JULY 1961

The RADIO Constructor

RADIO · TELEVISION · AUDIO · ELECTRONICS

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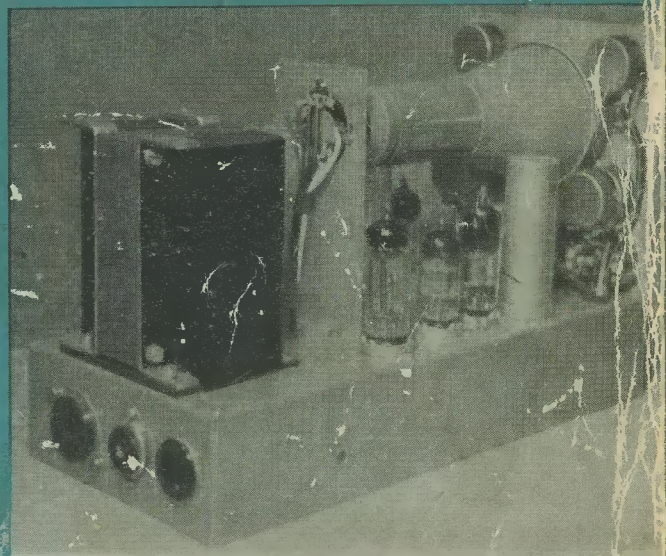


A Constructor's Oscilloscope

DATA Publications

ONE SHILLING AND NINEPENCE

VOLUME 14 NUMBER 12

HARVERSON SURPLUS CO. LTD.

GRAM AND TAPE EQUIPMENT BARGAINS

MONAURAL AMPLIFIER KIT

This comprises a complete kit of parts (including UCL82 valve) to build a quality 3W amplifier, size 7 x 3¼ x 6¼in. Efficient Circuit with volume and tone controls. Everything supplied including mains and O.P. transformers, metal rect., knobs, etc., and comprehensive instructions.

ONLY **39/6** Post and packing 4/6 extra.

5in. loudspeaker (3Ω) to suit, **14/6** extra. All parts sold separately.

A.M. RADIOGRAM CHASSIS

A modern chassis by a famous maker. Size 15½ x 7 x 6½in. high, incorporating fully delayed AVC and negfeedback. Valves ECH81, EF89, EBC81, EL84, EZ81. Attractive brown and gold dial with matching knobs. Controls—w/change (L.M.S. and gram), tone, tuning and vol. on/off. Complete with O.P. trans., valves, knobs, etc.

£9.19.6 Plus 4/6 P. & P.

F.M. TUNER HEAD

Made by famous manufacturer. 88-100 Mc/s. Non-drift. Uses ECC85 valve.

(PRICE (less valve) **14/6** plus 1/6 P. & P. ECC85 valve 8/6 extra.

RECORD CHANGERS

Write for our new super list of Tape Decks and Changers.

B.S.R.

Monarch UA8 4-spd. a/changer **£6.19.6**
TU8 4-spd. single player less P.U. **£2.10.0**
UA14 Stereo Changer **£9.5.0**

NOTE: Any of the above with Stereo Cartridge and Fittings, 16/– extra. Carriage and ins. on each of above 5/– extra.

TAPE DECKS

LATEST B.S.R. MONARDECK (single speed) 3¾in. per sec., simple control, uses 5¾in. spools **£7.5.0**
plus 5/6 carr. and ins. (tapes extra).

TRUVOX MARK III TAPE DECK. New and Boxed. **£10.6.6**
Plus 6/– carr. and ins. (tapes extra).

MIDGET I.F. TRANS. & COILS

A Pair of midget 465 kc/s I.F. transformers, plus LW and MW coils. PRICE **10**/– per set. P. & P. 1/9.

Set of I.F. transformers for transistor superhet, **12/6**. P. & P. 1/9.

HI/FI STEREO/MONAURAL AMPLIFIER

A 5 valve Hi/Fi amplifier with switched stereo/monaural operation. Output 3 watts per channel, provision for bass and treble speakers on each. Volume and tone controls fitted both channels. All housed in stylish blue/grey metal case, with gold finished knobs and trimmings.

£9.19.6 plus 4/6 P. & P.

READY BUILT AMPLIFIER

A 3-valve amplifier (ex-relay unit). Comprising 10F3 RF amp., 10P14 Audio amp. (3W) and U404 rect. Inputs for AC/DC mains, 6 pre-set channels and crystal P.U. Complete in attractive brown and cream bakelite case, with 8in. 15Ω speaker fitted. Ideal gram., guitar amplifier, etc. ONLY **21/–** Plus 6/6 P. & P.

THE WORLD FAMOUS E.M.I. ANGEL TRANSCRIPTION P.U. (Model 17A)

A Pick-up for the connoisseur originally priced at £17.10.0. The last remaining few offered at

£4.10.0 Plus 5/– P. & P.

E.M.I. 4-SPEED RECORD TURNTABLE AND PICK-UP

Heavy 8¾in metal turntable. Low flutter performance. 200/250v shaded motor with tap at 80v for amplifier valve filament if required. Turnover LP/78 head.

89/6 COMPLETE Plus 4/6 P. & P.

SWITCHED ATTENUATOR

Audio to V.H.F. in four steps of 20dB ± 0.02dB up to 300 Mc/s. Cost £5.10.0. OUR PRICE **£2.19.6** Plus 1/– P. & P.

WIRE WOUND POTS

12 Wire Wound Colvern Pots—all different values.

P. & P. 9d. **10/6**

FOR FULL DETAILS AND ILLUSTRATIONS OF ITEMS ON THIS PAGE SEE JUNE ISSUE, PAGES 802, 803 and 804.

SUPER STEREO KIT

A kit of ready-built units only requiring interconnection. Comprising two midget 3W amplifiers, push button switch, transformer, control unit (bass, treble and vol.), power pack, one speaker (second speaker **14/6** extra), indicator light, valves (ECL82, EZ80 range), and comprehensive instructions.

59/6 Plus 6/6 P. & P.

SUPERHET CHASSIS

Modern AC/DC chassis with printed cct. and ferrite rod aerial. Although not completely built, the main components are mounted. L. & M. wave coverage. 4 valves (UBF89, UCL83, UCH81, UY85). Everything supplied including dial knobs, etc., and simple instructions.

£4.19.6 Plus 3/6 P. & P.

F.M. TUNER KIT

At last a quality F.M. Tuner Kit at a price you can afford. Just look at these fine features, which are usually associated with equipment at twice the price!

★ F.M. Tuning Head by famous maker. ★ Guaranteed Non-drift. ★ Permeability Tuning. ★ Frequency coverage 88–100 Mc/s. ★ OA81 Balanced Diode Output. ★ Two I.F. Stages and Discriminator. ★ E.M.84 Magic Eye. ★ Self powered, using a good quality mains transformer and valve rectifier. ★ Valves used ECC85, two RF80's, EM84 (Magic Eye) and EZ80 (rectifier). ★ Fully drilled chassis. ★ Everything supplied, down to the last nut and bolt. ★ Size of completed tuner 8 x 6 x 5½in. ★ All parts sold separately.

£4.19.6 Plus 8/6 P.P. & Ins.

Circuit diagram and illustrations, **1/6** post free.

STEREOPHONIC AMPLIFIER

Complete with 2 Speakers

A compact amplifier embodying the latest features, giving good reproduction and ample volume. Complete with valves (ECL82, ECL82, EZ80), panel, knobs, etc., and two 3Ω matched speakers.

£5.10.0 Plus 4/6 P. & P.

SPECIAL OFFER

DON'T MISS THIS

MULLARD O.C.76 ... 10/6
MATCHED PAIR ... £1.0.0

Post and Packing 6d.

83 High St. Merton SW19

CHErrywood 3985/6

CONDENSER / RESISTOR PARCEL

50 mixed P.F. Condensers and 50 mixed Resistors. An assortment of useful values. All popular sizes—all new—a must for the serviceman and constructor.

P. & P. 1/–. ONLY **10/–**

20,000 VALVES in stock

SEND FOR YOUR REQUIREMENTS

G.E.C. FIRST GRADE TRANSISTORS

Set comprising one 874 mixer, two 873 I.F's, one GET114 driver, two GET113 matched output and one diode.

£1.18.6 Post 1/–.

COSSOR C.R.T. SNIP

108K 10in. New and boxed. 15/–, plus 6/– P. & P.

75K 10in. New and boxed. 15/–, plus 6/– P. & P.

ION TRAP MAGNETS

To suit Cossor C.R.T., 2/9 each. P. & P. 3d.

MAZDA CRM 172

Not a Regun. Picture tested—12 months' Guarantee.

£3.17.6 12/6 P. & P.

CYLDON 12 CHANNEL TURRET TUNERS

New purchase offered at still lower price I.F. 33–38 Mc/s. Complete with PCC84 and PCF80 valves and 8 sets of Coils for Band I Channels and 8, 9, 10 Band III. New and unused. Value over £7.

OUR PRICE **32/6** post paid.

E.M.I. 4-SPEED STEREO PLAYER

To suit our stereo amps.

£6.12.6 Plus 5/– carr.

PAIR OF MOTORS

Two miniature motors (each 3½ x 3 x 1½in). Can be run in parallel from 115v A.C. or in series from 200/250v A.C. Ideal tape motors, models, etc.

35/– per pair, plus 2/9 P. & P.

1/6 H.P. MOTOR

140 watts (approx. 1/6 H.P.). Series wound 220/250 volt 50 cycle motor. Off load 14,000 rev./min., on load 8,500 rev./min. Ideal small saw, sewing machine, etc.

Post free. **30/–**

TRANSISTOR BARGAINS

ALL FIRST GRADE

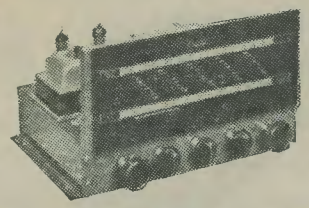
OC71	8/–
OC72	12/–
OC72 Matched Pair	25/–
OC45 Green Spot	15/–
OC45 Blue Spot	15/–
OC44	15/6
OA41 Diode	3/6

Postage on all above 6d.

● FOR FULL DETAILS AND ILLUSTRATIONS OF ITEMS ON THIS PAGE SEE JUNE ISSUE, PAGES 802, 803 & 804 ●

A70B	12/6	EBF80	9/–	EL42	10/–	MH41	7/6	R16	19/6	UF89	8/6	2D13C	5/3	7C5	8/–
AC/Pen	17/6	EBF89	9/6	EL84	8/6	MKY4	16/–	S21/UM	7/9	UL41	9/6	2X2	4/6	7C6	8/–
AC5 Pen DD	17/6	EBL1	15/–	EL91	5/–	ML4	8/6	SD6	5/–	UL84	9/–	3D6	5/–	7R7	12/6
AC6/Pen	7/6	EBL21	22/–	EM4	10/–	MS/Pen	6/–	SD61	2/3	UR1C	12/6	3Q5	9/6	7Q7	13/6
ATP4	5/–	EBL31	22/–	EM80	9/6	MSP4	17/–	SP2	11/3	UR3C	10/6	4THA	6/9	8A1G	7/6
AZ1	15/6	ECC31	10/–	EM81	9/6	MSP41	13/6	SP4	11/6	UU6	17/6	5U4G	6/6	9	4/6
AZ2	12/6	ECC32	9/6	EM84	9/6	MU14	8/6	SP13	8/3	UU7	13/–	5Z3G	12/6	9A1	7/6
AZ31	10/–	ECC34	19/9	EY51	9/3	N14	12/6	SP41	3/3	UU8	19/9	5Z4G	9/–	9D2	4/–
B36	15/–	ECC81	8/–	EY86	9/3	N16	9/–	SP42	12/–	UU60/250	11/3	6AG5	2/9	10D1	10/9
B65	8/6	ECC82	9/6	EZ40	7/3	N108	19/–	SP61	19/9			6AQ5	7/6	10F1	8/6
C1	12/6	ECC83	9/6	EZ41	7/3	OB2	7/9	SU2150	7/9	UY41	7/6	6BG6G	17/6	10F3	12/6
C1C	12/6	ECC84	9/6	EZ80	7/–	OC3	7/6	T41	9/–	UY85	7/6	6BJ6	6/–	10P14	18/–
CBL1	19/9	ECC85	9/6	EZ81	7/–	OD3	5/6	TH2321	18/–	V914	6/9	6C5GT	6/6	11D5	5/9
CL4	12/6	ECF80	12/6	EZ90	7/3	OM1	12/6	TP22	15/–	VMS4B	12/6	6D1	4/–	12J7	9/6
CY1	18/7	ECF82	12/6	FCL3C	18/6	OZ4	5/6	TP2620	15/–	VP2B	10/6	6F7	9/9	12SA7	8/6
CY1C	17/6	ECH3	23/–	FCL3C	18/6	P14	7/6	TSE4	8/6	VP4	15/–	6F8	9/9	12G7	7/–
CY31	16/7	ECH42	9/6	FW4/500	9/6	P16	5/–	TSP4	7/9	VP13A	7/6	6F11	11/6	12SK7	6/–
D41M	12/6	ECH81	8/6	GT1C	10/–	PCC84	9/–	U10		VP41	6/–	6FL5	11/6	12SL7	6/9
D42	12/6	ECL80	9/3	GZ32	11/–	PCC85	9/3	U17	11/9	VPT4	7/6	6F32	9/6	12R7	8/6
D43	6/–	ECL82	10/3	H30	5/–	PCF	9/6	U21	17/9	VR505	6/9	6H6	3/–	12ST7	8/6
DAF96	8/6	EF9	21/–	H242DD	12/–	PCF82	11/9	U35	17/9	VSL631	7/–	6J7G	6/–	18	17/9
DF96	8/6	EF36	5/6	HL13C	7/9	PCL82	11/6	U37	19/9	VU111	10/–	6K7G & M	5/–	19AQ5	10/6
DH101	19/6	EF37	14/–	HL41DD	16/–	PCL83	13/6	U50	7/6	W21	11/9	6K25	18/–	19X3	10/6
DK96	8/6	EF39	5/6	HL133DD	10/–	PEN4/DD	19/9	U52	6/9	W61	10/6	6N7	8/–	20F2	19/9
DL33	9/3	EF40	14/6	KT33	12/–	PEN46	7/3	U74	10/–	X24	19/9	6P25	12/6	20P1	19/9
DL63	9/6	EF42	10/3	KT45	12/6	PEN383	18/6	U81	12/6	X41	15/–	6P28	23/–	25A6	10/6
DL66	16/6	EF50	4/6	KT55	18/6	PEN453DD	19/9	U101	12/6	X79	17/9	6Q7GT	6/6	25L6	10/–
DL68	14/–	EF51	7/9	KT66	17/–	PL33	18/6	U191	17/6	Z109	15/9	6R7G	10/–	25Y5	10/–
DL74	9/3	EF54	5/–	KT708	11/6	PL36	14/6	U339	17/–	Y63	7/6	6SC7G	7/6	25Z4	9/6
DL82	35/–	EF80	7/–	KT71	9/–	PL81	11/9	U403	15/6	Z14	10/6	6SF7	7/6	35L6	9/6
DL96	8/6	EF85	7/–	KT74	12/–	PL82	8/–	U404	10/6	Z63	7/6	6SK7M	6/9	35Z4	6/–
DW2	9/6	EF86	11/6	KT76	12/–	PM12M	7/6	UABC80	9/6	Z66	17/6	6U7G	8/6	35Z5	9/–
DW4/500	13/6	EF89	9/–	KTW63	7/–	PP35	8/9	UBF80	9/–	Z359	10/9	6V6G	7/–	41STH	11/–
EA50	1/6	EF91	5/–	KTZ41	8/–	PX25	25/9	UCC84	12/6	1A5GT	6/–	6Z5	8/3	43	10/–
EABC80	8/6	EK2	8/6	KTZ63	8/–	PY80	7/6	UCC85	10/6	1A7GT	12/–	7B8	11/–	43U1	10/–
EB34	2/6	EL2	11/3	L63	5/6	PY81	8/3	UCF80	16/–	1D6	10/6				
EB41	8/–	EL32	5/–	MH4	8/3	PY82	7/–	UCH42	9/9	1L4	3/6	12 — 6K7G 35/–			
EBC3	21/–	EL33	13/–	MH4/150	7/9	PY82	8/6	UCH81	9/9	1LN5	5/–	100 assorted tag strips.			
EBC33	6/3	EL35	12/6	R10	17/–	UCL82	9/–	UCL83	14/9	1R5	6/6	1-way up to 9-way			
		EL38	19/9			UF85	9/–			1S4	9/–	15/– per 100			
										1S5	6/–				

ARMSTRONG AF 208 AM/FM RADIOGRAM CHASSIS



★ Full VHF Band (87–108 Mc/s and Medium Band, 187–570M. ★ 7 Valves ★ 5 Watts Output ★ 15dB Negative Feedback ★ Separate wide range Bass and Treble Controls ★ 2 Compensated Pick-up Inputs ★ Frequency Response 30–22,000 c.p.s. ±2/dB ★ Tape Record and Playback Facilities ★ Continental Reception of Good Programme Value ★ For 3, 7½ and 15 ohm speakers. Send S.A.E. for leaflet

PRICE 22 GUINEAS Carr. Free

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

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

Special offer **£6.5.0** post free

Stereo/Monaural **£6.19.6**

BUILD THIS REPRODUCER BARGAIN

SPECIAL SINGLE PLAYER KIT

B.S.R. TU9 4-speed Gram-Pick-up Unit **£4.5.0**
Handsome portable case 13¾" x 15" x 8¾", with room to play 12" records **£2.5.0**
Ready built 3-watt, printed circuit, amplifier with two valves and 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 1¾" x ¾" x ¾". High Q and good band width. Data supplied.

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 2 Transistor. M.W. and L.W. Radio Kit 32/6. Phones 7/6 or deaf aid earpiece 12/6.

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, ¼W 4d., ½W 4d., 1W 6d., 1½W 8d., 2W 1/–. **HIGH STABILITY.** ½W 1%, 2/–. All preferred values 10Ω–10MΩ. Ditto 5% 100Ω–5MΩ, 9d. each.

WIRE-WOUND RESISTORS

5 watt	25 ohms–10,000 ohms	1/3
10 watt		1/6
15 watt	12.5 kΩ–50 kΩ 10W, 3/3	2/–

WIRE-WOUND POTS Pre-set min. TV type. Knurled slotted knob. All values 10 ohms to 25k, 3/– each, 30k, 50k, 4/–. Ditto ½W Carbon Track 30k to 2 Meg. 3/–.

3W Lab. Colvern, etc. Standard size Pots, 2½" 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 1½A 7/6. 3A	10/6
Ditto 1.4, 2, 3, 4, 5, 6.3V 1½A	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.** Miniature 3V4, etc., **4/6.** Small pentode, **4/6.** Multi-ratio push-pull, **7/6.** Ditto push-pull 10 watts, **15/6.** Goodmans heavy duty 10/20W 6k push-pull **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 ⅝" x ⅝" x 3/16"
ACOS CRYSTAL MIKE 40 25/–

ALADDIN FORMERS and cores. ¼" 8d., ⅜" 10d **0.3" FORMERS** 5937 or 8 and cans TV1 or 2, ¾" sq. x 2¼" or ¾" sq x 1¼". 2/– with cores.
SLOW MOTION DRIVES. Epicyclic ratio 6-1, **2/3.**
SOLON IRON, 25W, 200V or 230V, **24/–.**
MAINS DROPPERS. 3" x 1½". 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, 1/– per foot; 3-way 1/– per foot.
MIKE TRANS. 50:1, 3/9; 100:1, potted, **10/6.**
LOUDSPEAKERS. 3 ohm. 2½", **19/6;** 5" Rola, **17/6;** 7" x 4" 18/6; 4" Hi-Fi Tweeter, **25/–;** 8" Plessey, **19/6;** 6½" 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. 1⅜" x 1½" x 1¾", **10/–;** 500pF. standard with trimmers, **9/–;** midget, **7/6;** with trimmers, **9/–;** 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.

RADIO COMPONE

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

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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/–
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IMPORTANT ANNOUNCEMENT

Commencing with the next issue, August, the format of *The Radio Constructor* is to be increased to 9¾in by 7¼in.

The new format will allow us to provide extra reading matter and, where necessary, illustrations will be enlarged and therefore easier to follow.

The improvements to the magazine will involve us in considerable extra costs, therefore there will be a small increase in price of this magazine, which in future will be two shillings per copy. Annual subscriptions will be twenty-nine shillings per annum inclusive of postage to any part of the world.

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. 128
An Experimental Remote Control Servo System

THERE IS A CERTAIN FASCINATION IN BEING able to control remote operations electronically. Normally such operations are of a simple switching nature, but it can also happen that a closer degree of remote control is required. This month's circuit is for an experimental servo remote control system incorporating a master potentiometer and a motor-driven slave potentiometer. When the master potentiometer is adjusted, the slave potentiometer automatically resets itself to a corresponding position. Remote services may, in consequence, be mechanically coupled to the slave potentiometer, whereupon the degree of rotation undergone is directly controllable by the master potentiometer.

This is the first servo control system to be included in the "Suggested Circuits" series. Systems of this type have not been described here previously owing to the difficulty of specifying a low-cost, and generally available, motor for the slave position. However, a large number of inexpensive low-voltage reversible d.c. motors for model toys, etc., have been imported into the U.K. over the last year or so, and these lend themselves very readily to a device of this nature. It must be pointed out that, since the performance of these motors may vary from model to model, the circuit given this month is essentially of an experimental nature.

Assuming a rotation in the slave potentiometer of 300°, the prototype indicated the circuit to be capable of some $\pm 1°$ of accuracy in resolution of setting. Doubling the voltage applied to the master and slave potentiometers could theoretically halve this resolution.

A meter capable of reading 20mA d.c., or a high-resistance voltmeter, is required for setting up the circuit.

Servo Systems

A basic servo system of the type to be discussed here may consist of two potentiometers, a reversible motor, an amplifier, and a means of controlling the direction of rotation of the motor. The potentiometers may be connected in a bridge circuit, across whose arms is applied a voltage. When the sliders of the potentiometers are at the same setting along their tracks the bridge is balanced and zero voltage appears between the sliders. Conversely, if one potentiometer has a different setting to the other a voltage appears between the sliders, its magnitude and polarity depending upon the relationship between the two settings.

The sliders of the potentiometers may be connected to the input of an amplifier whose output actuates a switching device (which may be a relay, valves, or transistors). The switching device then controls the supply to a motor. The motor is coupled to one of the potentiometers which then becomes the slave potentiometer, the remaining one being the master potentiometer.

The system now functions in the following manner. If the master potentiometer is adjusted to a new position a voltage appears between the two sliders, and this is applied to the amplifier. The amplifier output, via the switching device, next causes the motor to drive the slave potentiometer to a position corresponding to the new setting of the master potentiometer. If the latter is further adjusted, in the reverse direction, a voltage once more appears between the two sliders, but it has a different polarity to that given previously. This new voltage is applied to the amplifier and the switching device as before but, because it is of opposite polarity, the amplifier and switching device cause the motor to rotate in the reverse direction. The

consequence is that the slave potentiometer follows the master potentiometer as before, coming to rest when the voltage across the two sliders becomes equal.

Normally, when the slave potentiometer takes up a new position the inertia in the system causes the motor to drive its slider past the correct setting. As a result the amplifier and switching device reverse the motor. Once again, however, inertia causes the motor to drive the potentiometer past the correct setting, whereupon the amplifier and switching device reverse it once more. This process can continue indefinitely and is known as "hunting". Summing up, the overall operation of the servo system consists of the slave potentiometer following the master potentiometer to any new position of the latter, after which it hunts about this new position.

It is usually considered desirable to arrange a servo system such that hunting occurs continually, because this ensures that the system is sufficiently sensitive to follow very small changes in setting of the master potentiometer. Although the slave potentiometer hunts, its *centre* setting within the hunting range corresponds exactly to that of the master potentiometer. By careful design it is possible to make the range of rotation over which hunting occurs very small, with the result that the setting of the slave potentiometer can be considered, for practical purposes, as being constant.

The above description of a servo system presumes that the master and slave components consist of potentiometers connected in a bridge circuit. It should be pointed out that this is only one of many ways in which servo control may be obtained. It is, for instance, possible for either control to consist of a variable condenser or inductor, or of any other device capable of feeding a signal to the amplifier and switching device in order to control the motor. To take an example, in a direct reading radio compass the control can be effected by the angular relationship between a ground transmitter and a direction finding loop in an aircraft.

The Circuit

The circuit of the servo system which forms the basis of this month's article appears in

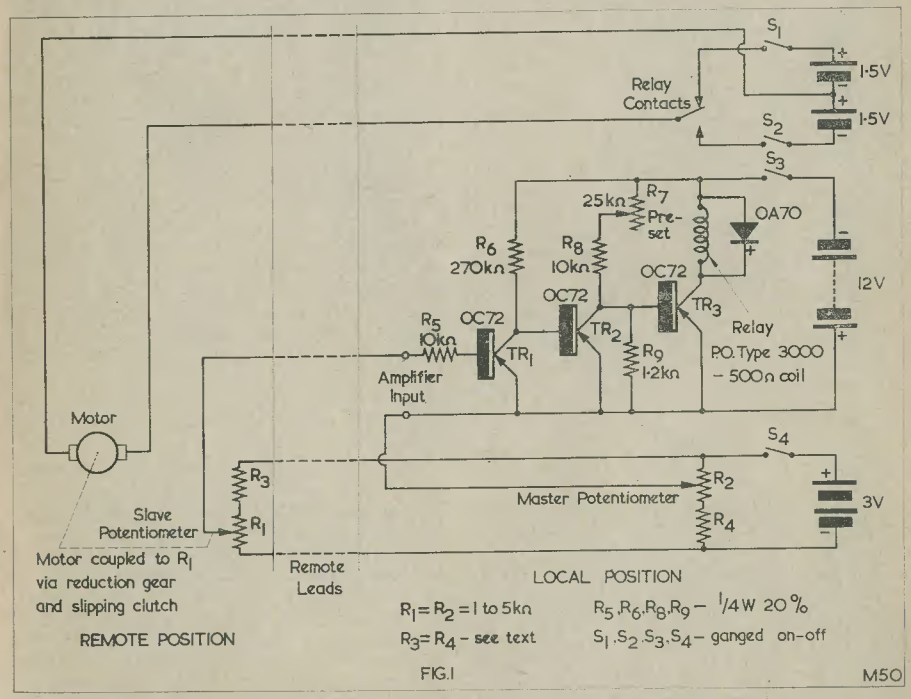


FIG. 1 M50

Fig. 1. As may be seen, it includes a master and slave potentiometer employed in a bridge circuit similar to that just considered.

Ignoring R_3 and R_4 (which are low value resistors) for the moment, the potentiometers R_1 and R_2 form a bridge circuit across the arms of which is connected a

3 volt battery. A d.c. voltage appears on the sliders of R_1 and R_2, its magnitude and polarity depending upon their relative settings. This voltage is applied to the input terminals of the three-transistor d.c. coupled amplifier TR_1, TR_2 and TR_3. A relay is connected in the collector circuit of TR_3, this energising when the input to the base of TR_1 goes negative and de-energising when the input goes positive.

Two 1.5 volt cells connect to the motor via the changeover contacts of the relay in such a manner that, when the relay is de-energised, the upper cell supplies the motor and, when the relay is energised, the lower cell supplies the motor. The cells are applied to the relay contacts and the common motor connection with inverse polarity. Therefore, when the relay is energised the motor rotates in the reverse direction to that given when the relay is de-energised.

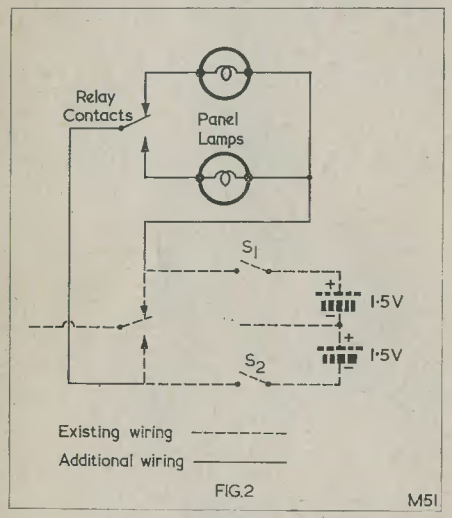


FIG.2 M51

The motor is coupled to the slave potentiometer via a reduction gear (or train of gears) and, preferably, a slipping clutch.

The servo system is now complete. If the master potentiometer, R_2, is adjusted to a new position, a signal is applied to the amplifier which causes the relay either to energise or de-energise. The relay contacts then cause the motor to rotate in the desired direction until the setting in R_1 corresponds to that in R_2. Having arrived at this setting the motor over-runs slightly, with the result that its direction of rotation reverses. The motor then settles down to hunting on either side of the required setting in the slave potentiometer.

In the circuit given here, the desired voltage relationship between the sliders of R_1 and R_2 corresponds not to zero voltage but to a voltage which causes a small negative potential to be applied to the base of TR_1 (relative to its emitter). This voltage corresponds, theoretically, to a current in the relay coil which attracts the armature just sufficiently to allow its centre contact to lie between the two outside contacts, so that no voltage is applied to the motor. In practice, such a relay setting will almost certainly be unstable, and the system will tend to hunt continually.

