man's venturesome character still exists and it still needs an outlet. Space travel can provide that outlet. Without such a safety-valve, man's inherent aggressiveness may become too great to be confined within the confines of our world and the holocaust may well be precipitated.

So, not only am I certain that space travel is feasible, I earnestly hope that it will commence—*soon.*

Radio Topics ?

The above may seem to be, at first sight, a little out of character in a feature which has the title "*Radio* Topics". But I don't think it is. Because those with knowledge of radio and electronics (viz. the readers of this magazine) are *exactly* the kind of people who can grasp and understand the technical information which is made available concerning present achievements in the space field. Many laymen, when they think about such things at all, seem to find points as relatively simple as why a satellite stays in orbit quite incomprehensible. They are encouraged to maintain their lack of knowledge by the manner in which the popular press treats matters of a technical nature. Press men know, from past experience, that a good method of getting a story over is to create a personification. For instance, you don't try to sell *films*—you create, instead, images of the stars who play in them. Similarly, if you want to give publicity to a flight into space you hold a press conference in which those "interviewed" are the two monkeys who survived it. And it gets front page treatment.

It would, of course, be a dull world if there were no newspaper stunts. But these are rather momentous times in which we live; and it is not out of place to judge achievements against their full technical background.

Infra-Red Telephone

The transmission of audio frequency signals by modulation of a light beam is by no means a new idea. Nevertheless a Press release, which has just come to hand, describes what is, so far as I know, the first commercial equipment to employ this principle. In this case the modulated "light" beam is infra-red. Infrared Industries Inc., Massachusetts, have just introduced an infra-red telephone by means of which two people can talk to each other provided that they are within line-of-sight. If necessary, they can also talk to each other round corners, with the aid of mirrors.

The Infra red Industries telephone, called the "Infraphone", comprises a transmitter which sends out an infra-red beam modulated at audio frequency and a receiver which responds to a similar type of beam. Two Infraphones are required to set up a system, and reception and transmission at either end can occur simultaneously. The Infraphone units are about the size of a dual-lens reflex camera and they may be comfortably held in the hand by means of a pistol grip. "Aiming" at the complementary Infraphone is achieved with the aid of a tubular rifle-like sight. The weight of a unit is less than 26 ounces.

The Infraphone should prove especially useful where short range communication is required and it has the considerable advantage over walkie-talkie units that it requires no radio frequency allocation or operating licence. The initial price at about $20 a unit, is surprisingly low.

Full technical details on the Infraphone are not yet fully available, although I hope to find out more about it during the next month or so. All I can state at the time being is that it is powered by ordinary flash lamp batteries, that it employs a fully transistorised printed circuit amplifier, and that the infra-red pick-up device is a "photoconductor", or photo-sensitive semiconductor. The transmitter channel in each unit is: microphone, voice/infra-red converter, infra-red source and optics; and the receiver channel in each unit is: optics, infra-red/voice converter, amplifier and earphone.

Colour TV

In another part of this issue Smithy the Serviceman tells his assistant, Dick, that he doubts "whether we'll see colour television over here for quite a while yet. The receivers are too complex and expensive."

This seems to be fair comment, despite the recent statement by the B.B.C. that they were prepared to radiate colour. An interesting sidelight on this question may be gleaned from a report in *The Times* for 18th October, in which it is stated that Japan has become the third country in the world to have regular colour television. The first two countries? U.S.A. and Cuba.

In Japan monochrome television has become accepted everywhere, not only in practically all homes but also in such unlikely places as public bath-houses, railway stations and, even, cinemas. In the last instance t.v. programmes are watched during film intervals. Also, it appears, compact transistor receivers are now available and are "avidly bought".

Regular colour transmissions from the Japanese Broadcasting Corporation will be about an hour a day, and those from Nippon Television (which pioneered the project) 17 hours a week. At the time of the report, a 14in colour receiver costs £450 and a 21in colour receiver £550, as compared with a price of some £50 for a 14in monochrome receiver. The colour system used is the American N.T.S.C. system which, of course, allows colour transmissions to be reproduced on a monochrome receiver and monochrome transmissions to be reproduced on a colour receiver.

