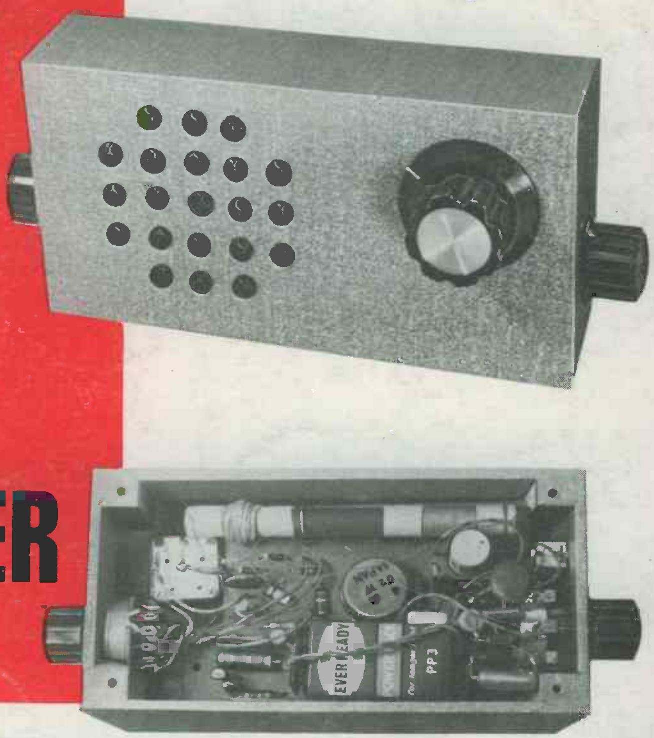
RADIO & ELECTRONICS CONSTRUCTOR

JULY 1974

22p

'NO-ALIGNMENT'

MEDIUM AND LONG WAVE I.C. RECEIVER



ALSO FEATURED

SIMPLE WIPER DELAY CIRCUIT

ANNUAL INDEX

AMTRON Metal Detector

UK 780

With the help of the AMTRON UK 780 metal objects and ores can be located underground. The sensitivity of this instrument is quite high, and certainly not inferior to that of much more expensive instruments. Its degree of stability is also quite outstanding, because of the low operating frequency of the two oscillators. The electronic circuits consist basically of four transistors, type BC 109B; the unit is powered by a 6 V battery.

£12.00 inc. VAT

Specifications:

Power Supply:	6 V DC	Max. detection depth of metal bodies of sizeable dimensions:	70cm
Current input:	3-4 mA		
Operating frequency:	150 kHz approx.		
Transistors:	(4) BC109B	Diodes:	(2) AA119

RECOMMENDED RETAIL PRICE LIST

UK45	Intermittent Warning Lights	£5.83
UK65	Transistor Tester	£1.82
UK80	Oscilloscope Calibrator	£2.91
UK92	Telephone Amplifier	£9.09
UK107	Fuzz Effect	£18.16
UK110	Stereo Amplifier	£12.71
UK112	Reverb. Preamplifier	£29.05
UK115	Hi-fi Amplifier 8w	£4.95
UK120	Hi-fi Amplifier 12w	£5.20
UK125	Stereo Control Unit	£7.27
UK127	Noise Reduction Unit	£10.51
UK130	Mono Control Unit	£4.57
UK135	High Impedance Pre-amp.	£2.37
UK140	Low Impedance Pre-amp.	£2.91
UK142	Tone Control Unit	£7.68
UK145	Amplifier 1.5w	£4.19
UK152	Stereo Output Differential Meter	£12.71
UK157	Private TV Loop Trans.	£5.44
UK160	I.C. Amplifier 8w	£12.71
UK162	Private TV Listener	£15.30
UK165	R.I.A.A. Stereo Preamp	£5.83
UK167	Stereo Preamp to R.I.A.A. or C.C.I.R. Standards	£7.68
UK170	Hi-fi Preamp with tone controls	£26.08
UK172	Universal Preamp	£17.37
UK175	Hi-fi Stereo Preamp	£35.28
UK180	4 Channel Sound Unit	£33.73
UK185	Hi-fi Stereo Amp. 20+20 w	£79.09
UK187	Hi-fi Quadrik Stereo Amp.	£110.45
UK190	Hi-fi Amplifier 50w	£34.66
UK192	Hi-fi Stereo Amp. 50+50w	£52.62
UK195	Miniature Amp. 2w	£4.03
UK220	Signal Injector	£2.91
UK230	AM/FM Antenna Amp.	£3.62
UK235	Acoustic Alarm for Absent Minded Drivers	£9.47
UK240	Parking Lights Auto Switch	£7.60
UK252	MPX Stereo Decoder	£17.37
UK255	Level Indicator	£7.68
UK270	IC Amp. 6w	£9.86
UK275	Mike Preamplifier	£7.68
UK285	VHF/UHF Antenna Amp.	£9.45
UK300	Radio Control Transmitter	£7.27
UK302	Radio Control Transmitter	£23.22

Send 10p for illustrated brochure

UK310	Radio Control Receiver	£3.62
UK325	'GXC2' Channel Splitting Unit 1000 and 2000Hz	£8.71
UK330	'GXC2' Channel Splitting Unit 1500 and 2500 Hz	£8.71
UK345	Superheterodyne RX	£7.27
UK370	R.F. Linear Amplifier	£40.83
UK375	CB Crystal Calibrator	£12.33
UK385	H.F. Wattmeter 10w	£15.64
UK390	Vox	£14.98
UK407	Squarer	£6.51
UK415	Resistor Box	£10.15
UK425C	Capacitor Box	£8.39
UK425S	Capacitor Box	£12.66
UK432	Utility Tester Kit	£24.01
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UK437	Audio Frequency Generator	£35.26
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UK470S	Marker Generator with Quartz Control	£27.20
UK475C	Electronic Voltmeter	£24.01
UK482	Auto. Battery Charger	£24.01
UK500	LW/MW/FM Receiver	£43.60
UK515	MW Radio Receiver	£8.71
UK520	AM Tuner	£5.06
UK525C	VHF Tuner 120-160 MHz	£12.44
UK540	LW/MW/FM Tuner	£33.36
UK546	AM/FM Receiver 25-200 MHz	£6.52
UK550S	LF Frequency Meter	£25.38
UK555	Field Strength Meter	£12.00
UK560S	Transistor Analyzer	£36.22
UK565	Probes for Elect. Voltmeter	£3.64
UK570S	Low Frequency Signal Generator 10 Hz-1 MHz	£23.58
UK575S	Square Wave Generator	£21.75
UK585	Electronic Beam Switch	£29.76
UK590	SWR Meter	£10.41
UK595	Electronic Fuse	£6.88
UK602	Elect. Potential Divider 24-14 VDC	£8.35
UK605	Power Supply 18 VDC 1A	£5.84
UK607	Stab. Power Supply 9VDC 100mA	£9.87
UK610	Power Supply 24VDC 0.5A	£5.84
UK615	Power Supply 24VDC 1A	£7.30
UK627	Storage Battery Voltage Divider	£7.25
UK630	Stab. Power Supply 6VDC-250mA; 7.5VDC 200mA; 9VDC 170mA; 12VDC 100mA	£10.16
UK640	200W Light Dimmer	£8.35
UK652	Stab. Power Supply 12V 1.5A	£18.16
UK665	Twin Power Supply 55VDC x2-2A x 2	£24.02

UK670	Buffer Battery Charger	£8.35
UK672	Stab. Power Supply 12VDC 15mA	£6.51
UK675	Regulated Power Supply	£65.29
UK682	Stab. Power Supply 4-35VDC 2.5A	£58.03
UK690	DC Motor Speed Governor	£3.64
UK692	Stab. Power Supply 5.5 to 16VDC-2A	£29.05
UK700	Electronic Chaffinch	£8.71
UK702	Ozonizer	£16.34
UK707	Windscreen Wiper Timer	£8.77
UK710C	4 Channel A.F.Mixer	£13.83
UK715	Photoelectric Cell Switch	£9.87
UK760C	Acoustic Switch	£13.83
UK765	Multiple Stereo Connector	£3.64
UK767	Multiple Stereo Connector	£4.70
UK780	Elect. Unit for Metal Detector	£12.00
UK790	Cap. Burglar Alarm	£8.71
UK795	Elect. Continuity Tester	£5.47
UK800	3 Way Crossover Filter 12db/Octave	£9.08
UK805	3 Way Crossover Filter 6db/Octave	£5.84
UK815	Ultrasonic Radar Burglar Alarm	£33.36
UK820	Elect. Digital Clock	£70.75
UK832	Photo-electric Rev. Counter	£23.19
UK835	Guitar Preamplifier	£5.47
UK837	Logical Demonstrator	£7.25
UK840	Adjustable Time Lag Car Burglar Alarm	£7.69
UK842	Binary Demonstrator	£14.14
UK850	Electronic Keyer	£18.01
UK855	Electronic Fuzz Box	£7.96
UK857	Electric Guitar Fuzz Sound	£11.63
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UK900	R.F. Crystal Oscillator 20-60MHz	£2.92
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UK910	R.F.Mixer 12-170 MHz	£2.92
UK915	R.F. Amp. 12-170MHz	£2.92
UK920	R.F. Mixer 2.3-27MHz	£2.92
UK925	R.F. Amp 2.3-27MHz	£2.92
UK930	R.F. Power Amp. 3-30MHz	£2.92
UK935	Wide Band Amplifier 3-30MHz	£2.92
UK960	VHF Convertor 144-146MHz	£18.79
UK965	CB Convertor (27MHz)	£28.27
UK995	Colour Bar and Dot Generator	£23.61
3009.00	Metal Instrument Cabinet	£5.82
3009.10	Metal Instrument Cabinet	£5.07
3009.20	Metal Instrument Cabinet	£6.54

ALL PRICES INCLUDE VAT

AMTRON UK

AMTRON UK., 4 & 7 CASTLE STREET, HASTINGS, SUSSEX TN34 3DY. Tel: (0424) 437875.
ALL educational enquiries to Phillip Harris Ltd., Ludgate Hill, Birmingham. Tel: 021-236 4041.

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Printed circuit B9A – B7G	3p
Chassis UX7 – UX5 – B9G – B7G	3p
Shrouded chassis B7G – B9A	4p
B8A – B9A chassis – B12A tube	5p

TAG STRIP
6 way **2p** Single **1p**

WRIST COMPASS
20p with Needle Lock

TO3 Mica Washer	2p
3″ Standard Tape - Boxed	20p
GP91-1 Cartridge, turnover stylii	75p
GC10/4B Cold Cathode	£5.00
Brand New Boxed 6K7G	25p

$1\frac{1}{4}$ glass fuses— 250 m/a or 3 amp (box of 12)	12p
3″ tape spools	8p
FX2236 Ferrox Cores	5p
PVC or metal clip on M.E.S. bulb holder	3p
All metal equipment Phono plug	2p
Bulgin, 5mm Jack plug and switched socket (pair)	30p
12 volt solenoid and plunger	40p
250 RPM 50 c/s locked frequency miniature mains motor	50p
200 OHM coil, $2\frac{1}{4}$″ long, hollow centre	10p
Belling Lee white plastic surface coax outlet Box	30p
R.S. 12 way standard plug and shell	50p

SWITCHES

Pole	Way	Type	
4	2	Sub. Min. Slide	10p
6	2	Slide	15p
4	2	Lever Slide	10p
6	4	Wafer Rotary	20p each
4	3	Wafer Rotary	20p each
3	7	Wafer Rotary	20p each
2	5	Wafer Rotary	20p each
1	3	+ off Sub. min. edge	10p
1	3	13 amp small rotary	12p
2	2	Locking with 2 to 3 keys	£1.50
2	1	2 Amp 250V A.C. rotary	20p
1	2	Toggle	10p

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HOST OF QUALITY, REASONABLE LEAD TRANSISTORS, SOME POWER. SILICON, GERMANIUM, ZENER DIODES, POT CORES HI-STAB RESISTORS, SOME WIREWOUND, CONDENSERS, CHOKES, TRIMPOTS, ELECTROLYTICS, ETC.
3lb. for **75p** + **30p** post and packing
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SUBMIN VERTICAL SKELETON PRESET 50, 100, 220, 470, 680 OHM **1**, 2.2, 4.7, 6.8, 10, 15, 22, 47, 68, 100, 220 K OHM. ONLY **3p** EACH

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SILVER METAL PUSH ON WITH POINTER, OR WHITE PLASTIC, GRUB SCREW, WITH POINTER AND SILVER CENTRE **10p** EACH.

ZM1162A INDICATOR TUBE

0-9 Inline End View. Rectangular Envelope 170V 2.5M/A **£3.60**

RESETTABLE COUNTER

English Numbering Machines LTD.
MODEL 4436-159-989
6–14 volt, 6 digit, illuminated, fully enclosed. **£2.50**

RESISTORS

$\frac{1}{8}$–$\frac{1}{4}$–$\frac{1}{2}$ watt	1p
1 watt	2p
Up to 5 watt wire	10p
10 watt wire wound	12p
15 watt	14p

SKELETON PRESETS

5K or 500K	4p
5K wirewound	5p

SAFETY PINS

Standard size, 10 for **4p**

WIREWOUND POTS

250, 300 OHM, 1K, 4 watt, 5K, 10K, 11K, 20K, 50K, all at **12p each**

Philips transformer, safety fused. In 200-220-240v. Out 240v 60ma + 6.3v 1a approx 2″ x $2\frac{1}{4}$″ x $2\frac{1}{2}$″ **£1.50**

5K Log Pot	15p
1meg Tandem Pot	25p
2 meg log switch pot	25p

THERMISTORS

VA1034
VA1040
VA1055
VA1066
VA1100
VA1077
15p each

STEEL BOX WITH LID

$10 \times 5\frac{1}{2} \times 3$″ grey hammer finish **£1**

RELAYS

6 volt, 2 pole c/o heavy duty contacts **60p**
P.O. 3000 type, 1,000 OHM coil, 4 pole c/o **60p**

ELECTROLYTICS

Mullard C426, TCC, CRL, CCL, Cullins, Hunts, STC Subminiature, etc

MFD/VOLT 2p 100/6, 6/3, 8/6, 200/3, 25/3.
3p 25/6.4, 500/6, 250/6.
4p 20/12, 100/25, 100/12, 25/12, 100/15, 64/10, 125/10, 50/50, 50/10, 100/18, 6/25, 2/350.
9p 8/500, 100/200. 400/40, 100/250-275, 4/16 reversible. 16/450
5p 8/50, 8/20, 8/40, 2.5/64, 12/50, 12/20, 10/20, 16/50, 16/40, 25/25, 50/25, 150/12, 150/25, 260/12, 4/60, 15/35, 5/50, 8/150, 1/75, 2/75.
6p 250/18, 400/16, 250/30, 550/12 150/40, 50/50.
50p 8/800, 12,000/12, 2000/50. 32-32-50/350.
20p 100-100/150, 100-100/275, 32-32/275.
£1 100-100-100-150-150/320

INDICATORS

Arcolectric green, takes M.E.S. bulb	15p
Bulgin D676 red, takes M.E.S. bulb	15p
12 volt red, small pushfit	20p
Mains neon, red. pushfit	20p

CAPACITORS

Mixed type PFDS, 2p. 1, 3.3, 4.7, 5.6, 10, 12, 15, 16, 18, 20, 22, 24, 25, 27, 30, 33, 37, 39, **47**, 50, 56, 68, 88, 100, 110, 120, 150, 200, 220, 250, 270, 300, 330, **470**, 500, 600, 680, 800, 1000, 2200, 3000, 3300, 5000.
Poly, met., film, paper, etc. MFD/Volt, 3p. .001/1250, .005/250, .03/350, .03/12, .03/200 .033/100, .0068/70, .056/350, .061/035, .069/350, .075/350, .08/350, .1/350, .1/500, .13/350, .25/150.
4p. 1500, 1800, 2200, 3000, 3300, 6800, 8200 PFD. .01/350, .013/350, .02/250, .05/125, .05/250, .068/200 .25/350.
5p. .033/100, .1/250, .25/500, .5/350.
6p. .1/600, .1/1500, .22/250. .5/250
10p. .01/1000, 1/350, 2/150, 2/200, 2/250 .1/900, .22/900.
40p. 5/150, 9/275AC, 10/150, 15/150, 40/150.