For home-constructor applications continual hunting may be a disadvantage due to the somewhat heavy currents liable to be drawn by the motor from the two 1.5 volt cells which supply it. To avoid the consequent heavy drain on these cells a suggested addition to the circuit is illustrated in Fig. 2. In this diagram a second set of changeover contacts on the relay controls two panel lamps, these being fed by the cells which supply the motor. The lamps may be installed at the local position. When, with the modified circuit, it is desired to reset the slave potentiometer the local position is initially switched on by means of the ganged four-pole switch S_1–S_4. The relay then commences to energise and de-energise as the remote motor hunts, causing the lamps to flicker on and off alternately. The master potentiometer is next set to its new position. At once the relay becomes energised or de-energised, as applicable, and the appropriate lamp remains steadily illuminated. As soon as the remote motor has driven the slave potentiometer to its new setting it commences to hunt once more, whereupon the lamps resume their alternate illumination. The system may then be switched off by S_1–S_4, with the assurance that the slave potentiometer is now accurately set to its new position (within the hunting range of the system).

Fig. 1 illustrates the slave potentiometer and motor positioned remotely from the local position, interconnection being provided by five wires. If these wires have a reasonably low resistance it is possible to make one of the potentiometer supply leads and one of the motor leads common, thereby reducing the inter-connecting leads required to four. A common lead should not, however, be employed if the inter-connecting wires have appreciable resistance, because the relatively heavy motor starting surges may find their way into the amplifier and cause erratic operation.

Features of Design

There are a number of design features which require a little further amplification.

As was mentioned above, the performance of the motor employed may vary with type. That used by the writer[1] was stated to run from d.c. supplies of 2 to 4 volts, but it was found that it operated quite reliably with a supply of 1.5 volts. It appeared to offer the same torque in both directions.

The three-transistor d.c. coupled amplifier was designed to use the minimum of components. Whilst being satisfactory for the purposes required here, it must be stated that the amplification it provides is non-linear. The prototype employed OC72's in the TR_1 and TR_2 positions, but any small a.f. transistors should cope satisfactorily in their place. Alternative transistors in the TR_2 position may, however, require different values of R_8. The relay stage, including TR_3, uses components which have been specified in previous articles in this series. Whilst other relays and transistors could be employed in their place, the writer can state from experience that the combination of an OC72 and a P.O. type 3,000 relay with a 500Ω coil offers a robust and reliable circuit which takes full advantage of a standard relay without over-running the transistor. Pre-set resistor R_7 brings TR_3 on to its correct operating point, and its adjustment is described later. The crystal diode across the relay coil prevents the formation of high reverse voltages when the relay de-energises, and it must be connected with the polarity shown or TR_3 will be damaged. Relay circuit operating conditions are described at the end of this article.

Three separate sources of supply are illustrated in Fig. 1. It is essential that the 12 and 3 volt batteries be separate, because of the varying potentials between the two. The two 1.5 volt cells *could* be combined with the 3 volt battery feeding the potentiometers, but the combined supply would require a very low source impedance to prevent motor starting surges from affecting the amplifier. Mains-driven power units could be used instead of batteries, and their outputs should be well smoothed in the case of the 12 and 3 volt supplies. Motors of the type considered here tend to overheat with poorly smoothed rectified supplies, and this fact should be borne in mind if it is also intended to replace the 1.5 volt cells with a mains supply.

With battery operation, as in Fig. 1, S_1–S_4 may be a four-pole wavechange switch.

The sensitivity of the system may be doubled by doubling the voltage applied across the potentiometers R_1 and R_2, and this point may be of assistance when finally setting up the system.

[1] This particular motor bore the trade name "Volta" and was purchased from M.R. Supplies Ltd., 68 New Oxford Street, London, W.C.1, at 5s. retail.

Since the desired relationship between the potentiometer sliders is given when R_1 slider is slightly negative of R_2 slider, resistors R_3 and R_4 have been included in Fig. 1 to limit the voltages tapped off in either potentiometer and ensure that their relative ranges coincide. The resistance required in R_3 and R_4 depends upon the values of R_1 and R_2, the sensitivity of the amplifier, and the applied potentiometer voltage. Results with the prototype would indicate that R_3 and R_4 should have values approximately 1/40 of those of the potentiometers for an applied voltage of 3. R_3 and R_4 may be short-circuited during setting up, and their value calculated, or found experimentally, afterwards.

Constructional Points

From the electronic point of view the circuit should present little trouble. The three-transistor amplifier should be laid out in logical manner, with R_5 furthest away from the relay, and the successive stages positioned, in order, between. R_7 should be set, initially, to offer maximum resistance. When the amplifier has been completed a milliameter capable of reading 20mA should be inserted in series with the relay coil (or a high-resistance voltmeter connected across the coil). Relay coil current should be negligible when the left hand end of R_5 is connected to chassis. Relay current will increase if the left hand end of R_5 is connected to a point (say 1.5V) negative of chassis. Under this condition R_7 should be adjusted to allow 20mA to flow through the relay coil (or 10 volts to appear across the coil) for a supply voltage of 12.

The most important feature in the circuit is the reduction gear between the motor and the slave potentiometer. The ratio required here has to be found experimentally, as it depends upon the characteristics of the motor. Results with the prototype indicate that a ratio lying between 300:1 and 1,200:1 should give satisfactory results. The gear ratio to aim at is that which causes the slave potentiometer to hunt over slightly more than the minimum range of which the system is capable. It should be remembered that the hunting range depends upon the inertia of the motor and relay, and upon the sensitivity of the amplifier. The r.p.m. (and hence the momentum) of the motor can be varied over a small range by varying the motor supply voltage. At the same time the sensitivity of the amplifier can be varied by altering the voltage across the potentiometers. However, the greatest degree of control is given by the reduction gear ratio itself.

A slipping clutch in the drive to the slave potentiometer is very desirable in order to

prevent damage to the motor or potentiometer should the slider of the latter be accidentally driven against its end stop. In the prototype, a slipping clutch was obtained by the simple process of making one of the gears offer a friction coupling to the motor spindle itself.

If it is found that the motor drives the slave potentiometer to one end of its track and continues to run for a central setting of R_2, the system is out of phase. The connections to the motor should be reversed to obtain correct operation.

Results with the Prototype

With the prototype the motor was coupled to the potentiometer by a reduction gear of approximately 100:1. This proved the reliability of the circuit, but the hunting range was rather high, taking up some 5° to 8° of potentiometer rotation. Increasing the gear ratio would have reduced the hunting.

Current flowing through the relay coil was negligible for negative voltages applied to the left hand end of R_5 (relative to the 12 volt positive rail) up to 0.075V. The relay energised (at 15mA coil current) at 0.088V and TR_3 passed its full collector current of 20mA at 0.15V. Thus, the range of input voltage capable of controlling the relay was 0.075 to 0.088V, i.e. 0.013V. Assuming an applied potential of 3 volts and a potentiometer rotation of 300°, the range of amplifier control may then be calculated as 1.3° of potentiometer rotation. With this figure, a maximum resolution accuracy, for the overall system, of $\pm 1°$ would seem reasonable.

The current drawn by the amplifier, with a 12 volt supply, was 20.8mA with the relay energised and 0.8mA with the relay de-energised. The current drawn from the 3 volt battery depends, of course, on the values of R_1 and R_2, and that from the 1.5 volt cells on the current requirements of the motor.

The Relay Circuit

The constructor is recommended to use the relay type specified, as this offers reliable operation. A relay coil resistance lower than 500Ω should *not* be used. With two contact sets the P.O. type 3,000 relay energises comfortably at 20mA, actual energising current being approximately 15mA. More than two contact sets should not be used as this increases energising current requirements.[2] The supply voltage should be reasonably well regulated, a desirable figure being better than ± 2 volts on 12 volts. Although not essential, it would be preferable to clamp TR_3 to a heat sink having the minimum dimensions of 1½in square.

[2] A suitable relay, fitted with two sets of changeover 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

Reception Set R206 Mk. II.—A. Melhuish, 31 Shepherds Bush Green, London, W.12, would like to obtain the manual for this receiver.

* * *

H.M.V. Model 651.—B. A. Seal, 270 Kempshott Lane, Basingstoke, Hants, wishes to gain possession of the service sheets for this broadcast receiver.

* * *

Band III TV Converter Design.—D. Bowers, 88 Grenfell Avenue, Saltash, Cornwall, is in urgent need of the October 1955 issue of *The Radio Constructor* containing this design —borrow or purchase.

R1481 Receiver and Indicator Unit 233.—P. Carroll, Read Grammar School, Drax, near Selby, Yorks, wishes to acquire the manuals for these equipments—particularly details of the power units.

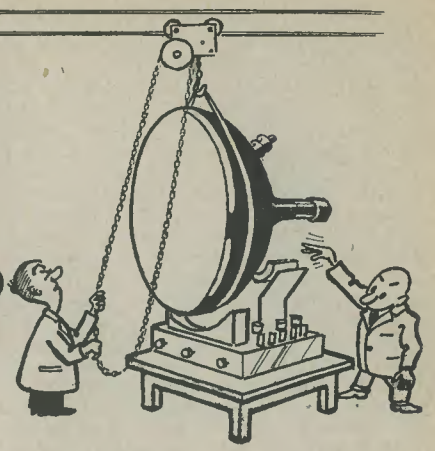
* * *

DB8 "Tape and Wire Recording".—E. J. Chipperfield, 43 Avondale House, Avondale Square, London, S.E.1, a blind enthusiast, urgently requires a copy of this book (now out of print) in order that his wife may transcribe into Braille.

* * *

Lembeck Radio.—J. Henty, 24 Edward Way, Ashford, Middlesex, requires the service sheet of this German manufactured receiver —loan or purchase.

In your Workshop



This month Smithy the Serviceman and his able assistant, Dick, investigate the causes of i.f. instability in television receivers

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Dick's youthful voice rose in volume as he approached the Workshop, and the last line of his song broke at full strength against the Serviceman's ears as his assistant opened the door.

"Oh dear", grumbled Smithy. "Have we *got* to have this sort of thing at nine o'clock in the morning?"

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Dick had an aptitude to break occasionally into improvised doggerel, and Smithy remembered with a grimace some of the ways in which the English language had been tortured in the past to fit his assistant's ideas of scansion and rhyme.

"Some of your outpourings", he said eventually, "*have*, in the past, been original. I don't call this latest effort original."

"That was merely", replied Dick loftily, "a variation on a very well-known theme. Purely for warming-up purposes."

"Well, my lad," retorted Smithy. "Let's see you warm up on the sets that we've got in for repair. There's a whacking great pile awaiting service today."

"Fair enough, Smithy," said Dick, equably, putting on his overall coat.

A thought suddenly struck him, and he took up an impressive attitude which was spoilt only by the fact that he had one of the coat sleeves inside out.

"Today we will both be hard-pressed
As we've numerous sets in for test.
I'll keep bright and breezy,
With faults that are easy,
And let Smithy get on with the rest!"

Dick grinned at the Serviceman with immaculate self-satisfaction.

"How's that," he remarked proudly, "for something straight off the cuff? You know, Smithy, I'm a real gone kiddy this morning."

The Serviceman groaned. It was going to be one of those days.

Unstable I.F.

Happily, Dick picked a television receiver for repair from the rack and placed it on his bench. He switched it on and waited for it to warm up. After some moments the line timebase commenced to operate, and a bright raster filled the screen accompanied by a loud hiss from the speaker.

"Just my luck," remarked Dick, his high spirits beginning to evaporate. "My very first set for the day, and it's unstable. It's oscillating like mad!"

Smithy glanced briefly at the screen of Dick's receiver.

"Turn the turret tuner through the channels," he commanded. "See if there's any change in the condition on Band I and Band III and between channels."

Obediently, Dick turned the turret knob slowly.

"The instability's there all the time, Smithy," he called out.

"Then", remarked the Serviceman, "it is almost certainly in the i.f. strip. You can fairly safely count the tuner out."

"That means", said Dick dolefully, "that I've got to get the chassis out of the cabinet."

"Not at this stage," replied Smithy. "First of all, have a look in the back and see if everything looks O.K. and that you haven't got the cathode lead to the tube wrapped around the first i.f. valve or something silly and obvious like that. There's a possibility that some i.f. is present on the tube cathode lead, despite the filtering after the vision detector, and this *could* cause instability if it accidentally coupled into the first i.f. stage. After your visual check, waggle all the i.f. bottles, both sound and vision, in their holders to make certain that they're making good contact. If this doesn't work, swap the i.f. valves in turn. If none of these ideas clears the trouble you can *then* get the chassis out of the cabinet."

Dick was already peering into the back of his receiver. Satisfied that no simple visible fault was causing the instability he commenced to rock the i.f. valves in their bases

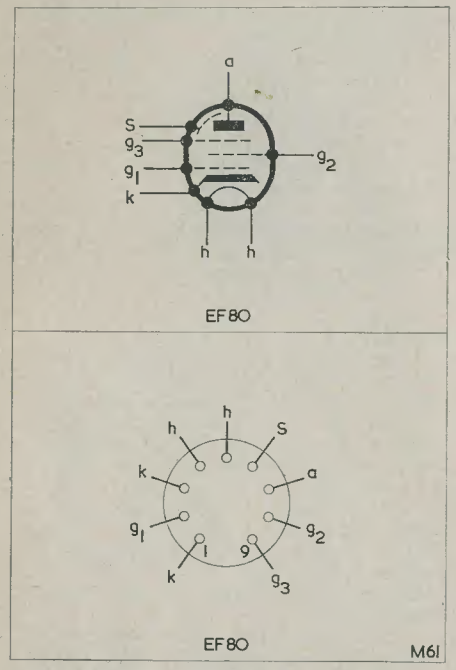

Fig. **1.** *Valves employed in television i.f. stages normally have an internal screen, which should not be confused with the screen-grid (g_2). In the EF80 the internal screen connects to pin 6 and the screen-grid to pin 8*

as Smithy had instructed. Suddenly the bright raster cleared. Dick switched the receiver to the local channel and was rewarded with a perfectly satisfactory Test Card, together with acceptable sound from the speaker.

"Smithy," he called out, "you're a genius! The second vision i.f. was the one. As soon as I moved the valve in its holder the fault cleared. What is more, however much I move the valve from now on I can't get the snag to reappear."

"That seems fair enough," remarked the Serviceman. "If the fault appeared intermittently I would have advised you to put a new valve in and waggle that about as well. The intermittent connection might be due to either a badly oxydised or dirty valve pin, which should not be present on the new valve, or to a bad connection to one of the pin sockets in the valveholder. Don't forget that the latter are often 'floating' and that they move around with the valve pin. Checking with a new valve would pretty soon show whether the trouble was one or the other."

"Couldn't the fault be caused by a pin socket on the valveholder losing its springiness, or getting oxydised?"

"It could do," replied Smithy, "although this fault doesn't seem to be so common these days."

A thought had crossed Dick's mind, and he frowned for a moment.

"I wonder", he remarked musingly, "which valve pin would require a bad connection to cause instability."

"The one to the screen would be the most obvious one," replied Smithy shortly.

"But if you had a poor connection to the screen," protested Dick quickly, "you wouldn't get any h.t. on to it and the valve wouldn't amplify in any case. So it couldn't oscillate!"

Smithy put down his soldering iron a little wearily.

"Valves of the type used in television i.f. strips", he said patiently, "have an internal screen which normally goes to a pin of its own. This screen is not the same as the screen-*grid*, or g_2, which goes to another pin."

"Oh, I see," said Dick, reaching for his valve manual and turning the pages. "A likely i.f. valve for a t.v. set would be an EF80, so let's look at its pinning." Dick peered at one of the pages in his manual. "You're dead right, you know, Smithy! With an EF80 the screen-grid goes to pin 8 and the screen to pin 6. (Fig. 1.) They're quite separate things."

"Of course I'm right," said the Serviceman, somewhat nettled. He prepared to turn back to his own bench.

"Just a moment, Smithy," called out Dick. "I think I've got something coming. Here, listen to this!

If you have got
An i.f. that's so hot
It possesses no stability,
First you must jostle
The suspected bottle,
Then look at its socket and see!"

Another Unstable Receiver

Smithy shuddered and hurriedly left his assistant to his own devices. The budding poet, wearing the expression of one who is inordinately pleased with himself, fitted the back on to his set. Humming to himself, he returned to the rack, selected another television receiver, and put it on his bench. He waited for the set to warm up.

After a while, a bright raster filled the screen, accompanied by a loud hiss from the speaker.

Confidently, Dick followed the procedure carried out on the previous unstable receiver. First of all, he turned the turret tuner through its channels. The instability was completely unaffected by turret position. Dick next took the back off the receiver and gazed inside, looking for obvious faults. There were none. His air of confidence wilting slightly, Dick next proceeded to rock each i.f. valve in its holder. The instability remained unaltered. Finally, Dick replaced each i.f. valve in turn with a new valve, returning the original valve to the chassis after each substitution and proceeding from stage to stage. The instability continued unabated, and Dick's confidence left him completely. He disconnected the receiver from the mains and started to remove the chassis-securing bolts.

"I've got *another* unstable t.v., Smithy," he called out. "And this time it's not a poor contact to any of the valves."

"Fair enough," said Smithy. "I'll have a quick look at it when you've got the chassis out."

Several minutes later Smithy wandered over to Dick's bench and surveyed the offending receiver.

"Hmm," he commented, after a close examination, "it *looks* all right. Now, the first approach to a t.v. with instability in the i.f. strip is to check each stage to ensure that there's no unwanted feedback from anode to grid."

"Which would be caused", suggested Dick, "by, say, an open-circuit screen decoupler?"

"An open-circuit screen-*grid* decoupler," said Smithy a little irritably. "I do wish you wouldn't use these loose terms."

"I stand corrected," said Dick. "An open-circuit screen-*grid* decoupler."

"That's more like it," conceded Smithy "Now, you must always remember that television i.f. stages use valves which have got whacking great slopes. Thus, the EF80 has a slope of about 7.5mA per volt, whilst some of the new frame-grid valves, like the EF183 and EF184, have slopes of some 12 or 15mA per volt respectively."

"By 'slope'," said Dick suspiciously, "I suppose you mean 'mutual conductance'."

The Serviceman nodded in agreement.

"Sounds a bit of a loose term to *me*," muttered Dick sulkily.

"All right, all right," said Smithy. "I'll use 'mutual conductance' from now on. Let's get back to the subject. Now valves having mutual conductances as high as the figures just mentioned require a fair bit of tying down if they're not going to go into oscillation. Especial care has to be taken to keep stray capacities between anode and grid to a minimum."

"Well, the screen-grid looks after that, doesn't it?"

"Only in so far", replied Smithy, "that it is interposed between the anode and the grid, and is decoupled to chassis via a condenser offering a very low impedance at the frequencies concerned. The screen-grid doesn't screen the wires inside the valve which travel from the pins up to the anode and grid electrodes."

"Is this where the internal screen comes in?"

"It is. Now go and have a look in the junked valve box, Dick, and see if you can find an EF80."

Dick drew out a box of unserviceable valves and looked inside it.

"I've got one here that's burned out," he called out after a moment.

"Fine," said Smithy. "Let the vacuum out of it so that we can have a shufti at its innards."

Dick wrapped the valve in an old rag to prevent particles of glass from flying out, and broke it carefully. After a moment he passed the valve over to the Serviceman.

"That's fine," said Smithy. "And it gives us an excellent view of just what that internal screen does. As you can see, it is connected to pin 6. (Fig. 2.) A wire goes up inside the valve from this pin and it connects to a cylindrical mesh screen which goes right round the anode. So that's one bit of screening looked after. At the same time another bit of metal, a piece of thin unperforated strip this time, comes down from the cylindrical screen support right into the base of the valve. Next door to pin 6 is the anode at pin 7, and the vertical part of the thin strip of metal provides very effective screening between the pin 7 wire and the grid wire going up on the other side of the assembly."

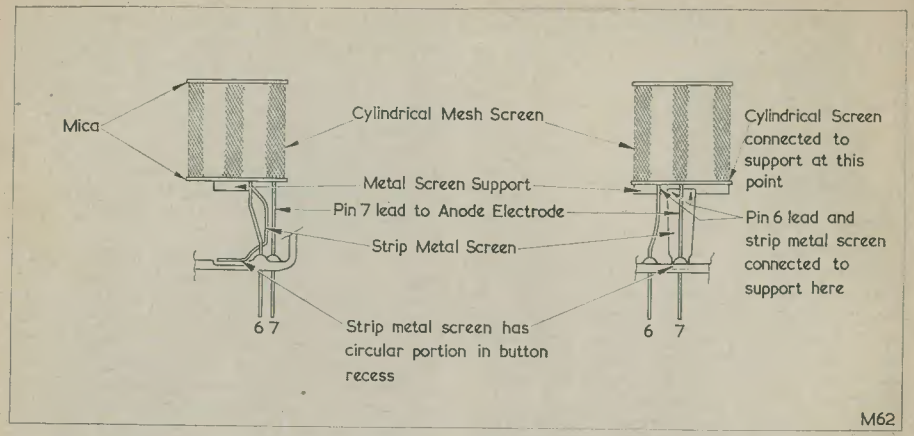

Fig. 2. Part of the EF80 valve examined by Smithy and Dick. The lead inside the valve from pin 6 connects to the metal screen support and, thence, to the cylindrical mesh screen which surrounds the electrodes and the strip metal screen which runs alongside the pin 7 anode lead. All connections shown are made by spot welds. The assembly illustrated here is typical only

"Well, that's neat," said Dick enthusiastically. "I see also that the metal strip, after doing its job of screening off the anode lead, ends up in a circular shape right at the bottom of the envelope, this shape fitting snugly into the circular recess in the glass button which holds the pins."

"That's right, lad," said Smithy. "The bottom of the screen plays an important part in the overall screening action for the valve. If the valve is inserted into a valveholder having a metal centre spigot (Fig. 3) you get an almost unbroken screening effect. The centre spigot provides a measure of screening between the anode and grid sockets, and their tags, in the valveholder. This screening extends to the top of the spigot. There is then a short gap due to the glass of the valve envelope together with an inevitable air-gap between the bottom of the glass and the top of the spigot. After this the circular plate in the valve takes over from the spigot, and the screening continues unbroken up to the electrode assembly itself."

"Why, I'm dashed!" said Dick. "I never knew that precautions such as this were taken at all."

"Well, they are," said Smithy. "Naturally, the internal screen we've just been looking at can only be considered as a typical example, and different makes and vintages of EF80 may show slight variations in design. But the basic effect will be the same.

"That internal screen," concluded Smithy, "performs a most important function and it prevents a lot of instability which might otherwise occur. Oh no, not again!"

But it was too late. With one foot mounted precariously on his stool Dick had already flung his arms wide and had launched into song, fitting words to a tune which even the Serviceman recognised as being that of "Trees".

"I think that I have never seen
A thing as useful as a screen.
A screen, whose purpose is expressed
In keeping feedback paths suppressed.
A screen can, on its own, forestall
Those faults that send you up the wall!"

Screen Decouplers

As the echoes died away Dick looked around modestly for applause, but all he encountered was the Serviceman's stern eye.

"Is there going to be any more of this?" remarked Smithy.

"I must remind you", replied Dick with dignity, "that in even the most downtrodden of us there exists a small but undaunted spark of creative fire."

"I've never known it get you as bad as this before," complained Smithy. "It's ages since you started churning out what you fondly imagine to be poems. And, even in the old days, you didn't keep it up as much as you have today."

"In the Philistine company", replied Dick, "I have to maintain in order to earn my daily crust, my abilities have been somewhat dormant. But I have very recently been inspired to composition by others whose aesthetic tastes are similar to my own. What has happened, actually, is that I got in with a bunch of Beats last night down at 'El Picador'."

"'El Picador'?"

"'El Picador'," confirmed Dick. "It used to be Joe's Caff until he put the bamboo wallpaper up last year."

Despite himself, Smithy grew interested.

"What sort of Beats were they?"

"Well, at first I thought they were the usual stand-off mob you get nowadays. You know the sort, weirds with beards and queens in jeans."

"I am fascinated", confessed Smithy, "by your description."

"Also," continued Dick, encouraged, "they started off with the old spiel like, natch, being gone, and all that."

"Suburban Jack Kerouacs?"

Dick paused. There were moments when he was not completely certain about Smithy.

"I wouldn't argue about that," he said hastily. "One of them said he is an Extinctionist."

"A *what*?"

"An Extinctionist. He said it was something to do with Jong Pol Sarter."

"You mean an Existentialist," commented Smithy. "And Jean-Paul Sartre."

"I suppose that *could* be right," Dick conceded. "There was a girl there who said she was a Zen Buddhist. I couldn't make her out at all. Dead keen on meditation, she was."

"It sounds a likely party."

"Oh, it was," confirmed Dick eagerly. "They had this jazz about taking turns in making up free verse, but I soon put a stop to all that."

"What did you do?"

"I got them on to limericks."

"Very sensible," said Smithy approvingly. "What were the limericks about?"

"People," replied Dick. "We had a smasher about you!"

"I think", said Smithy icily, "that that's enough talk about last night. Let's get back to the job in hand, which is i.f. instability. Now, I've already explained the lengths to which the valvemakers go in ensuring that good screening exists between grid and anode."

"That's right," agreed Dick, momentarily forgetting his exploits of the night before. "And you pointed out also that the screening provided by the spigot is carried on through the valve. Which means, I suppose, that the spigot is always connected to chassis?"

"Not entirely," said Smithy. "You may occasionally find the spigot used as a component anchoring point as well as a screen. In this case the spigot may have h.t. potential on it. However, it will be coupled to chassis via a large value condenser and so it will still do the same job as before. Such a technique, incidentally, doesn't seem to be used so frequently on printed circuit sets as it was on sets with conventional wiring."

Smithy paused to light a cigarette.

"When you're servicing an unstable i.f. strip," he continued, "the first thing to look for is, as I said, unwanted feedback from anode to grid. The most obvious cause of such feedback is probably open-circuit screen-grid decoupling condensers. These you can check by very quickly popping another condenser across them."

"We've got a gadget in the Workshop for doing just that, haven't we?"

"We have indeed," replied Smithy. "It's a gubbins I knocked up several years ago, and which I've used from time to time ever since. All it consists of is an insulated mounting carrying two 6BA steel screws filed to a point and having a 1,000pF ceramic condenser mounted between them. (Fig. 4.) You can apply the screw points to a printed circuit board, whereupon it bridges over a suspected decoupling condenser very easily. The idea behind having points on the 6BA screws is that you can dig these lightly through any flux or varnish that may be present on the copper side of the board, and so obtain good contact. The gadget has the further advantage that there is a very short lead length to the added condenser. I find it quite a useful tool."*

"I'll try it out on this set," said Dick. "Any other causes of i.f. instability?"

* This condenser tester was previously described in "In Your Workshop" in February 1958. Appreciative comments from readers are the cause of its being referred to again here.—*Ed.*

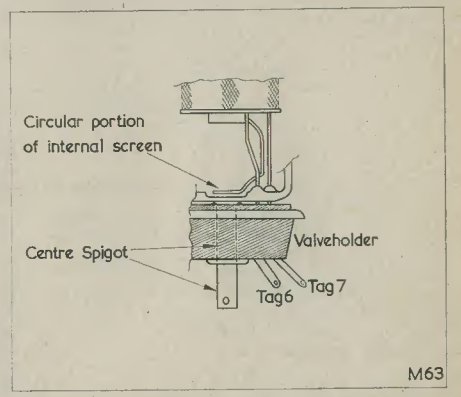

Fig. 3. An almost unbroken screening effect is given by the combination of the centre spigot of the valveholder and the internal screen in the valve. The valveholder is shown here in side view with all tags except 6 and 7 removed

"Screen-grids and screens are the most obvious," said Smithy. "After that you carry on to the routine business of checking decoupling condensers in heaters, h.t., a.g.c., and cathode circuits. Frequently, television i.f. coils in anode or grid circuits are damped down by shunt resistors having values around 5 to 10kΩ. When one of these goes open the resulting high Q in the coil could quite possibly cause instability. If you're *really* in trouble whilst chasing instability one approach could consist of connecting a damper consisting of, say, a 4.7kΩ resistor in series with a 1,000pF ceramic condenser (Fig. 5) between chassis and each grid and anode in turn. If you find a single grid or anode at which applying the damper causes the instability to clear dramatically, then it would be worthwhile having a look at the damping components in the appropriate tuned circuit. But you should have checked pretty well everything else in the chassis before you start on tests of this nature."

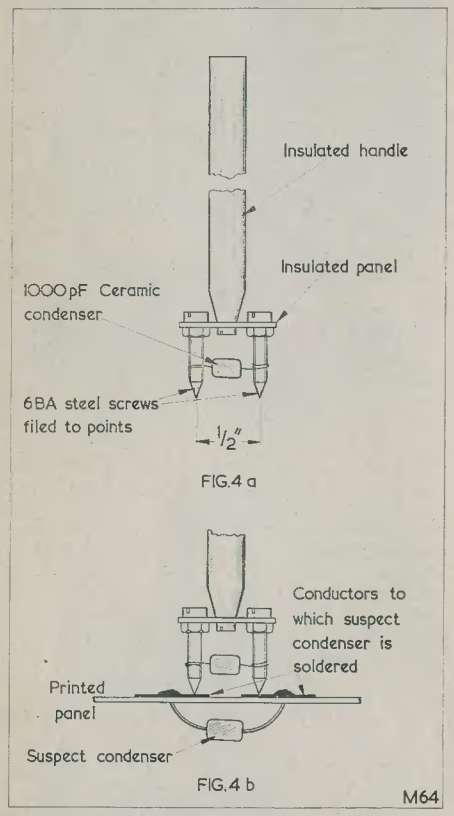

Fig. 4 (a). Smithy's condenser tester, designed for quick checks of decoupling condensers on printed circuit boards (b). Applying the tester to a printed board to test a decoupling condenser which is suspected of being open-circuit

"Any other points to check?"