Without Comment

My recent comments on the question of "bugs" (i.e. hidden listening devices) in Embassies and the like has prompted a rather belated response from Mr. C. W. Ward of Bexleyheath. He writes:

"After a casual re-perusal of 'Radio Topics' on page 62 of your August number, it occurs to me that one way of beating the concealed microphone in official premises, such as Embassies, etc., is the use of the deaf-and-dumb alphabet. This would perhaps appeal to those of our diplomatic service who have had a classical education and tend to fight shy of technological or scientific complications!"

Table

The "Radio Topics" Phonetic Alphabet

A for 'Orses.	N for Anchise.
B for Mutton.	O for The Garden Wall.
C for Yourself.	P for Penny.
D for Mation.	Q for Song.
E	R for Mo.
F for Vescence.	S
G for Police.	T for Two.
H	U for Ny.
I for Lutin.	V for La France!
J for Orange.	W
K	X for Breakfast.
L for Leather.	Y for Secretary.
M for Sis.	Z for Breezes.

Phonetic Alphabet

Talk of the deaf-and-dumb alphabet reminds me of the many phonetic alphabets which have sprung up during the last twenty years or so. During that period there has also been a joke alphabet going the rounds and, since it is getting near Christmas and there's no harm in having a bit of a lark, I append this, or most of it, in the accompanying table.

You may notice that some of the letters have been left blank. This is because the only entries I can remember for these letters involve puns which are too excruciating, even for a list such as this! Perhaps readers may have suggestions for the missing entries, whereupon these could be published at a future date.

"Radial"

Radial, the official journal of the Radio Amateur Invalid and Bedfast Club has an interesting item in the October issue. A project which had been in the minds of many members came into being with the commencement of the Cheshire Homes Amateur Radio Link on 22nd September. Contact was on 40 metres and the respective QTHs were Ampthill in Bedfordshire and St. Teresa's in Cornwall. The Hon. Secretary points out that this is not a Club Net but a link between Club members in the various Cheshire Homes, and that "it was a small beginning of what we hope will develop into something big".

A hope which will, I feel, be experienced by people outside the R.A.I.B.C. in addition to its members.

December 1960

This issue is for December 1960, and "Radio Topics" is the last item to reach the Editor for setting up in print. Whilst I write this, our regular contributors are already working on their articles for the January 1961 issue. What will the new year bring? From what the Editor tells me, plenty of interest and variety so far as *this* magazine is concerned!

And let me now take the opportunity of wishing all readers a Christmas which is truly Happy and Merry.

The $1,000,000 Camera

Since its inception into the U.S.A. just over a year ago, the Marconi Mk. IV television camera has brought over one million dollars worth of export business to Britain. A total of 70 cameras have been sold in the U.S.A., and world sales are well over 200. The camera, manufactured by Marconi's Wireless Telegraph Co. Ltd., features a short warm-up period, light weight and general ease of handling, and employs a 4½in image orthicon pick-up tube.

New "Vista" Range of Meters

The release of a new range of panel mounting meters having f.s.d. sensitivities commencing from 5μA d.c. is announced by Taylor Electrical Instruments Ltd., Montrose Avenue, Slough. The meter mouldings are in a smart contemporary style offering shadowless readings with an extremely high degree of visibility. The bases of the instruments in the new range are made so that they can be interchanged with standard models of earlier design.

A Simple TUNING COIL WINDER

by P. A. ROBINSON

In this light hearted article our contributor describes a coil winder which, constructed from ordinary Meccano parts, is capable of turning out "professional looking" wave-wound coils

THE PRODUCTION MACHINES USED BY manufacturers for the winding of Medium and Long wave, etc., coils are truly beautiful pieces of engineering; and these are also sold at beautiful prices! When thousands of coils have to be wound the outlays are well justified; but for the occasional winding job required by the amateur something very much simpler and less costly is indicated.

This article deals with the building of a coil winder, the total cost of whose parts is of the order of £1 5s., and which can be built by anyone sitting up in bed convalescing from an attack of influenza, provided they have enough strength to wield a screwdriver, a spanner and a pair of stout scissors. The use of a rocker arm and wire guide in the winder allows coils to be wound in the familiar wave-wound manner.