TRIMMERS, 15p each

100PF Ceramic, 30PF Beehive, 12PF PTFE 2500PF 750 volt, 33PF MIN. AIR SPACED 5PF, MIN. AIR SPACED, 50PF CERAMIC.

CONNECTOR STRIP

Belling Lee L1469, 4 way polythene. **3p each**

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1″ or $1\frac{3}{8}$″ or $\frac{3}{4}$″ **2p**

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36 ohm 25 watt + 79 ohm 9 watt **25p**

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$3 \times 2\frac{1}{2} \times \frac{1}{16}$″	2p
$4\frac{5}{8} \times \frac{1}{2} \times \frac{1}{8}$″,	2 for 1p
220K 3 watt resistors	2p
100 ohm 3 watt resistor	4p
VALVE RETAINER CLIP, adjustable	2p

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Sub-miniature Transistor Type	20p
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3 pin din to open end, $1\frac{1}{2}$yd twin screened lead **35p**

The largest selection

BRAND NEW FULLY GUARANTEED DEVICES

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AC107	0.22	AD161 &		BC150	0.20	BD131	0.55	BF182	0.44
AC113	0.20	AD162(MP)	0.75	BC151	0.22	BD132	0.66	BF183	0.44
AC115	0.22	ADT140	0.55	BC152	0.19	BD133	0.72	BF184	0.28
AC117K	0.32	AF114	0.27	BC153	0.31	BD135	0.44	BF185	0.33
AC122	0.13	AF115	0.27	BC154	0.33	BD136	0.44	BF187	0.30
AC125	0.19	AF116	0.27	BC157	0.20	BD137	0.50	BF188	0.44
AC126	0.19	AF117	0.27	BC158	0.13	BD138	0.55	BF194	0.13
AC127	0.20	AF118	0.39	BC159	0.13	BD139	0.61	BF195	0.13
AC128	0.20	AF124	0.33	BC160	0.50	BD140	0.66	BF196	0.16
AC132	0.16	AF125	0.33	BC161	0.55	BD155	0.88	BF197	0.16
AC134	0.16	AF126	0.31	BC167	0.13	BD175	0.66	BF200	0.50
AC137	0.16	AF127	0.31	BC168	0.13	BD176	0.66	BF222	£1.05
AC141	0.20	AF139	0.33	BC169	0.13	BD177	0.72	BF257	0.50
AC141K	0.32	AF178	0.55	BC170	0.13	BD178	0.72	BF258	0.66
AC142	0.20	AF179	0.55	BC171	0.16	BD179	0.77	BF259	0.94
AC142K	0.28	AF180	0.55	BC172	0.16	BD180	0.77	BF262	0.61
AC151	0.17	AF181	0.55	BC173	0.16	BD185	0.72	BF263	0.61
AC154	0.22	AF186	0.55	BC174	0.16	BD186	0.72	BF270	0.39
AC155	0.22	AF239	0.41	BC175	0.24	BD187	0.77	BF271	0.33
AC156	0.22	AL102	0.72	BC177	0.21	BD188	0.77	BF272	0.88
AC157	0.27	AL103	0.72	BC178	0.21	BD189	0.83	BF273	0.39
AC165	0.22	ASY26	0.28	BC179	0.21	BD190	0.83	BF274	0.39
AC166	0.22	ASY27	0.33	BC180	0.27	BD195	0.94	BFW10	0.66
AC167	0.22	ASY28	0.28	BC181	0.27	BD196	0.94	BFX29	0.30
AC168	0.27	ASY29	0.28	BC182	0.11	BD197	0.99	BFX84	0.24
AC169	0.16	ASY50	0.28	BC182L	0.11	BD198	0.99	BFX85	0.33
AC176	0.22	ASY51	0.28	BC183	0.11	BD199	£1.05	BFX86	0.24
AC177	0.27	ASY52	0.28	BC183L	0.11	BD200	£1.05	BFX87	0.27
AC178	0.31	ASY54	0.28	BC184	0.13	BD205	0.88	BFX88	0.24
AC179	0.31	ASY55	0.28	BC184L	0.13	BD206	0.88	BFY50	0.22
AC180	0.22	ASY56	0.28	BC186	0.31	BD207	£1.05	BFY51	0.22
AC180K	0.32	ASY57	0.28	BC187	0.31	BD208	£1.05	BFY52	0.22
AC181	0.22	ASY58	0.28	BC207	0.12	BDY20	£1.10	BFY53	0.19
AC181K	0.32	ASY73	0.28	BC208	0.12	BF115	0.27	BPX25	0.94
AC187	0.24	ASZ21	0.44	BC209	0.13	BF117	0.50	BSX19	0.17
AC187K	0.25	BC107	0.12	BC212L	0.12	BF118	0.77	BSX20	0.17
AC188	0.24	BC108	0.12	BC213L	0.12	BF119	0.77	BSY25	0.17
AC188K	0.25	BC109	0.12	BC214L	0.16	BF121	0.50	BSY26	0.17
ACY17	0.28	BC113	0.11	BC225	0.28	BF123	0.55	BSY27	0.17
ACY18	0.22	BC114	0.17	BC226	0.39	BF125	0.50	BSY28	0.17
ACY19	0.22	BC115	0.17	BC301	0.30	BF127	0.55	BSY29	0.17
ACY20	0.22	BC116	0.17	BC302	0.27	BF152	0.61	BSY38	0.20
ACY21	0.22	BC117	0.20	BC303	0.35	BF153	0.50	BSY39	0.20
ACY22	0.18	BC118	0.11	BC304	0.40	BF154	0.50	BSY40	0.31
ACY27	0.20	BC119	0.33	BC440	0.34	BF155	0.77	BSY41	0.31
ACY28	0.21	BC120	0.88	BC460	0.40	BF156	0.53	BSY95	0.14
ACY29	0.39	BC125	0.13	BCY30	0.27	BF157	0.61	BSY95A	0.14
ACY30	0.31	BC126	0.20	BCY31	0.29	BF158	0.61	BU105	£2.20
ACY31	0.31	BC132	0.13	BCY32	0.33	BF159	0.66	C111E	0.55
ACY34	0.23	BC134	0.20	BCY33	0.24	BF160	0.44	C400	0.33
ACY35	0.23	BC135	0.13	BCY34	0.28	BF162	0.44	C407	0.28
ACY36	0.31	BC136	0.17	BCY70	0.16	BF163	0.44	C424	0.28
ACY40	0.19	BC137	0.17	BCY71	0.22	BF164	0.44	C425	0.55
ACY41	0.20	BC139	0.44	BCY72	0.16	BF165	0.44	C426	0.39
ACY44	0.39	BC140	0.33	BCZ10	0.22	BF167	0.24	C428	0.22
AD130	0.42	BC141	0.33	BCZ11	0.28	BF173	0.24	C441	0.33
AD140	0.53	BC142	0.33	BCZ12	0.28	BF176	0.39	C442	0.33
AD142	0.53	BC143	0.33	BD115	0.68	BF177	0.39	C444	0.39
AD143	0.42	BC145	0.50	BD116	0.88	BF178	0.33	C450	0.24
AD149	0.55	BC147	0.11	BD121	0.66	BF179	0.33	MAT100	0.21
AD161	0.39	BC148	0.11	BD123	0.72	BF180	0.33	MAT101	0.22
AD162	0.39	BC149	0.13	BD124	0.76	BF181	0.33	MAT120	0.21

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
MAT121	0.22	2G304	0.27	2N2148	0.63	2N3055	0.55	2N4060	0.13
MJE2955	0.95	2G306	0.44	2N2160	0.66	2N3391	0.16	2N4061	0.13
MJE3055	0.62	2G308	0.39	2N2192	0.39	2N3391A	0.18	2N4062	0.13
MJE3440	0.55	2G309	0.39	2N2193	0.39	2N3392	0.16	2N4284	0.19
MPF102	0.46	2G339	0.22	2N2194	0.39	2N3393	0.16	2N4285	0.19
MPF104	0.41	2G339A	0.18	2N2217	0.24	2N3394	0.16	2N4286	0.19
MPF105	0.41	2G344	0.20	2N2218	0.22	2N3395	0.19	2N4287	0.19
OC19	0.39	2G345	0.18	2N2219	0.22	2N3402	0.23	2N4288	0.19
OC20	0.70	2G371	0.18	2N2220	0.24	2N3403	0.23	2N4289	0.19
OC22	0.52	2G371B	0.13	2N2221	0.22	2N3404	0.31	2N4290	0.19
OC23	0.54	2G373	0.19	2N2222	0.22	2N3405	0.46	2N4291	0.19
OC24	0.62	2G374	0.19	2N2368	0.19	2N3414	0.17	2N4292	0.19
OC25	0.42	2G377	0.33	2N2369	0.16	2N3415	0.17	2N4293	0.19
OC26	0.32	2G378	0.18	2N2369A	0.16	2N3416	0.31	2N5172	0.13
OC28	0.55	2G381	0.18	2N2411	0.27	2N3417	0.31	2N5294	0.60
OC29	0.55	2G382	0.18	2N2412	0.27	2N3525	0.83	2N5457	0.35
OC35	0.46	2G401	0.33	2N2646	0.52	2N3614	0.74	2N5458	0.35
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OC81D	0.17	2N699	0.39	2N2925	0.16	2N3819	0.31	2S323	0.62
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SL701C	TO-5	8	0.50	0.45	0.40
SL702C	TO-5	8	0.50	0.45	0.40
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μA703C	TO-5	6	0.28	0.26	0.24
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BP933	0.16	0.15	0.14
BP935	0.16	0.15	0.14
BP936	0.16	0.15	0.14
BP944	0.16	0.15	0.14
BP945	0.30	0.28	0.25
BP946	0.15	0.14	0.13
BP948	0.30	0.28	0.25
BP951	0.70	0.65	0.60
BP962	0.15	0.14	0.13
BP9093	0.45	0.43	0.40
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7402	0.18	0.17	0.16	7460	0.18	0.17	0.16	74155	£1.50	£1.45	£1.35
7403	0.18	0.17	0.16	7470	0.32	0.29	0.27	74156	£1.50	£1.45	£1.35
7404	0.18	0.17	0.16	7472	0.32	0.29	0.27	74157	£2.00	£1.90	£1.80
7405	0.18	0.17	0.16	7473	0.41	0.39	0.35	74160	£2.10	£2.00	£1.90
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7420	0.18	0.17	0.16	7489	£4.00	£3.75	£3.50	74180	£1.50	£1.40	£1.30
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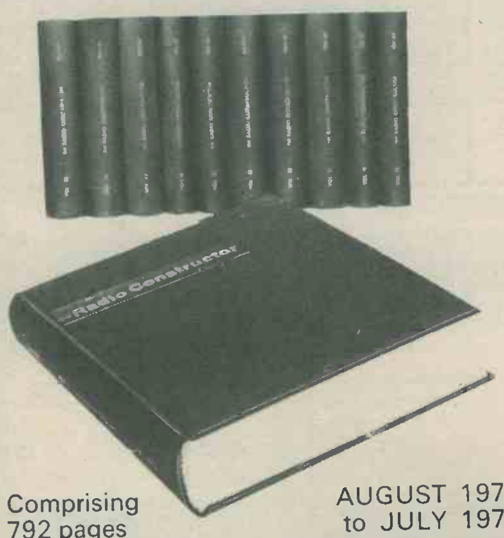

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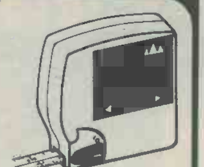

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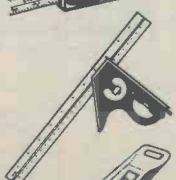

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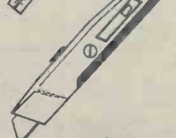

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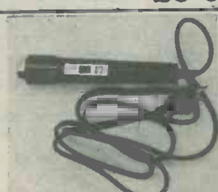

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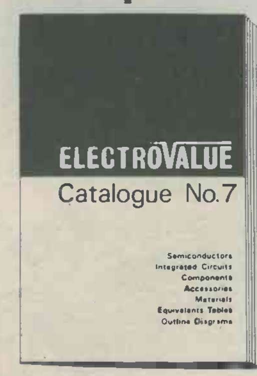

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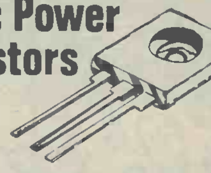

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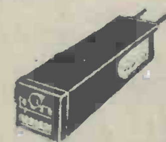

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AUGUST ISSUE WILL BE PUBLISHED ON 1st AUGUST

R.F. SIGNAL GENERATOR

This inexpensive signal generator can be a useful aid in the alignment of medium and long wave radio receivers

WHILST THERE IS, PERHAPS, A TREND AGAINST THE USE of signal generators for the alignment of medium and long wave radio receivers, many constructors still prefer to employ such generators instead of relying on broadcast transmissions. There is little or no advantage to be gained in using a signal generator for the peaking of aerial tuned circuits for maximum sensitivity. On the other hand, an accurately calibrated signal generator can save a considerable amount of time when the receiver oscillator circuit is being adjusted to give the correct frequency coverage.

The signal generator described in this article is inexpensive and easy to construct, and it consists of a variable frequency oscillator offering a range of approximately 1.7MHz to 425kHz, a 100kHz oscillator (not crystal controlled) and a 400Hz a.f. modulation oscillator. The variable frequency oscillator covers the entire medium wave band as well as the popular intermediate frequencies of 455, 465 and 470kHz. The 100kHz source is provided to enable the variable frequency oscillator to be calibrated. Either of the r.f. signals can be modulated by the 400Hz tone and this permits easy identification.

The unit is self-contained in a case measuring 6 by 4 by 2in. and is powered by a 9 volt battery. The current consumption of each r.f. oscillator is fractionally less than 1mA, and that of the modulating a.f. oscillator is approximately 0.7mA. The coils are all commercially made types.

CIRCUIT DIAGRAMS

The complete circuit diagram of the signal generator is given in Fig. 1. S1 (a) (b) is the combined on-off and function switch. In position 1 the supply is disconnected and the unit is turned off. Position 2 switches in the 100kHz calibrating oscillator incorporating TR2, the collector supply for which is obtained via half the secondary of the modulation transformer, T1. Position 3 of the switch causes the supply to be similarly connected to the variable frequency oscillator transistor, TR3. S2 is the modulation on-off switch, and it can only connect the supply to the modulating oscillator when S1 is in position 2 or position 3.

TR1 is the a.f. oscillator transistor, and it is biased by R1 and R2. R3 is the emitter load resistor, and T1 primary and VR1 make up the collector load. C1 and C2 tune T1 primary to resonate at approximately 400Hz, and they also offer a capacitive tap into the tuned circuit. Positive feedback is provided between this tap and TR1 emitter. VR1 allows the purity of the oscillator tone to be controlled.

The 100kHz oscillator stage employs TR2 in the grounded base mode. R6 and C4 are decoupling components, R7 provides base bias and C5 couples the base to chassis at radio frequencies. L1 and L3 give positive feedback between the collector and emitter of TR2 at a frequency determined by the tuned winding L2. The parallel capacitors, TC1 and C7, across L2 complete a tuned circuit resonant at 100kHz. The 100kHz signal at TR2 collector is passed to the output socket SK1 via C6.