"Plenty!" replied Smithy. "And most of them fall into the 'check earthing' category; this being especially true of printed circuit sets. Look at the earthing of i.f. coil cans, for instance. Some of these have spring clips to give the earth connection, and the clips may have gone weak or corroded with time. Also, you might find special earthing straps made of braid or wire coupling the earth sections of the copper pattern to the main metal frame of the receiver. These are a likely cause of trouble if they go open. And don't forget that the sound i.f. circuit may be causing trouble, especially if it follows a common vision and sound i.f. amplifier.

"Yet another possible cause", continued Smithy, "is given by the voltage on the a.g.c. line. If the a.g.c. clamp diode goes open-circuit the a.g.c. line might go positive (Fig. 6) and this could easily cause instability if the set were already on the verge. A final possibility is that some meddler may have got at the set before you and has given all the i.f. cores a twiddle. *Some* sets might go unstable if the vision i.f.s were all set up close to the same frequency."

"What you mean," said Dick, a gleam appearing in his eye, "is that:

It may tax your credibility
But the cause of instability
May be unreliability
In decoupling capability.
Another possibility
Is that a meddler's imbecility,
Spurred by over-accessibility,
Has moved slugs with permeability!"

More Instability

"That", said Smithy feelingly, after a pause of several moments, "is the worst to date."

"I thought it was rather good myself," replied Dick modestly. "Anyway, I think I'd better get down to work on this set."

"I should," agreed the Serviceman, shortly.

Several minutes passed before a cry of triumph from Dick informed Smithy that his assistant had located the fault.

"Where was it?" called out Smithy, without turning round from his bench.

"It was a cold joint on the screen-grid decoupler for the first vision i.f.", said Dick. "I found it with that two-pronged prodder of yours. By the way, Smithy, if the instability was in the vision i.f. strip, why did I get a hiss from the speaker?"

"I would say", replied Smithy somewhat cautiously, as he put his soldering iron down for a moment, "that, in this case, it was because the unstable stage was a common vision and sound i.f. amplifier. It would then be in the sound as well as the vision i.f. strip. But it doesn't pay to be too dogmatic about these things. It's quite possible for instability in *either* the sound or the vision i.f. strip to affect the performance of the other."

"Fair enough," said Dick, as he re-soldered the cold joint to the decoupling condenser.

Several minutes later, Dick walked over to the rack and selected another television receiver to replace the one he had just repaired. He carried the new set over to his bench, switched it on and waited for it to warm up.

After a while, a bright raster filled the screen, accompanied by a loud hiss from the speaker.

"I've got *another* unstable set," wailed Dick.

"This must be your lucky morning," replied Smithy unsympathetically. "Anyway, you know the drill by now."

Dick carried on with the procedure used on the previous receivers. All would have been well had not repetition made him over-confident and careless. As he rocked the sound i.f. valve in its holder his little finger accidentally touched the metal framework of the receiver chassis. At the same time his wrist brushed the primary tags of the sound output transformer. There was a roar of anguish as Dick hastily removed his hand. His involuntary movement caused the sound output transformer to be violently wrenched away from its flimsy mounting on the printed circuit board, whereupon it became jammed

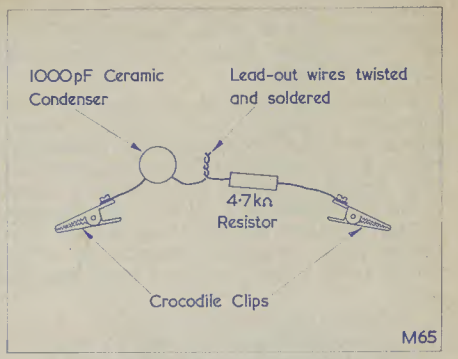

Fig. 5. A damper for locating troublesome instability faults, as explained in the text. The crocodile clips are connected between chassis and successive grids and anodes if the i.f. strip. Since a device of this nature is required only occasionally there is little point in providing flexible leads to the clips, and the component lead-out wires may be used instead, as shown. Maximum overall lead length, from clip screw to clip screw, should be 3in

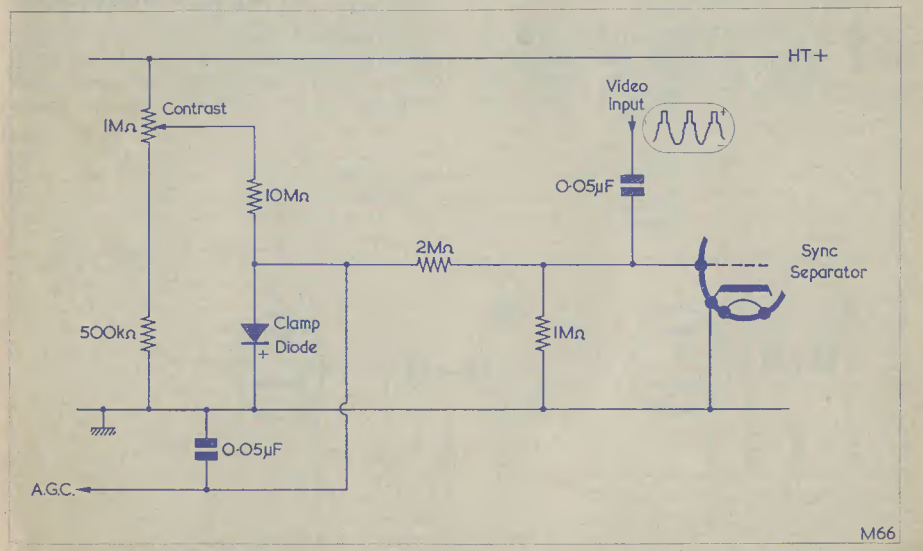

Fig. 6. A basic mean level a.g.c. circuit with fairly representative component values. The video input would normally be obtained from the anode of the video output valve. If the clamp diode becomes open-circuit the a.g.c. line goes positive

between the heater dropper resistor and the chassis framework. The valve heaters died out, and smoke began to rise from the dropper resistor.

Smithy, his attention attracted by the unwonted sounds from Dick's bench, turned round and was shaken into momentary silence at the sight of Dick standing thoughtfully beside a receiver from which a dense cloud of smoke was rising. He became entirely appalled, however, when he saw that his assistant, completely ignoring the scene on his bench, was once more breaking into verse.

"The boy stood at the burning set
Whence all but he had fled.
The flames outlined his silhouette . . ."

"*Switch it off, you dunderhead,*" yelled Smithy furiously.

Coming back to his immediate surroundings with a start, Dick look bemusedly at the receiver and quickly unplugged it from the mains. The smoke died away, and the Workshop slowly filled with the acrid fumes given off by the over-run dropper.

Licence Endorsed

"*Well,*" said Smithy, emphatically. "After *that* episode words simply fail me!"

Dick stayed silent for a moment. He appeared to be pondering a question of great importance.

"Do you know, Smithy," he remarked eventually. "I think I'll concentrate 100% on servicing from now on."

Smithy cast a threatening glance at his assistant.

"The very next time", choked the Serviceman, "you break into rhyme, when you're paid to do something much better, I fear I shall put my iambic foot right on your iambic pentameter!"

Smithy stopped suddenly, and groaned in utter despair.

"It's happened," he finished hopelessly, "and I don't know how. You've gone and got *me* at it now!"

A Phase Shift AUDIO OSCILLATOR

By J. G. RANSOME

MOST CONSTRUCTORS AT ONE TIME OR another find that they require a source of pure sine waves for amplifier testing and the like. There are three common circuits that could be employed to generate such sine waves, the Wien bridge, the bridged-T and the phase-shift oscillator; of the three, perhaps the phase-shift oscillator is the most popular amongst amateurs because it is very stable, cheap, and easy to get into operation.

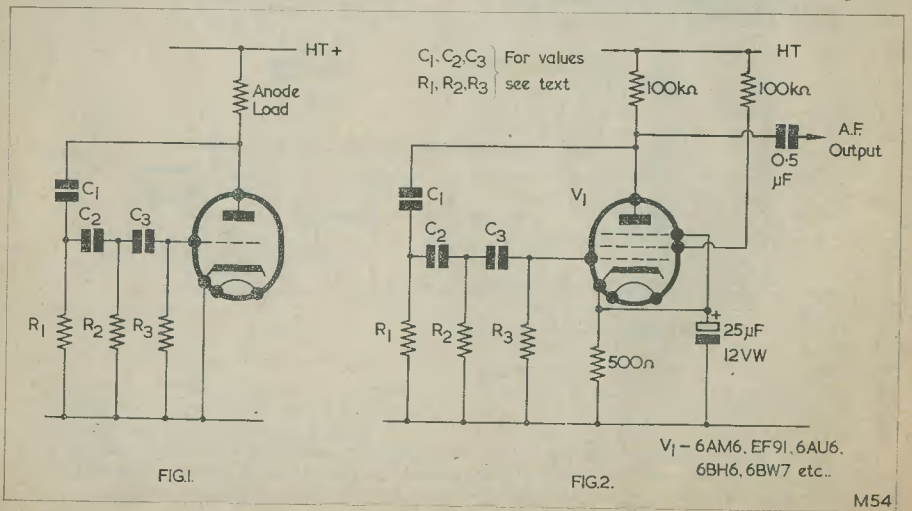

FIG.1.

V1 – 6AM6, EF91, 6AU6, 6BH6, 6BW7 etc.

FIG.2.

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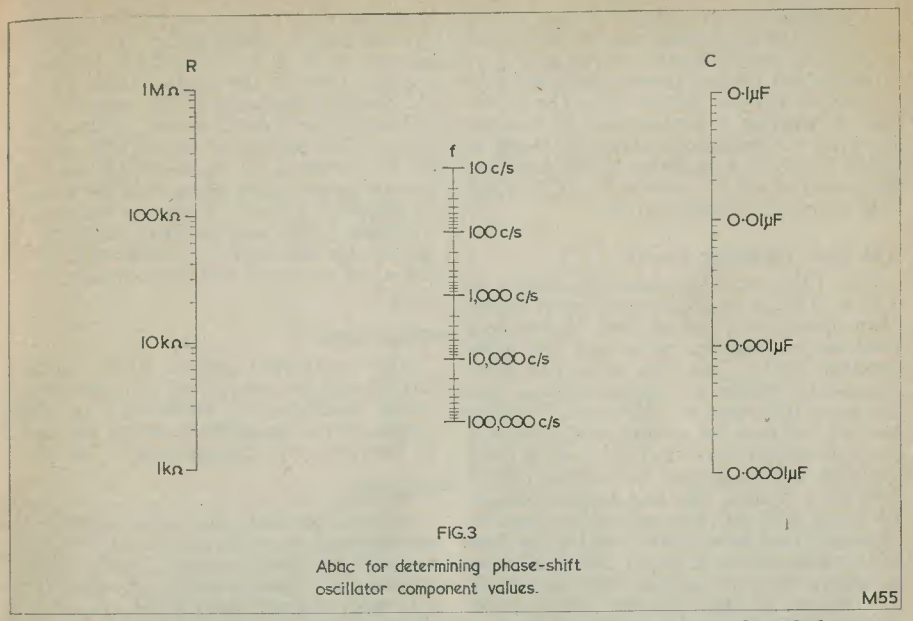


FIG.3

Abac for determining phase-shift oscillator component values.

M55

To use this abac, lay a straight-edge over the two known values and read the value of the unknown where the straight-edge meets the upright line. Example: If the frequency of operation is to be 1,000 *c/s and condensers of* 0.01μ*F are to hand, we may then find the values of the resistors to be used by joining the* 0.01μ*F and* 1,000 *c/s points. Read off the relevant resistor value. In this case it will be* 6.7*k*Ω

The Phase-shift Oscillator

The basic circuit of the phase-shift oscillator is shown in Fig. 1 and an explanation of the operation of the circuit will probably not be out of place. Let us assume that a small negative potential is applied to the grid of the triode. This reduces the flow of electrons to the anode of the valve and therefore reduces the anode current. Reducing the anode current reduces the voltage drop across the anode load and results in a rise in anode voltage. Thus, a negative voltage on the grid of the valve causes the anode voltage to rise. In consequence, the anode is out of phase with the grid by 180°. Variations in anode voltage are fed back to the grid by the RC network, R_1, C_1, R_2 C_2, and R_3 C_3. However, each RC pair produces a phase-shift of its own, and if we arrange for each group to produce a phase-shift of 60° at a chosen frequency then the whole network will have a phase-shift of 180° at that frequency. This is just what we need for sustained oscillation. The valve produces a phase-shift of 180° between its grid and anode and the RC network produces a phase-shift of 180° between anode and grid thus producing a total shift of 360° and feeding back to the grid a signal in phase with the initial signal. This ensures sustained oscillation. There is one other consideration before we discuss the practical circuit. It will be obvious that there must be a signal loss in the phase-changing RC network and, therefore, the valve will have to have a substantial voltage gain in order to overcome this loss. It can be shown that the minimum gain required is 29 times if perfect components are used.

It is usual (and convenient) to give all condensers and resistors of the phase-shift network the same value. For a particular frequency of operation the values of the components may be calculated from the expression:

$$f = \frac{1}{2\pi\ RC\sqrt{6}}$$

Where f is the operating frequency in c/s
R is the value of the resistors to be used for R_1, R_2 and R_3 in ohms, and
C is the value of the condensers to be used for C_1, C_2 and C_3 in Farads.

A practical circuit is shown in Fig. 2. The values of the condensers may be calculated or read off from the abac shown in Fig. 3. A pentode is used to provide sufficient gain to ensure reliable oscillation. The 0.5μF output coupling condenser may be reduced in value, for frequencies above 1,000 c/s, to about 0.1μF. An oscillator in this form has been used as the a.c. source in a CR bridge and has given excellent service.

The Final Oscillator Circuit

The final oscillator circuit is shown in Fig. 4. This is a more comprehensive circuit than those previously outlined. It has been used as an amplifier tester and has given excellent results. The basis of the unit is the phase-shift oscillator comprising $V_{1(a)}$ and the associated network. However, it will be noticed that there are a number of differences from the circuit shown in Fig. 2. R_2 is made variable, thus providing a small amount of frequency control. R_1 and R_3 now consist of three sections, two of which may be short-circuited by the switch S_1 having three centre frequencies of about 250, 1,000 and 6,000 c/s, each being variable over ±10% by means of R_2. Should other centre frequencies be required then suitable resistors will have to be substituted for those shown.

The oscillator output is taken from the anode of $V_{1(a)}$ via the switch S_2. Operation of this switch selects either the oscillator output or a 50 c/s tone from the heater supply. From S_2 the signal is taken through the coupling condenser to the output control potentiometer R_8 and, thence, to the grid of $V_{1(b)}$. This section of the ECF82 operates as a conventional phase-splitter and the output signal can be taken from the cathode or anode as desired. Since two outputs are available which are balanced and out of phase, this unit will find application in the testing of push-pull and stereophonic amplifiers.

Construction

The component layout is in no way critical and any convenient arrangement will prove satisfactory. However, for those constructors who prefer to adopt the layout of the prototype, this is shown in Fig. 5.

Operation

Having checked all wiring against the circuit diagram, switch on and allow the unit to warm up. Next, connect a pair of headphones (or other means of reproducing an a.f. tone) between one of the outputs and chassis. Set S_2 to the "50 c/s" position and advance the output control until a 50 c/s note is heard. If there is no output and the valve lights up check the connections to $V_{1(b)}$. Should a good strong 50 c/s tone be heard in the headphones, set S_2 to the "Oscillator" position, set S_1 to the 250 c/s position, and manipulate R_2 until a note is heard. Should no signal be heard at any setting of R_2 then check the wiring to $V_{1(a)}$. If a note is heard then switch to the second range and repeat the operation on R_2. If results are satisfactory switch to Range 3 and again repeat the adjustment of R_2 until oscillations are heard. It will almost certainly be found that the oscillator will cease to function at certain settings of R_2. This is quite normal and once the sweep range for satisfactory operation for each position of S_1 has been found experimentally, then R_2 may be calibrated accordingly.

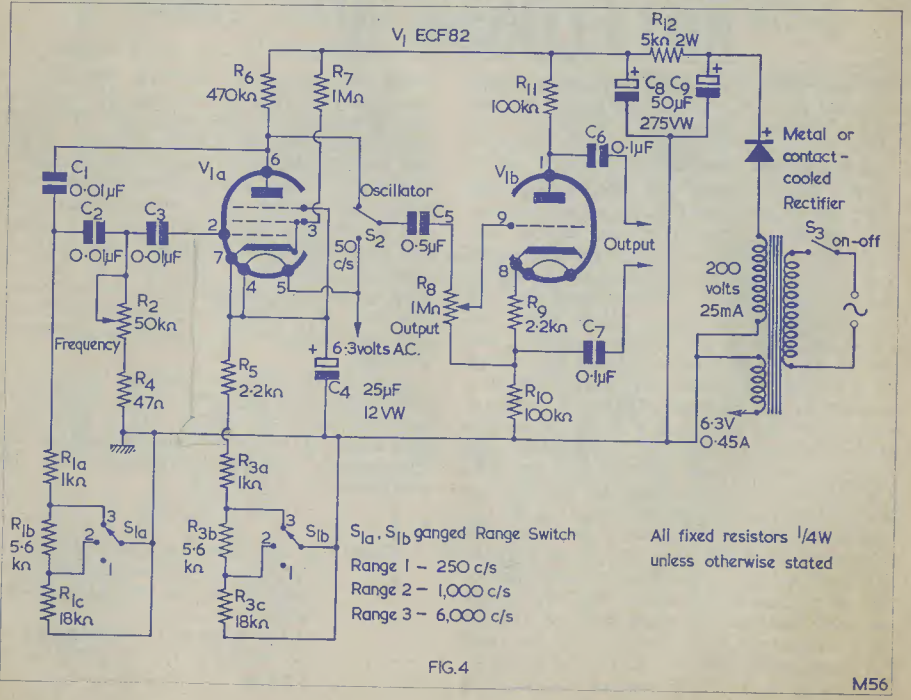


FIG.4

M56

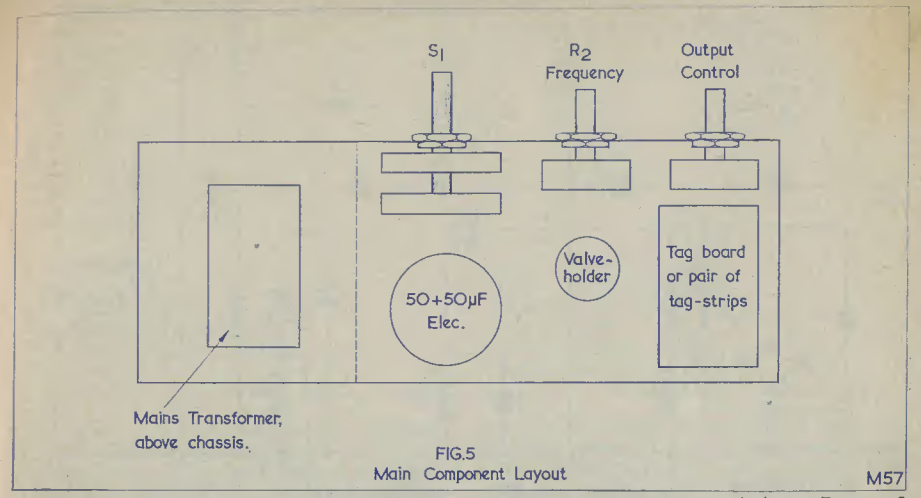


FIG.5
Main Component Layout

M57

A 2-Waveband TRANSISTORISED TUNER

by A. S. CARPENTER

A simple but highly efficient design using only two transistors and employing variable inductance tuning

NOW THAT TRANSISTORS ARE AVAILABLE to constructors at competitive prices it becomes possible to add considerably to one's enjoyment of the radio hobby without having to worry too much about the financial aspect. Although it is not reasonable to expect a cheap surplus transistor to perform so well as a manufacturer's tested and branded component, nevertheless very pleasing results can be obtained and at least one is spared the worry of accidentally damaging such a transistor, since only a few shillings are involved.

Today, transistorised receivers, like their valved contemporaries, fall into two classes, viz., t.r.f. and superhet, the latter variety being the most sensitive of the two and, of course, the most expensive to construct. For simplicity, however, the t.r.f. type has much to recommend it and can, when properly used, provide very real entertainment of good quality.

A great many simple transistor circuits employ a diode for demodulation purposes in the aerial circuit followed by three, four, or even more transistors to provide a.f. amplification and, whilst the final value of audio output might be acceptable, the selectivity is likely to be atrocious due to the diode being used at the front end of the circuit. The sensitivity of such a set is in fact no more than that of a crystal receiver and is therefore of little practical use. Many of the simpler circuits fail to provide Long waveband facilities and, since a great deal of the country still relies on receiving the Light programme on 200 kc/s, this is a very serious omission.

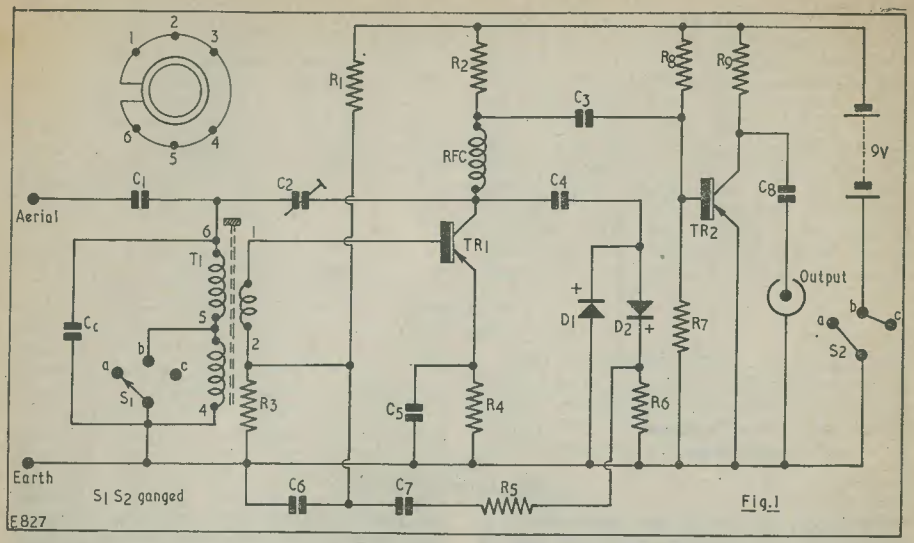


Fig. 1

The Tuner

The tuner presented here—which overcomes the above mentioned difficulties successfully—might be more fully described as "core-tuned" since no variable tuning condenser is needed due to the use of a special inductor. It includes an r.f. stage, uses a voltage doubler demodulator and is reflexed for extra gain.

The output may be fed either into the "gram" sockets of a broadcast receiver or to an amplifier, the latter function being that for which the tuner was designed. Alternatively, phones may be plugged into the output socket, whereupon it will be necessary to fit a volume control. Details of a suitable volume control are given later. Details will also be given for using a loudspeaker and, as a guide to the amount of volume obtained, it can be stated that the prototype has driven an 8in speaker unit at good volume over 100 miles from the transmitter, although the distance necessitated the use of an aerial. In strong signal areas sufficient pick-up should be obtained on the built-in ferrite aerial inductor as was intended in the original design.

The Circuit

The circuit is given in Fig. 1, which also shows the tag layout on the inductor tag-ring. The two transistors TR_1 and TR_2 are

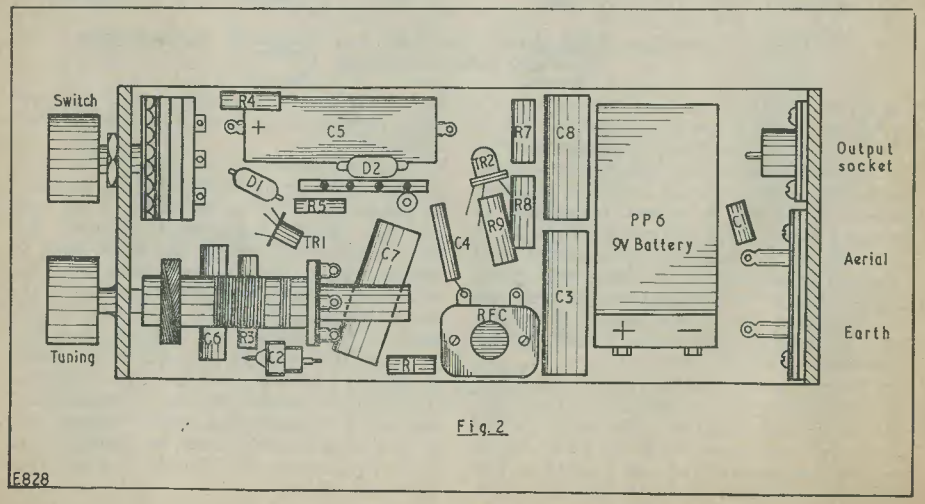


Fig. 2

Components List

Resistors

R_1	68kΩ
R_2	4.7kΩ
R_3	10kΩ
R_4	1kΩ
R_5	2.2kΩ
R_6	10kΩ
R_7	10kΩ
R_8	560kΩ
R_9	4.7kΩ

Crystal Diodes

OA70

T_1 Teletron FX25

RF choke, Osmor type QC1

S_1 2-pole, 3-way yaxley

2 control knobs

Condensers (miniature types)

C_1	75pF
C_2	30pF concentric trimmer
C_3	0.25μF
C_4	50pF
C_5	25μF electrolytic
C_6	6,000pF
C_7	0.25μF
C_8	0.1μF

Transistors

TR_1 White spot

TR_2 Green/Yellow spot

Battery, Ever-Ready PP6

Tag Strip (4+1)

Coaxial socket

Aerial/Earth socket

operated in the familiar earthed emitter mode to obtain maximum gain.

Before tracing the signal path it might be as well to consider T_1, the ferrite aerial inductor, the inductance of which can be varied by screwing the core (which extends the whole length of the unit) in and out of the former. A threaded brass stem protrudes in such a way that a standard control knob may be fitted by using the special bush provided. Also pre-fitted to the inductor is the condenser marked C_c in Fig. 1 which has a value of 500pF.

A suitable impedance match into the base of TR_1 is accomplished by means of the low impedance winding between tags 1 and 2 on T_1. The selected signal is therefore applied to TR_1, which acts as an r.f. amplifier, and reappears, considerably amplified, at the junction of C_2, C_4 and the r.f. choke. Finding the choke too great a barrier the r.f. signal passes via C_4 to the demodulator comprising crystal diodes D_1 and D_2. A controllable portion of the r.f. is, also, passed back via C_2 to the base of TR_1 to improve sensitivity and gain. The crystal diodes detect the signal, and the resultant audio frequency is developed across R_6. Now, however, instead of feeding the a.f. signal direct to TR_2 it is applied to R_5 and

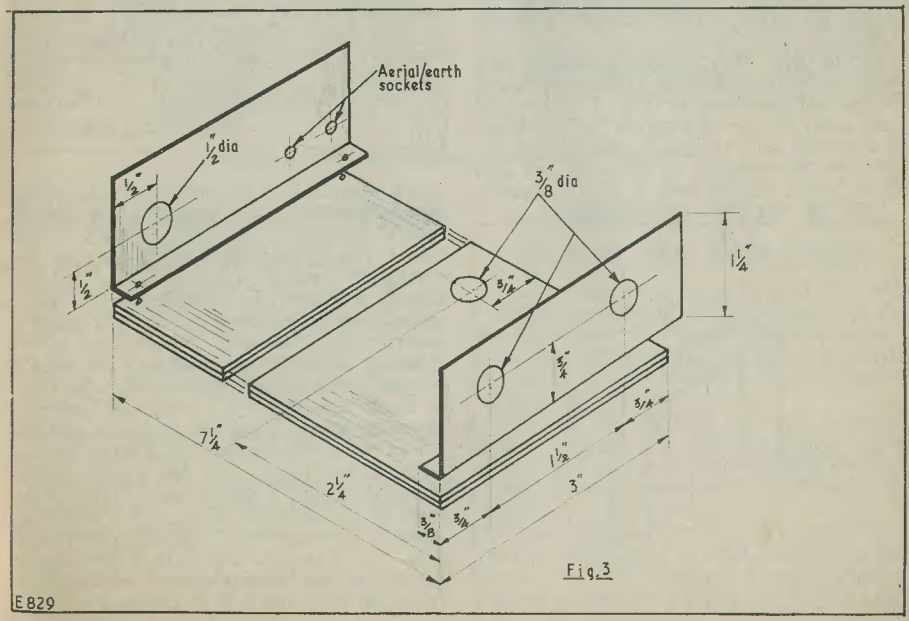


Fig. 3

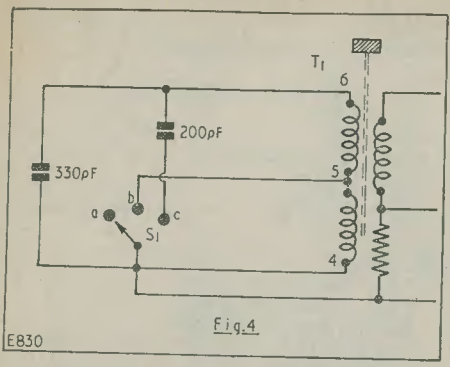


Fig.4

C_7, being subsequently fed to TR_1 via the inductor low impedance winding. TR_1 now operates in its second role, viz. as a.f. amplifier. When the audio frequency signal appears at the collector of TR_1 it encounters the high impedance offered by C_2 and C_4, and the low impedance given by the r.f. choke. The a.f. signal passes through the choke to the junction of R_2 and C_3 and, thence, to the base of TR_2 for further and final amplification.

The action of C_6 is similarly of interest in the reflex action just described, since it serves a treble role. Firstly, it makes the bottom terminal of the low impedance winding of T_1 "earthy" as far as r.f. is concerned; secondly, it bypasses any radio frequency signal remaining after demodulation; and, thirdly, it acts as a barrier to a.f. so that the latter may be successfully passed to TR_1.