It is advisable to quietly procure the bits and pieces *before* the influenza sets in, for to ask the wife to go round to the local toy shop for Meccano parts will only promote sidelong glances and a hurried return of the doctor. This is no idle remark, as the author well knows.

For those of us who once enjoyed the thrill of a bulky Meccano box bulging from a Christmas stocking the construction will be child's play (literally). For those who did not, now is the time to rectify this shocking oversight on the part of Santa Claus.

It should be pointed out for the benefit of the uninitiated that it is not necessary to buy a Meccano *set*. Any part can be bought separately and a comprehensive parts list can be had free of charge from any Meccano agent. This is a four page buff coloured leaflet in which is printed a picture of each part, the part number and its price.

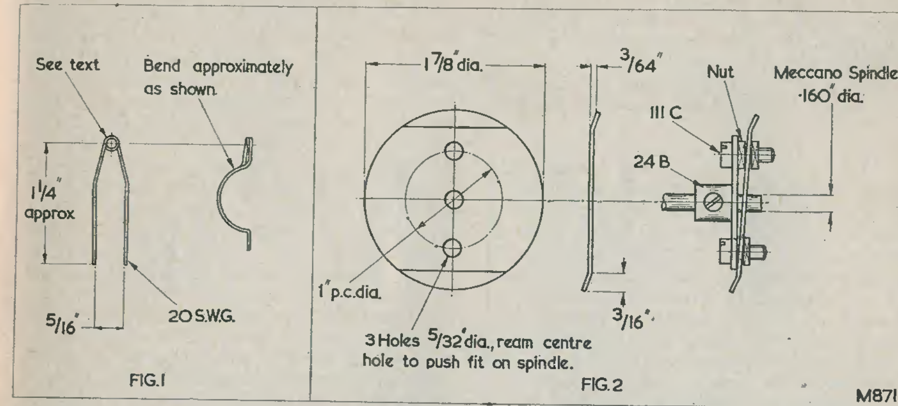
Armed with this parts list, the shopping list as given in the text can be studied, and the picture of each part can be seen. Once you know what a part looks like, it will not be difficult to recognise where it fits in the assembly by consulting the photographs which accompany this article. These should provide all the instructions required to assemble the purely Meccano part of the winder; but, for the sake of completeness, the following notes may first be read.

Meccano Assembly

The first four items, part no. 55A: two are used as the idler gear spindle supports, the other two are bolted on to part no. 62 to form the "rocking arm". As shown, the 57-tooth gear (part no. 27A) is on the winding spindle, the 60-tooth gear (part no. 27D) is on the cam spindle. Unfortunately their sizes are such that their spindle centres do not coincide with the Meccano strip holes, so the idler gear has to be employed to couple the two gears. A 62B is bolted to the diagonal strip in order to form a better bearing for the winding spindle. The other side diagonal has been made an angle girder to give added rigidity, the flange being placed on the lower side in order to give a clearer photograph of the spindle locking collars (part no. 59), etc. Bend the crank yourself (approx. 1⅞in throw) out of the longest spindle (part no. 13); but take care not to distort the spindle section as this must run true. On the extension of this spindle, the former on which the coil is to be wound must be held in position. The small iron dust cored types will screw on to the spindle up to the required point of winding if one thickness of insultating tape is first bound, not too evenly, round the spindle. Larger diameter core types will require more layers of tape, and considerably bigger size formers can be built up on a wood roller (part no. 106), this mounting on to the spindle.

Winding Wire

Wire for winding is best bought on the 2oz size bobbin. The one shown holds



36 s.w.g. enamelled cotton covered and this size winds quite well. A little tension should be kept on the wire whilst winding by loading up the tape which lies over the bobbin. The wire should then be threaded first under the winding spindle, then over the cam spindle, under the bottom spindle (which is only a wire guide), round the two pulleys (part nos. 22 and 23) and up through the wire "winding on" guide. (See Fig. 3.)