TR3, in the variable frequency oscillator section, is in the common emitter mode. Its base is biased by R5, whilst R4 provides stable oscillation over the tuning range by reducing the r.f. current in L4. Winding L5 is tuned by VC1, and positive feedback from collector to emitter is given by way of the coupling windings, L4 and L6. C8 is a d.c. blocking capacitor. The output signal at TR3 collector is passed via C3 to output socket SK2.

COMPONENTS

A d.p.d.t. slide switch is specified for S2 although it is only employed as a s.p.s.t. switch in the circuit. The reason for this is that d.p.d.t. slide switches are much more readily available than s.p.s.t. types. Similarly, a standard 4-pole 3-way rotary switch is specified for S1 although only two of the poles are used.

By A. P. Roberts

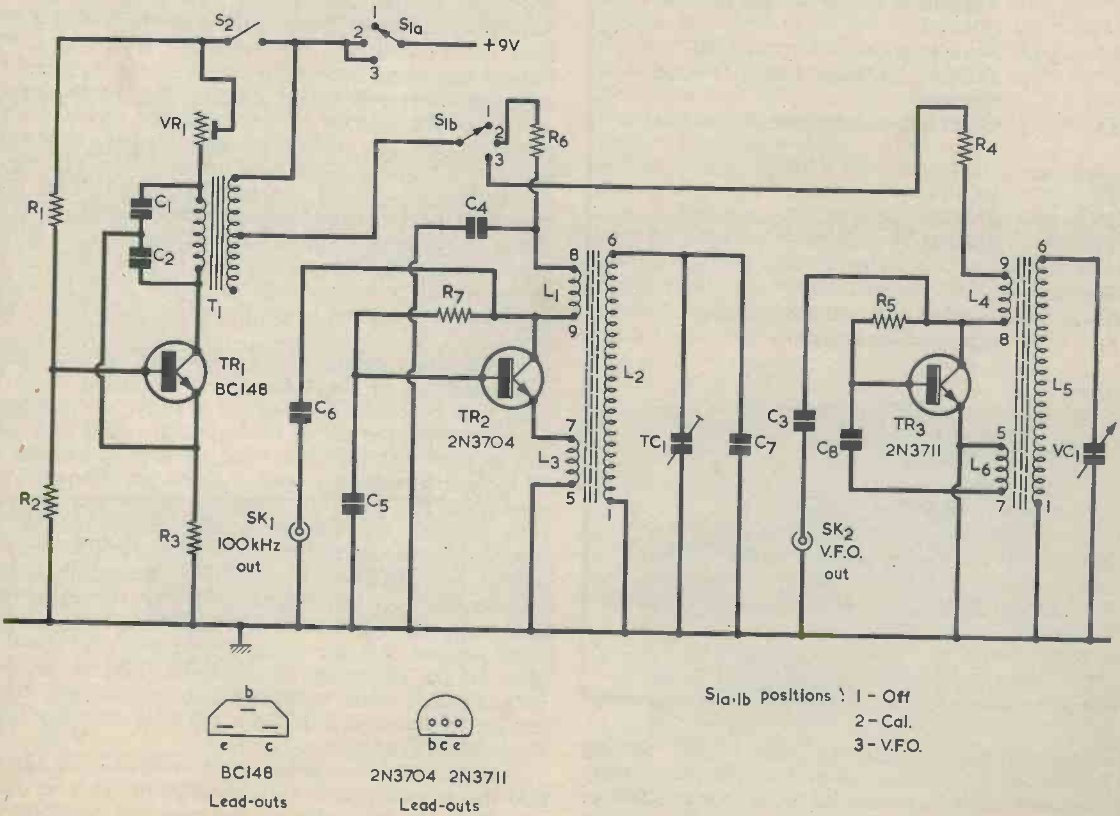


Fig. 1. The circuit diagram of the r.f. signal generator. This produces output frequencies primarily intended for the alignment of medium and long wave broadcast superhet radios

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1	8.2kΩ
R2	2.7kΩ
R3	12kΩ
R4	2.7kΩ
R5	680kΩ
R6	4.7kΩ
R7	560kΩ
VR1	50kΩ sub-miniature skeleton horizontal mounting

Capacitors

C1	0.033μF polyester (see text)
C2	0.033μF polyester (see text)
C3	0.002μF polystyrene
C4	0.022μF polyester
C5	0.005μF polystyrene
C6	2pF silvered mica
C7	680pF polystyrene or silvered mica
C8	0.001μF polystyrene
VC1	410pF variable, air-spaced, Type 00 (Jackson Bros.)
TC1	10-40pF trimmer, ceramic (see text)

Inductors

L1, L2, L3	Miniature Dual-Purpose Coil, Transistor Usage Range 1T Blue (Denco)
L4, L5, L6	Miniature Dual-Purpose Coil, Transistor Usage, Range 2T Blue (Denco)
T1	OC81 driver transformer (see text)

Transistors

TR1	BC148
TR2	2N3704
TR3	2N3711

Switches

S1 (a) (b)	4-pole 3-way miniature rotary
S2	d.p.d.t. slide switch

Battery
9-volt battery type PP3 (Ever Ready)

Miscellaneous
Battery connector
2 B9A valveholders
2 coaxial sockets
Plain perforated s.r.b.p. board, 0.1in. matrix
2 knobs
Aluminium chassis, 6 × 4 × 2in. with base plate (see text)
4 rubber feet
Panel Signs Sets Nos. 4 and 5 (see text)

T1 is an a.f. driver transformer for an OC81D driving two OC81's in a Class B push-pull output stage. Only half the secondary is employed. The exact make of transformer used is not important and the author checked circuit operation with several different types, all of which worked satisfactorily. Should it happen that a particular transformer causes the frequency of oscillation to be considerably removed from 400Hz, the effect of using values of capacitance other than 0.033μF in the C1 and C2 positions could be tried, both of the new capacitances having the same value. Working from the writer's experience, however, it is doubtful whether such a change in capacitance values would be needed.

Capacitor VC1 is a 410pF single gang air-spaced component, and is available from Henry's Radio Ltd. TC1 is a small ceramic trimmer. That used by the author had a nominal capacitance range of 10 to 40pF. If difficulty is experienced in obtaining a ceramic trimmer with this value, a suitable alternative is the 10 to 60pF ceramic trimmer listed by Henry's Radio Ltd. as Type C4.

THE CASE

The case is a 6 by 4 by 2in. 16 s.w.g. aluminium chassis with base plate. The chassis deck is used as the front panel of the signal generator and one of its long sides becomes the bottom, as may be seen from the photographs. The particu.ar chassis employed does not have corner pieces to which the base plate can be screwed; instead the long sides of the base plate have flanges which fit inside the chassis. The author obtained his chassis and base plate from H. L. Smith & Co. Ltd., 287 Edgware Road, London, W.2. The base plate can be secured to the chassis by self-tapping screws passing into the flanges, but the author did not find this necessary with the prototype and the base plate was simply held in position as a push fit. Four rubber feet are fitted to the chassis long side which is now the bottom of the case. Those at the end where VC1 will be later mounted should be positioned such that a PP3 battery can stand between their mounting nuts and the adjacent short side of the chassis. One of the photographs of the interior of the generator shows what is required here. The rubber feet should have a size which causes the bottom of the case to be at least ⅜in. above the surface on which the unit is placed. This gives clearance for the projection below the case bottom of the threaded sections of the two r.f. oscillator coils. A final point concerning the rubber feet is that those at the back should be positioned such that their mounting nuts do not foul the lower flange on the chassis base plate.

Fig. 2 shows details of the drilling of the front panel. The positions of the three small mounting holes for VC1 can be found by making a paper or cardboard template with the aid of the capacitor itself and using this to mark out the holes. The rectangular cut-out for S2 is made by drilling a hole of about ¼in. diameter, and then filing this out to a rectangle of the required size with a small flat file. Normally, the holes for the mounting screws of this type of switch are 6BA clear.

SK1 and SK2 are both surface mounting coaxial sockets, and each requires two ¼in. 6BA mounting bolts with nuts. VC1 requires three *short* 4BA mounting bolts, these passing into the three tapped holes on the front plate of the capacitor. These bolts need to be short because their ends must not pass beyond the inside surface of the capacitor front plate, where they could damage the fixed or moving vanes.

A Denco Blue Range 2T coil provides L4, L5 and L6, and this is mounted to the case bottom with its centre ⅞in. from the rear edge of the case and centrally disposed along the 6in. dimension of the case. The Range 1T coil which provides L1, L2 and L3 is mounted to the right of the Range 2T coil, as seen viewing the case from the rear. The centre of this coil is also ⅞in. from the rear

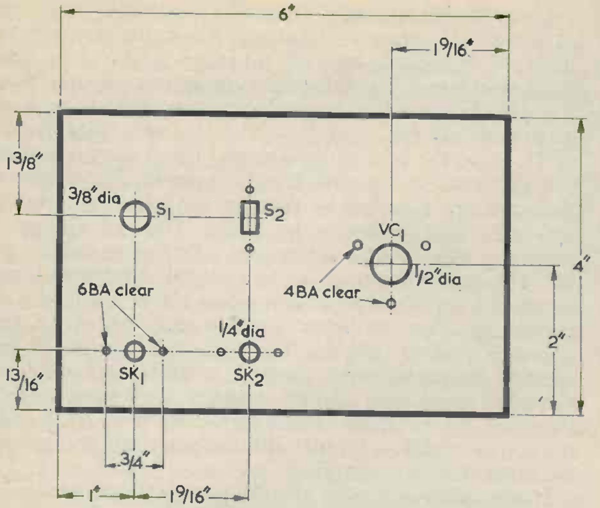
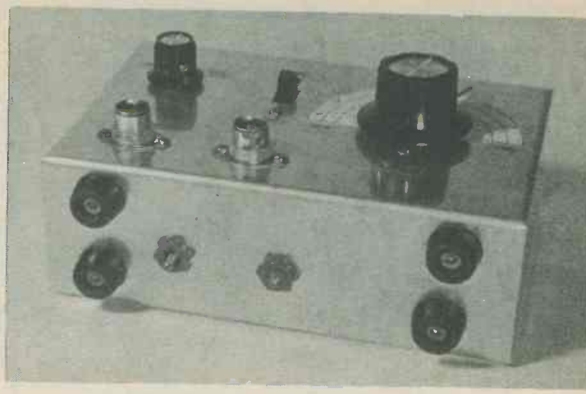


Fig. 2. Drilling details for the front panel of the signal generator



The coils are fitted to the bottom of the case with the core stems projecting outwards for a short distance

edge of the case.

The coils have a 0BA threaded section and are supplied complete with plastic mounting nuts. These nuts must be fastened 'finger tight' only. Some 0BA washers are placed over the threaded section on the Range 1T coil so as to raise it about ¼in. off the inside bottom surface of the case. It was found necessary to do this as, otherwise, absorption effects prevented the circuit from oscillating.

MODULATION OSCILLATOR

Constructional details of the a.f. modulation oscillator are given in Fig. 3. The parts are assembled on a plain perforated s.r.b.p. ('Paxolin') board having a hole matrix of 0.1in.

Construction commences by cutting the board, which has 27 by 16 holes, from a larger board. The two 6BA clear mounting holes are then drilled out, after which the components are mounted and wired up. TR1 has special lead-outs which can be clipped into the holes in the board. It may not be necessary to mount T1 in exactly the position shown with some makes of transformer, but the layout of its lead-outs is always in the same configuration. If it has no mounting lugs the transformer can be glued to the board.

The wiring under the board is shown in broken line in Fig. 3. In most cases the component lead-outs should themselves be long enough to meet their connection points. It should be noted that one of the wires below the board is insulated with sleeving. Finally, connect the lead to the solder tag, which is held under one of the mounting nuts for the panel, and connect four insulated leads about 4in. long at the appropriate points for later connection to S1 and S2.

The s.r.b.p. panel is mounted at the top of the case above VC1 and must be placed well forward. The top edge in Fig. 3 is towards the front of the case. The panel may be used as a template to mark out the two 6BA clear mounting holes required in the case top. The panel is mounted with 6BA bolts and nuts, with ¼in. spacing washers between the case top and the panel. The two connections to S2 are then made.

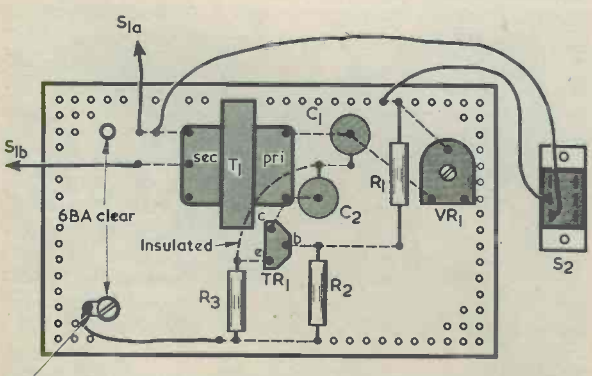
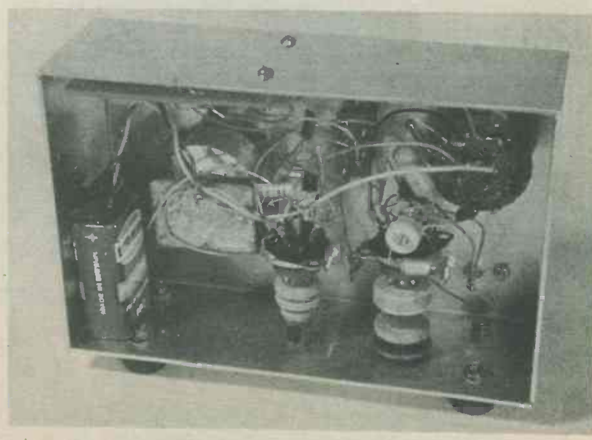


Fig. 3. The a.f. modulation oscillator components are wired up on a plain perforated board



The components fit comfortably into the case without crowding

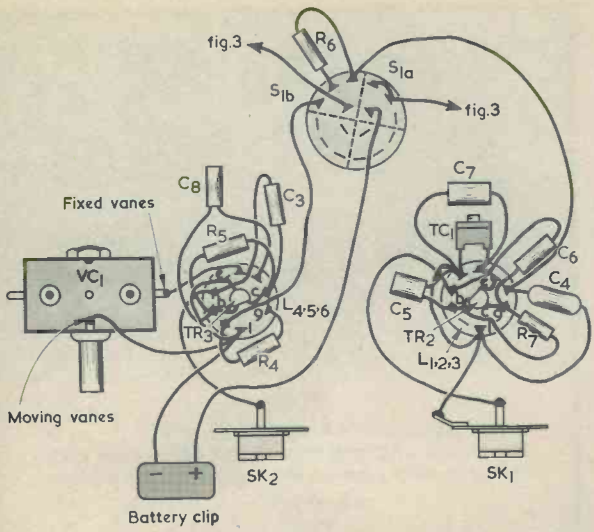


Fig. 4. The wiring of the two r.f. oscillators

R.F. OSCILLATORS

Wiring details for the two r.f. oscillators are shown in Fig. 4. Soldered connections are not made direct to the coil pins, but to two B9A valveholders which are fitted over these pins. The valveholders are held just outside the case whilst being wired up, and they are thens pressed on to the coil pins when wiring is complete. It would be very difficult to carry out the wiring whilst the valveholders are in their final positions on top of the coils. The variable frequency oscillator obtains its chassis connection from the metal frame tag of VC1. There is a space for the battery at the side of VC1, as shown in the photographs of the case interior.