On/off and wavechange switching are accomplished by means of a miniature rotary switch and reference to Fig. 1 will reveal that, when S_1 S_2 is at position "a" the tuner is switched off. Turning the switch to position "b" switches on the unit and also short-circuits tags 5 and 4 of T_1, thereby switching the inductor to Medium waves. At position "c" the whole of the tuned winding is brought into use and the Long waveband thus becomes available. To power the unit a 9 volt battery (Ever-Ready type PP6) is used.

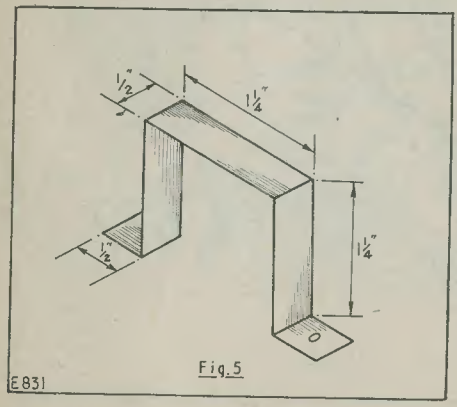


Fig.5

Constructional Details

As mentioned earlier the unit was used to feed into an existing amplifier and the framework was built to this end. The illustrations, Figs. 2 and 3, show the layout of the components and also the various dimensions. The "breadboard" principle is used, most of the components being fixed to a piece of $\frac{1}{8}$in hardboard 7$\frac{1}{4}$in x 3in. Two panels are also required (see Fig. 3) and these may be made from tin plate, 18 s.w.g. aluminium, or any similar material. Components can, if necessary, be retained to the board by nuts and bolts but to avoid spoiling the appearance of the board (which is in fact the top panel when in use) the items may be secured with one of the many strong adhesives now readily available. The hole drilled in the board should not be covered during the wiring-up process as this will be used for tuning purposes on completion. Fig. 7 shows the appearance of the completed tuner.

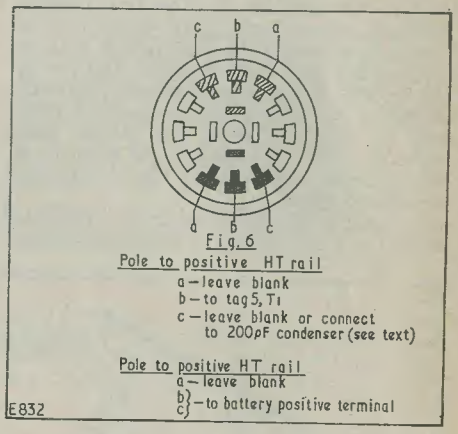


Fig.6

Pole to positive HT rail
a – leave blank
b – to tag 5, T1
c – leave blank or connect to 200pF condenser (see text)

Pole to positive HT rail
a – leave blank
b } – to battery positive terminal
c }

It will be found convenient to run a bare copper wire along one side of the baseboard to form a negative h.t. rail and another, similarly placed along the opposite side, to act as the positive rail. The battery can be retained by means of the simple fitting depicted in Fig. 5, which can be cut from a piece of thin tinplate. During the wiring-up operation the core of T_1 is best removed so that the inductor tags are more easily accessible, care being taken to leave sufficient room for later insertion of the core.

Switch details are shown in Fig. 6 and, although a 4-pole 3-way type is depicted, the choice of component is not important. The two poles and their three terminals are shown shaded and solid respectively, and the remainder of the contacts should be ignored.

The Tuning Dial

Before replacing the inductor core a suitable piece of plain paper is glued around its complete length, this being of such a thickness as to permit free but firm core rotation. The core is then placed in position and screwed fully home. Later, when transmissions are tuned in, a coloured ball-point pen may be inserted through the tuning aperture (see Fig. 7) and the appropriate point marked on the core.

Operation

When all is ready the unit may be connected to an amplifier and switched on, whereupon a distinctive hiss should be heard. C_2 should be unscrewed as far as possible and, when an aerial is plugged in, transmissions should be tunable by means of the appropriate control knob. C_2 may then be set for optimum operating conditions. If oscillation becomes evident, C_2 should be unscrewed slightly.

Modifications

It might be found that it is not possible to tune down to 208 metres even when the core of T_1 is fully out. This is due to condenser C_c (Fig. 1), plus the aerial-earth capacity. To overcome this difficulty the small modification shown in Fig. 4 may be made. The existing condenser C_c is removed and one of approximately 330pF fixed in its place, whilst a further 200pF condenser is connected between tag "C" on the switch and tag 6 on the inductor. Care should be taken to avoid damage to the coil wire and connections when removing C_c.

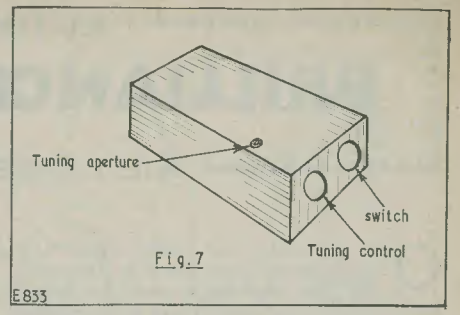


Fig.7

If, as mentioned earlier, it is intended to use the unit as a self contained receiver, a volume control can be included by replacing R_6 with a 10kΩ potentiometer, the end of R_5 shown in Fig. 1 connecting to D_2 being taken instead to the slider. If a loudspeaker is to be used R_9 should be replaced by the primary winding of an output transformer, C_8 being removed. One side of the output transformer secondary winding should now be connected to the output socket and the other to the positive h.t. rail.

Final Points

The white spot and green/yellow spot transistors may be altered to XA103 and XA104 respectively if preferred; also, condensers C_3 and C_7 can be given a larger capacity to improve the response should this be desired. All other component values should be as specified. The r.f. choke must be a good quality component since a great deal of the operational efficiency depends upon it.

BRENTFORD EVENING INSTITUTE

During the session 1961–62 classes are being arranged in the following subjects:

Radio Amateurs' Course in preparation for the London City and Guilds Examination. Wednesday, 7 to 9 p.m. Course fee 30s.

Morse Code for amateurs. Tuesday, 7 to 9 p.m. 10s. per term.

Mathematics for Radio Amateurs. Thursday, 7 to 9 p.m. 10s. per term.

Radio Servicing. Tuesday, 7 to 9 p.m. Course fee 30s.

All classes open week beginning Monday 18th September.

LANDING THE PYE WAY IN POLAND

It has been announced by Pye Telecommunications Limited of Cambridge that the Polish Government have placed an order with them for a Pye Instrument Landing System for use at Okecia, the Warsaw International Airport.

This will be the first instrument landing system ever to be employed in Poland—providing a radio-navigational aid which will enable Western aircraft to land safely in conditions of bad visibility.

There are now 133 Pye Instrument Landing Systems installed at airfields throughout the world and this includes 13 installations at airports in Eastern Europe.

AUTOMATIC BRILLIANCE CONTROL

By D. J. LINSEY, A.M.I.P.R.E.

OVER THE PAST FEW YEARS THERE HAVE been many devices used in television. We have had frame and line flyback suppression, automatic picture and frequency control, "slim line" and an alternative programme, to name a few. Now it is a light sensitive device

Control of Contrast

The light sensitive device used by the manufacturers automatically adjusts the contrast of the picture as the ambient light of the room changes, and the control may consist of a light sensitive resistor which modifies the vision a.g.c. voltage.

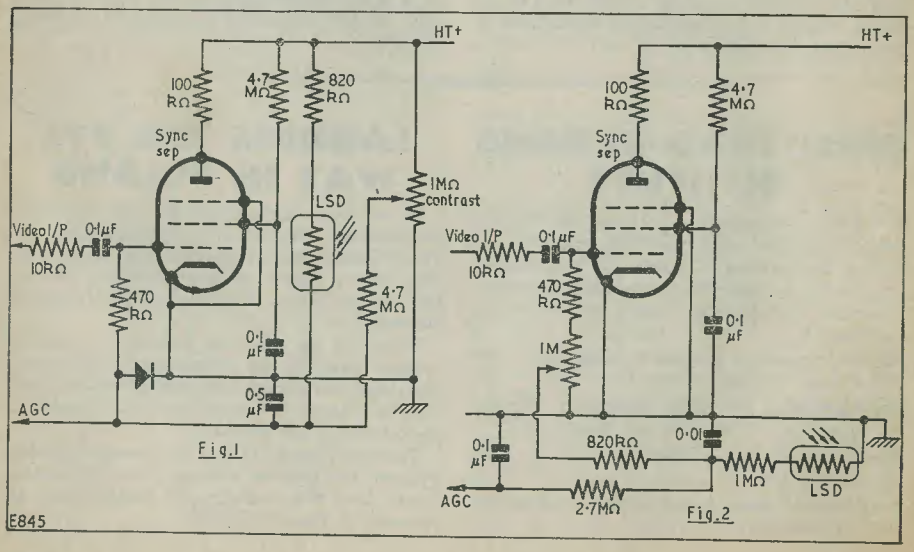
If the ambient light increases the resistance of the light sensitive device decreases, resulting in a reduction of the a.g.c. voltage, and an increase in vision gain. If the ambient light decreases the resistance of the light sensitive device increases, more a.g.c. voltage is applied to the controlled stages and the contrast is reduced. The light sensitive device used is the Mullard photoconductive cell ORP60 or equivalent. Figs. 1 and 2 show typical light sensitive device a.g.c. circuits.

A big disadvantage with varying a.g.c. voltage by light changes is that in fringe areas, where there is little or no a.g.c. voltage due to the low signal input, the light sensitive device cannot work.

In strong signal areas, moreover, the reverse may happen. As the a.g.c. voltage varies with the ambient light there is a serious danger of cross-modulation in the receiver, and this has actually been experienced by the writer. What happens in this instance is that, if the contrast control is set at low room lighting and the ambient light is then increased, less a.g.c. is fed back to the r.f. stages. In consequence the r.f. stages overload and cross-modulation takes place. Quite often the whole r.f. and i.f. stages become unstable and the video output valve is overdriven and glows red hot. These effects are most noticeable when mean level a.g.c. circuits are employed.

Control of Brilliance

An alternative arrangement with a light sensitive device is to vary the black level or brilliance of the picture, and not the contrast, by changes in ambient room lighting.



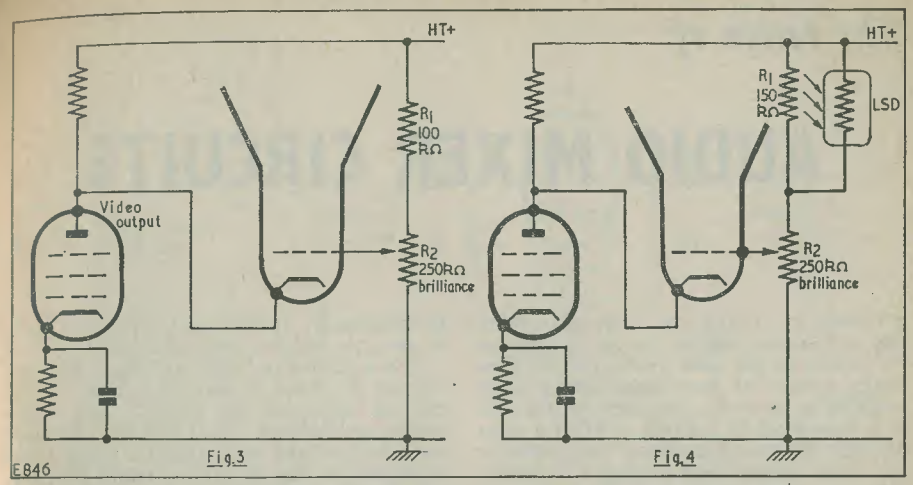


Fig. 3 shows a conventional television brightness circuit. As the grid of the c.r.t. goes positive the brightness of the c.r.t. increases. It will, therefore, be evident that if the light sensitive resistor were connected in series with the brilliance control we have a simple but effective control device.

To modify such a circuit to automatic brightness control all that must be done is to increase R_1 to 150kΩ and connect the light sensitive resistor in parallel as in Fig. 4. As the ambient light increases the resistance of the light sensitive resistance decreases, causing the grid voltage of the c.r.t. to rise and the brilliance to increase. Obviously, the reverse effect may also take place.

In the circuit of Fig. 4, with an h.t. of 200V and at normal brilliance level, a potential of 72V was measured on the grid of the c.r.t. with a small light in the room. When the normal room lighting was switched on this voltage rose to 85. About 15V swing on the grid of the c.r.t. was found to give the right amount of variation in brilliance on the c.r.t. screen. Other suitable values for R_1 and R_2 were 100kΩ and 150kΩ respectively.

The photoconductive cell measures only 16mm long and 6mm in diameter. It has an end-on incidence of illumination and has tinned wire connecting leads. It should be mounted "looking out" of the cabinet front.

The writer has used the device described here for some time without any trouble whatsoever.

NEW G.E.C. "LONG LIFE" DOUBLE TRIODE VALVE

A new G.E.C. double triode valve, type A2900, has been introduced by the M-O Valve Co. Ltd., Brook Green, Hammersmith, a subsidiary of the General Electric Co. Ltd. This valve is fitted with the B9A base and it has been designed to replace the international type 12AT7, particularly in computer and switching applications where long life and reliability are essential. Since the characteristics are similar in many respects to the 12AT7 and dimensions and base are also alike, no circuit modifications are required in the majority of applications.

Key features of this new valve, of special interest to designers of industrial equipment, are a close control of characteristics and a life expectancy of up to at least 10,000 hours under approved working conditions.

The performance of the A2900 reflects an extremely tight control of manufacture. Anode current differences between the two triode sections will not exceed 1.25mA over a mean average spread of 10.5± 1.5mA, while mutual conductance between the two systems will not differ by more than 1 mA/V over a mean average of 6.2±0.8mA/V. This close degree of tolerance in the specification will remove many of the difficulties experienced in these respects by the use of a normal double triode valve.

A guarantee exists for the A2900 covering lives up to 10,000 hours. Particulars of this life guarantee together with full technical data can be obtained on application to the M-O Valve Co. Ltd.

The design of

AUDIO MIXER CIRCUITS

by **F. E. ASH**

SOONER OR LATER THE HI-FI ENTHUSIAST will come across some application where he will need to mix two or more audio signals to feed either to a main amplifier or to a tape recorder. In the case of a tape recorder, mixing is often a most desirable feature and allows sound effects, etc., to be added whilst making a recording.

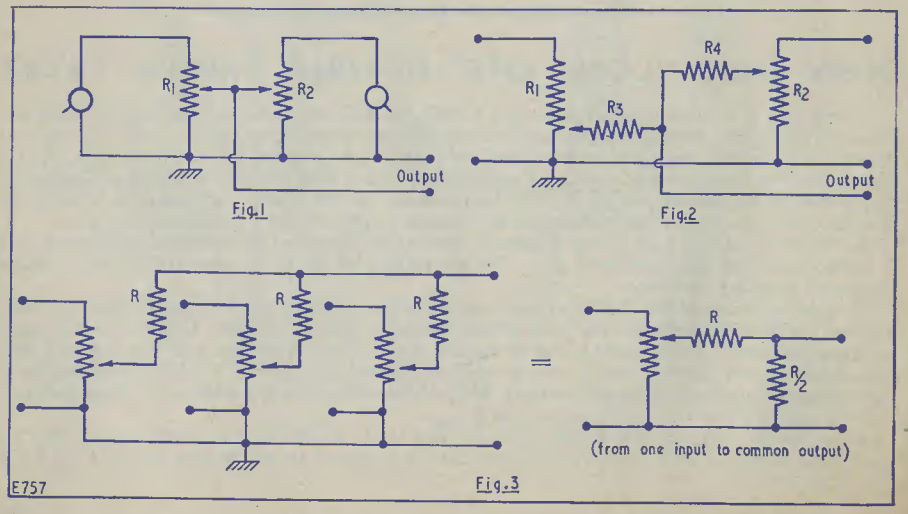
Several mixer circuits have been published for use with various amplifiers, but in the majority of cases where a mixer is required, a standard circuit will not suffice, because the user will need some special requirement, such as an extra channel for microphone —and adding this to an existing design may not be a practical proposition.

It is therefore proposed to give some fundamental design considerations, from which constructors may be given a lead to design audio mixer units to suit their own particular requirements.

To start with, let us consider the simplest case—mixing two audio signals of comparable amplitude. Provision must be made to control the volume level of each signal independently. If the simple circuit of Fig. 1 is used, the volume controls interact.

If it is desired to "fade out" one signal by turning R_1 down to zero, the slider of R_2 will be automatically earthed, and both signals will fade out. This may be overcome by including fixed resistors in the slider arms as shown in Fig. 2. To be really effective these resistors must be large compared with the associated potentiometers.

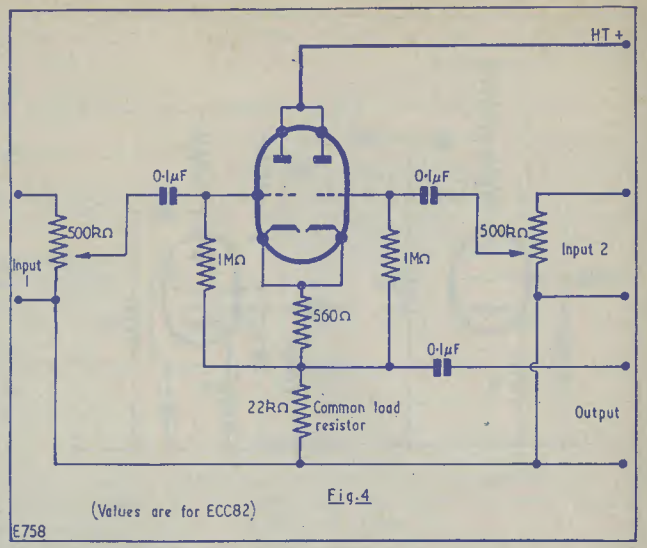
If R_1 is turned down to zero to fade out the first signal, the second signal, after leaving R_2, is applied to a potential divider consisting of R_3 and R_4. These are normally of equal value, so the available output voltage is reduced by 50%. Suppose that no signal is applied to input 1, but R_1 is now turned up to a maximum. The available output voltage is now $\frac{R_1+R_3}{R_1+R_3+R_4}$ of its full value, i.e. more than 50%. If $R_1=R_3=R_4$, the value will rise to 60%. By making R_3 and R_4 larger than R_1 this variation can be reduced.



Whenever two signals are mixed by this method a maximum loss of 50% occurs. If three signals are mixed by this method (as shown in Fig. 3), two-thirds of the available signal is lost from one input to the common output, as will readily be seen from the equivalent circuit.

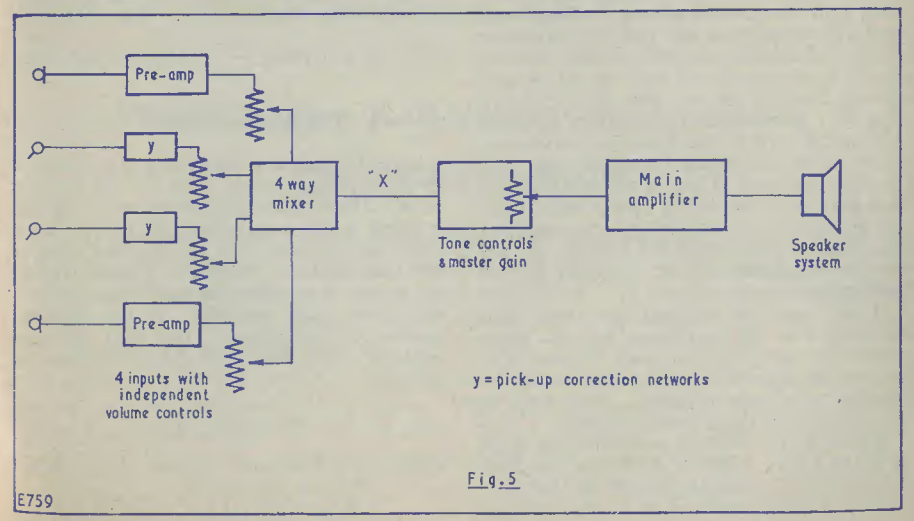
It will now be appreciated that a loss occurs whenever signals are mixed, and it is not practicable to use an existing amplifier for mixing without compensating for this loss in some way. The answer is to provide a separate mixer unit—including valves—which may be used in conjunction with the existing equipment. The main requirement of such a unit is that it should require the same input as the amplifier itself and give the same output—i.e. the gain from input to output should be approximately 1. If this condition is satisfied, an amplifier that was previously used with a pick-up and radio feeder, selection being by means of a change-over switch, can incorporate the mixer in place of the switch, and the two signals can be mixed, the level of each signal being independently variable.

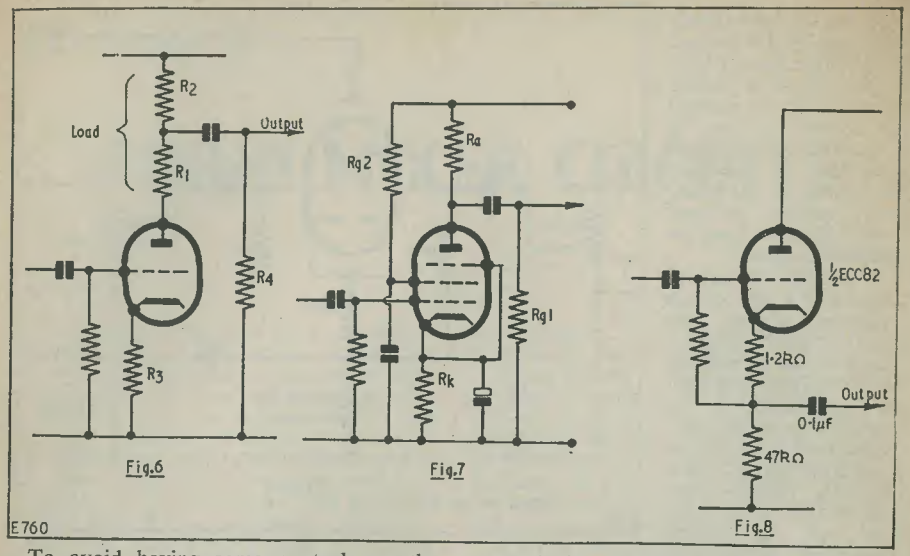
A gain of 1 may immediately suggest to some readers the cathode follower, and indeed quite an effective mixer for two channels may be designed using the circuit of Fig. 4.



Since the inputs are entirely separate, the setting of the potentiometers will not be interdependent; and no series resistors are needed in the input circuits. The net gain from either input to the output terminals is slightly less than one, so the circuit can be used with existing equipments.

The low impedance output is also an advantage, since the mixer unit can be mounted at some distance from the main amplifier without any loss of the upper frequencies.





To avoid having some controls on the amplifier and some on the mixer unit—which may be mounted separately—it is advisable to mount the tone controls and master gain control in the mixer unit, thereby keeping all controls together.

From an economical point of view, separate tone controls will not be possible on each channel, and it is doubtful whether they would serve any useful purpose, since in general the setting of bass or treble controls is dependent mainly upon the acoustics of the room or hall in which the equipment is to be used.

The block diagram of a typical system using four channels is shown in Fig. 5. It should be noted that any pick-up correction circuits required should be included between the pick-up concerned and its associated volume control, as indicated in the block diagram. The pick-ups shown are assumed to be of the crystal type, which in the absence of the mixer unit would be sufficient to load the amplifier itself if fed in at point "x". If magnetic pick-up heads are used, these would require an additional pre-amplifier stage and suitable correction circuits. In any case pre-amplifiers will be necessary for the microphone inputs.

If an input is required for tape, it is advisable for the correction to take place within the tape amplifier itself. It may also be desired to take off a separate outlet for feeding to a tape recorder. This may be paralleled with the normal output.

The best valve for the pre-amplifiers is the Mullard EF86, whilst a double triode such as the ECC83 would be suitable as the mixer valve. If the mixer unit is to be mounted remotely from the main amplifier a cathode follower output is advisable; and one half of the double triode can be used as the mixer, and the other half as the cathode follower output stage. In this case it is more convenient to connect the tone controls between these two stages, as connecting them to the output would destroy the low output impedance, unless unusual values are used.

The Mixer Stage

Only a low gain is required from the mixer stage itself—sufficient to just compensate for loss in the input resistors. It has already been shown that this loss depends on the number of channels used. With two channels $\frac{V_{in}}{V_{out}}=2$, with three $\frac{V_{in}}{V_{out}}=3$, whilst with four $\frac{V_{in}}{V_{out}}=4$. The gain required is rarely likely to exceed 5 and it is something of a problem to obtain such a low gain as this from a valve. There is no advantage to be gained in using a high anode load; in fact, a more linear output can often be obtained using a low load resistor. Neither is it necessary to use a high μ triode—one half of an ECC82 would be quite suitable. If the cathode resistor is unbypassed, the gain can be reduced. The gain under these conditions is given by

$$A'=\frac{A.R_a}{R_a+A.R_k}$$

where A′ is the gain without the cathode bypass capacitor C_k
A is the original gain (with C_k)
R_a is the anode load resistor, and
R_k is the cathode bias resistor.

Finer adjustment of the gain can be obtained by using a split anode load as shown in Fig. 6.

The output voltage is reduced by a factor of $\frac{R_2}{R_1+R_2}$ of its normal value with the full load when using this method.

A table is given showing circuit values for the ECC82 when used in this application for gains of 2, 3, 4, 5 and 6.

TABLE 1
ECC82 (ONE HALF) AS AUDIO MIXER
(*See Fig.* 6)

Gain req'd	R_1	R_2	R_3	R_4
2	39kΩ	10kΩ	1.2kΩ	330kΩ
3	33kΩ	15kΩ	1.2kΩ	330kΩ
4	27kΩ	18kΩ	1.2kΩ	330kΩ
5	22kΩ	22kΩ	1.2kΩ	330kΩ
6	18kΩ	27kΩ	1.2kΩ	330kΩ

Microphone Pre-amplifiers

As mentioned earlier, the EF86 is the valve recommended for this application. The manufacturer's data for this type is very comprehensive and gives numerous operating conditions. Some of these are quoted in Table 2.

TABLE 2
EF86 AS VOLTAGE AMPLIFIER (*Fig.* 7)

V_b (V)	R_a (kΩ)	R_{g2} (MΩ)	R_k (kΩ)	Gain	R_{g1} (kΩ)
250	100	0.39	1.0	112	330
250	220	1.0	2.2	180	680
200	100	0.39	1.0	106	330
200	220	1.0	2.2	170	680

Higher gain can be obtained by the use of grid current biasing, and even higher gains by using starvation techniques, although in the latter case the upper frequency limit is likely to be reduced.

The Output Stage

As mentioned earlier, a cathode follower output stage is recommended if the unit is to be used remote from the main amplifier. The average constructor seems under the impression that there is some magic in designing a cathode follower; but, in point of fact, a perfectly satisfactory circuit can be obtained from the manufacturer's operating conditions simply by putting the recommended anode load in the cathode lead. A suitable circuit is shown in Fig. 8, employing one half of an ECC82.

West Country Ambulances Equipped with Pye Radiotelephones

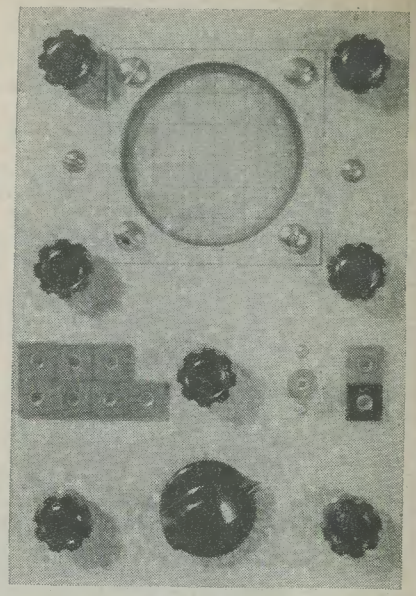
Pye Telecommunications Limited of Cambridge have been awarded the contract for the supply of radiotelephone equipment for Devon County Ambulances. The installation will be carried out in four stages, the first part consisting of one fixed station, remote controlled, and 15 mobile units. On completion the scheme will comprise four fixed stations and approximately 60 mobile equipments.

It is anticipated that ambulances in the Torbay area will be equipped with radiotelephones before the start of the main holiday season. With the inclusion of the radiotelephone equipments now being supplied to the Monmouth County Council all ambulances in south-west England and south Wales will be equipped with Pye radiotelephone units.

Pye Telecommunications Limited have now equipped the ambulances of over 100 county boroughs and county councils in England and Wales with radio communications equipment.