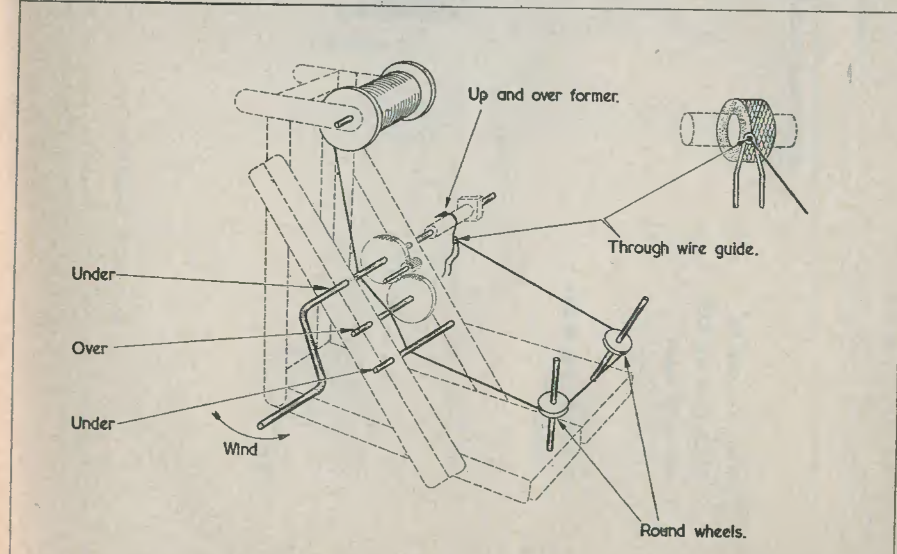
Cotton or silk covered wire must be used. Wire which is enamelled only is too "slippery". Bakelite formers are also slippery enough to give trouble during the first few turns of winding: they should be given a coat of rubber solution and allowed to dry before being used.

After final assembly, do not forget a drop of thin oil for each bearing surface.