In Fig. 4, valveholder tags to which there are no coil connections are used as anchor tags. Similarly, the outside contact tag of S1 (b) which is selected when this switch is set to 'off' is used as an anchor tag for R6. Before wiring to the switch, confirm the three outside tags corresponding to each of the centre tags. Their relative positioning may differ from that shown in the diagram. Coil L1, L2, L3 is oriented such that TC1 can be adjusted from the case rear.

The author employed Strip-Fix Plastic Panel Signs (available from the publishers of *Radio and Electronics Constructor*) to provide legends at the controls and to give a scale for VC1. The wording used was 'OFF', 'CAL' and 'VFO' at S1, 'MOD' and 'OFF' at S2, '100kHz' at SK1, 'VFO' at SK2 and 'TUNE' at VC1. These legends were taken from Panel Signs Set No. 4. The scale for VC1 was taken from Panels Signs Set No. 5, and the legend 'MHz' (also from Panel Signs Set No. 4) was positioned at its two ends. A pointer is added to the control knob for VC1. This can be a piece of stiff wire glued to the underside of the knob.

CALIBRATION AND USE

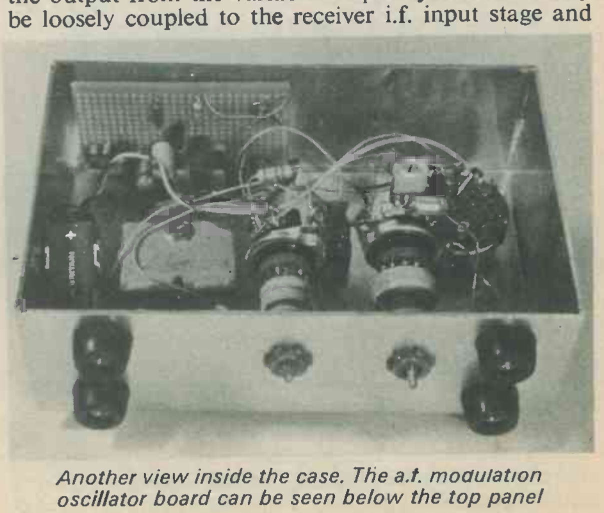
Set up the cores of the two coils so that about $\frac{1}{8}$ to $\frac{1}{16}$in. of the metal threaded stem protrudes from the plastic. Secure the threaded stem of the Range 2T coil by lightly locking it with a 6BA nut.

Connect a short length of wire to the centre connector of the 100kHz output socket and place this lead near a superhet broadcast receiver tuned to Radio 2 on the long wave band. Turn the signal generator on, selecting the 100kHz oscillation without modulation, and a whistle should be heard from the receiver. Adjustment of TC1 and the core of the Range 1T coil should enable the frequency of the whistle to be lowered. The trimmer and core are adjusted so that the whistle is so low in frequency that it cannot be heard. The radio is now receiving the second harmonic of the oscillator at 200kHz, and it is possible, with careful adjustment, to bring this harmonic to within a few Hz of the Radio 2 frequency. The oscillator fundamental will then be accurately set to 100kHz. The core of the coil may be secured in position by passing a 6BA nut over its threaded stem and lightly locking this against the threaded plastic section. The adjustments to TC1 and the coil core should be such that only a small portion of the brass stem is protruding.

If the receiver is now switched to medium waves, it should be found that harmonics from the signal generator are received at 100kHz intervals. Switching on the 400Hz modulation will help to identify these harmonics. VR1 can be set up at this stage. The receiver should be tuned to one of the harmonics with the modulation switched on, whereupon VR1 is then set up for purest tone. The note will probably sound distorted at extreme settings of VR1, but towards the centre of its travel a point should be found where a pure sounding note of good amplitude is obtained.

Switch in the variable frequency oscillator by means of S1, and connect a short length of wire to the centre connector of SK2. Position this wire near the receiver, with the latter switched to medium waves. Then rotate the knob of VC1. The output of the signal generator will probably be received at two or more settings of VC1. One of these settings will be with the vanes of VC1 almost fully enmeshed, and the output of the signal generator will then be at the intermediate frequency of the receiver. This point can be proved by varying the receiver tuning, whereupon it should be found that the signal is not tuned out. With VC1 at around this setting, the unit can be used as an i.f. alignment generator. The point may be marked temporarily on the scale of VC1.

If, subsequently, the signal generator is to be used for the i.f. alignment of a newly constructed superhet, the output from the variable frequency oscillator may be loosely coupled to the receiver i.f. input stage and



Another view inside the case. The a.f. modulation oscillator board can be seen below the top panel

VC1 adjusted for maximum output. The i.f. transformers are then peaked up at this frequency. Since most i.f. transformers on the home-constructor market are supplied pre-aligned at the factory as part of the test procedure, the process just described will produce an intermediate frequency in the receiver which is either at, or very close to, the nominal figure.

The same method can be used with 1.6MHz i.f. transformers, since this frequency is also within the range of the variable frequency oscillator.

If the receiver tuning dial has a reasonable accuracy, it should be possible to locate the 10th harmonic of the calibration oscillator at the point marked 1MHz, or 300 metres. The receiver should be tuned to the harmonic as accurately as possible. The v.f.o. is then switched on and VC1 adjusted for an output from the receiver. This should be given with VC1 vanes about one third to one half enmeshed, and the scale of the generator can be marked for 1MHz at this point.

If the signal generator is coupled too tightly to the receiver it is possible that the latter will give an output at a number of settings of VC1. This is due to such effects as a harmonic of the variable frequency oscillator beating with a harmonic of the receiver oscillator. Reception due to oscillator harmonics may be cleared by reducing the coupling to the receiver whereupon the correct signal, corresponding to fundamentals in both the signal generator and receiver oscillators, may be more readily identified.

Having established the 1MHz point on the scale of VC1, switch on the calibration oscillator and carefully retune the receiver to its 9th harmonic at 900kHz. Switch back to the variable frequency oscillator and tune this lower in frequency (VC1 capacitance increasing) until its signal is picked up by the receiver. The 900kHz point may now be marked on the signal generator scale.

This process is repeated above and below 1MHz, until a generator scale is obtained which is marked off at 100kHz intervals from 500 or 600kHz up to 1.6 or 1.7MHz. It should be found that the required range is given with the core of the Range 2T coil in its initial position, locked with the 6BA nut. If it is found necessary to adjust the core, possibly say to extend the low frequency end of the variable frequency oscillator range, the core may be adjusted accordingly and the lock nut refitted.

The calibration oscillator can be used for calibrating the lower frequency ranges of short wave receivers. Harmonics are available up to several MHz, the upper limit depending largely upon the sensitivity of the receiver being calibrated.

The calibration oscillator should be set up against Radio 2 on 200kHz, as described earlier, each time before use. It should be coupled loosely only to the receiver, so as to prevent loading effects on the oscillator output pulling it off frequency. Fitting the metal back to the case causes only slight detuning of the coils. For most accurate results with the calibration oscillator, a small hole may be drilled in the back of the case to allow access to TC1 when the back is in position.

As a final point, it should be mentioned that both the range 1T and 2T coils are normally employed as aerial input coils and not as oscillator coils, whereupon there is a very slight risk that incorrect phasing for feedback may be given by a particular coil. Should either coil fail to oscillate for no observable reason, the effect of temporarily transposing the connections to its pins 8 and 9 should be tried. ■

NEWS . . . AND .

PASSIVE PROBE KITS

The series of passive probe kits recently introduced by Precision Electronic Terminations (EMI) Limited, of Sevenoaks, Kent, has now been adopted as standard accessories for the range of oscilloscopes by Scopex Instruments Limited, of Letchworth, Herts. Sold as an optional extra or as a complete package, the scope/probe combination affords electronics engineers a ready-to-use precision measuring instrument.

Recently, the Training Services Agency "Skillcentres", run by the Manpower Services Commission, placed an order for 150 units complete with P.E.T. passive probe kits.

The sprung hook tip of the P.E.T. probe enables easy attachment to the tiny contacts of transistors and i.c's. This coupled with its light weight and extremely flexible cable makes it eminently suitable for today's miniaturised circuitry.

SECOND QUEEN'S AWARD FOR BBC

The BBC has received the Queen's Award to Industry for the second time in five years. The award is for technological innovation in the transmission of sound and vision signals over a single vision link and relates to an original development by engineers of the Corporation's Research and Designs Departments.

Until recently, the sound and vision signals from the television studios were carried separately to the transmitting stations. The newly developed technique makes it possible to add the sound to the picture signal so that only one combined signal need be distributed to transmitters.

The pulses which carry the sound signals in coded form are 'tucked into' the vision signal during the brief moments that are allowed for synchronising the receiver with the transmitter.

The synchronising periods cannot be used to carry picture detail but they do provide 'free' time for the transmission of the sound pulses; it is from this that the name of the new development – *Sound-in-Syncs* – is derived.

The sound signals are recovered at the transmitting station and then broadcast in the usual way. One advantage to the viewer is that the television sound quality is generally improved. No modifications to domestic receivers are necessary; indeed, viewers all over the country have for some time been getting their television sound by this means.

For transmissions such as Eurovision, where many switching operations are required, *Sound-in-Syncs* is particularly valuable because it eliminates the need to establish separate sound circuits. Once the vision link has been established the appropriate sound simply rides with the picture to its destination.

Experiments are in progress to establish the usefulness of *Sound-in-Syncs* over satellite links and the Post Office is considering its use for the Confravision service which uses television to link meetings or conferences. The BBC has also developed a more robust version for outside broadcast use where the problems of improvised circuits impose greater difficulties.

The licensing agreement negotiated with Pye TVT Limited, Cambridge, has led to the commercial manufacture and sale of *Sound-in-Syncs* equipment.

TELEFUNKEN RADIO WITH CASSETTE RECORDER

Telefunken introduced a new radio with cassette recorder at the Radio Show recently held at the Kensington Palace Hotel.

The radio/cassette recorder, which is illustrated here, has 4 wavebands, FM, MW, LW (19–49m band). FM fine tuner (AFC). Mains or battery operation, with electronic switch-over. Long-life system, i.e. batteries fitted are regenerated during mains operation.

Cassette tape speed: $1\frac{7}{8}$ i.p.s. A microphone is included, with a special mounting to attach it to the recorder.

Dimensions (W/H/D) $12\frac{1}{2}$ x 7 x 3 ins.

. . . COMMENT

OPENING OF HENRY'S HI-FI CENTRE AT HARROW

Peter Sellers ably assisted by the Wombles of Wimbledon was the star attraction at the Gala opening of Henry's Hi-Fi Centre at Harrow recently.

Thousands of local people turned up to see the festivities and in particular Peter Sellers – whose new film *The Optimists of Nine Elms* was premiered only two days before and the Wombles whose seond single disc 'Remember You're a Womble' is in the top five of the charts. They were not disappointed as Sellers lapsed into inspired 'goonery' for a radio interview with Douglas Cameron of London Broadcasting and the Wombles set about encouraging the audience to tidy up the streets of Harrow just as they themselves do to Wimbledon Common.

After he had cut the ceremonial tape to officially declare the Hi-Fi Centre open Peter Sellers then drew the winning entries for the Henry's Hi-Fi Contest in which £300 of Hanimex stereo/audio equipment was given in prizes.

The contest was run in conjunction with London Broadcasting who gave live coverage to the opening.

Delighted at the crowds who turned up for the opening Henry's Retail Director, David French remarked 'You can't beat the old-time showmanship when it comes to attracting the crowds. At times it was reminiscent of Beatlemania outside the store.'

He had good reason to be pleased. The new Centre opened to bumper business and after the stars had left the people of Harrow got down to the serious business of inspecting the vast range of hi-fi equipment on display.

The Hi-Fi Centre at Harrow is the first in a series of suburban developments by the Henry's radio group – which has hitherto had a concentration of shops in Central London.

ROYAL TELEVISION SOCIETY AWARDS 1974

The Society's Gold Medal for outstanding contributions to television has been awarded to Dr. Walter Bruch who is Chief of the Basic Television Research Department of A E G Telefunken, a post he has held since 1959. He invented the PAL system of colour television.

Dr. Jacob Bronowski receives the Society's Silver Medal for outstanding creative achievement in television in front of the camera. Dr. Bronowski wrote and presented the outstanding BBC series 'The Ascent of Man'.

Peter Willes, Yorkshire Television's Head of Drama, receives the Society's Silver Medal for outstanding creative achievement in television behind the camera. Mr. Willes began his television career with Associated Rediffusion in 1955.

I. J. Shelley and N. W. White receive the Geoffrey Parr Award in recognition of a notable contribution to television engineering. The Award is made for their work on the design and development of automatic monitoring and control equipment for unattended transmitters.

The John Logie Baird Travelling Scholarship is open to postgraduates between 21 and 30 years of age who are students at a United Kingdom educational establishment. The 1974 Scholar is Peter J. Best of the University of Manchester Institute of Science and Technology.

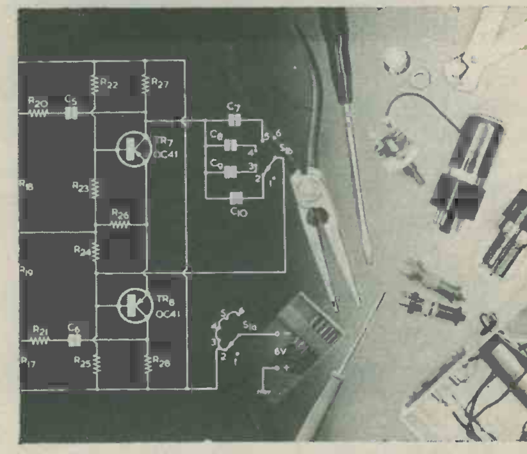
"I think I'm getting something from Outer Space!"

MULTIVIBRATOR CAPACITANCE BRIDGE

By G. A. French

This month's article in the 'Suggested Circuit' series describes an unusual capacitance bridge capable of measuring capacitances from below 10pF to greater than 1,000pF. Although this range may at first sight seem limited it should be remembered that it includes a high proportion of the capacitances that are, in normal radio work, most likely to be unknown. These include variable capacitors, which are rarely marked with their values, and the smaller silvered mica and ceramic components having printed capacitance values on their bodies. These printed values are frequently erased or obliterated due to handling.

The capacitance bridge has the considerable advantages of low cost and extreme simplicity of design.



BASIC BRIDGE

THE OPERATION OF THE CAPACITANCE bridge can be explained with the aid of the basic diagram shown in Fig. 1. Here, TR1 and TR2 are two transistors in a conventional multivibrator, and component values in the multivibrator are such that each transistor is turned on for exactly half the multivibrator cycle. Thus, the waveforms at the collectors of the two transistors are similar in amplitude and shape but opposite in polarity. TR2 is turned on when TR1 is turned off, and vice versa.

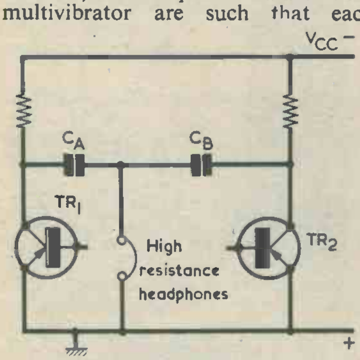


Fig. 1. In this diagram TR1 and TR2 are transistors in a 50:50 multivibrator. A null is given in the headphones when the two capacitors have equal values

The multivibrator runs at a convenient frequency in the audible range, and coupled across the collectors are the two capacitors CA and CB. A pair of high resistance headphones connects between the junction of the two capacitors and chassis. It will be apparent from a first consideration of the circuit that if CA and CB have the same value then the a.f. voltage at their junction relative to chassis should be zero, because positive excursions at one transistor collector will be balanced out by negative excursions at the other. If, in consequence, the value of CA is not known, and if CB is made a variable capacitor fitted with a scale calibrated in terms of its own capacitance, CB can be adjusted until there is a null in the audio signal applied to the headphones. The value of CA may then be read from the scale fitted to CB, and the circuit performs as a capacitance bridge.