A CONSTRUCTOR'S OSCILLOSCOPE

by D. NOBLE, G3MAW
and D. M. PRATT, G3KEP



PART 1—*A Construction of the Mullard Design*

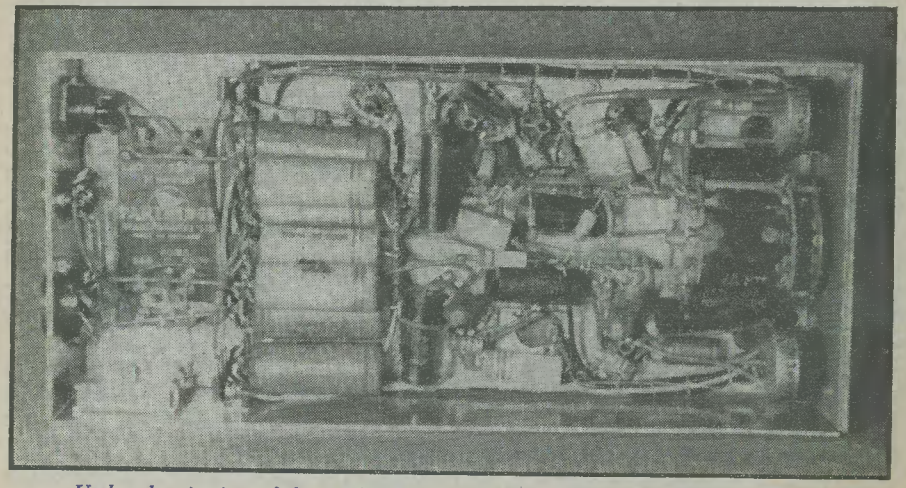
Design Considerations

The oscilloscope to be described in this series of articles* was designed to meet the need for an adequate but not over-elaborate instrument suitable for most radio and television applications. It uses standard components, most of which may be obtained through normal channels. No special e.h.t. transformer is required, as the Mullard DG7-32 cathode ray tube used will operate on a final anode voltage as low as 400 volts.

Details of an attenuator probe and high-gain probe of limited bandwidth for use with the instrument will be given later.

Conventional chassis and wiring methods are used and despite its small size, the oscilloscope is designed to be easily assembled.

* The circuit of the oscilloscope was published in "Circuit for a Simple Oscilloscope", *Mullard Technical Communications*, Volume 4, No. 32, this being based on a report prepared by L. S. Brown of the Mullard Applications Research Laboratory. Further information was given in *Scope for Service*, Mullard Publication No. TP374.



Under-chassis view of the oscilloscope. Note that the mains transformer is fitted with tags and not flying leads

Specification

	Direct Input	Probe x 10	Pre-amplifier
Input resistance	1MΩ	10MΩ	0.5MΩ
Input capacitance	20pF	10pF	10pF
Maximum sensitivity	100mV/cm	1,000mV/cm	1mV/cm
Maximum signal input	30V	300V	3V
Frequency response (to 3dB)	2 c/s to 2.5 Mc/s	5 c/s to 20 kc/s	

Circuit Description

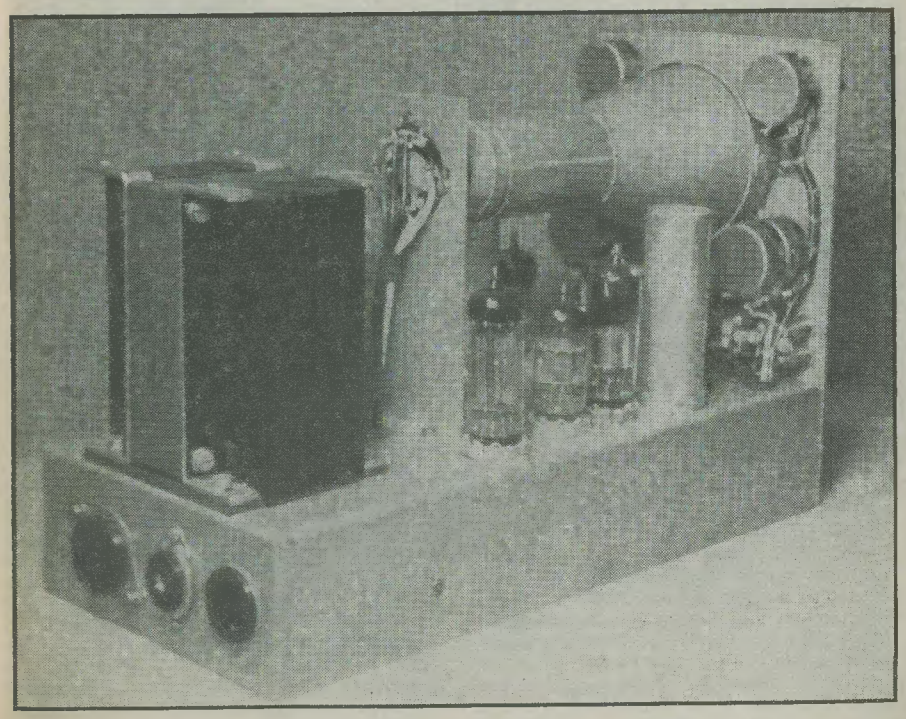
The main circuit diagram for the oscilloscope is given in Fig. 1.

Y Amplifier

A simple high gain circuit is used incorporating two triode-pentodes, V_2, V_3. The circuit comprises a cathode follower, two pentode amplifiers and a phase-splitter giving push-pull output to the tube deflector plates. The gain control (RV_{21}) is provided after the cathode follower, from which point is taken the connection to the internal sync socket also. The two pentode sections provide a gain of about 60 times, some frequency correction being given by the cathode decoupling condensers, C_8, C_{10}, which are effective only at high frequencies. The frequency response of the amplifier to 3dB is 2 c/s to 2.5 Mc/s.

Timebase

The timebase oscillator consists of the EF80, V_5, in a Miller-transitron circuit. The associated double-triode, V_4, is used as a sync amplifier and as a phase-inverter. The timebase frequency is dependent upon the time constant of RV_{44}, the fine frequency



Above-chassis view of the completed oscilloscope

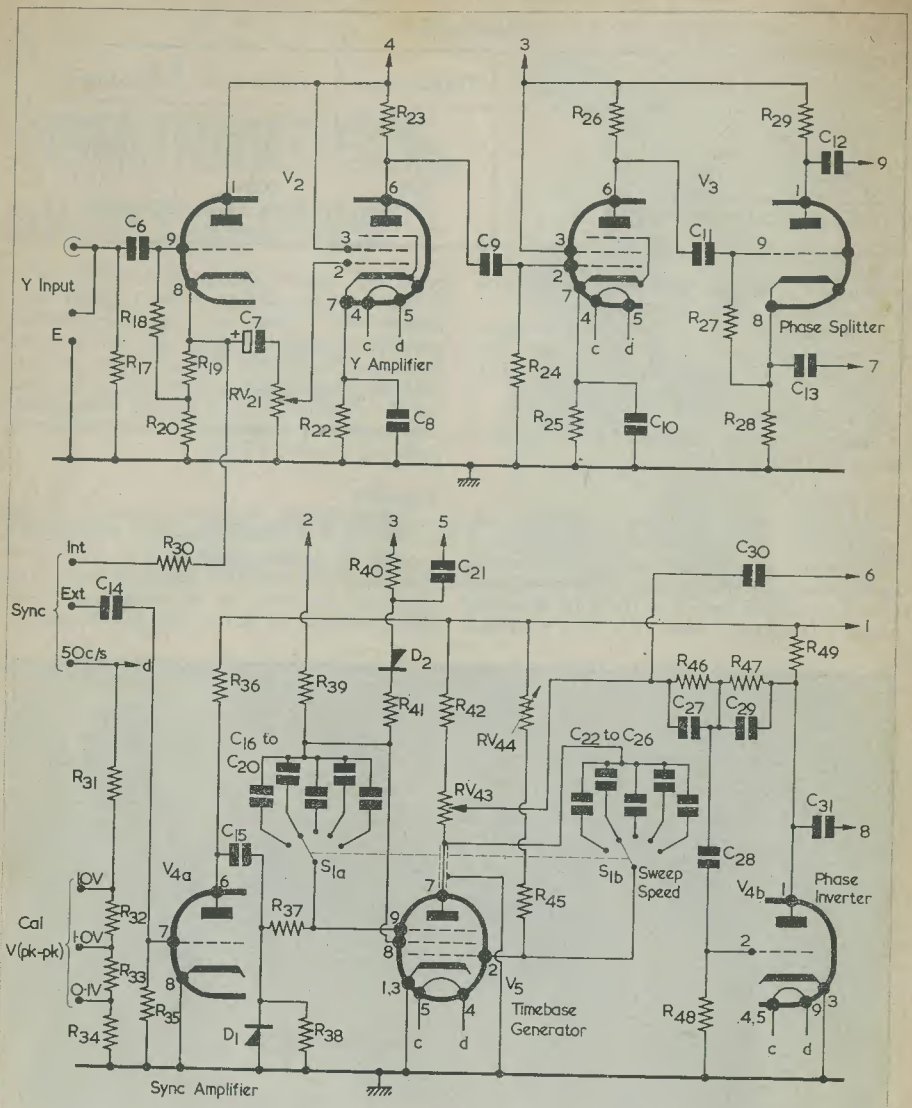


FIG.1
Main Circuit Diagram

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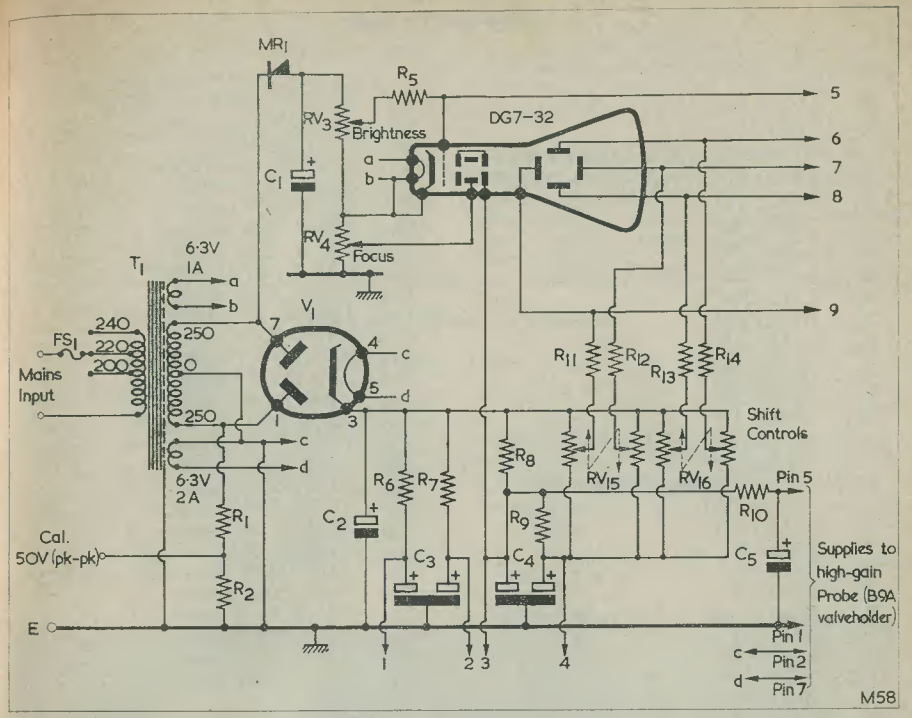
control, R_{45}, and a condenser selected by $S_{1(b)}$, the coarse frequency control. The frequency coverage is from 20 c/s to 20 kc/s in five ranges with overlap between ranges.

$S_{1(a)}$ selects a G_2–G_3 coupling condenser of the correct value to give constant drive on each range. The slider of the X-gain control RV_{43} feeds one X deflector plate via C_{30}, while other plate is fed via C_{31} from the anode of the phase-inverter, $V_{4(b)}$, the amplitudes being kept equal by feeding the grid of the phase-inverter from the balancing network comprising R_{46}, R_{47}, C_{27} and C_{29}.

The sweep width is variable from 2cm to 8cm, and blanking of the flyback lines is provided by the flat-topped waveform developed across R_{40} and fed to the c.r.t. grid via C_{21}.



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Shift Controls

In the original circuit no shift controls were provided, but they were considered desirable and are shown in Fig. 1. The two potentiometers, RV_{15}, RV_{16}, are double 2MΩ linear components with common spindles, and can be obtained from A.B. Metals Ltd.

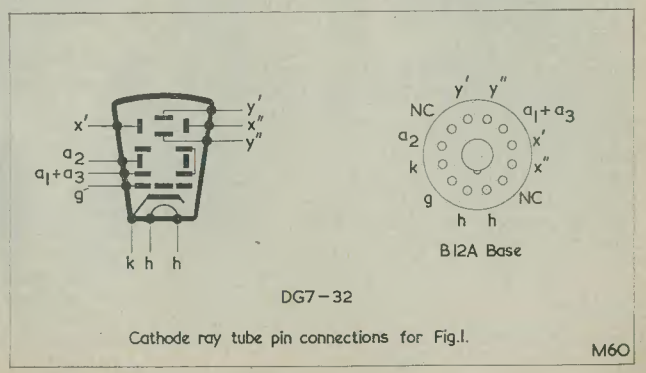
Sync Amplifier

Provision is made for synchronising signals to be fed from an external source via the "Sync Ext." socket on the front panel, or from the input signal, or from 50 c/s by using a shorting link between the appropriate sync sockets.

The diode D_1 provides d.c. restoration of the amplified synchronising signal at the anode of $V_{4(a)}$, which is then fed as a positive-going signal to the suppressor grid of the oscillator valve (V_5).

Calibration

Calibration reference voltages of 0.1, 1 and 10 volts (peak to peak) are obtained from a potential divider network (R_{31}–R_{34}) in the heater supply. A 50 volt reference voltage is also provided from one half of the h.t. secondary winding of the mains transformer T_1 via R_1 and R_2. The waveform of the 50 volts calibration supply tends, however, to be distorted, since the positive peaks are cut off due to the effect of the resistance of the transformer winding and the heavy current drawn by the rectifier at the instant of conduction.



Cathode ray tube pin connections for Fig.1.

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Components List

Resistors

R_1	150kΩ 1W
R_2	22kΩ ¼W
RV_3	50 kΩ Linear A.B. Metals Type 37
RV_4	100kΩ Linear A.B. Metals Type 37
R_5	270kΩ ¼W
R_6	2.2kΩ ¼W
R_7	2.2kΩ ¼W
R_8	2 x 8.2kΩ 2 x 2W in parallel
R_9	8.2kΩ 2W
R_{10}	100kΩ ½W
R_{11}	3.9MΩ ¼W
R_{12}	3.9MΩ ¼W
R_{13}	3.9MΩ ¼W
R_{14}	3.9MΩ ¼W
RV_{15}	2 x 2MΩ 2-gang Linear A.B. Metals Type D37
RV_{16}	2 x 2MΩ 2-gang Linear A.B. Metals Type D37
R_{17}	1.2MΩ ¼W
R_{18}	1MΩ ¼W
R_{19}	330Ω ¼W
R_{20}	10kΩ ¼W
RV_{21}	10kΩ Linear A.B. Metals Type 37
R_{22}	220Ω ¼W
R_{23}	5.6kΩ ½W
R_{24}	1MΩ ¼W
R_{25}	270Ω ¼W
R_{26}	5.6kΩ ½W
R_{27}	10MΩ ¼W
R_{28}	10kΩ ½W
R_{29}	10kΩ ½W
R_{30}	10kΩ ½W
R_{31}	390Ω ¼W
R_{32}	470Ω ½W
R_{33}	47Ω ¼W
R_{34}	2 x 10Ω ¼W in parallel
R_{35}	1MΩ ¼W
R_{36}	82kΩ ¼W
R_{37}	100kΩ ¼W
R_{38}	10kΩ ¼W
R_{39}	27kΩ ½W
R_{40}	10kΩ ¼W
R_{41}	10kΩ ¼W
R_{42}	4.7kΩ ½W
RV_{43}	25kΩ Linear A.B. Metals Type 37
RV_{44}	2MΩ Linear A.B. Metals Type 37
R_{45}	390kΩ ½W
R_{46}	1MΩ ¼W
R_{47}	1.2MΩ ¼W
R_{48}	10MΩ ¼W
R_{49}	100kΩ ¼W

Potentiometers are ±20% tolerance, all other resistors are ±10%.

Condensers

C_1	32μF 350V electrolytic
C_2	16μF 350V electrolytic
C_3	25+25μF 300V electrolytic
C_4	25+25μF 300V electrolytic
C_5	16μF 350V electrolytic
C_6	0.1μF 500V paper
C_7	25μF 50V electrolytic
C_8	220pF 350V ceramic
C_9	0.1μF 500V paper
C_{10}	220pF 350V ceramic
C_{11}	0.05μF 350V paper
C_{12}	0.25μF 350V paper
C_{13}	0.25μF 350V paper
C_{14}	1,800pF 350V silver-mica
C_{15}	0.01μF 350V paper
C_{16}	0.05μF 350V paper
C_{17}	0.01μF 350V paper
C_{18}	2,200pF 350V silver-mica
C_{19}	560pF 350V silver-mica
C_{20}	150pF 350V silver-mica
C_{21}	0.1μF 350V paper
C_{22}	0.1μF 350V paper
C_{23}	0.02μF 350V paper
C_{24}	0.005μF 350V paper
C_{25}	1,200pF 350V silver-mica
C_{26}	300pF 350V silver-mica
C_{27}	33pF 350V ceramic
C_{28}	0.05μF 350V paper
C_{29}	33pF 350V ceramic
C_{30}	0.25μF 350V paper
C_{31}	0.25μF 350V paper

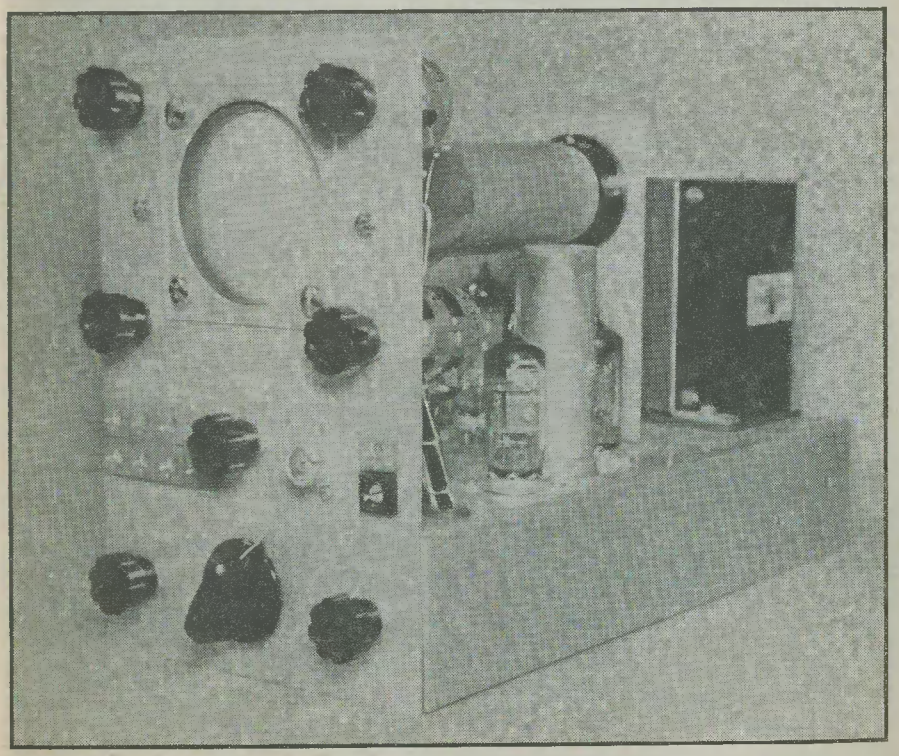
Miscellaneous

CRT Mullard DG7–32 with M.E.A. Mumetal Shield Type ST9B
V_1 EZ80
V_2, V_3 ECF80
V_4 ECC81
V_5 EF80
D_1, D_2 OA81
MR_1 Westalite Contact Cooled Rectifier Type 18RA1–1–16–1
T_1 Partridge Mains Transformer Type H250/40
FS_1 Belling-Lee Fuse Holder Type L575 with 1 amp fuse
$S_{1(a),(b)}$ 2 pole, 5 position rotary switch (see note below)
6 B9A valve bases (McMurdo Type BM9/U)
1 B12A tube base (McMurdo Type X12/E)
1 Mains input plug and socket assembly (Bulgin Type P360)
2 3-way tagstrips (Bulgin Type T19)
2 5-way tagstrips (Bulgin Type T20)
1 7-way tagstrip (Bulgin Type T23)
2 7-way tagstrips (Bulgin Type T24)
8 4mm sockets (red) (Belling-Lee Type L1318/Red)
1 4mm socket (black) (Belling-Lee Type L1318/Black)
Plugs to fit (Belling-Lee Type L378/4)
1 Coaxial input socket (Belling-Lee Type L604/S/Cd)
7 Bulgin midget fluted Instrument knobs Type K111
1 Pointer knob (Bulgin Type K370)
C.R.T. mask (Standard Insulator Co. Ltd. Type S.I.C.5882
Panel Signs Set No. 3 (Data Publications Ltd.)
4 2BA hank bushes
4 2BA chrome screws
2 4BA chrome screws
Chassis, front panel and tube mounting brackets (see note below)
Graticule and filter (see note below)
Grommets, nuts bolts, etc.

Note: Details of $S1_{(a),(b)}$, the chassis metalwork and brackets, and the graticule and filter are given in Part 2 of this series. The filter, which is optional, employs 0.01 in green gelatine manufactured by Strand Electric Co. Ltd.

Names and Addresses of Suppliers

Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.
Magnetic and Electrical Alloys Ltd., Mercury House, Theobald's Road, London, W.C.1.
The Standard Insulator Co. Ltd., Standard Works, Bridge Road, Camberley, Surrey.
Partridge Transformers Ltd., Roebuck Road, Chessington, Surrey.
A.B. Metal Products Ltd., Walkden House, Melton Street, Euston Square, London, N.W.1.
Strand Electric and Engineering Co. Ltd., 29 King Street, London, W.C.2.
A. F. Bulgin and Co. Ltd., Bye Pass Road, Barking, Essex.
The McMurdo Instrument Co. Ltd., Victoria Works, Ashtead, Surrey.
National Switch Factory Ltd., Keighley, Yorkshire.
Data Publications Ltd., 57 Maida Vale, London, W.9.



Three-quarter view of the chassis and front panel

Power Supply

A single Partridge type H250/40 mains transformer (T_1) is used. It supplies 250–0–250 volts at 40mA for h.t., 6.3 volts at 2A for all the valves, and a separate winding for 6.3 volts at 1A for the tube heater. In the Mullard publication, *Scope for Service*, a transformer with flying leads is specified; but as this is only available to special order, provision has been made on the chassis for fitting the equivalent type with tagboard connections, as can be seen in the accompanying photographs.

The EZ80 full-wave rectifier V_1 supplies an h.t. voltage of just over 300 which feeds the final anode of the c.r.t. and the valves. A negative voltage of approximately the same value is provided by the metal rectifier MR_1, and this is supplied to the tube cathode, giving a total available tube voltage of about 600 volts. The rectifier used is of the contact cooled variety, but any alternative type capable of carrying a few milliamperes at the required voltage may be used providing the appropriate alterations are made to the chassis construction.

It should be mentioned that in place of the octal socket which can be seen at the rear of the instrument (see illustrations) the chassis drawing provides for the fitting of a Belling & Lee miniature fuse holder. The chassis is also designed for the electrolytic condensers, C_3 and C_4, to be of the prong fixing types with associated mounting plates, because of their smaller diameter.

(To be continued)

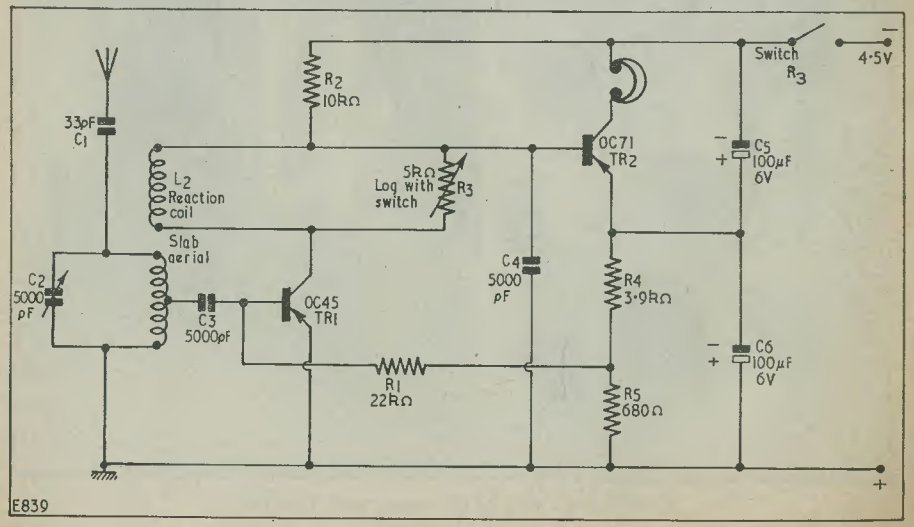
A SIMPLE TRANSISTOR SET WITH REACTION

By S. SMITH

THE FOLLOWING DESIGN REQUIRES, AS THE bulky items, a ferrite slab aerial, a variable condenser, and a potentiometer. Two transistors, four resistors and five condensers then complete the receiver. Of the latter, two condensers are not really vital in all cases: it is difficult to imagine a two-transistor set with fewer components.

A ferrite slab aerial (see the accompanying circuit diagram) provides an r.f. signal, which is coupled from the low impedance tap in L_1 via C_3 to the r.f. transistor (OC45) TR_1. The reaction coil, L_2, in the collector circuit of TR_1 provides positive feedback, the amount of which is controlled by R_3 acting as a short-circuit. Any ferrite aerial with a reaction coil is suitable but, as a rule-of-thumb, the greater the volume of ferrite enclosed by the windings the stronger the induced r.f. signal. Therefore, in the prototype, a rather bulky slab aerial was used. The positive feedback causes detection with reaction, and gives high selectivity together with the maximum amplification of the resultant audio signal of which TR_1 is capable.

TR_1 is biased, via R_1, with the potential built up across R_5 by the emitter current of TR_2. If TR_1 happens to pass extra current there is an extra potential drop across R_2, which is directly coupled to the base of TR_2; hence by emitter-follower action the voltage across R_5 drops and TR_1 is thus biased back so reducing the extra current.



Similarly, if TR_2 happens to pass extra current, TR_1 is biased to pass more current accordingly and, as in the preceding paragraph, so bias back TR_2. The circuit is thus very stable.

C_4 completes the r.f. circuit of TR_1. R_2 is the audio load for TR_1, TR_2 being a simple audio amplifier. The resistor R_4 is of sufficient value to limit the current through TR_2 in order that the transistor does not "bottom", even on full drive, across its collector load. In the prototype, the collector load was a pair of headphones having a d.c. resistance of 3kΩ and an a.c. impedance of 4kΩ.

Notwithstanding the presence of C_5 and C_6, there is a measure of negative feedback of lower frequencies via R_1. This does not make the quality of reproduction intolerable but, should the constructor prefer to hear a good booming bass in the headphones, R_1 may be split into 10kΩ plus 10kΩ with a 25μF (or more) condenser from their junction to the battery positive rail, thereby filtering out the feedback.

It was stated at the beginning of this article that two of the condensers are not vital in all cases; these two and C_1 and C_5. C_1 is used to couple in an external aerial but the slab aerial will be sensitive enough, in areas of high signal strength, to enable the external aerial, and therefore C_1, to be dispensed with. C_5 provides a low impedance between h.t. negative and the emitter of TR_2; if the battery is in good condition, C_5 is unnecessary.

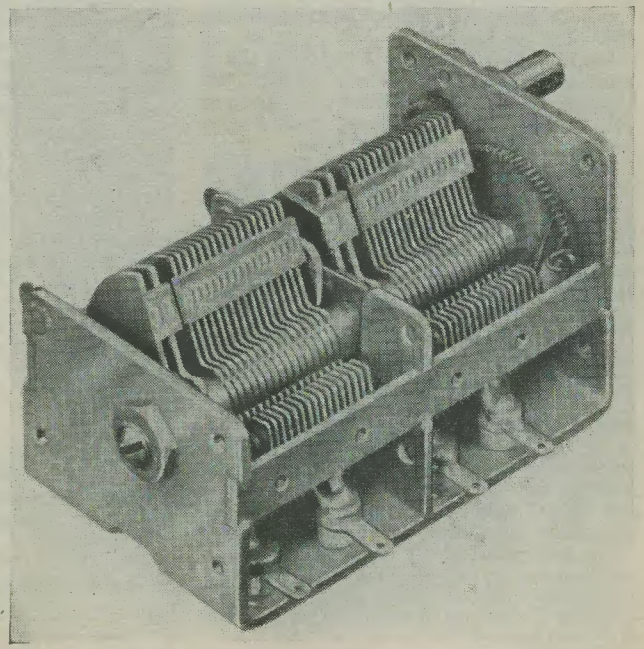
The ferrite slab aerial employed in the prototype was an FX1959 slab with windings added by the suppliers, and is available complete from Messrs. Watts Radio, 8 Apple Market, Kingston-upon-Thames, Surrey.

TRADE REVIEW . . .

Jackson Brothers (London) Ltd., of Kingsway Waddon, Surrey, is a firm which has been very well known to the home-constructor and to the professional engineer for many years. This company has introduced a number of new components recently which deserve especial mention.

There are, firstly, two new precision tubular trimmers having the especial feature of employing p.t.f.e. as the dielectric and which can, in consequence, offer low losses over a wide temperature range. These are tested at 3,500 volts d.c. The trimmers are single hole bush mounting, a threaded screw with locking device entering the dielectric cylinder for capacity adjustment. Capacity ranges are 0.5 to 12pF and 1 to 20pF respectively.

Another innovation is the type P gang tuning condenser for a.m./f.m. and a.m. applications, this being capable of incorporating the "capacitance law" which is popular in Europe. Type P condensers are already finding increasing uses in the home and export market. The accompanying illustration shows a condenser of this type, and it will be noted that this has two sets of stators in each gang, one high capacity for a.m. and one low capacity for f.m. Drive is obtained via an integral sprung-cog reduction gear.



Type P tuning condenser manufactured by Jackson Bros.