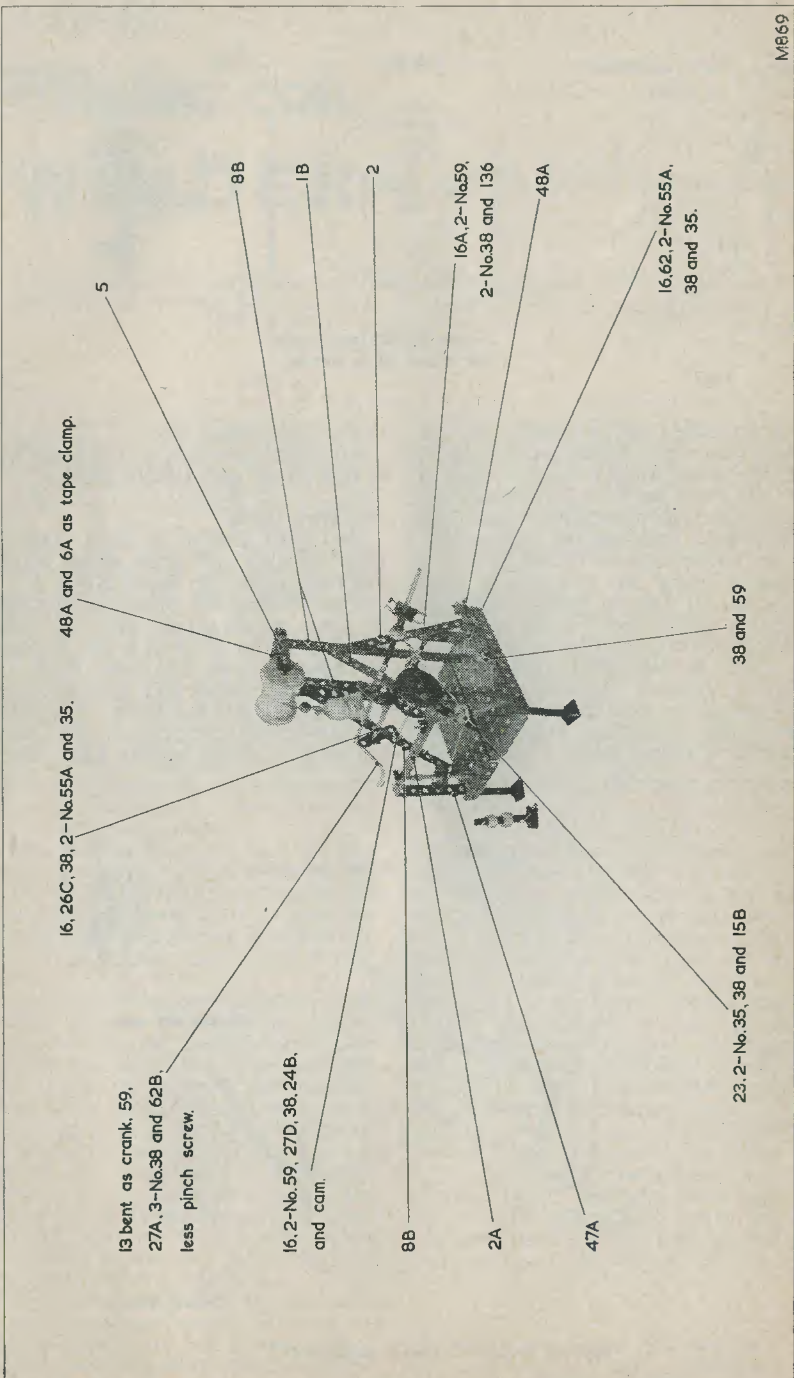
The Wire Guide

Two parts have to be made. One is the wire "winding on" guide shown in Fig. 1. The other is the cam shown in Fig. 2.

The "winding on" guide is a short piece of 20 s.w.g. tinned copper wire bent round a section near the point of a dart or safetypin for approximately 1½ times to form the smallest and neatest hole through which the winding wire will run freely. The wire will then resemble the spring end of a safety-pin but with a much smaller coil. The two



Route of wire from bobbin to coil former.



'legs" must be left long enough for clamping firmly on either side of the top bolt of the rocking arm (which should be approximately under the winding spindle). After clamping, bend a right angle just above the rocking arm, then sweep round in an easy bend until the eye touches the coil former to be used at a point just below its horizontal centre line. The winding wire running through the eye will then only rub on the top of the circular eye as it carries on up and over the top of the former. As may be gathered, winding is performed by turning the former *anti-clockwise* looking from the crank end.

Construction is not very critical as this is not a precision winder, and good enough results can be obtained by aiming at keeping the "winding on" guide rubbing on the coil as it grows in diameter. If the guide rubs too hard on the coil, it should be eased off by levering out with the thumb-nail. The legs are far enough apart at the clamped end to form a stable section and will allow this operation to be done fairly and squarely. The coil can then continue to be wound in the same place on the former.