In practice, the signal reproduced by the headphones does not fall to a zero null when CA and CB are equal in value. This is because the collector of a multivibrator transistor does not rise at once to Vcc potential when the transistor turns off; instead it rises to Vcc potential at a rate governed by the charging of the cross-coupling capacitor connected to the base of the other transistor. On the other hand, the collector of a transistor which is just turning on in the multivibrator cycle is brought almost immediately to its low level state. As a result, the two collector waveforms do not exactly balance each other out for a short period after the multivibrator changeover, whereupon a small signal content at multivibrator frequency is still passed to the headphones in Fig. 1 when CA and CB are equal. More efficient cancellation would be given if TR1 and TR2 controlled two further transistors, and the signals for CA and CB were taken from the collectors of these second transistors. However, such an addition would complicate what sets out to be a very simple design. Also, since the null given when CA and CB couple to the two multivibrator transistor collectors is quite distinctive, it was felt that a working bridge would be satisfactory if it followed the basic design inherent in Fig. 1.

It will be seen, from Fig. 1, that stray capacitance between the headphone leads cannot upset circuit balance when CA and CB are equal. Also, one of the headphone terminals is at chassis potential, with the result that the positioning of the headphone lead and its consequent changing capacitance to earth cannot have any effect on circuit operation. Neither terminals of CA or CB are at chassis potential which means that, should CB be a variable capacitor, its metal framework must be insulated from chassis. If, however, the collector load resistor for TR2 is given a relatively small value, TR2 collector has a low a.f. impedance to chassis and the metal framework of the variable capacitor may then be connected to this point. It need only be fitted with a plastic control knob, and no difficulties due to hand-capacitance will arise as this knob is adjusted.

PRACTICAL CIRCUIT

A practical working circuit is given in Fig. 2 where the two transistors, TR1 and TR2, appear in a conventional multivibrator. This runs at a frequency of approximately 1kHz. R4 has the relatively low value of 1kΩ in order to maintain a low impedance to chassis for the variable capacitance in the bridge, as has just been explained. R1 has the same value as R4 to maintain symmetry. The period in the multivibrator cycle during which TR1 is cut off is controlled by the values of C1 and R2. The length of the period when TR2 is off is controlled by C2 and the series combination of R3 and VR1. The latter is a small skeleton preset potentiometer, and it is adjusted for equal periods of conduction in TR1 and TR2. The adjustment is achieved in the manner shown in Fig. 3. Here, a testmeter switched to a low voltage range is coupled to the collectors of TR1 and TR2 by way of two 4.7kΩ resistors positioned near the collectors. These resistors ensure that multivibrator operation is not affected by the testmeter and its leads. VR1 is then adjusted for a zero voltage reading in the testmeter, after which the meter and the two 4.7kΩ resistors are removed.

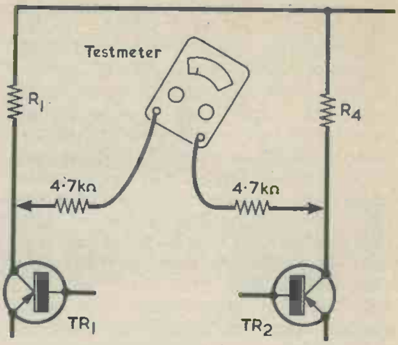


Fig. 3. A testmeter coupled across the two collectors via isolating resistors gives a zero voltage reading when VR1 is correctly set up

Adjusting VR1 for zero voltage in the testmeter of Fig. 3 ensures that TR1 and TR2 both have the same average voltage at their collectors, and this in turn indicates that both transistors are turned on for equal periods in the multivibrator cycle. If very accurate results are required, R1 and R4 can be resistors having a tolerance of 1% or 2%. However since, for most of the cycle, the transistor collectors are either at Vcc potential or are just above chassis potential, an adequate performance will be given with R1 and R4 at 5%. The cross-coupling capacitors, C1 and C2, can be normal polyester components or similar, and do not need a close tolerance on value. TR1 and TR2 are germanium rather than silicon transistors as, in general, silicon transistors have reverse base-emitter voltage ratings which are too low to allow them to be used in the present simple multivibrator circuit. Capacitor C3 is the usual supply bypass component.

The signals at the two collectors are applied to the test terminals, and thence to the unknown capacitor, and to the variable capacitance. Appearing between their junction and chassis are the headphones, as in Fig. 1. These may be standard 4,000Ω headphones. Connected across the phones are VR2 and R5. VR2 is employed to set the volume in the phones to a level which enables the null to be most clearly perceived. Normally, VR2 is adjusted to insert maximum resistance into circuit when measuring low values of capacitance, and to insert minimum resistance when measuring high values, which allow a greater signal strength to be passed to the phones. VR2 is wired so that the resistance it inserts into circuit increases as its spindle is turned clockwise.

No values are specified for VC1 and VC2 as it is probable that constructors will wish to employ components that are already on hand. The author used a 3-gang 500pF capacitor for VC2, the three sets of its fixed vanes being connected together to give an overall 1,500pF capacitor. This enabled capacitances up to some 1200pF to be measured. However, the minimum capacitance offered by this arrangement was of the order of 25pF and so VC2 could not be used to measure test capacitances below about 35pF.

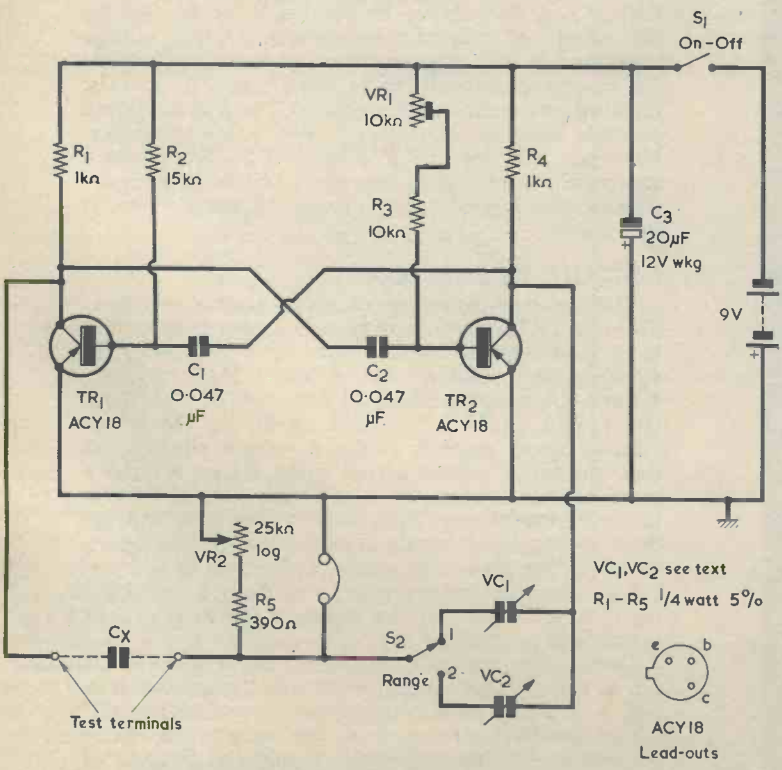


Fig. 2. The practical working circuit for the multivibrator capacitance bridge. VR1 is adjusted for 50:50 operation

These capacitances were measured with the aid of VC1 which, in the author's case, was a 50pF Jackson Brothers type C804 variable capacitor. A 50pF C804 capacitor has a minimum value of 3.8pF, and it was found possible to just resolve a null when the test capacitance was 5pF. Readers making up the circuit may use variable capacitors of similar values, remembering that the highest value of test capacitance that can be measured is a little lower than the maximum variable capacitance and that the minimum value of test capacitance is a little higher than the minimum variable capacitance.

VC1 or VC2 are selected by means of the range switch S2. This switch should be a type having relatively low stray capacitance between its contacts, and a toggle switch would be satisfactory.

Both VC1 and VC2 are fitted with plastic knobs, pointers and scales. These, together with the test terminals, S1, S2, VR2 and a jack socket for the headphones may be conveniently mounted on a front panel made of an insulating material. The wiring to the test terminals and to VC1 and VC2 should be spaced out to keep stray capacitances low. The moving vanes of the two variable capacitors connect to TR2 collector, and the fixed vanes to S2.

THE NULL

As was stated earlier, the null given when the variable capacitance is equal in value to the test capacitance does not consist of a signal at zero audio level. There is a noticeable reduction in signal level as the null point is approached and also a change in the character of the tone reproduced by the headphones. For settings in the variable capacitance well removed from the null position the tone in the headphones is roughly similar to a sine wave at 1kHz. However, the 'rounded' character of a sine wave note disappears at the null point leaving only a more 'reedy' tone which gives the subjective impression of being slightly higher in pitch. The change in the nature of the tone is readily perceptible and will be easily recognised after experience has been obtained with several test capacitors.

Initially, the variable capacitor selected by S2 may be adjusted with VR2 inserting maximum resistance nto circuit. Reducing the resistance given by VR2 to a level which causes the tone in the headphones to take up a low level will then allow more precise final location of the null.

Both VC1 and VC2 are calibrated by measuring known values of capacitance. After a number of calibration points have been marked out, graphs may be drawn for the two capacitors and final scales made up including intermediate values.

As a final point, the current consumption from the 9 volt battery is approximately 9.5mA. ■

D.C. VOLTAGE MULTIPLIER

By C. S. Thomas

An unusual means of increasing a d.c. supply voltage

WITH THE CONTINUALLY INCREASING COST OF DRY batteries it is tempting, when using transistor radios and similar equipment in a car, to operate these from the car battery. Usually, some simple form of regulating and smoothing arrangement is required, and this can be readily provided in cars having a 12 volt battery. Since much transistor equipment operates with a 9 volt supply, the excess voltage from the car battery can then be conveniently lost in the regulating and smoothing circuit.

Such is not the case with cars having a 6 volt battery. The circuit described in this short article offers a means of increasing the voltage available from a 6 volt battery and, with certain limitations, it can be used for the supply of transistor equipment. Output voltage regulation is only fair, and the unit is mainly suitable for supplying currents up to some 50mA or so. The circuit draws a current of around 0.7 amp at all output currents and, in consequence, has a low efficiency. However, it is felt that a current of 0.7 amp from a car battery is negligibly low when compared with the considerably higher currents drawn by the car circuits themselves.

CIRCUIT OPERATION

The circuit of the voltage multiplier appears in Fig. 1. TR1 and TR2 are two small power transistors appearing in a multivibrator which runs at a frequency of approximately 150Hz. The collector load resistors, R1 and R4, have the unusually low value of 10Ω. Since either TR1 or TR2 is turned on during the multivibrator cycle, there is always a voltage slightly less than the input voltage across either R1 or R4. At a nominal input voltage of 6 volts the current flow in R1 and R4 is 0.6 amp. Thus there is a continual current drain on the input supply at least equal to this figure. However, battery voltage will be higher than its nominal value when the battery charges and so a continual input current drain of the order of 0.7 amp can be assumed in practice.

During the multivibrator half-cycle when TR1 is off, its collector goes negative towards the lower supply rail. A charging current then flows through R1 to C1, whose positive plate cannot fall more than about 0.6 volt lower than the upper supply rail because of the presence of silicon diode D1. Thus, C1 charges from the 6 volt supply via R1. In the next multivibrator half-cycle TR1 becomes conductive, where-

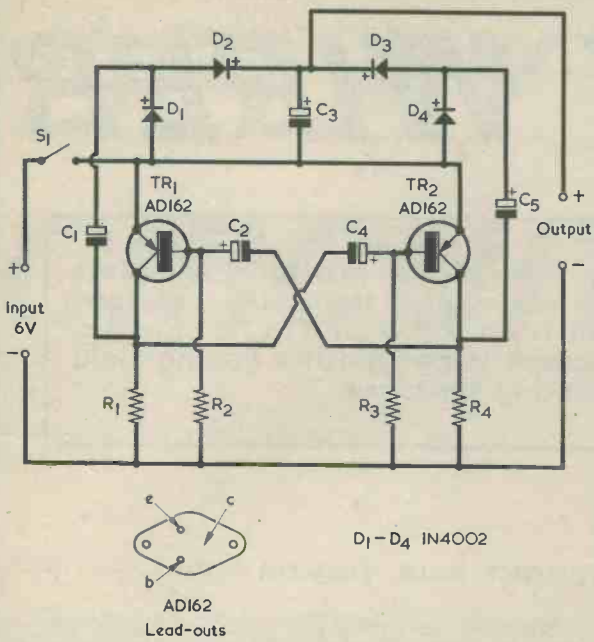


Fig. 1. The circuit of the voltage multiplying unit

COMPONENTS

Resistors
R1 10Ω 5 watt wire-wound 5%
R2 560Ω ¼ watt 10%
R3 560Ω ¼ watt 10%
R4 10Ω 5 watt wire-wound 5%

Capacitors
C1 2,000μF electrolytic, 10 V. Wkg.
C2 8μF electrolytic, 10 V. Wkg.
C3 1,000μF electrolytic, 10 V. Wkg.
C4 8μF electrolytic, 10 V. Wkg.
C5 2,000μF electrolytic, 10 V. Wkg.

Semiconductors
TR1 AD162
TR2 AD162
D1–D4 1N4002

Switch
S1 s.p.s.t. toggle

upon the negative plate of C1 is taken up to a potential just below that on the upper supply rail. Diode D1 is now reverse biased, and C1 loses some of its charge via D2 into reservoir capacitor C3.

A similar process occurs with TR2 and C5 on the other half-cycles. When TR2 is turned off, C5 charges from the 6 volt supply via R4 and D4. When TR2 becomes conductive, C5 discharges via D3 into reservoir capacitor C3.

To sum up, on one set of alternate half-cycles C1 is charging and C5 is discharging into C3, whilst on the other set of alternate half-cycles it is C5 that is charging and C1 which is discharging into C3. When no output current is drawn from the circuit the output voltage is double the input voltage less the voltage drop in two forward biased silicon diodes and the saturation voltage across either TR1 or TR2.

REGULATION RESISTANCE

The simplicity of the circuit imposes two restrictions on performance. There is, firstly, the low efficiency which has already been mentioned. Secondly, even if there were no losses elsewhere in the circuit the regulation resistance of the output can never be less than 10Ω. This is because there is a 10Ω series resistor in each capacitor charging circuit.

In practice, the regulation resistance is more of the order of 20Ω. With an input at the nominal value of 6 volts, the output voltage off-load is 10.6 volts, this dropping to 9.7 volts at a load current of 50mA. When the input voltage is 6.6 volts, which is more in keeping with what would be given by a charged battery, the output voltage is 11.8 volts, dropping to 11 volts at 50mA output.