TV and FM DX via Sporadic-E

By A. H. Uden

DURING THE PAST FEW YEARS THERE HAS been increasing interest in long distance t.v. and f.m. reception. Quite a number of viewers and listeners do, in fact, obtain fairly regular reception in this country of the nearer Continental television and f.m. sound broadcasting stations. This is especially possible when certain types of meteorological conditions prevail in the lower atmosphere.

Sporadic-E

However, the present article is concerned with Dx reception from the more distant parts of Europe. This can occur at distances between about 600 and 1,300 miles due to reflection by highly ionised patches or "clouds" which form in the region of the E layer of the ionosphere. These "clouds" are known collectively as "Sporadic-E", and are able to reflect radio waves of much higher frequency than the normal E layer.

Many mysteries still surround Sporadic-E and several theories exist as to the means by which it may be formed. They include generation by meteor showers and upward rising currents from electrically charged thunder-clouds in the lower atmosphere. Sporadic-E effects have also been observed following big displays of the Aurora Borealis ("Northern Lights"). It is largely a summer-time phenomenon, occurring mainly between May and September in any year.

T.v. and f.m. signals propagated in this manner are often strong and usually subject to a rapid fading. Multi-path effects occasionally accompany such reception, resulting in "ghost" images on the picture and "edgy" sound reproduction, though this rarely lasts any length of time.

The best times of the day for Sporadic-E reception are the mid-morning, mid-afternoon or early evening. It occurs quite at random and lasts for periods of from half an hour up to several hours.

Signals received by this mode in television Band I (i.e. 41–68 Mc/s) come from such countries as Sweden, Finland, Poland, Czechoslovakia, Rumania, Russia, Italy, Spain and Portugal. Examples of such t.v. Dx, together with details of simple receiver modifications, were described recently in *The Radio Constructor*.*

The author, situated 40 miles north-west of London, at Aylesbury, has obtained similar results in v.h.f. Band II (i.e. 87.5–100 Mc/s). In the past three years or so, nearly 40 different f.m. sound broadcasting stations have been identified from southern Italy and the Island of Sicily. Many of these stations are satellites with effective radiated powers as low as 80 *watts*! F.m. broadcasts have also been identified from Sweden, Finland, Spain and North Africa.

Receiving Equipment

Aerial direction and height is not too critical with this mode of propagation; indeed, all the author's reception has been entirely on roof-space aerials only 280ft above sea level. Both of the aerials used are Belling-Lee horizontal "H" types. One is directed towards the B.B.C. f.m. station at Wrotham and the other to Norwich.

Separate coaxial feeder cables about 45ft in length, run to a simple selector switch close to the receiver. This is an R.C.A. High Fidelity tuner unit type LMI 32230/B and employs the following line-up: EF95 r.f. amplifier, EF91 mixer, ECC81 oscillator and a.f.c., three 6AU6's acting as first i.f. amplifier, second i.f. amplifier and first limiter, and second limiter respectively. The f.m. detector is an EB91. Athough this tuner unit has a very high sensitivity it must be emphasised that signals propagated in the manner described are often received at strengths in excess of 100μV—sufficient to drive the majority of receivers on the domestic market.

This type of Dx can occur *anywhere* in this country, though it is mainly confined to the times and distances mentioned earlier and to v.h.f. Bands I and II.

It is hoped that this short article will encourage readers to experiment further for themselves in receiving distant t.v. and f.m. stations, thereby adding to the steadily growing number of viewers and listeners who already do so.

The Table

The table accompanying this article gives details of European f.m. stations logged by the author, together with the probable mode of propagation. As may be seen, a high proportion of the stations received may be the result of Sporadic-E propagation.

* "Long Distance TV, A Report on Exceptional Dx Reception", *The Radio Constructor*, November 1960.

LIST OF EUROPEAN FM STATIONS LOGGED IN BUCKINGHAMSHIRE FROM SEPTEMBER 1957 TO 30th SEPTEMBER, 1960

Beside the station name will be found the actual location of the transmitter —where known. Frequencies are given in Mc/s. In the end column is listed the date on which the station was first identified. This is followed by a code letter or letters to indicate the probable mode of propagation by which the station was received.

	Mc/s	*Date and Mode*
FRANCE		
Bordeaux	98.1	27/9/58/T
Bourges (Neuvy)	89.36/93.0	12/9/58/T
Bourges (Neuvy)	(88.4/94.9)	11/9/60/T
Caen (Mont Pincon)	87.8/91.5/95.6	From 9/57/T
Caen (Mont Pincon)	99.6/91.5/95.6	From 29/8/60/T
Lille (Old Station)	88.7/92.2	8/7/58/T
Lille (Bouvigny)	88.7/92.2	From 3/4/60/T
Lyon (Mont Pilot)	92.7	19/5/58/T
Marseille (Etoile)	95.4	14/6/59/MS
Metz	89.7	19/5/58/T
Mulhouse	92.1	10/7/58/T
Paris (Grenelle)	96.1	10/7/58/T
Paris (Eiffel Tower)	90.35/97.6	24/10/59/T
Reims (Hautvilliers)	99.181	2/6/60/T
HOLLAND		
Hoogezand	91.8/94.9	29/10/58/T
Hulsberg	95.1/97.5	14/6/59/T
Irnsum	88.2/97.2	16/5/59/T
Markelo	96.2/98.3	16/5/59/T
Mierlo	99.9	18/2/59/T
Lopik	92.6/96.8	15/1/61/T
GERMANY (West)		
Aachen W.D.R.	89.89/98.4	14/6/59/T
Biedenkopf H.R.	91.2	20/11/57/T
Dusseldorf B.F.N.	89.15	12/9/59/T
Feldberg A.F.N.	94.9	20/6/57/T
Flensburg N.D.R.	97.8	25/5/59/T
Hamburg N.D.R.	96.3	25/5/59/T
Harz (Torfhaus) N.D.R.	88.2/96.0/99.9	23/10/58/T
Herford B.F.N.	93.0	12/9/59/T
Kleve W.D.R.	91.5	14/6/59/T
Langenberg W.D.R.	87.9/95.7	24/5/59/T
Linz S.W.F.	97.8	29/10/58/T
Munster W.D.R.	94.5	14/6/59/T
Nordhelle W.D.R.	93.9/98.7	14/6/59/T
Oldenburg N.D.R.	87.6/95.4	24/5/59/T
Teutoburger Wald W.D.R.	94.2/99.6	23/10/58/T
Verden B.F.N.	90.3	12/9/59/T
GERMANY (East)		
Brocken (Harz) Deutschlandsender	97.4	31/12/59/T
Sonneberg Deutschlandsender	97.6	27/6/60/T

	Mc/s	*Date and Mode*
DENMARK		
Aarhus	91.7/95.9	23/5/59/T
Sonderjylland	95.1/99.9	17/5/59/T
Vestyjlland	90.2/99.2	23/5/59/T
Aalborg	98.1	14/9/59/T
SWEDEN		
Borlange	89.4	26/7/60/sp-E
Gavel	93.9	26/7/60/sp-E
Stockholm	92.4	24/6/58/sp-E
FINLAND		
Koli	90.1	24/6/58/sp-E
Turku	94.3	24/6/58/sp-E
Vaasa	93.1/95.2	26/7/60/sp-E
U.S.S.R.		
Smolensk T.V. (Russian Channel V)	93.25 (Vision) 99.75 (Sound)	25/7/60/sp-E
SPAIN		
Valencia Radio Mediterranéo	94.8	3/8/60/sp-E
NORTH AFRICA		
?	92.0	3/8/60/sp-E
A.F.R.T.S.	89.7	3/8/60/sp-E
ITALY, SICILY & SARDINIA		
M. Cammarata	95.9/97.9	20/6/59/sp-E
M. Faito	94.1/96.1	14/6/59/sp-E
Gambarie	95.3/97.3	2/6/60/sp-E
Palermo	94.9/96.9	20/6/59/sp-E
M. Serpeddi	96.3	9/7/60/sp-E
?	98.9	20/6/59/sp-E
?	99.9	9/7/60/sp-E
?	87.9	16/8/60/sp-E
?	89.1	16/8/60/sp-E
?	89.7	16/8/60/sp-E
?	91.5	16/8/60/sp-E
?	92.3	16/8/60/sp-E
?	93.5	16/8/60/sp-E
?	94.1	16/8/60/sp-E
?	94.5	16/8/60/sp-E

EXPLANATION OF CODE LETTERS

"T": Propagation via the troposphere.

"sp-E": Sporadic -E(ionospheric propagation).

"MS": Propagation via meteor showers.

In one or two cases where it has not been possible to positively identify the station, only the frequency is listed under the country of origin.

A 3-Station
Switched Coil Pack

A.M. STATION SELECTION SIMPLIFIED

By A. S. CARPENTER

NOWADAYS, WHEN "ETHER SEARCHING" has ceased to be fun for the family, the familiar radio dial with its expensive reduction drive mechanism and other appendages tends to be superfluous. The dial has, in fact, in a large number of cases become nothing more than a decorative attachment with its pointer set to the "Light" (or nearly so!) for a very large part of the listening time.

It is doubtful if the average family receiver needs an elaborate tuning mechanism at all; but what the family *do* need is a means of selecting the station they require instantly and accurately, the minimum number of stations needed being probably three, viz. the local Regional station, the Light programme, and one other.

The obvious and practical method of providing such selection is by means of a switched, pre-tuned coil pack incorporated into a superhet circuit. Switched tuning is possible, of course, with a t.r.f. receiver, but as several electrical and mechanical snags make themselves evident the superhet circuit is preferred for its higher sensitivity and stability. Furthermore, the superhet circuit permits a coil pack of very small physical dimensions to be constructed since the coils that it contains are each tuned to a different frequency.

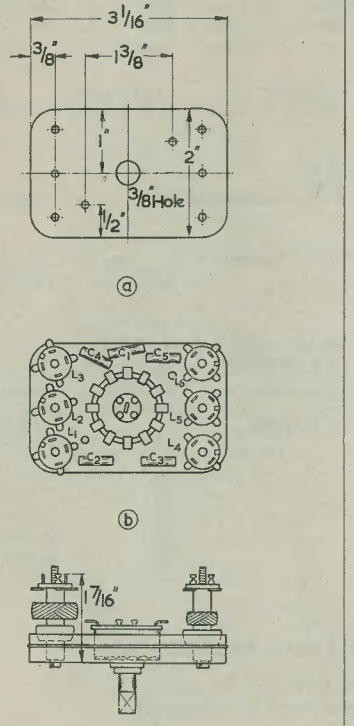


FIG.1 (a) Chassis drilling details
(b) Layout
(c) Side view

M958

A Practical Arrangement

The coil pack described here was built recently to provide the simple means of station selection outlined above, and was used in conjunction with a simply constructed a.m. tuner. The pack is illustrated in Fig. 1 where it will be observed that six coils and a switch, plus five fixed condensers, are mounted in an area no larger than $3\frac{1}{16}$in x 2in x $1\frac{1}{2}$in.

The rotary switch is mounted centrally and selects the following transmissions:

On the Medium waveband—the West Home Service. Radio Luxembourg.

On the Long waveband—the "Light" programme (200 kc/s).

Alternative transmissions may be received by suitably retuning the coils.

The theoretical circuit of the pack is shown in Fig. 2, which illustrates the switching operation clearly. Coils L_1, L_2 and L_3 are the aerial coils, and L_4, L_5, L_6 the oscillator coils.

When the switch is rotated an aerial coil is brought into circuit together with its oscillator counterpart, In Fig. 2, for example, the switch is theoretically selecting coil L_1 (which is a Medium waveband aerial coil tuned to the West Home service) together with L_4 (which is its corresponding oscillator coil). When the switch is moved to the next position L_2 and L_5 are brought into use, these being adjusted to receive the "Light" programme on the Long waveband.

The fixed condenser C_1 serves to roughly tune all the aerial coils, final individual tuning being accomplished by means of each coil core. With the values specified for C_1, the coils tune about mid-band position which is satisfactory enough for two of the requirements; but its capacity is too great to permit Radio Luxembourg to be tuned, and C_4 has been included to make this possible. The same set of conditions exists in the oscillator section where C_2 performs a similar function to C_1, and C_5 is the counterpart of C_4.

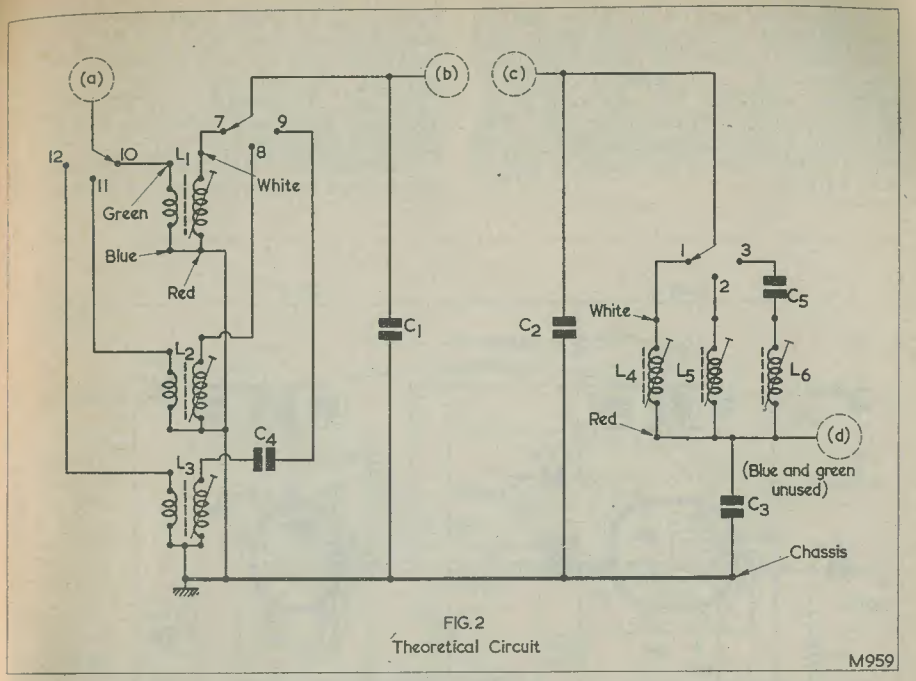
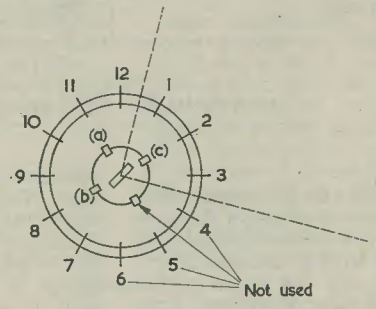


FIG.2
Theoretical Circuit

M959



Tag (c)-To one side of C_2 and to external circuit
Tag 1-To white tag on L_4
Tag 2-To white tag on L_5
Tag 3-To white tag on L_6 via C_5

Tag (b)-To one side of C_1 and to external circuit
Tag 7-To white tag on L_1
Tag 8-To white tag on L_2
Tag 9-To white tag on L_3 via C_4

Tag (a)-To socket provided for 'Aerial' via 50pF condenser
Tag 10-To green tag on L_1
Tag 11-To green tag on L_2
Tag 12-To green tag on L_3

FIG.3
Switch Details

M960

In actual fact each oscillator coil has two windings but, to simplify switching and construction, none of the primary windings are used, nor is a separate "padding" condenser employed for each coil, as C_3 serves all three. Provision has also been made for a fine tuning adjustment but, as this is fitted to the actual tuner, it will be dealt with later.

however, is the switch threaded section long enough to take more than one nut so that, during the time the pack is being placed in position, the switch and its wiring are "floating". To overcome this difficulty two additional holes were drilled (see Fig. 1 (*a*)) for fixing purposes.

Mounting the six coils is surprisingly simple since each merely requires a 6BA bolt

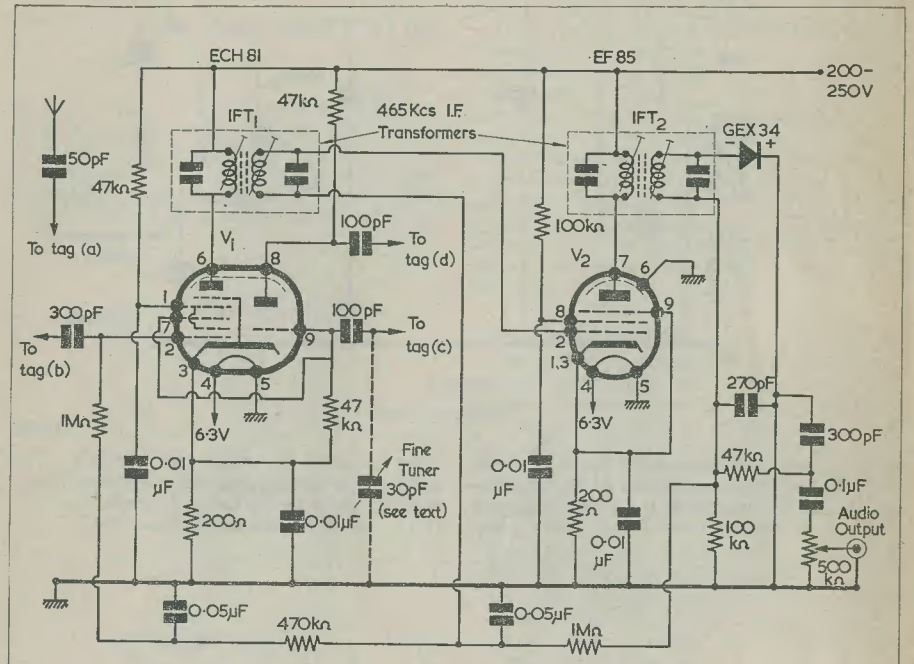


FIG.4.
A suitable AM Tuner Circuit for use with the Pack

M961

Construction

The "chassis" used for the prototype consisted of an "Elastoplast" waterproof Dressing tin. The lid was removed then replaced over the base of the tin in order to obtain a double thickness of metal, and this made a firm mounting even after drilling. If preferred, however, the pack can be built on a Paxolin group board cut to the size illustrated, with five tags fitted for external connection purposes. In the original, flying leads were used for this purpose, four only being required due to the chassis connection being automatically "made" when the coil pack was mounted.

The common method of securing coil packs is by means of the switch retaining nut, the switch bush being passed through a hole cut in the main chassis. Seldom, passed through the "chassis" into its threaded base. The four tags provided on each coil are colour coded as shown in Fig. 2.

Details of the various connections from the switch to the coils, etc., are given in Fig. 3. A soldering iron with a pencil bit is required and, although the coils and tags are quite sturdy, the iron should be hot enough to permit very quick joints to be made. Wiring up the pack is not a tedious job but, rather, one that requires to be done carefully without undue hurry. Final checking will be greatly facilitated if wires with different coloured insulation are used. The four flying leads are best left until last.

Using the Pack

Due to the use of this pack it becomes possible to construct an efficient tuner of small physical dimensions even when octal-based valves are used. A suitable circuit is given in Fig. 4, and in Fig. 5 a suggested layout is shown, illustrating that a chassis no larger than 6 x 3½ x 2in may be employed. The pack can be mounted sub-chassis if desired, but the chassis will then need to be 2½in deep.

instance, be capable of withstanding mains voltage. In this case, also, the usual safety precautions regarding a.c./d.c. apparatus must be observed.

Whilst a 500kΩ volume control is shown this might already exist in the amplifier proper, whereupon the audio output should be taken from the 0.1µF blocking condenser and chassis.

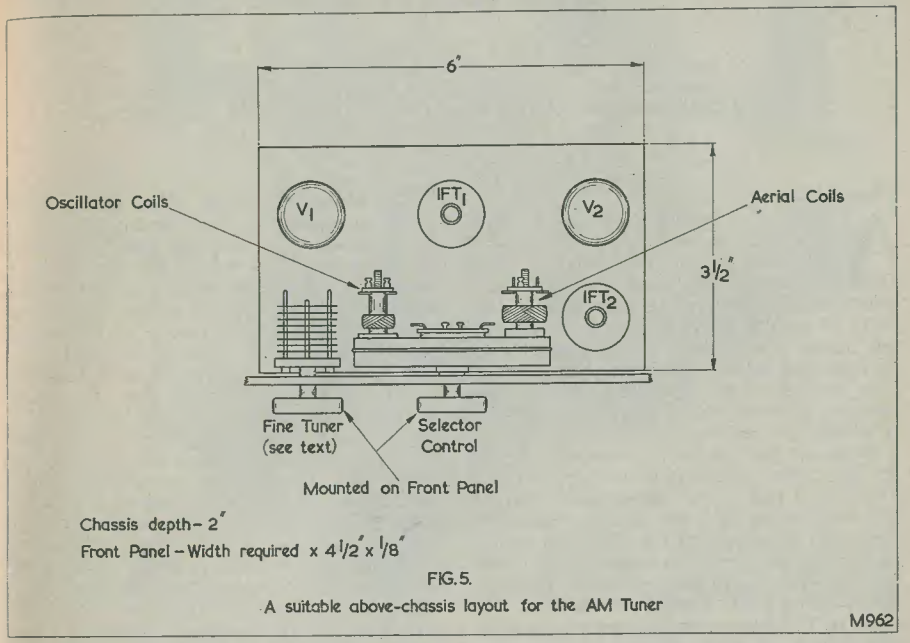


FIG.5.
A suitable above-chassis layout for the AM Tuner

M962

The tuner circuit is quite conventional except that a 30pF variable air-spaced trimmer is included (shown in dotted line in Fig. 4) and arranged as a panel control fine tuner to compensate for any frequency drift that might occur. Undelayed a.g.c. is also included.

The 50pF condenser in the aerial lead must on no account be omitted when no mains isolating transformer is employed in the power supply, and its insulation should, in this

Since no "tracking" problems arise the precise value of intermediate frequency is not critical provided it approximates to the standard and, once the i.f. transformers are aligned, it merely becomes necessary to adjust the various cores of the coil pack to obtain the desired transmissions. During the whole of the alignment process the fine tuner knob should be set so that the condenser vanes it controls are approximately at the half-enmeshed position.

Components List
(Fig. 2)

Condensers

C_1	150pF
C_2	150pF
C_3	300pF
C_4	200pF
C_5	200pF

Chassis
(See text)

Switch
Miniature 4-pole, 3-way

Coils—"Weyrad" H-range

L_1	HA3
L_2	HA1
L_3	HA3
L_4	HO3
L_5	HO1
L_6	HO3

Getting Started on 2-Metres

PART 4

"SURE-FIRE" 2-METRE TRANSMITTER

by J. N. WALKER, G5JU

NOTE: To operate the "Sure-Fire" 2-metre Transmitter a Post Office Amateur Licence is required. Full particulars may be obtained from General Post Office, Radio and Accommodation Department, Headquarters Building, St. Martin's-le-Grand, London, E.C.1

Introduction

ALTHOUGH NUMEROUS ARTICLES HAVE appeared dealing with two metre transmitters, one has only to listen around to learn that there are still many amateurs who are finding considerable difficulty in getting a transmitter to work with any degree of efficiency. After using up a lot of time and getting nowhere, some of these lose interest in the band and divert their energies to fields where results are quicker to obtain—which is a pity!

What are the reasons for these difficulties? As the writer understands it, there are two. The first is lack of r.f. drive, particularly in the later stages of a transmitter, where the frequency is rising into the very high region. In many areas there is the necessity to avoid the 48 Mc/s harmonic, which is liable to break through into a television receiver. The jump to 72 Mc/s generally causes a considerable falling off in r.f. output.

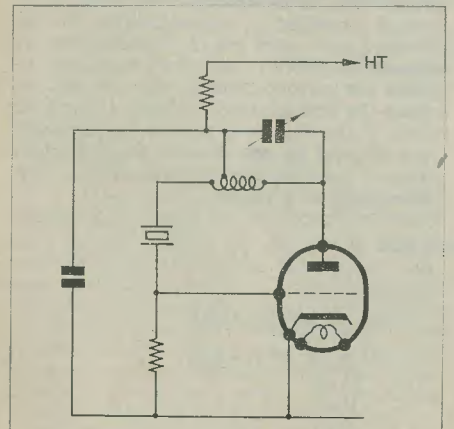
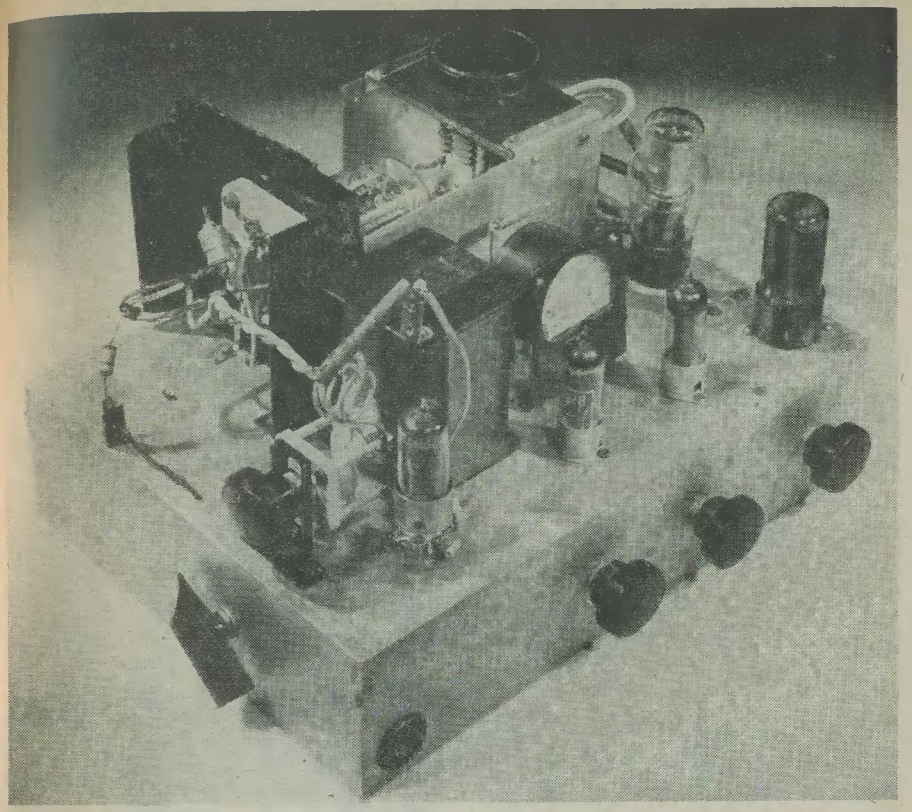


FIG.1.
The Squier overtone circuit
M52

The second thing the writer has in mind is the popularity (at least among those who write articles!) of what for lack of a better term can be called "trick" circuits which, it seems, do not always function as they should. For example, given a particular crystal and valve it is possible to take a circuit, which may be the Squier overtone, a tritet, or a cathode-coupled type, and arrive at constants which give quite satisfactory operation. However someone else building up the circuit to the exact details supplied, but with of course a different valve and crystal, will often find difficulty in obtaining correct operation. At least this is the case with the fairly popular Squier circuit, shown in Fig. 1, where small differences in crystal activity and in its self-capacity lead to large variations in performance. Most of those who have tried this circuit (unless they have been very lucky) will have found it easy to obtain (*a*) self-oscillation or (*b*) no oscillation at all, and much time is sometimes necessary to achieve just that degree of coupling which leads to a solid crystal lock.

Again, some published circuits start off with a small valve as the oscillator. This is all very well in its way, but from then on the constructor is hard put to it to build up adequate drive from one frequency multiplying stage to the next. Low power drive stages admittedly have much to recommend them at the lower frequencies, when there is no difficulty in amplifying to a sufficient degree at or near the output frequency. But this does not hold true at v.h.f.—or, at least, it entails the use of special valves and some trouble in ensuring complete stability.

All very true, will say the reader who has "had a go". And the answer? Firstly, to avoid any sort of unusual circuit and, secondly, to make quite sure that plenty of drive exists right at the start. And that is what the following design sets out to do. Given good valves there can be every confidence that a transmitter built as



Above-chassis view of the completed "Sure-Fire" 2-Metre Transmitter

described will give plenty of r.f. output, and that with no fussing and fiddling.

The Circuit

The circuit of the transmitter is given in Fig. 2, and it will be seen that no attempt has been made to economise in valves. To do so would, indeed, defeat the object. At the same time the only expensive valve is the one in the output stage and, here, most would agree that a double tetrode is practically essential.

The first stage uses a 6V6 valve as a perfectly straightforward crystal oscillator working on the crystal fundamental of 8 Mc/s. There are other valves which will serve but the 6V6 (or one of its variants) is well tried and proven and does the job adequately.

For the following stages, valves of higher mutual conductance are used—possibly another 6V6 in the second stage would function satisfactorily but the N78 chosen definitely produces excellent r.f. output at 24 Mc/s without drawing a heavy anode current.

Next another N78, with ample drive on its grid to ensure good efficiency as a tripler to 72 Mc/s. One does not have to use anything particularly sensitive to detect the output—a neon lamp lights up when applied to the glass envelope and the output is something like two watts.

The next valve, which has to produce output at 144 Mc/s—and as much as possible of it—is probably the most important in the chain. An N78 proved unsatisfactory as it cannot handle sufficient input, but a 5763 works really well. Before the advent of the 5763 a QVO4-7 has been used in a similar position, with entirely satisfactory results, and it would probably perform well here since its general characteristics are similar. However, it is wise to try a new valve when it becomes readily available.