The Cam

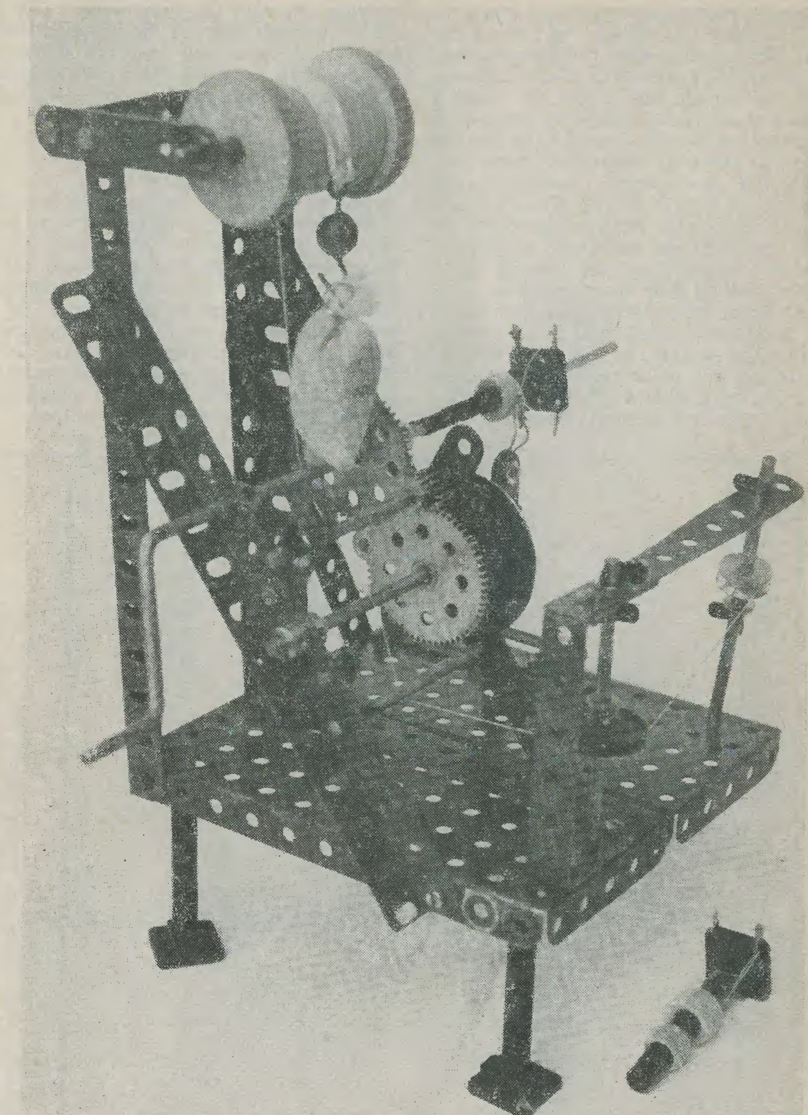
Next to be made is the cam, which couples to the rocking arm by engaging with the groove of the pulley (part no. 22). This is a piece of apparatus designed to send cold shivers down the back of any respectable engineer: but no apology will be given here. Of the four types of cams tried out, the one advised in this article is the easiest to make: also, it will do all that is necessary, its characteristic can be altered with a pair of pliers while *in situ*, and it gives a push-pull output.

SHOPPING LIST

(Set out for easy reference to diagram)

Part	Meccano Part No.	How Many	Remarks
Flanged plates $5\frac{1}{2}$in x $2\frac{1}{2}$in	52	2	
Bolts $\frac{7}{32}$in and nuts	37	33	
Bolt $\frac{3}{8}$in	111C	1	
Washer	38	12	
Collar with screw	59	6	
Perforated strip $2\frac{1}{2}$in long	5	2	
Perforated strip $1\frac{1}{2}$in long	6A	1	
Perforated strip $7\frac{1}{2}$in long	1B	1	
Perforated strip $5\frac{1}{2}$in long	2	1	
Perforated strip $4\frac{1}{2}$in long	2A	1	
Angle girder $7\frac{1}{2}$in long	8B	3	
Perforated strip slotted	55A	4	
Double angle strip	48A	2	
Double angle strip	47A	1	
Double arm crank	62B	1	Used as a bearing
Single arm crank	62	1	
Handrail support	136	1	
Spring clips	35	11	
Bushed wheel, 6 holes	24B	1	
Gear wheel 57 teeth	27A	1	
Gear wheel 60 teeth	27D	1	
Pinion 15 teeth	26C	1	
Axle rod $3\frac{1}{2}$in long	16	3	
Axle rod 4in long	15B	1	
Axle rod $2\frac{1}{2}$in long	16A	1	
Axle rod $11\frac{1}{2}$in long	13	1	Bent as crank
Hook loaded large	57B	1	
Loaded sack	122	1	
Pulley	23	2	
Pulley	22	1	