Power transistors are specified for TR1 and TR2 because transistors of this type are more capable of withstanding current surges as the capacitors charge. The two transistors dissipate little heat and do not need to be mounted on heat sinks. The circuit tends to radiate a certain amount of 'hash' at radio frequencies, whereupon all the components should be screened by being fitted in a metal box having input and output sockets. If the car has a negative earth the box is connected to the negative input terminal. Should the car have a positive earth, on-off switch S1 is transferred to the negative input and the box is made common with the positive input terminal

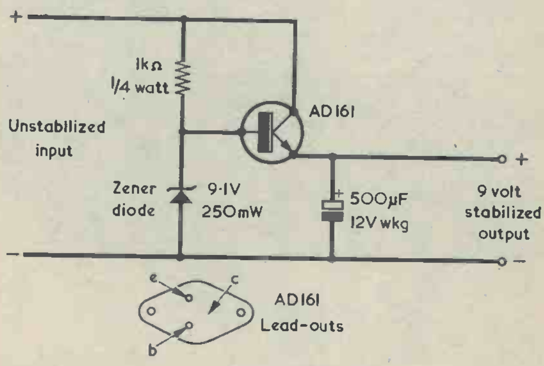


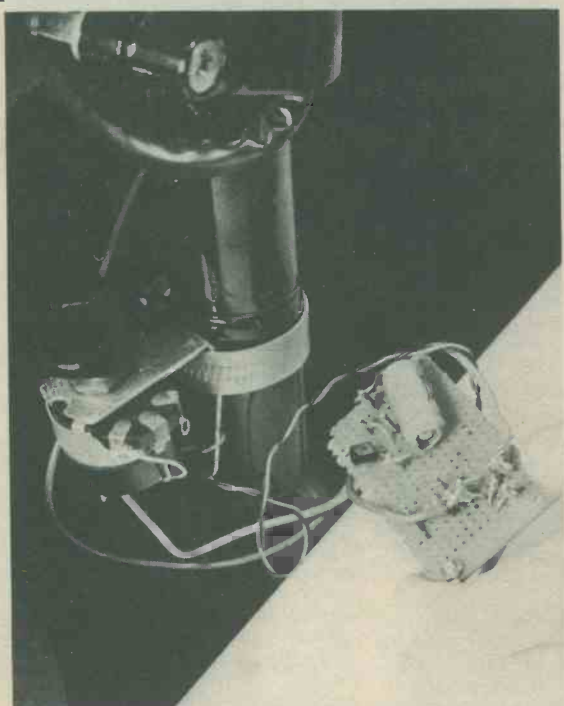
Fig. 2. A voltage stabilizing circuit which can be connected to the output of the voltage multiplier

There will be a level of 'hash' also on the output terminals, but this may be removed by a subsequent stabilizing circuit. A typical example of a suitable stabilizing circuit is given in Fig. 2. As with the AD162's in Fig. 1, the AD161 in Fig. 2 does not need a heat sink at the currents envisaged here. If the supplied equipment has exposed metalwork which is common to one of its supply rails, care should be taken to prevent this coming in contact with the car body in case any supply short-circuits result. ■

SIMPLE WIPER

Employing a unijunction timer, this circuit provides complete double sweeps of a car windscreen wiper, the delay between sweeps being continuously variable from 0.5 second to 1.5 minutes. It may only be used with windscreen wiper motors having field coils and self-parking switches

This article gives constructional details af a very simple circuit which can be used to make the windscreen wipers of a vehicle execute complete double sweeps with selected delays between sweeps. Although it is suitable only for 12 volt cars having self-parking wipers which are driven by a motor with field coils, it is a very simple circuit which requires no relay or other moving parts. The author's prototype unit is installed in a Morris Minor 1000, which has a 12 volt electrical system with positive earth.



The prototype delay unit. The potentiometer and on-off switch are mounted on the steering column, whilst the remainder of the components are fitted to the perforated board. TR1 and C1 can be seen in this view

SLIGHT RAIN, FOG OR MIST

When one is driving in slight rain, fog or mist or whenever there is a small amount of water forming on the windscreen, one has to employ the wipers from time to time in order to see clearly. On the other hand, if one leaves the wipers operating continuously, the blades soon begin to scrape on the windscreen, since the amount of water is inadequate to provide the required lubrication between the rubber and the glass. One must therefore keep switching the wipers on and off every few moments.

A circuit which automatically causes the wipers to make complete double sweeps at pre-set intervals (without ever leaving them stationary in the middle of the windscreen) can make driving much more pleasant in conditions of slight rain, fog or mist. Indeed, the writer uses the delayed operation much more frequently than the normal continuous wiper movement; the latter has been designed to cope with the heaviest rain one is likely to meet. Even in moderate rain one can use a short delay between sweeps of the blades without visibility being impaired and this reduces the frequency with which the blades pass in front of one's eyes.

The action of the normal wiper switch of the car is completely unaffected by the addition of the circuit to be described. Closing this switch will provide the normal undelayed wiper action for use in heavy rain, snow or sleet.

The component values used in the prototypes were chosen so that any delay between about 0.5 second and 1.5 minutes could be selected to suit the prevailing weather conditions. However, longer delays can easily be obtained by changing the component values, if desired. This is not necessary for normal use.

UNIJUNCTION AND THYRISTOR

The circuit to be described employs a unijunction transistor timing circuit to fire a thyristor (or silicon controlled rectifier). Although it is not necessary to understand the theory of operation in order to construct the delay unit, some details of the working principles will be given since many readers will be more satisfied if they understand the operation of the circuit.

DELAY CIRCUIT

By J. B. Dance, M.Sc.

POSITIVE EARTH CIRCUIT

The circuit, used by the author in a car which has the positive terminal of the 12 volt battery earthed, is shown in Fig. 1. One advantage this circuit has over most other designs of wiper delay circuit is that only two leads are required from the circuit board to the existing car wiring. These two leads are marked A and B in Fig. 1.

The delay between successive double sweeps of the wiper blades is controlled by the variable resistor VR1. The on-off switch S1 is ganged to VR1 so that only one control knob is required for the whole circuit.

Let us first consider the normal operation of the self-parking wipers before the circuit is added. When the ignition is switched on, one side of the wiper motor is connected to the negative supply line from the ignition switch. No current can flow through the motor, since the car wiper switch S2 and the self-parking switch S3 are normally open.

When the wiper switch S2 is closed, the current flows through this switch and through the wiper motor to the negative supply; the wipers therefore move. The self-parking switch S3 is closed except when the wiper blades are at or near their parked position.

If the wipers are switched off by opening S2, the blades will continue to move until they reach their parked position, since the wiper motor current can continue to flow through S3 until this position is reached.

CIRCUIT OPERATION

Let us now consider the operation of the additional circuitry in Fig. 1.

When the on-off switch S1 is closed, current flows from the positive (the car chassis) side of the 12 volt supply through VR1 and R1 to charge the capacitor C1. The voltage across this capacitor therefore increases steadily until it is adequate to cause the emitter circuit of the unijunction device to conduct. The device is then switched rapidly to full conduction by the normal feedback action which occurs in unijunction circuits.

The current flowing through the unijunction transistor develops a pulse across R3 which is fed to the gate

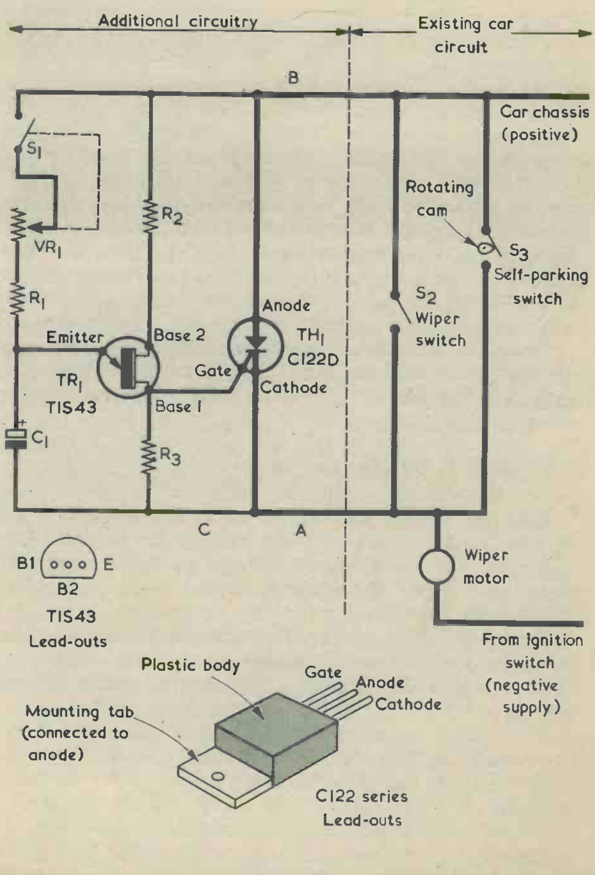


Fig. 1. The circuit of the delay unit connected to a 12 volt car system with positive earth. The thick lines show the wiring which carries the wiper motor current

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1	6.8kΩ
R2	100Ω
R3	100Ω
VR1	1MΩ potentiometer, log, with switch S1 (see text)

2off

Capacitor

C1	50μF electrolytic, 25 V.Wkg. (see text)

Semiconductors

TR1	TIS43
TH1	C122D (see text)

Switch

S1	S.P.S.T. toggle (part of VR1)

electrode of the thyristor. This pulse causes the thyristor to be switched to conduction. The current from the chassis side now flows through the thyristor to the wiper motor and the wipers move.

A thyristor continues to conduct until the current passing through it falls below the 'holding' level. In the circuit of Fig. 1, the switch S3 closes soon after the wiper blades have commenced to move. This provides a short-circuit across the thyristor and current ceases to flow through the device; it therefore returns to its non-conducting state.

However, the wipers continue to move, since the current can flow through S3. They park in their normal self-parking position when S3 opens after one double sweep of the blades.

VARIABLE TIME DELAY

When S3 opens, the supply voltage is again applied to the left-hand part of the circuit of Fig. 1. The capacitor C1 commences to charge again and the thyristor is fired after a delay, so that the wipers make another double sweep.

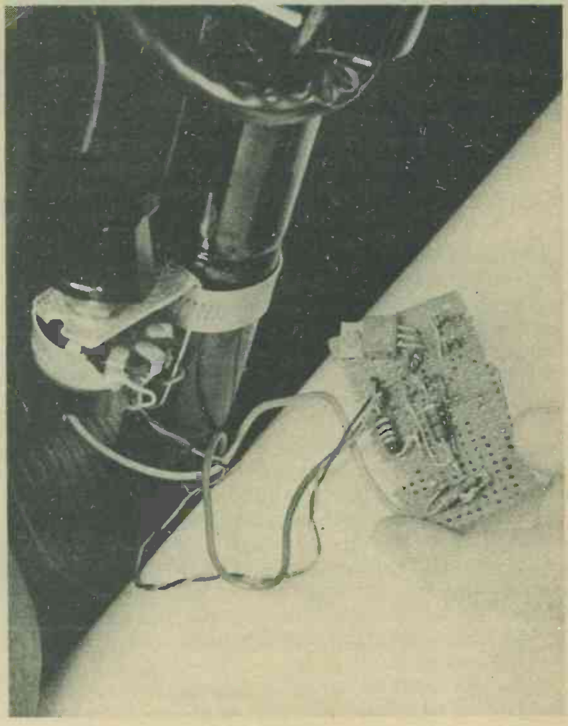
The time for which the wiper blades remain in their parked position between sweeps is determined by the rate at which C1 charges. This is controlled by the setting of VR1.

If C1 is increased to 100μF and the value of VR1 is unaltered, the delay time at any setting of VR1 will be approximately doubled. However, if VR1 is also reduced to 500kΩ, the delay times will be similar to those obtainable with the component values of Fig. 1. A 250kΩ potentiometer may be employed for VR1 if C1 is increased to 100μF or 250μF.

The component values are in no way critical. Indeed, tolerances in the marked values of the components (especially in the value of C1) will cause some variations in the delay times from one circuit to another, but such variations do not matter in this application.

POWER SUPPLY

It should be noted that the 12 volt supply is applied to the circuit whenever the ignition is switched on if both S2 and S3 are open. A current therefore flows through the unijunction device whenever the ignition is switched on and the wipers are not being used normally with S2 closed. This current is typically 2mA, so it is far too small to have any adverse effect on the car electrical system.



The opposite side of the prototype circuit board. Visible here are the thyristor and the three fixed resistors

If S1 is open, no charging current can flow to C1. The thyristor is therefore never fired and the wipers do not operate.

The reader may well ask why the on-off switch for the delay unit is not placed at point A or B in Fig. 1 so that no current would flow through the circuit except when the delayed wiper action was in use. The reason for not using such a system is that a typical armature type of windscreen wiper motor requires about 4 amps and this is greater than the rating of the normal type of switch ganged to a variable resistor.

LOG LAW POTENTIOMETER

A potentiometer with a logarithmic law is specified for VR1. The smaller values of the time delays are thereby spread out and one can easily adjust the control to obtain the delay required. Although the longer delay values are compressed together by the logarithmic law track this does not matter, since if the delay is about a minute one does not wish to be able to set it to the nearest second!

The values used in the prototype are shown in the Components List. When VR1 was set to its minimum value, the delay between successive sweeps of the wiper blades was very short. When VR1 was set to the mid-point of its travel, a delay of about 15 seconds was found. (A linear component would have produced a delay of about 45 seconds at the mid-point.)

Although a linear component can be used for VR1, the writer strongly recommends the use of a logarithmic potentiometer for ease of adjustment at low values of the delay.

NEGATIVE EARTH UNIT

A similar circuit can be employed in cars which have the negative terminal of the battery earthed. The full circuit is shown in Fig. 2 to avoid any possibility of ambiguity. It should be emphasised that this circuit has not been checked out by the writer in a practical installation.

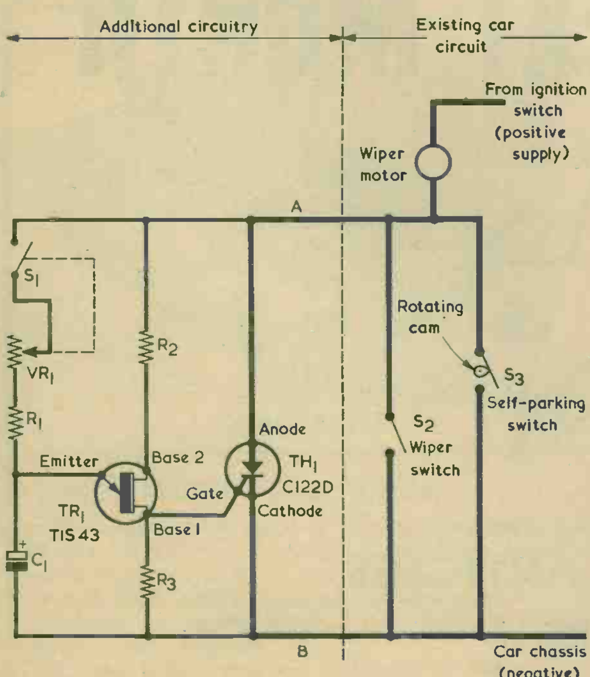


Fig. 2. A suitable circuit for the delay unit when installed in a car with a 12 volt negative earth system

Whilst examining the circuits of Figs. 1 and 2 it should be remembered that current (from positive to negative) through the thyristor can only flow in the direction of the arrowhead in the circuit symbol, i.e. from anode to cathode.

WIPER MOTOR

As was stated at the beginning of this article the delay circuit may only be used with windscreen wiper motors having field coils and a self-parking switch. It must *not* be employed with permanent magnet motors. When a permanent magnet motor is switched off by the self-parking switch, a short-circuit is placed across the windings to provide braking. This short circuit is obtained via the wiper switch (when it is in the 'off' position) and via the self-parking switch. The short-circuit is not removed until the wipers are next operated. The circuit described here could not start such a motor because of the short-circuit across it.

The circuit may also not be used with cars having 6 volt electrical systems.

DESIGN POINTS

Readers may be interested in a few design points relating to the circuit.

The unijunction device will not be triggered if its peak current rating exceeds the value of the current which the 12 volt car supply can drive through VR1 and R1, since the peak current required to trigger the emitter circuit would not then be reached.

The peak current has a maximum value of 5μA in the case of the TIS43, whilst the minimum value of the intrinsic stand-off ratio for this device is 0.55.

Thus if VR1 has its maximum value of 1MΩ, the current passing through it when the emitter voltage approaches the peak of the characteristic is 0.55 multiplied by 12 volts and divided by 1MΩ, which equals 6.6μA. This exceeds the maximum peak current rating of any TIS43 device and triggering will occur.