Finally, an 829B (or QQO7-40) double

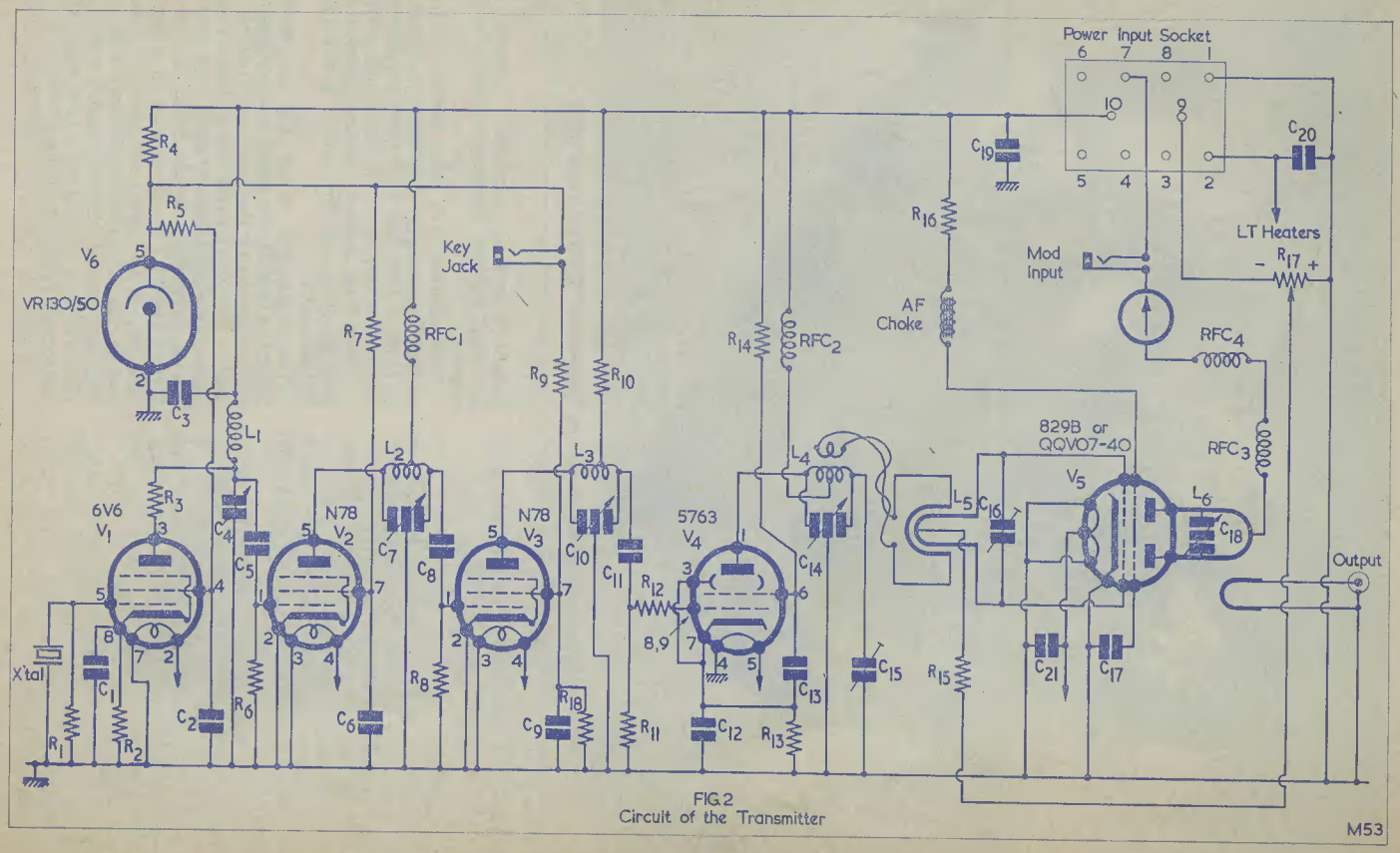


FIG.2
Circuit of the Transmitter

M53

Components List

(Set out for easy refereuce to Fig. 2)

Resistors

R_1	47kΩ ½ watt
R_2	220Ω ½ watt
R_3	12Ω ½ watt
R_4	7.5kΩ 10 watt wirewound
R_5	470Ω ½ watt
R_6	47kΩ ½ watt
R_7	470Ω ½ watt
R_8	47kΩ ½ watt
R_9	470Ω ½ watt
R_{10}	250Ω ½ watt
R_{11}	47kΩ ½ watt
R_{12}	12Ω ½ watt
R_{13}	220Ω ½ watt
R_{14}	30kΩ 1 watt
R_{15}	4.7kΩ ½ watt
R_{16}	5kΩ 1 watt
R_{17}	10kΩ 10 watt wirewound
R_{18}	100kΩ ½ watt

Valves

V_1	6V6 or 6V6G Brimar
V_2	N78 Osram
V_3	N78 Osram
V_4	5763 Brimar
V_5	829B or QQV07-40 Mullard (see text)
V_6	VR150/30 Brimar

Valveholders

I.O. type B8/U (2 of) McMurdo
B7G type BM7/U (2 of) McMurdo
B9A type BM9/U McMurdo
7-pin ceramic (V_5) (M.V.H. 17 base)

Condensers

C_1	0.002μF moulded mica
C_2	0.002μF moulded mica
C_3	0.1μF paper
C_4	60pF variable Eddystone. Cat No. 582
C_5	20pF silver mica
C_6	2,200pF Hi-K tubular or disc ceramic
C_7	34 x 34pF variable Eddystone. Cat. No. 584
C_8	25pF silver mica
C_9	2,200pF Hi-K tubular or disc ceramic
C_{10}	25 x 25pF variable Eddystone. Cat. No. 583
C_{11}	10pF silver mica
C_{12}	2,200pF Hi-K tubular or disc ceramic
C_{13}	2,200pF Hi-K tubular or disc ceramic
C_{14}	15 x 15pF variable Eddystone. Cat. No. 476
C_{15}	10pF concentric trimmer
C_{16}	10pF concentric trimmer
C_{17}	2,200pF Hi-K tubular or disc ceramic
C_{18}	8 x 8pF variable Eddystone. Cat. No. 739
C_{19}	500pF moulded mica
C_{20}	500pF moulded mica

Coil Formers

L_1,L_2	Eddystone Cat. No. 646

Chokes

RFC_1	Eddystone Cat. No. 1010
RFC_2	Eddystone Cat. No. 1011
RFC_3	Eddystone Cat. No. 1011
RFC_4	Eddystone Cat. 1022
AF	20/30H, 20mA

Miscellaneous

Aluminium chassis 12 x 9 x 3in
Metal bracket (C_{14}) Eddystone Cat. No. 708
10-way socket, Eddystone Cat. No. 534
10-way plug, Eddystone Cat. No. 535
Pointer knob (R_{17}), Eddystone Cat. No. 1027
Instrument knob (C_{18}) Eddystone Cat. No. 591
Instrument knobs (4 of), Eddystone Cat. No. 592
Insulated jacks (2 of), Igranic
Crystal holder, type X3/UA, McMurdo
Moving coil meter (150 or 200mA f.s.d. —see text)
Coaxial plug and socket, tagstrips, sleeving, etc.

tetrode, which can run at some 80 to 100 watts, according to the applied anode voltage and degree of loading. As the writer always likes to obtain a long and useful life from a valve, excessive anode voltages are avoided. 500 volts can be considered ample, particularly when modulation is applied. In any case, whilst a higher anode voltage would produce more output, it would be insufficient to make much difference to signal strength reports.

Valves are important but they are not everything—the working conditions and the interstage couplings must be correct. For simplicity ordinary capacitive coupling is used, except at the final stage. Probably still better results could be secured by going to a lot of trouble in the making up of coupling transformers. Those with an experimental bent may care to try but, as observed earlier, the present aim is a straightforward design, without those bothersome frills which sometimes work straight away but more often than not entail hours of work before satisfactory results are obtained.

In the writer's opinion, many amateurs use too high a capacity for coupling between the anode of one stage and the grid of the next, forgetting that the grid to cathode path of the driven valve is generally of quite low impedance as well as having the grid leak in parallel with it. Consequently it is only too easy to impose a heavy damping on the tuned circuit, and the valve (usually a pentode or tetrode which should work into a high impedance load) is prevented from producing the output of which it is capable. This factor is all the more important as the frequency rises into the v.h.f. region. Reference to the circuit diagram and parts list will show that the coupling condensers are only 10pF to 25pF. Those who have transmitters not working too well could try some experiments with lower value coupling condensers and will probably be pleasantly surprised at the improvement which is almost sure to follow.

Whilst the crystal oscillator utilises the usual single-ended (unbalanced) circuit, the subsequent stages all have approximately balanced anode circuits which, at very high frequencies, definitely lead to a higher efficiency. As the output stage uses a double tetrode valve both input and output circuits have obviously to be balanced, and link coupling between the 5763 anode and 829B grids is indicated—it also permits ready adjustment for maximum drive.

There are a few other details which may be of interest. Cathode bias, as well as the usual grid leak, is employed in the c.o. stage, V_1, since the crystal thereby oscillates more readily when switching on and the anode current is reduced a little. Bias on the two following stages is derived solely from the drop across the grid resistors and with all three valves the screen voltage is held to 150 volts with a VR150/30 valve. The primary reason for fitting this stabiliser is to obtain freedom from the chirp or "pulling" which generally occurs, even with a crystal oscillator, when the screen h.t. is not stabilised and when several multiplying stages follow. The 5763 seems to like cathode bias and this is necessary, anyway, to hold the anode current down when the key is up. Here the screen is not stabilised as it is desirable to apply a voltage rather greater than 150.

A separate h.t. supply is required for the anode of the 829B but the screen voltage of this valve is taken from the 300 volt exciter supply, through a comparatively low value resistor. To allow for modulation without undue complication, an audio frequency choke is also placed in series with the screen supply; and quite a small choke will suffice as the current is not much more than 10mA. The choke is allowed to remain in circuit when using c.w.

An r.f. choke is used to feed h.t. to the approximate centre tap on coil L_2 and thence, to the anode of V_2. Another choke (a v.h.f. type) is used with L_4. In the final stage, two chokes in series are fitted to ensure good isolation of r.f. from the h.t. supply line.

Elsewhere *chokes should not be fitted* or tuned anode-tuned grid effects may occur, leading to uncontrollable instability. As it is, the transmitter is perfectly stable and, with the good screening provided, it has not been found necessary to neutralise the output valve.

Small Hi-K ceramic condensers are used at points where a low impedance path is essential and the constructor is advised to employ these types only. The keying jack is in series with the screen supply to V_3 and a small external key-click filter is desirable —it can consist of a 0.1μF condenser in series with a 2,000Ω resistor.

It is assumed a separate bias supply is available for V_5, the actual value of bias applied being adjusted with the variable wire-wound potentiometer R_{17}. If a suitable component is hard to come by, two fixed resistors can be substituted so that a bias of about 80 volts results. Or a battery can be employed, omitting any series resistors. Power leads are taken to a 10 pin socket.

Metering facilities can be arranged to suit the individual constructor. In the present case, a meter reading V_5 anode current (the meter in the prototype has a full scale deflection of 50mA, and the photograph illustrates the shunt resistor which increases this reading to 150mA full scale) is fitted in a position where it is easily seen whilst tuning up. This single meter is sufficient for the purpose, once the earlier stages are in approximate resonance. A meter to read V_5 grid current will be found helpful, particularly during initial setting up, and the use of such a meter is discussed later. The modulation input jack (at the rear of the chassis in the photograph) enables the audio output from the modulator to be fed in series with the h.t. supply, but this can of course be done at some other point in the circuit—at the power pack, for instance.

Construction

A substantial chassis forms a solid foundation for the transmitter and a good idea of the placement of the various parts can be gained from the photographs. There is no undue cramping of parts but neither are any unduly long r.f. leads allowed. The tuning condensers are positioned in between the valveholders so that in each case the lead from the anode tag to the condenser lug is very short. Everything is readily accessible, although a soldering iron with a pencil bit is very helpful for the wiring to the miniature valveholders.

Each stage follows on in proper sequence, tagstrips being fitted to the chassis and side aprons were required, to hold components and leads. No screening of any kind is required below the chassis but it may be noted that the V_5 anode circuit is isolated above the chassis. Details of the coils are given separately and it will be seen they are all supported on their own leads, well in the clear and away from the metal of the chassis.

The photograph of the under-chassis is sufficiently clear to make further detailed explanation unnecessary, but some hints on the above-chassis construction will prove helpful.

The 5763 valveholder is not flush with the chassis but is mounted on pillars some $\frac{5}{8}$in or $\frac{3}{4}$in high. This is because the anode circuit is above the chassis and anode leads are, thereby, kept short. Holes in the chassis are required for the heater, screen and grid connections. The concentric trimmer C_{15}, fitted for balancing purposes, is held on stiff wiring at the rear of the tuning condenser, C_{14}.

The 829B valveholder is fitted to a sheet of brass, bent to form a more or less square screening compartment. An Eddystone Cat. No. 650 diecast box used instead of brass would probably be an improvement electrically, as well as leading to a neater appearance.

The grid line is of 14 s.w.g. copper wire, total length 6in, bent to the shape shown in the photograph. Tuning to resonance is effected with the concentric trimmer C_{16} and experiment was necessary to find the correct point for its attachment—hence the solder marks.

The cathode of the 829B is held down to chassis with the shortest possible length of copper strip and a Hi-K ceramic condenser is essential for really effective screen decoupling.

The coupling link is made up of 18 s.w.g. wire enclosed in low-loss sleeving. The 5763 end is formed into a single turn loop; the other is bent to follow the contour of the grid line at its closed end for about 1in each side. It is tied securely with thread, adjustment being made at the 5763 end of the link.

A brass plate measuring approximately 6 x 3$\frac{1}{2}$in screens off one side of the 829B, but otherwise the valve is left open to the air, to obtain good ventilation. The anode tuning condenser (a butterfly type) is mounted on a sheet of Paxolin (about 4 x 2$\frac{1}{4}$in) the latter being clamped with L-section metal strips to the brass screen and to another smaller piece of metal at the rear. The rotor is allowed to float electrically, a large knob on the spindle permitting fine adjustment.

The connecting blocks on the valve anode pins are brass inserts taken from a small mains connector (the usual twin porcelain type). On the other side of the butterfly condenser is the anode line, made up of 7in of 12 s.w.g. wire ($\frac{1}{8}$in diameter tubing would perhaps be a little better) bent to shape and made to fit directly on to the condenser lugs. The feeder coupling loop is a single turn of 18 s.w.g. wire, covered in sleeving and engaging with the closed end of the anode line. Any preferred type of coaxial socket can be used.

Coils

The coils should be made to agree closely with the details which follow, whereupon there should be no difficulty in tuning to the correct harmonic first time.

- L_1 (8 Mc/s crystal oscillator) 14 turns of 18 s.w.g. enamelled wire close wound on 1in diameter former.
- L_2 (24 Mc/s tripler) 10 turns of 18 s.w.g. enamelled wire close wound on 1in former. Centre tap connection.
- L_3 (72 Mc/s tripler) 5 turns of 14 s.w.g. bare wire self-supporting, 1in outside diameter, ends spaced to fit condenser lugs. Centre tap connection.
- L_4 (144 Mc/s doubler) 3 turns of 14 s.w.g. bare wire, self-supporting, $\frac{5}{8}$in outside diameter, ends spaced to fit condenser lugs (see photo). Centre tap connection.

Setting Up

The power supplies required are 300 volts at some 100mA for the exciter stages; 500 volts at about 150mA for the final anodes; 6.3 volts 5.0 amperes l.t. for heaters; and a

grid bias source of about 200 volts at up to 50mA (but see earlier notes on this point). To begin with h.t. is not applied to the final V_5, and R_{16} is opened to prevent screen current flowing.

On energising the earlier stages, the crystal stage should be found to give a good output with the 60pF tuning condenser C_4 approaching full mesh. As usual, the setting should be such as to ensure ready oscillation when switching on.

Next C_7 is rotated. The correct 24 Mc/s harmonic will show a strong output with the condenser at nearly full mesh. The 32 Mc/s harmonic also gives appreciable output but at a much lower capacity setting and it is relatively easy to distinguish between the two.

Now comes the 72 Mc/s stage. The correct harmonic will be found at considerable strength with the vanes of C_{10} at about half mesh. A lower frequency harmonic will not be found unless by mischance the previous stage has been tuned to 32 Mc/s, whilst other higher frequency harmonics are very much weaker than the desired one of 72 Mc/s.

Next, the 5763 stage. Tuning here is effected by the setting of the trimmer C_{15}, and this latter has to be adjusted to come near to the valve output capacity, which is quoted as 4.5pF. With C_{15} at near half maximum capacity, output on 144 Mc/s should be found—ample to light a small neon lamp quite brightly at one end or the other of L_4. C_{15} is then finally adjusted one way or the other until the neon lamp lights more or less equally at each end of the coil. No measurable r.f. should then be found at the point where the r.f. feed choke joins the coil.

The h.t. supplies to the final valve can now be completed and the grid bias adjusted to between 70 and 80 volts. Before switching on, a dummy load—a 12 volt 36 watt car headlamp bulb will serve—should be attached to the output socket as the valve may be harmed if it is operated without a load of some kind.

If a grid current meter has not been fitted as a permanent feature, it will be well at this stage to wire one in temporarily, on the "cold" side of R_{15}, to give an indication of final grid current. Any meter with a full scale deflection of between 10 and 50mA will serve.

It is unlikely that grid current will be registered to begin with, but the anode current meter will soon give an indication that drive voltage is reaching the grids. At first, the link coupling between L_4 and L_5 should be fairly loose—if it is tight, the tuning of both L_4 and L_5 will be flat. The grid circuit of V_5 is then brought to resonance by adjusting C_{16}, using a rod of insulating material for the purpose, to avoid hand capacity effects. Experiment with the degree of link coupling is essential, re-tuning C_{14} as necessary but not again touching C_{16}. The loop coupling will, of course, have a considerable effect on energy transfer and a well defined optimum point will be found. The link should finally be fixed in the correct position, using either thread or polystyrene cement, so that accidental movement is not possible.

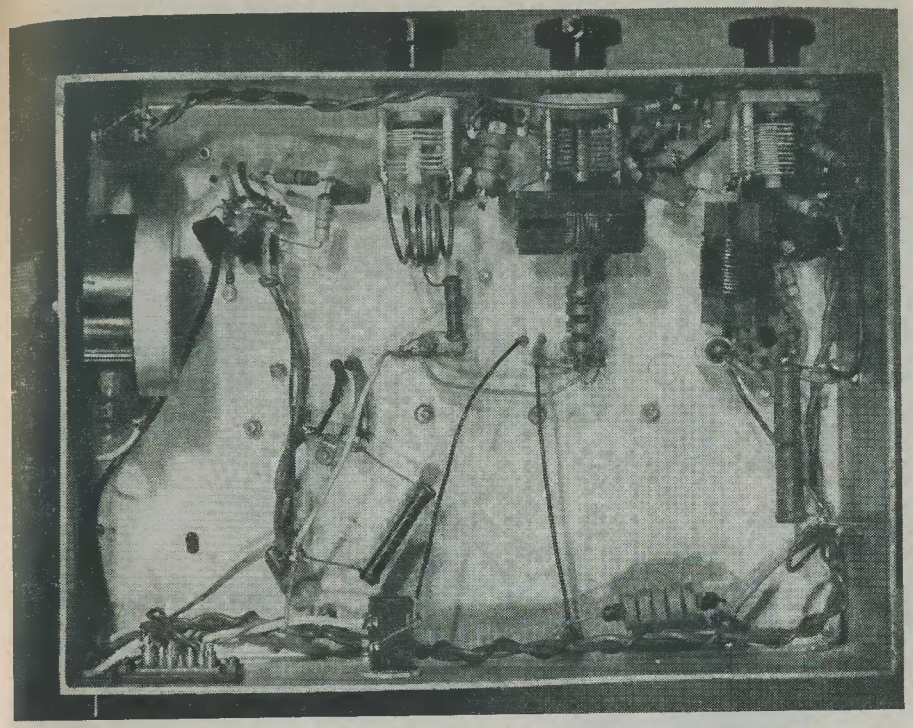
Once a substantial amount of anode current is obtained, the p.a. tank, L_6, C_{18}, should be tuned to resonance, as indicated by a dip in the anode current and by the lamp load glowing. The final dip should be about 10% of the full off-tune current; if less, the output coupling to the p.a. tank should be slackened off and *vice versa*.

Those who possess a grid dip oscillator of sufficiently wide range can anticipate the foregoing procedure by checking the tuned circuits before any power is applied and thereby simplify the final tuning up. Conversely, those who wish to obtain calibration points for a grid dip oscillator or for an absorption wavemeter will be in a position to do so when the transmitter has been set up and is operating correctly.

Anode currents to the various stages can be checked by opening the circuits at the appropriate points (always on the "cold" side) and clipping in meter leads. The anode current of each of the first three valves is in the region of 20/25mA and that of the 5763 about 45mA. The grid current to the 829B will depend on the value of grid bias voltage and will be between 2 and 4mA, which is ample for efficient operation of the transmitter, both on telegraphy and telephony.

Because of the VR150/30 stabiliser valve, the c.w. note will be found clean and of a real T9x character. For telephony operation, the secondary of the modulation transformer is simply placed in series with the h.t. supply to the final stage. The impedance presented by the valve will, of course, depend on the anode current which, in turn, will depend on the amount of aerial loading. This loading should be such that a dip is still observable when rotating C_{18} each side of resonance and in any case it is recommended that 150mA be not exceeded. At this rating—500 volts, 150mA—the impedance works out at 3.3kΩ but, although not directly in the audio circuit, the screen grids add some loading in parallel and a good figure to work to is 3kΩ. Up to 40 watts of audio should be available from the modulation.

It has been assumed that the aerial feeder is of the standard 70/80 ohms coaxial type. Should 300 ohm feeder be employed, a different output socket will be required (neither side earthed) and a larger coupling



Below-chassis view of the transmitter. Note component layout and position of the coils

loop will be called for to secure proper loading.

Other P.A. Valves

There are two other types of valve suitable for use in the p.a. stage. One is the QQV06/40, which is rather more efficient than the 829B and can be expected to give a greater output for an equal input, although perhaps not to an extent which will make any considerable difference in received reports.

With the QQV06/40, the maximum power ratings are lower than with the 829B, but the supplies recommended earlier are quite suitable for the newer valve. The base itself, and also the base connections, remain the same. There will be a small reduction in heater current of some 0.7 amperes, but otherwise there are no changes to take into account.

For those who, at least to start with, will be content with lower power, the 832A type of valve (the Mullard equivalent is the QQV03/20A) can be substituted. This valve is quite a bit smaller than the others and the maximum input on telephony is restricted to about 25 watts. Some economy can also be effected in the associated power supply, which need only be called upon to supply, say, 80mA at 350 volts. Again, a smaller modulator delivering some 15 watts will suffice.

The 832A fits into the same valveholder and has the same connections as the other types mentioned. The bulb length is shorter and the inter-electrode capacities are lower, so some benefit will result if the anode and grid lines are lengthened, the former by about one inch, and the latter by half an inch. Other than these points, and the lower anode volts, no changes are required.

In this form, the transmitter can be expected to give good results with all valves, including the p.a. working from a single 250 volt source of h.t., and the transmitter can be readily adapted for portable operation, substituting a 30 volt battery for p.a. bias.

Modulator

Many good designs have already been published in these pages and elsewhere, so there is no real need to give a circuit here.

Points to note are that sufficient audio power is available to give full modulation of the carrier (not forgetting inevitable losses in the modulation transformer), and that good matching to the p.a. load is made.

Trouble from r.f. feedback into the modulator is often found on 2 metres, where a comparatively short length of lead can develop appreciable r.f. voltage. Hence it is wise to take precautions at the outset, by placing a resistance/capacity filter between the microphone input socket and the grid of the first valve, and by adding v.h.f. chokes and bypass condensers (of fairly low value, say 100pF) at the output of the modulation transformer, to prevent r.f. entering at these points.

If feedback still occurs, it can probably be cured by screening the interconnecting leads and by altering the positions (and therefore the degree of stray pick-up) both of the leads and perhaps of the units forming the whole equipment. At these frequencies a really effective earth is difficult to arrange. Nevertheless, because of other aspects, the whole equipment must, of course, be earthed.

(CONCLUSION)

radio topics

BY RECORDER

SHOULD BRITAIN INTRODUCE A 625-LINE television system? And when are we going to see colour television?

These two questions are being raised with increasing urgency as the months and years roll by and the country which, in 1936, started the first high definition television service in the world, now flounders along with a standard which is as out of place in the modern world as the acoustic gramophone.

During the War

During the war, television broadcasting ceased in this country because the transmissions offered an excellent signal source for direction-finding equipment in enemy aircraft. Also, there were few receivers in the country and the use of television as an information medium would not be worth the trouble of maintenance and replacement component manufacture entailed. From 1939 to 1946, in consequence, British television went off the air. (Even so, the development already carried out on domestic television was of considerable help to our war effort. For instance, do you remember those 45Mc/s radar i.f. strips which appeared on the post-war surplus market in such quantities? These strips started their design life before the war as the r.f. stages of Channel 1 t.r.f. television receivers—a fact which effectively emphasises the fact that, when it is lively and up to date, the domestic radio sector of the electronics industry can often offer immediate help in a national emergency.)

In 1946, British television resumed transmission, and it employed the 405-line system used before the war. Sir Robert Fraser, Director-General of I.T.A., is on record as stating (at the Brighton R.T.R.A. conference this year) that "whilst experts debated the relative superiority of 625 lines, the fact was that we made a sorry miscalculation in allowing television to be resumed on 405 lines". But I don't think very much blame attaches to those who made the decision 15 years ago. We had just come to the end of an exhausting war and, considering the mental climate of the country at that time, the decision seemed to be fair enough.

Nevertheless, it has got us into a bit of a pickle at the present time.

As soon as post-war British television got under way, it caught on with the public to a fantastic extent, and set makers could hardly turn out enough receivers to meet the demand. Pressure on manufacturers began to ease off a little around 1954 to 1955. However, on 22nd September, 1955, Independent Television was launched, and the industry was off on the band-wagon once again; only this time it was a Band III band-wagon.

The first rumblings of growing trouble in the television industry started several years ago when sales started to vary according to the severity or otherwise of hire purchase restrictions. Even so, the overall number of sets sold each year was still high, this being especially true of the twelve months following the removal of hire purchase controls in 1958. Now, however, the country is close to saturation point. There are over twelve million receivers in use, the replacement demand is low, and there are reportedly very considerable stocks of unsold television receivers in the "pipeline" between the manufacturer and the retailer.

Every one of these sets, whether in use or in the "pipeline", is a 405-line model.

Introducing 625 Lines

Why, when we have quite a good workable television system running on 405 lines, and the country is saturated with 405-line receivers, is there a continual urge to introduce the 625-line system?

From the point of view of increased definition in the reproduced picture, the 625-line system offers an improvement which is certainly significant. As I pointed out in the September 1960 issue of *The Radio Constructor*, a 625-line signal can give 55% better vertical resolution than can a 405-line signal. If we employ the 8Mc/s channel width standard which was proposed by the Television Advisory Committee in its 1960 Report, the 625-line system can, also, offer horizontal resolution which is 20% better than that given by a 405-line signal. So the 625-line picture gives a large reduction in picture "lininess" together with a significant, although not exceptional, increase in horizontal resolution. (Assuming a flat transmitter characteristic, the 20% improvement in horizontal resolution would be similar to that given by a 405-line receiver which can fully resolve the 3Mc/s bars of Test Card C as compared with one which can only fully resolve the 2.5Mc/s bars.)

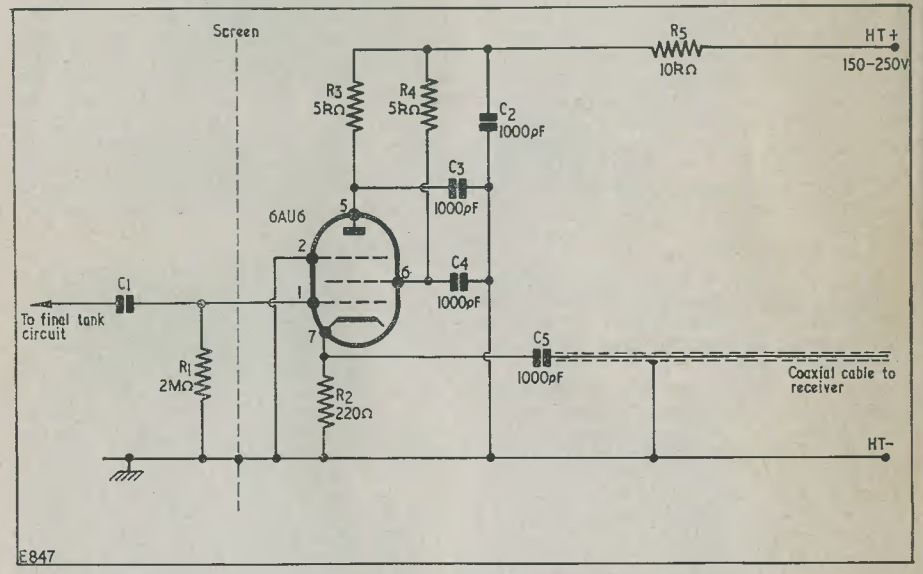
There are other, technical, advantages with the 625-line system. Firstly, negative video modulation is used, with the result that any impulsive interference reaching the cathode ray tube shows up as black instead of white, and is consequently less noticeable. Also, a.g.c. can be taken from the tips of the sync pulses instead of from average picture level, thereby allowing more accurate control to be given in receivers of the less expensive type. (If gated a.g.c. is used, negative modulation incurs the use of simpler circuits with fewer components than does positive modulation.) Secondly, the 625-line system has f.m. sound with its obvious advantage that impulsive interference may be suppressed. Thirdly, the 625-line system has vertical equalising pulses, with the result that good interlace can be reliably achieved without the necessity of complicated sync separation circuits. Fourthly, the 625-line system would enable Britain to have direct exchange, with both Western and Eastern Europe, of television programmes either on tape or over the air; thus obviating the necessity of line standards conversion with its unavoidable degradation of picture quality. Fifthly (and this is a point I went into in some detail last September) if we mass produced 625-line receivers for the home market we would, by reason of the practical manufacturing and design experience gained, be able to similarly mass produce domestic 625-line receivers in very large quantities for the export market.