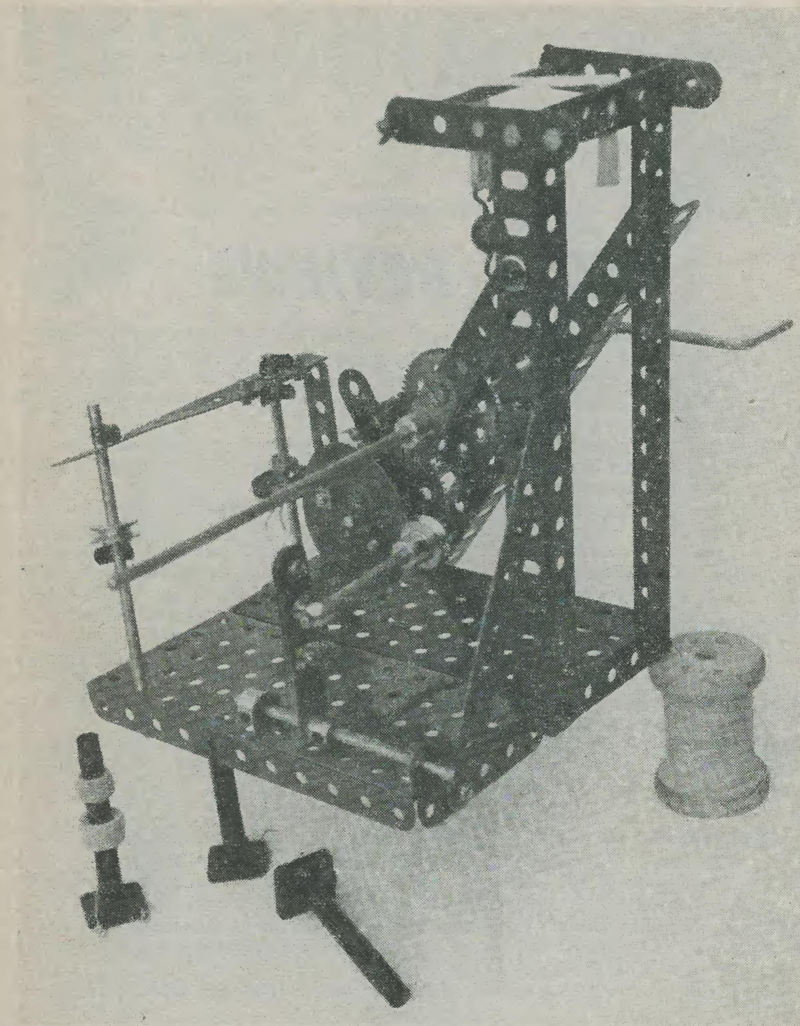
$4\frac{1}{2}$in of approx $\frac{1}{2}$in wide plain white household tape.
2in square of 20 B.G. sheet metal. 4in of 20 s.w.g. tinned copper wire.
2 oz. bobbin of 36 s.w.g. enamelled/cotton covered, copper wire, or as required.
1 tin of Polystyrene cement.



View of the simple tuning coil winder constructed by the author

It is a 1$\frac{7}{8}$in dia. circle of sheet metal cut from the stoutest tin can that comes to hand (the one illustrated is cut from 21 B.G. brass). It can be cut near enough circular with a pair of stout scissors or snips by anyone none the worse for drink, provided the metal is first nibbled away to within approx $\frac{1}{8}$in around the scribed circle. The final cut should be made slowly and as close to the scribe mark as possible, turning the metal into the scissors. The swarf will curl off at the other side and help keep the rate of turning constant.

Scribe a centre-line across the circular plate. Scribe the $\frac{1}{2}$in radius centres and drill, as shown in Fig. 2. The centre hole, being a good fit on the Meccano spindle, will act as a locator and hold the cam central when



A further view of the tuning coil winder made from Meccano parts

it is later bolted, "on the skew", to the bushed wheel (part no. 24B).

If the cam were bolted flat on to the bushed wheel no movement would be imparted to the "rocking arm". In consequence, one side of the cam is raised out from the bushed wheel by a Meccano nut thickness (for thinner width coils try one washer thickness). The rocking action provided by offsetting with a nut (or washer) does not provide a final answer, because it causes the wire to be wound on the coil in graceful sweeps from one side to the other—a sine wave in fact. A sine wave in the middle of the width of the coil is satisfactory, but the wire must then nip smartly up to the edge and pop back quickly again before it has time to fall over at either side. The final cam characteristic is obtained by bending the two opposite edges of the cam, nearest the fixing bolts. This can be done carefully *in situ*; but better still before assembly, as shown in Fig. 2. The side of the cam which is held forward by the packing nut is bent *forward*, the side of the cam which is held back against the bushed wheel is bent *backward*.