If the valley current of the unijunction transistor characteristic is less than the continuous current which flows through R1 of Figs. 1 and 2 when the emitter is conducting, the device will not switch off. The valley current has a minimum value of 2mA in the case of the TIS43. Thus the emitter resistor R1 should have a minimum value of 12 volts divided by 2mA, or 6kΩ. The value specified, 6.8kΩ, is therefore satisfactory.

In some initial experiments with the circuit of Fig. 1, the writer did not connect the lower end of R3 directly to the cathode of the thyristor, but broke the circuit at point C. The junction of the lower ends of C1 and R3 was connected to the negative supply line from the ignition key. A separate power supply was thus provided for the unijunction circuit.

In this case it was found that there was a strong tendency for the wipers to keep operating continuously without any delay. Presumably a pulse was developed across the inductive motor circuit when S3 opened in the parking position and this pulse triggered the thyristor.

The thrysistor must be able to pass the wiper motor current. The device specified is rated at 8 amps and should be adequate for any 12 volt type of wiper motor.

The C122D device used in the prototype is rated at 400V peak inverse voltage. However, the more economical C122F (75V p.i.v.) or the C122B (300V p.i.v.) would have been equally satisfactory in this application.

All these thyristors are available from Jermyn Industries, Vestry Estate, Sevenoaks, Kent.

CONSTRUCTION

The only control knob required is that for VR1 (ganged with S1). This variable resistor is conveniently clamped to the steering column about a foot beneath the steering wheel. Only two wires are needed from the remainder of the circuit to VR1 and S1. The connection between S1 and the slider of VR1 is made at the component itself. VR1 is wired so that it inserts increasing resistance into circuit as its spindle is turned clockwise. In consequence, the delay increases as VR1 spindle is turned clockwise.

In the prototype the remaining components were mounted on a small piece of Lektrokit perforated board. This was placed in a thick polythene bag and fitted into a suitable space above the parcel shelf. However, any other reasonable method of mounting the components could be employed. Care must be taken to avoid short-circuits to the car chassis.

NO HEAT SINK

The C122D thyristor has a tab which can be bolted to a heat sink. However, the writer found that no heat sink was required in this application. Although the maximum current flowing through the silicon controlled rectifier is about 4 amps, this current flows only for a short period each time the wipers commence to move from their parked position.

The mean dissipation in the silicon controlled rectifier is at a maximum when VR1 is set to its minimum value. In the prototype the thyristor was found to be barely warm after the circuit had been operating continuously for a few minutes with the delay set to the minimum value. Similar results would be given by the C122F and C122B thyristors.

The wiring which carries the windscreen wiper motor current in Figs. 1 and 2 is shown by thicker lines than appear in the remainder of the circuit. Wire which can carry 4 amps should be used for connecting the parts of the circuit shown by thick lines. The other wires (including those to VR1) can have quite a small diameter.

The lead marked 'B' may be connected to the earthing point on the control box or to any point on the vehicle chassis.

The lead marked 'A' may be connected to the car wiper switch, S2, but it is generally easier to connect it to one side of S3 on the wiper motor. It is easy to find which of the motor leads is connected to S3. If one removes the motor leads one by one and switches the wipers on and off, the wipers will stop immediately (without automatically parking) when the connection to S3 is removed. The wire from 'A' should be connected to the same point on the wiper motor as this wire. ■

New Products

"SCISSORS STYLE" CUTTING AIDS

A new range of production aids has been introduced in the UK by Adcola Products Ltd. Designed to deal with a wide variety of wire cutting and sheet metal trimming applications, Adcola Cutters feature 'scissor-type' operation.

All the cutters incorporate a special serrated cutting edge to provide a positive, non-slip, clean cut on copper and steel wire up to about one mm diameter. The scissor style appearance is based on surgical concepts and is claimed to give production operators easier and more accurate control when trimming excess wire lengths from component assemblies. Manufactured to precision standards in high quality chromium stainless steel, three models are available.

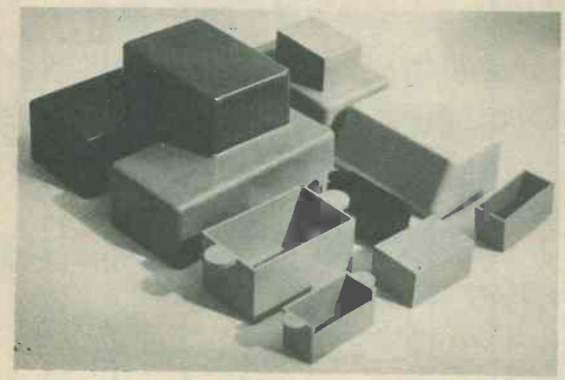
The FM17 cutter replaces conventional side cutters for use with single or multi-stranded wire. The serrated cutting edge ensures a good clean cut eliminating burred wire edges.

Cutter FM16 features a side-snips configuration allowing for use as tin snips to cut small radii. It is possible to successfully cut right to the very point of the cutting edge making the cutter ideal for fine detail work.

The FM17 cutter is spring loaded to ensure it returns to an open position. The design of the tool also ensures a standard finished wire length termination of 1.2 mm from the PCB making it ideal for solder flow bath applications.

Adcola cutters are priced from £5.10p, plus VAT and details may be obtained direct from Adcola Products Ltd., Adcola House, Gauden Road, London, SW4.

PLASTIC BOX RANGES



Albol Electronic and Mechanical Products are offering two new ranges of ABS plastic boxes.

The first range, for electronic/electrical circuits and controls, are in four sizes; the second, in three sizes. Standard colours offered are grey, blue, orange and red.

Type 1000, boxes for casing, all have lids (or bases) that are screwed with self-tapping screws; the lids can be sunken, flush, or flush with one edge overlapping. Removal of the lids reveals p.c.b. guide slots moulded into the inner sides of the box walls. Three of the range are rectangular, and the fourth is rectangular with one side sloping.

Type 1000 boxes vary in price from 44 to 83 pence, and the MG series from 13 to 23 pence for small quantities, all reducing with volume orders.

Albol Ltd., 3 Crown Buildings, Crown Street, London, SE5.

PUSH BUTTON SWITCHES

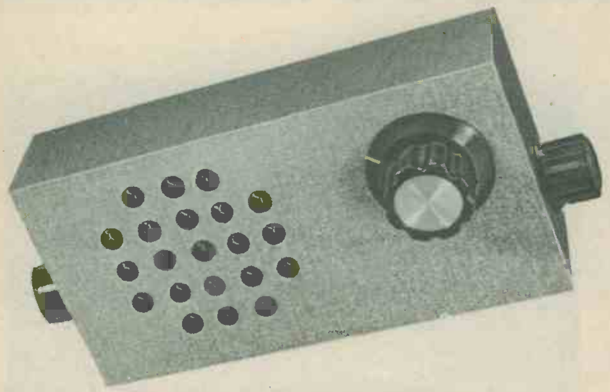
Complementing their range of FEME miniature toggle switches, FR Electronics now have available a series of Push Buttons with single or two pole changeover contact. Action is either push on, push off or momentary.

Contacts are silver, rated at 3A. 250V. A.C. and 5 amps at 30V. D.C.

Moulded button tops are available in white, blue, red and black.

Life at rated load exceeds 40,000 operations, dielectric strength 1000V. RMS, insulation resistance 20,000 m.ohms. at 500V. D.C. and the operating temperature range is –55°C to +85°C.

Further details are available from FR Electronics, Switching Components Group, Wimborne, Dorset.



By R. A. Penfold

MEDIU
LONG
I.C. REC

This little receiver incorporates two integrated circuits and requires no alignment after construction

THIS DESIGN IS A COMPACT MEDIUM AND LONG WAVE broadcast receiver which uses two integrated circuits and one transistor. An output power of 250mW r.m.s. is available from the internal speaker, and there is an output socket for an earphone, which can be either a crystal or a magnetic type. A t.r.f. circuit is employed, whereupon no alignment is required and the set is ready for immediate use after it has been built.

Construction is greatly simplified by taking advantage of integrated circuit techniques, since far fewer parts are employed than would be required in a receiver of similar performance having discrete semiconductor components. The set is completely self-contained. As a Class B output stage is used there is only a moderate current consumption from the PP3 battery, which in consequence has a good operational life.

THE CIRCUIT

The circuit of the receiver is shown in Fig. 1. Integrated circuit IC1, which is a Ferranti ZN414, forms the basis of the tuner section. This is a 10-transistor device and it has its own detector and a.g.c. circuit. It derives its power from the 9 volt supply via R7 and one section of the wavechange switch, S1(a). D1 and D2 are forward biased silicon diodes, and when S1(a) is in the medium wave position they allow a voltage of about 1.25 volts to be available for R2 in the IC1 circuit. D3 is a forward biased germanium diode and a voltage of around 0.25 volt is dropped across it. Thus, when S1(a) is set to long waves the voltage applied to R2 increases to about 1.5 volts.

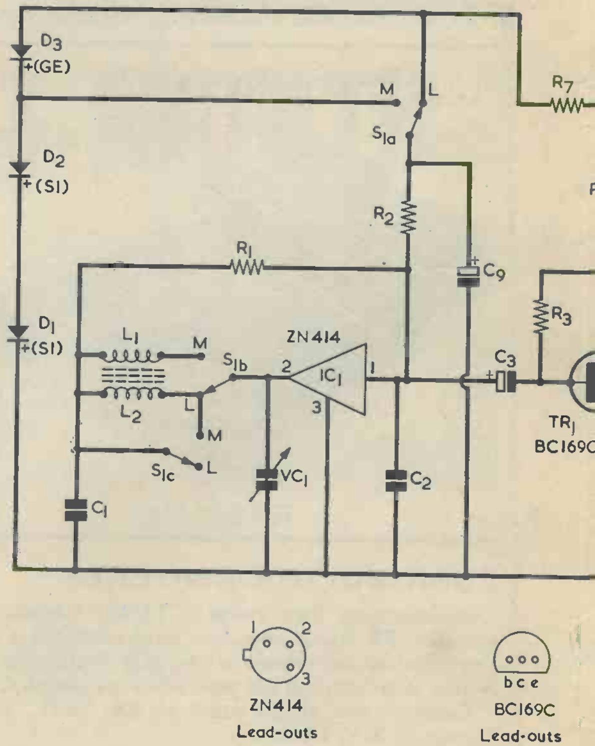


Fig.1 The circuit of the receiver. The insets showing top views of the MFC 4000 apply to different versions of this integrated circuit.

MEDIUM AND LONG WAVE I.C. RECEIVER

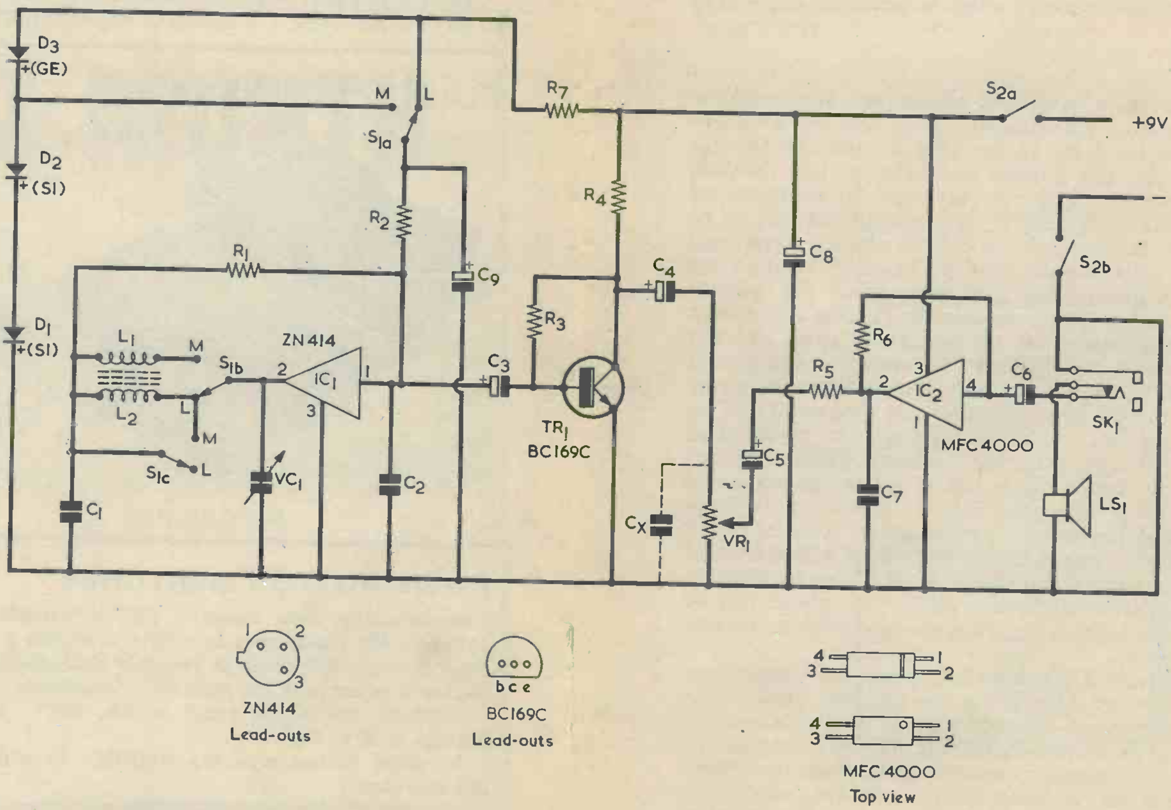
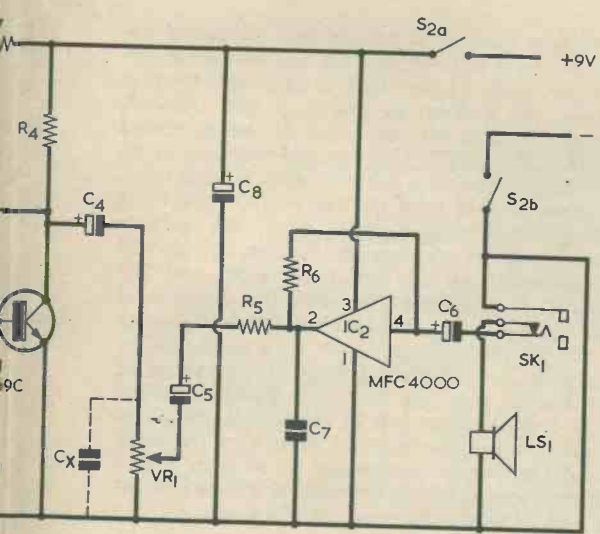
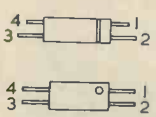


Fig.1 The circuit of the receiver. The insets showing top views of the MFC 4000 apply to different versions of this integrated circuit.

UM AND WAVE CEIVER





MFC 4000
Top view

COMPONENTS

Resistors
(All fixed values $\frac{1}{4}$ watt 10%)

R1	100kΩ
R2	470Ω
R3	2.7MΩ
R4	4.7kΩ
R5	3.3kΩ
R6	12kΩ
R7	3.9kΩ
VR1	25kΩ potentiometer, log, with switch S2(a)(b)

Capacitors

C1	0.01μF miniature plastic foil, side wires
C2	0.1μF miniature plastic foil, side wires
C3	4μF electrolytic, 10 V.Wkg.
C4	4μF electrolytic, 10 V.Wkg.
C5	4μF electrolytic, 10 V.Wkg.
C6	150μF electrolytic, 10 V.Wkg.
C7	0.022μF miniature plastic foil, side wires
C8	50μF electrolytic, 10 V.Wkg.
C9	16μF electrolytic, 10 V.Wkg.
VC1	300pF variable miniature, 'Dilemin' (Jackson Bros.)