The Question of Colour

The 405 *versus* 625-line controversy has now taken a new turn because people in this country have suddenly woken up to the fact that there is such a thing as colour television. The *Daily Express* took up the cudgels for colour television on 9th May and started a series of 45-minute public demonstrations employing a receiver manufactured by the General Electric Company. The pictures received were 405-line B.B.C. transmissions and the receiver was set up at the *Daily Express* offices in Fleet Street. The *Daily Express* gave front page coverage to this project and has, up to the time of writing, carried on a campaign for colour television regardless, so far as I can see to date, of whether this be on 405 or 625 lines. Shortly after the *Daily Express* demonstrations commenced the Postmaster-General was questioned about the introduction of colour transmissions in this country. The reply was that this would depend upon whether we introduced a 625-line system or not. If the public bought 405-line colour receivers before such a decision were made these would be useless if the 625-line system were, eventually, introduced. This is very reasonable of course, and brings us back to the question: do we introduce a 625-line system or not?

To that question it has been stated that we must wait until the Pilkington Committee makes known its findings next year. But time is getting short. The Pilkington Com-

mittee is looking into many aspects of future television broadcasting and is receiving evidence from bodies which range from the B.B.C. to the Musicians' Union; and it must be remembered that the Television Advisory Committee gave a satisfactory answer to the 625-line problem considered on its own as long ago as May 1960. After four years' work the T.A.C. decided in favour of the introduction of 625-line transmissions, making the unassailable point that these must be accommodated in Bands IV and V if existing 405-line transmissions in Band I and Band III are to be maintained. It seems possible that the Pilkington Committee will be asked for an early recommendation on the 625-line question alone.



An electronic T/R switch which automatically cuts out the receiver when transmitting

There the situation rests. It is feasible that further developments may have taken place by the time this contribution appears in print. If so, let us hope that these will have caused us to at least *commence* to find our way out of our 405-line rut. The changeover will have to be made at some time; and it would be disastrous if we now embarked on colour television using a line standard which is employed nowhere else in the world.

Electronic Send-Receive Switch

Turning away from the subject of television for the moment, the accompanying circuit diagram shows a neat electronic send-receive switch which was described in Bud Pounsett's "Sideband" column in the March issue of the Australian journal *Amateur Radio*. Bud Pounsett (VK2AQJ) points out that connecting electronic T/R switches in the line to the aerial or aerial coupler can cause attenuation of received signals due to absorption by the final tank circuit of the transmitter. With the circuit shown here C_1 is connected to the input to the final tank circuit (a possible point being at the final anode) whereupon, when the transmitter is off, the aerial couples to C_1 via the tank circuit and the latter provides additional selectivity without attenuation due to absorption. Under this condition the 6AU6 acts as a cathode follower, feeding the aerial signal to the receiver via C_5. When the transmitter is on, the high-level r.f. in the tank circuit causes the 6AU6 to cut off due to leaky-grid action in C_1 and R_1; and little r.f. is fed to the receiver. Thus the circuit automatically cuts the receiver when sending.

The device has been used successfully on s.s.b. by VK2EL and others. VK2EL fits his switch in a small shielded box, in which the grid pin and C_1, R_1 are fully screened from the rest of the circuit. Complete isolation between input and output is essential for correct operation of the circuit. If desired, R_2 could be replaced by a tuned circuit link coupled to the receiver. Condenser C_1 must be capable of withstanding the d.c. and r.f. voltages applied to it, and the value in pF quoted for this component in *Amateur Radio* is 5,000 divided by d.c. anode volts.

The report does not state the output impedance of the 6AU6 as a cathode follower but, assuming a gm of some 4mA per volt, this should be around 250Ω. This, shunted by the 220Ω in R_2 causes an impedance of nearly 120Ω to be applied to the coaxial cable. Rather high for 75Ω cable and, if it is considered important for the short run of cable likely to be used, it might be possible to get a better match to such cable by using a lower value for R_2 and/or a sharp cut off valve having a higher mutual conductance.

Photographing from the TV Screen

The technique of taking satisfactory photographs from the television screen is one which may not always be fully understood by the radio enthusiast, and it is pleasant to be able to pass on the advice of photographic experts on this matter. Grateful acknowledgments are due to Wallace Heaton Ltd. for permission to reproduce the following two paragraphs from the Spring issue of *PhotoGRAPHIC**.

"We are frequently being asked for the correct exposure when photographing the television screen image. Our experience with a film of 80-100 ASA suggests aperture at *f*/5.6 and with a 200 ASA *f*/8 to *f*/11, with 1/25th (or 1/30th) second. Faster shutter speeds than 1/25th or 1/30th would *not* cover the complete screen image as the picture is built up line by line.

"These values are, of course, only indications as the brilliance of the picture and the method of development may vary. Basically, one should make sure that all other light sources in the room are switched off. They would produce light diffusion and reflections. The camera should be on a tripod and parallel to the set. If the television picture only is to be reproduced go suitably close to the screen, if necessary with a close-up supplementary lens. Set the television screen picture as bright as possible, just avoiding flickering. Furthermore, the picture should be set to a minimum contrast, so that the darkest parts are grey and to the eye of insufficient contrast."

* *PhotoGRAPHIC* is published four times a year by Wallace Heaton Ltd., 127 New Bond Street, London, W.1.

SOME equivalent CIRCUITS

By J. B. DANCE, M.Sc.

EQUIVALENT CIRCUITS HAVE AN EXTREMELY wide variety of uses in electronics ranging from practical applications to pure theory. Simple equivalent circuits are frequently used by people who do not even realise that they are using an equivalent circuit. An equivalent circuit consists of an arrangement of real or imaginary components which could replace an actual circuit thereby giving exactly, or approximately, the same performance either under all conditions or under certain specified conditions, e.g. a certain frequency of operation. An equivalent circuit may contain such imaginary things as negative resistances, but nevertheless it may be extremely useful for calculations on the corresponding real circuit. Equivalent circuits are useful when dealing with valves, loudspeakers and their cabinets, transformers, aerial circuits and almost all kinds of networks. The simplest way of calculating the gain of a valve or transistor circuit is normally by means of an equivalent circuit. This article attempts to explain some of the basic ideas in detail in the hope that the reader will find practical applications for them and that they will help him to understand more advanced work. The wide variety of uses of equivalent circuits are best studied by considering various simple examples.

Let us first consider the simplest possible equivalent circuit, namely two resistors, R_1 and R_2, in series with no connection at the junction of the two. Almost all readers will know that it is possible to find a value of a single resistor, R, such that this single resistor can replace the two series resistors in any circuit whatsoever. The value of R is, of course, given by the equation $R=R_1+R_2$.

Even single components can often be represented by equivalent circuits. When a condenser is used at high frequencies the inductance of the leads and electrodes may be of great importance. The condenser can then be represented as a condenser and inductance in series, it being seen that the combination forms a resonant acceptor circuit which behaves as an inductance at frequencies

above that of resonance. Similarly, most inductances can be represented as an induc tance in series with a resistance—not to mention the distributed capacitance.

Transformers

Very many different types of equivalent circuits have been proposed for transformers. Many of these separate the mutual inductance from the leakage inductance and transfer components from the primary to the secondary circuits, etc. In an elementary article, it is not practical to consider transformer equivalent circuits in detail, but there is one very useful point which will be required in a later calculation. Consider the transformer shown in Fig. 1 (*a*) with a secondary load R_L, n_1 primary turns and n_2 secondary turns. If the transformer were perfect at the frequency concerned, and only a.c. voltages are considered, the circuit could be represented by Fig. 1 (*b*) in which the transformer is omitted and the load resistance has been altered to $\left(\frac{n_1}{n_2}\right)^2 R_L$. In each case, the same current flows from the input and the same power is dissipated in the resistors, but the current through the resistors is different. In practice, transformers are not perfect, but with a well designed iron-cored component the equivalent circuit gives results which are almost exactly correct.

Cells and Batteries

If a current is taken from a cell or battery (or any source of power whatsoever), the voltage across the cell falls somewhat and this fall in voltage is almost exactly proportional to the current delivered by the cell. This is often inconvenient in practice for, if one requires to know the actual voltage of the cell, one has to calculate it. The calculation is performed by imagining the cell to be replaced by the simple equivalent circuit shown in Fig. 2.

The e.m.f. (electro-motive force) of a cell, E, may be considered to be the voltage across the terminals of the cell when it is not delivering a current. Let V be the voltage across the cell terminals under any conditions. In the equivalent circuit of Fig. 2 the actual cell is replaced by the two components within the dotted lines, that is by a hypothetical resistance, *r*, in series with a hypothetical cell of which the terminal voltage is always E. This imaginary cell may be called a constant voltage generator, its voltage being independent of the current passing through it and always equal to the e.m.f. of the actual cell. The resistance, *r*, is known as the internal resistance of the cell.

When no current is being taken from the cell (that is when the load resistance, R, is infinite or is disconnected), the terminal voltage, V, of the actual cell equals the voltage of the imaginary cell, E, because no current flows through *r* and therefore there is no voltage drop across this imaginary resistor. As the load resistance is lowered, the current delivered by the imaginary cell of Fig. 2 increases, thereupon the voltage drop across the resistor *r* increases. This voltage drop equals *ir* where *i* is the current passing through the circuit. The actual voltage across the dotted box of Fig. 2 is therefore given by the equation: $V=E-ir$. This voltage falls as the current increases, the fall being proportional to the current. The equivalent circuit inside the dotted line therefore behaves as the actual circuit, and the idea is useful because it enables us to calculate the actual terminal voltage of any cell if we know

(i) The e.m.f. of the cell,
(ii) The internal resistance of the cell, and
(iii) The current which the cell is delivering.

When the cell is on charge, a current is passed through it in the reverse direction, the terminal voltage then becoming higher than the e.m.f. The equivalent circuit again gives us the correct answer because the voltage across *r* must now be added to the voltage across the imaginary cell.

In actual practice, the drop in voltage when a current is taken from the cell is only approximately proportional to the current being delivered by the cell, therefore the equivalent circuit of Fig. 2 will not represent the performance of a cell exactly but only to a close degree of approximation. Alternatively, it may be said that the method is absolutely exact, but the internal resistance of the cell depends to a slight extent on the current passing through the cell. The equivalent circuit of a cell has been discussed in some detail because it is very similar to valve equivalent circuits.

Thévenins's Theorem

The Thévenin (or Helmholtz) theorem is one of the most important theorems associated with equivalent circuits. Although it sounds complicated, it is actually not so, but it does require some thought. It may be simplified to the following form: Any linear network (however complicated), containing any number of sources of voltage, and any number of resistors is, when regarded from one pair of terminals, equivalent to a single resistor in series with a source of voltage. The resistor is equal to that measured between the terminals with all voltage sources shorted, the voltage source being equal to the open circuit voltage between the terminals. If condensers or inductances are

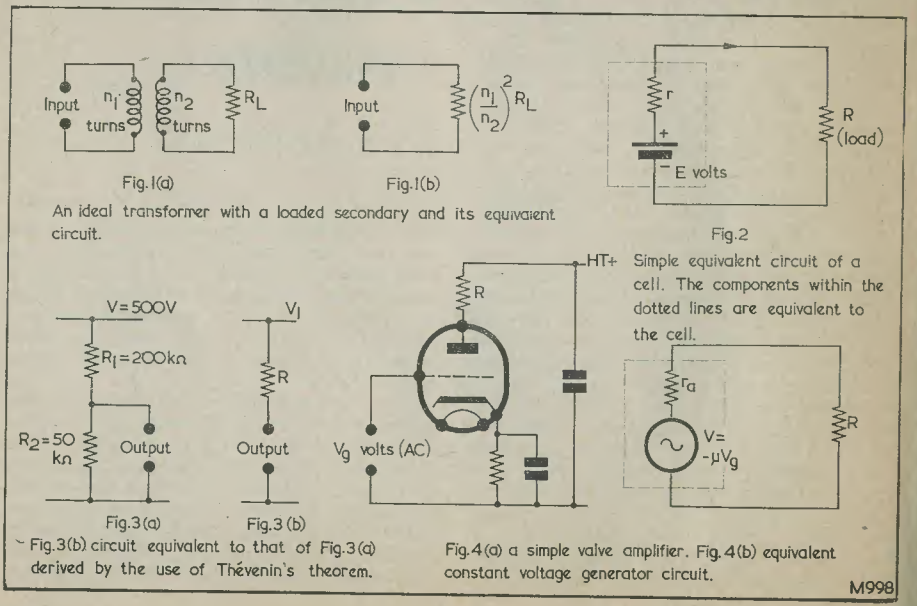


Fig.1(a) Fig.1(b)

An ideal transformer with a loaded secondary and its equivalent circuit.

Fig.2

Simple equivalent circuit of a cell. The components within the dotted lines are equivalent to the cell.

Fig.3(a) Fig.3(b)

Fig.3(b) circuit equivalent to that of Fig.3(a) derived by the use of Thévenin's theorem.

Fig.4(a) a simple valve amplifier. Fig.4(b) equivalent constant voltage generator circuit.

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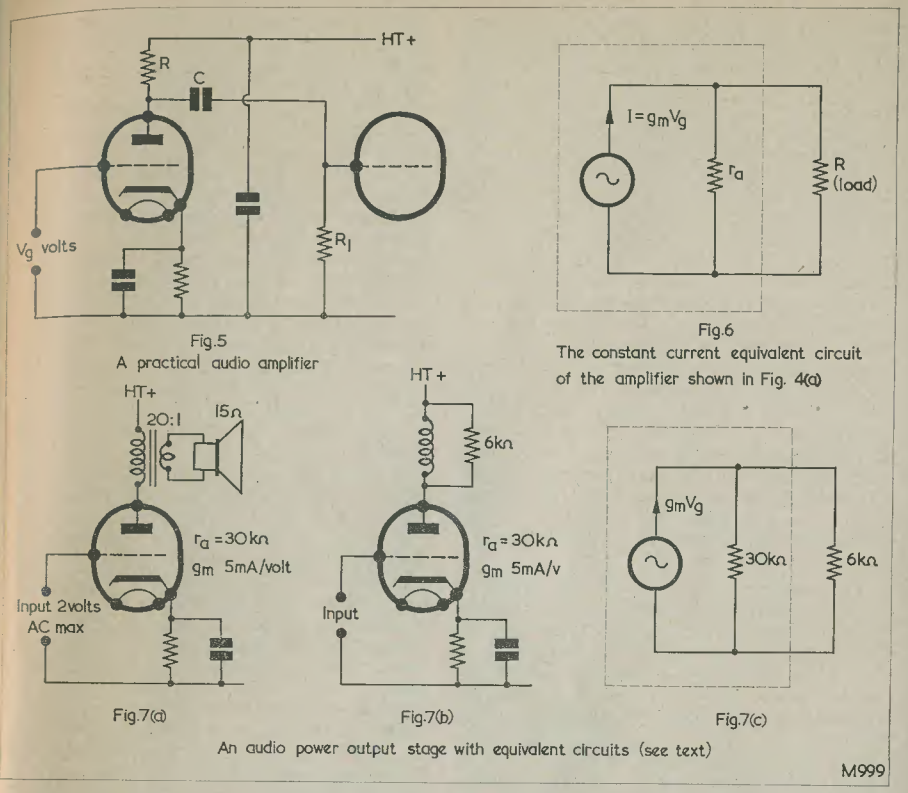

Fig.5 A practical audio amplifier

Fig.6 The constant current equivalent circuit of the amplifier shown in Fig. 4(a)

Fig.7(a) Fig.7(b) Fig.7(c)

An audio power output stage with equivalent circuits (see text)

M999

present in the network, a more complicated form of the theorem must be used in which the word impedance is substituted for resistance. A linear network is one which does not contain such things as rectifiers in which the current is not proportional to the voltage.

The equivalent circuit of Fig. 2 is an example of the use of the theorem because the actual cell is replaced by an imaginary cell in series with a resistor. As a second example, let us suppose that a certain valve electrode (or any other piece of apparatus) should be supplied with an h.t. voltage derived from the potential divider network shown in Fig. 3 (*a*). Thévenin's theorem states that the potential divider may be replaced by a single resistor in series with a voltage source as shown in Fig. 3 (*b*). The two circuits are not merely intended to provide the same output voltage at a particular value of output current, but they are intended to provide the same voltage as each other whatever current may be taken from the output, providing that this current is the same for both circuits. That is, the regulation is the same for each circuit.

The values of V_1 and R for the circuit of Fig. 3 (*b*) must be chosen so that the circuits are equivalent; this may be done by the use of the theorem as follows. In the circuit of Fig. 3 (*a*) the voltage across the output terminals, when they are not connected to anything, is 100 volts. Therefore, by the theorem, V_1 in Fig. 3 (*b*) must be 100 volts. When the power supply in Fig. 3 (*a*) is shorted, the two resistors are in parallel when measured from the output terminals. The value of the resistance so measured can be calculated from the equation:

$$\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}=\frac{1}{200{,}000}+\frac{1}{50{,}000}=\frac{1}{40{,}000}$$

Therefore the value of R in the circuit of Fig. 3 (*b*) will be 40kΩ. In actual practice the power supply would not be shorted out but the power supply leads would be disconnected before the power supply terminals were shorted.

Constant Voltage Valve Equivalent

If certain assumptions and approximations are made, Thévenin's theorem may be applied to valve circuits in order to obtain a constant voltage valve equivalent circuit; this brings valves within the scope of normal circuit calculations. Consider the simple valve amplifier shown in Fig. 4 (*a*) and suppose that it is necessary to calculate the gain from the input to the valve anode. If the two decoupling condensers are large enough, the cathode and the h.t.+ line may be considered to be at earth potential with respect to a.c. voltages. As the d.c. voltages are only necessary to make the valve work, and do not come into our calculations on the a.c. gain of the valve, everything connected with the d.c. circuit arrangements has been omitted from the equivalent circuit diagram shown in Fig. 4 (*b*). In this equivalent circuit, the valve has been replaced by the components inside the dotted box, consisting of a constant voltage generator in series with a resistor, r_a. The constant voltage generator is an imaginary thing which always generates a constant a.c. voltage, V, which is independent of the anode current flowing through the valve. The internal resistance of a cell corresponds to r_a but is usually known as the valve anode resistance. As the equivalent circuit applies to a.c. only, r_a is the valve a.c. resistance. The d.c. resistance of the valve is something different. The valve a.c. resistance is quoted by the valve manufacturers for the normal working conditions.

The voltage generator of Fig. 4 (*b*) is considered to generate an a.c. voltage of $-\mu V_g$ volts where μ is the amplification factor of the valve, as quoted by the manufacturers, and V_g is the a.c. voltage between the grid and cathode. The presence of the negative sign (which could be omitted for most purposes) is explained by the fact that making the grid of the valve more positive causes the anode to become more negative. The voltage from the generator, $-\mu V_g$, is divided proportionally between r_a and the load resistor, R. It is obviously impossible to utilise the imaginary part of the voltage across the hypothetical resistor, r_a. The voltage appearing across R is

$$-\mu V_g \frac{R}{r_a+R} \text{ for the input voltage } V_g.$$

$$\text{Gain}=\frac{\text{Output voltage}}{\text{Input voltage}}=\frac{-\mu R}{r_a+R}$$

It has been assumed that the load on the valve is a pure resistance. In a practical resistance-capacity coupled audio amplifier (Fig. 5), C and R_1 take some current and this will affect the calculation somewhat. If C is very large, R and R_1 are effectively in parallel. The value of these resistors in parallel should therefore be put into the above equation in order to calculate the gain. If C is not large the gain may still be calculated by using the above equation, but it is necessary to allow for the phase change. This is most easily done by using the "*j*" operator notation, a process which is outside the range of this article.

As a simple application of the above formula, let us consider one triode section of a 12AX7 double triode connected as an audio amplifier as in Fig. 5. Making the simplifying assumption that R_1 of Fig. 5 is high enough for the shunting effect of R_1 and C to be neglected, we can put values into the formula for the gain. From data published on the 12AX7, $\mu=100$ and $r_a=62k\Omega$ for normal operation. If the load resistance R is 50kΩ,

$$\text{Gain}=\frac{-\mu R}{r_a+R}=\frac{-100\times 50}{62+50}=-45 \text{ approx.}$$

The negative sign can, of course, be ignored. If the two triode sections of the valve were connected in cascade, a gain of about $(45)^2$, i.e. over 2,000 could be obtained. An even higher gain of about 60 per stage can be obtained if R is made larger.

For a 12AU7, $\mu=17$ and $r_a=8k\Omega$. If the same value of R, i.e. 50kΩ, were used as in the previous example, the gain would be about 14 per triode or about 200 for both sections of the valve connected in cascade. Although the 12AU7 gives a much lower gain than the 12AX7, the output impedance of the 12AU7 circuit can be made lower; the 12AU7 is more suitable at fairly high levels.

Generally it is not possible to neglect the effect of the coupling components unless an approximate answer is satisfactory. It may also be necessary to calculate the gain at low or high frequencies at which coupling condensers, or stray capacitance, cause effects which cannot be neglected.

The Constant Current Equivalent Generator

The constant voltage equivalent generator circuits constitute one possible way of looking at certain circuits. Another very similar method uses a constant current generator with a shunt resistor across it and involves Norton's theorem. This theorem, in its simplest form, states that: Any linear network containing any number of voltage sources and any number of resistors is, when regarded from one pair of terminals, equivalent to a resistance which shunts a constant current generator. The resistance is that measured between the terminals with all voltage sources shorted out and the constant current generated is equal to that which flows between the terminals when they are shorted. The theorem can be extended to include reactive components (i.e. coils and condensers). The constant current generator can be used in equivalent circuits for cells, but it is not generally as useful as the constant voltage generator for this purpose. It is, however, especially useful in calculations dealing with pentode valves.

Instead of replacing the circuit of Fig. 4 (*a*) by the constant voltage equivalent circuit of Fig. 4 (*b*), it may be replaced by the constant current equivalent circuit shown in Fig. 6. It is again assumed that the decoupling condensers are large. The components inside the dotted box are equivalent to the valve providing that only a.c. voltages and currents are considered. These components consist of a resistor in parallel with a constant current generator which generates a constant a.c. current of magnitude g_mV_g where g_m is the mutual conductance of the valve and V_g is the a.c. voltage between grid and cathode. The value of the shunt resistance is equal to the anode resistance of the valve as quoted by the manufacturers.

The current through the load resistance R in Fig. 6 equals:

$I \frac{r_a}{R+r_a}$ where I is the total current from the generator.

$$\text{Therefore the voltage across R}=IR\frac{r_a}{R+r_a}$$

$$=g_mV_gR\frac{r_a}{R+r_a}$$

$$\text{and the gain}=g_mR\frac{r_a}{R+r_a}$$

It is interesting to note that as $\mu=-g_mr_a$,

$$\text{the gain}=-\mu\frac{R}{R+r_a}$$

which is the same as the formula obtained by the use of a constant voltage generator.

In a normal r.f. or i.f. pentode amplifier r_a is very much greater than R. Therefore $R+r_a=r_a$ approx.

$$\text{Gain}=g_mR\frac{r_a}{R+r_a}=g_mR \text{ approx.}$$

The gain of an r.f. or i.f. stage is proportional to the mutual conductance of the valve, it therefore being important to choose a valve with a high mutual conductance for the first r.f. stage of a receiver in order to obtain a large gain and hence a high signal to noise ratio. The formula also makes the need for a high dynamic impedance (i.e. load or R) obvious if a high gain is required.

A further typical use of the constant current equivalent circuit is shown in the following example. Let us suppose that a valve with an anode resistance of 30kΩ and a mutual conductance of 5mA/volt is to be used as an audio output valve feeding into a 15 ohm speaker through an output transformer of ratio 20:1 as shown in Fig. 7 (*a*). If the maximum a.c. input voltage to the grid of the valve is limited to 2 volts, the maximum power output from the speaker can be calculated assuming, for the sake of simplicity, that the inductance of the primary winding of the transformer is high enough for its shunting effect to be neglected.

The 15 ohm speaker resistance is first transferred into the primary circuit where its effective resistance becomes $15\times(20)^2=6{,}000$ ohms as shown previously. This is represented by the equivalent circuit of Fig. 7 (b).

The shunting effect of the inductance is stated in the problem to be high enough to be neglected, and therefore the circuit can be transformed into the equivalent circuit of Fig. 7 (*c*), where the valve itself is replaced by the components inside the dotted box. The total a.c. current supplied by the generator $=g_m V_g = 5 \times 2 = 10$mA.

The units are in mA because g_m is expressed in mA/volt. This current divides itself between the two resistors in inverse proportion to the resistance values. Current through

6,000 ohm resistor $= 10 \times \frac{5}{6} = \frac{25}{3}$ mA*

$$= \frac{25}{3,000} \text{ amps.}$$

Voltage across 6,000 ohm resistor = current $\times$ resistance $= \frac{25}{3,000} \times 6,000 = 50$ volts.

Power dissipated in 6,000 ohm resistor $= 50 \times \frac{25}{3,000} = 0.4$ watt approx.

The imaginary 6,000 ohm resistor is the speaker resistance transferred into the primary circuit. This power of 0.4 watt is therefore the power output from the speaker.

Both the constant voltage and constant current equivalent circuits are, in theory, equally applicable to either triodes or pentodes. Whilst it may be possible to calculate the gain of a pentode stage by the use of the constant voltage equivalent generator, the value of the amplification factor of a pentode is very high and cannot be measured as accurately as the value of the mutual conductance. The amplification factor for pentodes is not always quoted by valve manufacturers, therefore it is usually best to use the gain formula which was calculated by the use of a constant current generator, the amplification factor need not then be known. Constant current circuits are also especially useful when the load consists of several components in parallel.

It must be stressed again that the equivalent circuits of valves are fictitious, being merely circuits containing simple imaginary components which would produce the same current and voltage in the load as are produced by the valve in actual practice when a certain a.c. voltage is applied to its grid. It should be remembered that the valve merely controls the current passing from the h.t. supply whereas, in the equivalent circuit, the h.t. supply is completely omitted. The equivalent circuits are of no use for determining the d.c. voltages required for the valve. It is important to note that in calculations on valve equivalent circuits the valve is assumed to behave in a linear way (i.e. a.c. current is proportional to a.c. voltage). The calculations are therefore liable to be particularly inaccurate when the valve operates with a large input or on a non-linear part of its characteristic. In such cases the gain may be calculated from graphs of the valve characteristics, but this is more troublesome than using formulae derived from equivalent circuits. The capacity between valve electrodes becomes appreciable at high frequencies, allowing for this however, equivalent circuits are useful up to about 10 Mc/s. At higher frequencies the inductance of the leads and valve electrodes becomes appreciable, and therefore any equivalent circuit becomes rather complicated.

Discussion on reactive loads and reactive circuits has been deliberately avoided in this article, but the same principles can be used for calculations on reactive loads. Readers who are newcomers to electronics will at least appreciate that the large amount of data published on valves certainly has its uses!

*The fraction $\frac{5}{6}$ is derived from the fact that 5,000Ω is the combined resistance of 6,000 and 3,000Ω in parallel.—*Editor.*

Book Review . . .

UNDERSTANDING MICROWAVES. By Victor J. Young, Ph.D. 292 pages, 5½in x 8½in. Published by Chapman and Hall Ltd. Price 32s. net.

Microwave engineering has tended to be rather a specialised branch of electronics due, perhaps, to the necessity of transferring one's thinking from the more "obvious" concepts of conductor-carried current to the field of cavity and waveguide phenomena. The author of this book fully appreciates this point and avoids a mathematical approach to the subject.

The book commences with electrostatics and magnetostatics, carrying on through a.c. theory to transmission lines. A chapter on Poynting's Vector and Maxwell's Equations then appears before continuing to waveguides and resonant cavities. The final chapters deal with aerials, microwave oscillators, radar, and microwave communications.

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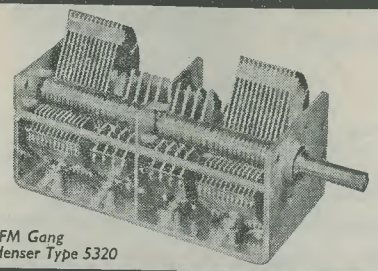

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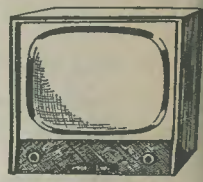

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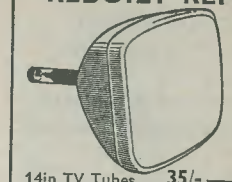

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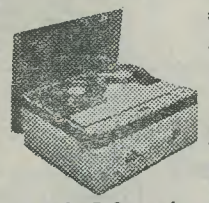

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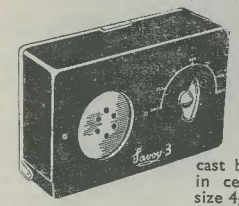

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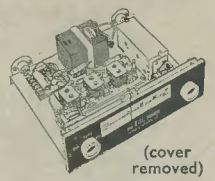
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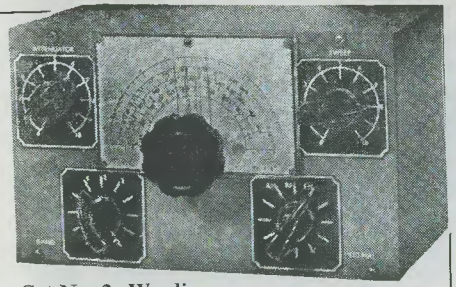

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