When tightening the cam plate on to the bushed wheel care must be taken not to distort the cam with excessive nut pressure. It is probably best to tighten up the nuts as much as possible *with the fingers only*, after first applying a coat of adhesive to the bolts and to all points which the cam will touch on its mounting.

Bending the cam alters its characteristic nearer to the ideal and away from the sine wave form. The ideal cam would wind a coil whose wire went *straight* while crossing the width of the coil and which turned the corners instantly the edges were reached. Such "straight line" cams are used on production wave winders.

BOOK REVIEWS

MULLARD REFERENCE MANUAL OF TRANSISTOR CIRCUITS. 308 pages, 241 figures, 8½in x 5½in. Published by Mullard Ltd. Price 12s. 6d. in U.K.

The *Reference Manual of Transistor Circuits* has been prepared by the Technical Service Department of Mullard Limited, with active co-operation from the Company's semi-conductor engineers and scientists.

Its purpose is to help those, except senior designers, with some professional, or for that matter spare-time, interest in radio and electronics to realise the possibilities of the transistor, and to guide them in exploiting its possibilities most usefully.

The Manual contains details of more than 60 circuit designs using transistors or semi-conductor diodes. Of these, about a dozen are new circuits, and some 25 are made generally available for the first time. They range from circuits for use in domestic radio and audio equipment to pulse circuits, d.c. amplifiers, converters and others of interest to the industrial equipment designer. In each case as much practical information as possible is given, component values are included, and the principles of operation are described to enable the user to make, at least, any small modifications he may require.

A subsidiary aim of the Manual is to help the non-specialist reader to a better appreciation of transistor data. To this end, the first chapters contain general background on the properties of transistors. Some notes on construction and manufacturing techniques are given and there are also short chapters on semi-conductor diodes and the photo-transistor.

The *Mullard Reference Manual of Transistor Circuits* is available from radio dealers; alternatively copies may be obtained from the Home Trade Sales Division of Mullard Ltd., Mullard House, Torrington Place, London W.C.1. (Postage and packing 1s. in U.K.)

AN INTRODUCTION TO THE CATHODE RAY OSCILLOSCOPE. By Harley Carter, A.M.I.E.E. 132 pages, 5¾in x 8½in, 99 illustrations and 3 folded circuits. Price 15s.

In this new enlarged edition a section about phase distortion is added to amplifiers for vertical voltage and the last chapter is fully revised. It describes, together with their circuit diagrams, three complete cathode-ray oscilloscopes. In each case the circuits are fairly simple and the designs are based as far as possible on the use of commercially available components of normal commercial tolerances.

The construction of these instruments should be well within the capacity of the serious experimenter or hobbyist.

These "general purpose" oscilloscopes are frequently used by technicians and shop engineers who, while experts in their own branches of industry, may have only a nodding acquaintance with electronics. It is with this class of users particularly in mind that the present book has been written.

There are also, who may find this book of interest—the serious experimenter, the technical apprentice and the student in technical training establishments, to mention only a few.

The various chapters deal with the principles and construction of the cathode ray tube itself, and with the subsidiary apparatus and circuits which, with the tube, comprise the cathode ray oscilloscope. A number of practical applications of the oscilloscope are briefly described. Technical information and data on commercial cathode ray tubes suitable for use in oscilloscopes are given, and the final chapter contains the designs, circuits and specifications of several complete instruments.

The author has refrained from any attempt at mathematical treatment, and has endeavoured to render the explanations sufficiently simple for those having only a slight knowledge of electronic circuits while at the same time avoiding offence to the more expert reader. (Postage and packing 1/4 in U.K.)

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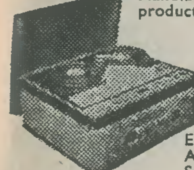

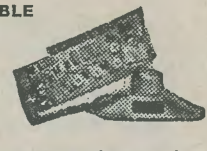

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