Inductors

L1, L2	medium and long wave ferrite aerial coils (see text)

Semiconductors

IC1	ZN414 (Ferranti)
IC2	MFC4000 (Motorola)
TR1	BC169C
D1, D2	Small silicon diode (see text)
D3	Small germanium diode (see text)

Loudspeaker

LS1	$2\frac{1}{2}$ or $2\frac{3}{4}$in. speaker, 15Ω (see text)

Socket

SK1	3.5mm jack socket with break contact

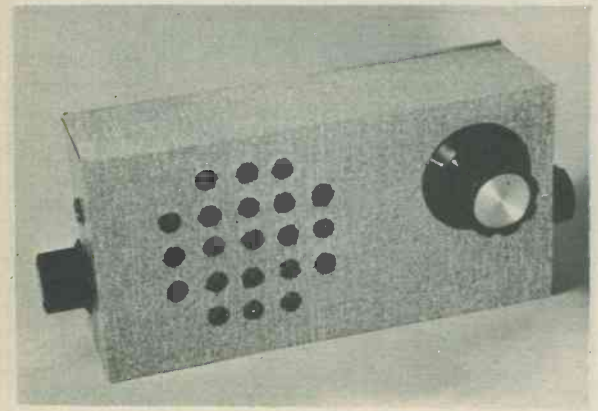
Switches

S1(a)(b)(c)	3-pole 2-way rotary, miniature (see text)
S2(a)(b)	D.P.S.T. toggle (part of VR1)

Miscellaneous
1 large knob
2 small knobs
PP3 battery (Ever Ready)
Battery connector
Ferrite rod, $4\frac{1}{2}$in. by $\frac{3}{8}$in. diameter
Speaker fabric
Materials for case
Paxolin panel

The gain of the ZN414 tends to drop off on the long wave band, and the purpose of providing a slightly increased supply voltage on long waves is to equalise circuit performance over the two bands. This is possible as the gain of the i.c. is dependent upon supply voltage. Indeed, it is by reducing the voltage at pin 1 on strong signals that the device produces its a.g.c. action.

D1 and D2 can be any small silicon diodes, such as the BAY31, OA200, etc. Cheap surplus types are quite suitable. D3 is any small germanium diode, suitable types being the OA91, OA90, AA119, or similar. Again, a cheap surplus type can be employed.



The completed receiver in its case. The control on the front panel is for tuning, whilst those at the ends are for wavechange and for volume and on-off switching

L1 and L2 are the ferrite rod aerial coils and these are coupled directly to the input of IC1. No low impedance coupling winding is required as the i.c. has a very high input impedance. It is necessary for L2, the long wave coil, to be short-circuited when the receiver is switched to medium waves as it otherwise has an adverse effect on medium wave tuning. S1(c) fulfils this function. VC1 is the tuning capacitor and R1 is a biasing resistor. C1 is an r.f. bypass capacitor and provides d.c. blocking for the bias at the input of the integrated circuit. C9 provides a bypass for the upper end of R2, and it is across R2 that the detected audio signal from the i.c. is developed.

This signal is coupled via C3 to TR1, which is a high gain common emitter amplifier. It is biased by R3, and R4 is its collector load resistor. The amplified signal for TR1 is coupled via C4 to the volume control VR1. The capacitor CX, shown connected into circuit by broken line, may be required in some receivers if instability should occur at high volume settings when the set is switched to the long wave band. It should have a value of 0.005µF, or higher if this is necessary to clear the instability.

C5 and R5 couple the signal from the volume control to the second integrated circuit. This is a Motorola MFC4000 and it incorporates a driver transistor and a Class B output stage. C7 is a stabilizing capacitor, and R6 is a biasing resistor which provides a high level of d.c. and a.c. negative feedback. C6 couples the output of the i.c. to the speaker or earphone, and C8 is the main supply bypass capacitor. The output jack has a single break contact which disconnects the loudspeaker when an earphone is plugged in. The MFC4000 can be obtained from several retailers as MFC4000B or MFC4000P. The latter version is available from Henry's Radio Ltd.

The on-off switch for the receiver is S2(a)(b), and this is ganged with the volume control, VR1.

Ideally, the speaker should have an impedance of 16Ω, as this is the recommended load for the MFC4000. It would be in order to use a 15Ω speaker but not one with an impedance lower than this. The MFC4000 will work satisfactorily with a 25Ω speaker or even a 40Ω speaker, although the available output power reduces as the speaker impedance increases. It is intended that the speaker employed have a diameter of $2\frac{1}{2}$in. or $2\frac{3}{4}$in. but, as retail stocks of small speakers of this nature tend to fluctuate, the constructor may have to accept a compromise in terms of impedance and size.

CASE

The prototype receiver is housed in a simple home-made case having a removable back and inside dimensions of 6 by 3 by $1\frac{1}{4}$ in. This housed the speaker employed by the author satisfactorily but the 3in. dimension and the depth may have to be increased to take other speakers if they should happen to be fractionally larger. So far as cabinet depth is concerned, the constructor should read the assembly instructions which are given later and then check the cabinet depth needed to accommodate the Paxolin component board, which rests on the speaker frame, and the battery, which is positioned between the component board and the back, and between the speaker magnet and the case bottom. A case of the type employed by the author is easily constructed from $\frac{1}{8}$in. plywood or faced hardboard with the sections glued together. Reinforcing corner pieces can be employed and these also provide a suitable means of mounting the back of the case. The corner pieces can be seen in Fig. 5 and in the photograph of the rear, and it will be noticed that these accept wood screws passed through suitably positioned holes in the case back. The cabinet can be given a smart finish by being covered with a suitable plastic veneer.

Alternatively a commercially produced plastic case can be used provided it has the required dimensions. The case must, of course, be made of a non-metallic material so as to avoid screening the ferrite rod aerial.

An effective speaker aperture can be made by drilling twenty-one $\frac{1}{4}$in. diameter holes with $\frac{1}{2}$in. spacing in the pattern shown in the photograph. A piece of speaker fabric is glued to the inside of the case behind this matrix of holes. It will be helpful to make these holes after the remainder of the constructional work has been carried out as this will enable the final position of the speaker to be evaluated more accurately.

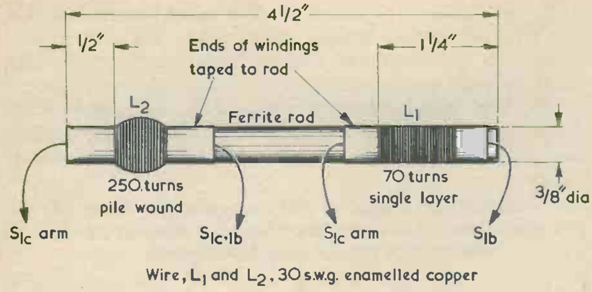


Fig. 2. Details of the ferrite rod aerial windings

FERRITE AERIAL

The ferrite rod aerial is home-wound on a 4½in. length of ⅜in. diameter ferrite rod. This rod was obtained from Amatronix Ltd., 396 Selsdon Road, South Croydon, Surrey. There are only two windings, and both of these are wound with 30 s.w.g. enamelled copper wire. Details are given in Fig. 2. The ends of the windings are taped to the rod to prevent the coils unwinding. L2, which is pile wound, must be wound tightly or it will tend to spring apart even when the wire ends are taped to the rod. L1 is close-wound in a single layer. If desired, a coat of polystyrene dope can be applied to the coils after completion to hold them firmly.

COMPONENT PANEL

Most of the components are mounted, and wired up, on a piece of plain $\frac{1}{16}$in. Paxolin. This is shown, full-size, in Fig. 3. The construction of this commences by cutting out the panel to 4½ by 2¾in. The two cut-outs for VR1/S2 and VC1 are then made. A circular cut-out for the speaker magnet has to be made also, and this can be done with either a fret or coping saw. The hole should have a diameter which just accommodates the magnet of the speaker to be used, and should allow the board to be a tight fit on that magnet. If the hole is accidentally made a little too large, the effective diameter of the magnet may be increased by winding thin tape round it. Next, the positions of the component mounting holes can be marked and then drilled using a 3/64in. diameter twist drill. The holes for the MFC4000 pins should be positioned to suit the particular i.c. employed. The components are then mounted as indicated in the diagram, and lead-out wires are bent over at 90 degrees on the reverse side of the board. The lead-outs are then soldered together, the underside wiring being shown in broken line in the diagram. The lead between R7 and pin 3 of the MFC4000 should be positioned so that it clears the speaker frame, and it may need to be insulated with sleeving. The two points marked 'A' are joined together, below the board, by an insulated lead. A number of leads pass from the panel to components mounted in the case. Insulated leads about 3 to 4in. long are connected to the panel at these points. Their free ends are not connected until all the parts, including

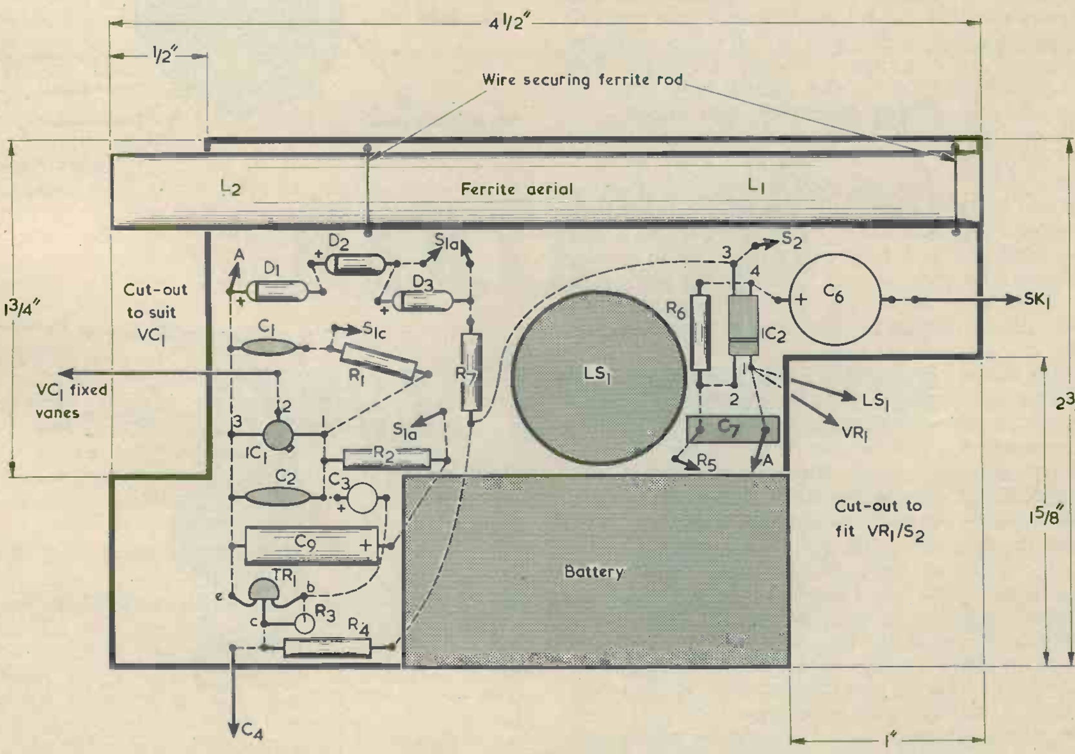
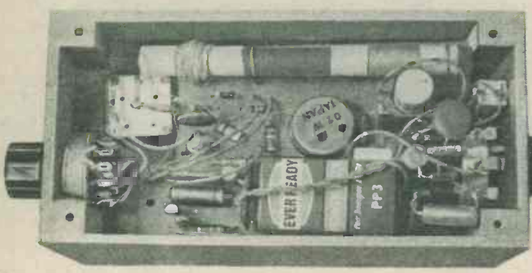


Fig. 3. Components and wiring on the Paxolin panel. The legends 'L2' and 'L1' indicate the positions taken up by these coils on the ferrite rod. Holes for the MFC4000 should correspond to the particular version employed



The internal layout of the components. Most of the smaller parts are mounted on a Paxolin panel which fits over the speaker magnet

the component panel assembly, are mounted in the case.

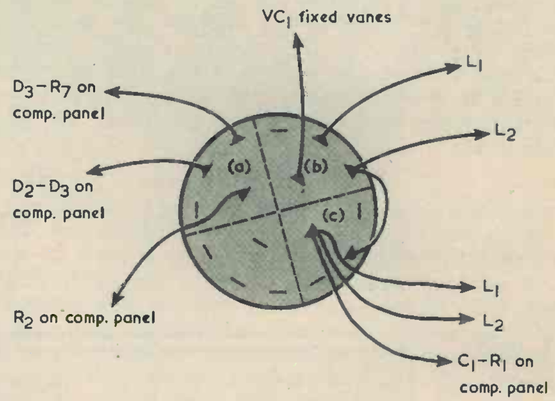
It is important to ensure that D1, D2 and D3 are connected into circuit with correct polarity. If any of these diodes is connected into circuit the wrong way round it is possible for very nearly the full 9 volt supply to be applied to the ZN414, which may suffer damage thereby. Should any doubt exist, wire up all the components on the board with the exception of the ZN414. Then temporarily apply the negative terminal of a 9 bolt battery to the junction of D1 and C1, and the positive terminal, via a 3.9kΩ resistor, to the junction of D3 and R7. Measure the voltage across all three diodes, with the voltmeter negative test clip at the junction of D1 and C1 and the voltmeter positive clip at the junction of D3 and R7. If all is well the voltmeter will indicate approximately 1.5 volts. The temporary connections to the board may then be removed and the ZN414 connected into circuit.

The ferrite rod aerial is mounted by means of two pieces of single core p.v.c. covered wire. Each piece of wire is looped over the rod with its two ends passing through two holes in the board. The two ends are then tightly twisted together on the reverse side of the board so as to hold the rod securely. Take care to ensure that the two wire ends of each loop do not come into contact with each other, or a short-circuited turn will result, preventing the ferrite aerial from functioning correctly.

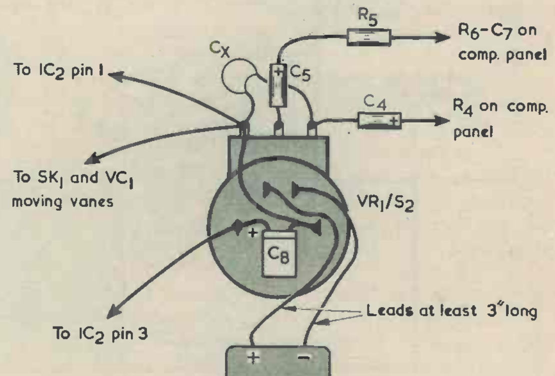
Fig. 4(a) shows the connections to the wavechange switch. This component is a miniature 3 way 4 pole switch with an adjustable end stop which is set up for 2 way operation. The switch is available from a number of suppliers. Only three of its poles are used in the present circuit. Before wiring to the switch, check the outside contact tags corresponding to each of the centre tags with the aid of an ohmmeter or continuity tester, as their relative positioning may differ from that shown in Fig. 4(a).

As there is a shortage of space on the component panel, some of the parts are mounted on VR1/S2. This wiring is shown in Fig. 4(b). The earth lead from VR1 to VC1 is insulated and connects first to SK1 and then passes on to the moving vanes tag of the capacitor. It passes below the board and should be positioned so that it will clear the speaker when the latter is in its final position. Capacitor CX is not wired into circuit until the receiver has been completed and tested, and then only if any instability should be evident, as explained earlier.

As with switch S1, it is desirable to identify the tags for each pole on S2 by means of an ohmmeter or continuity tester, as their positioning may vary from that shown in the diagram.



(a)



(b)

Fig. 4 (a). Connections at the wavechange switch
(b). Some of the components are wired direct to VR1/S2

GENERAL LAYOUT

Fig. 5 shows the general layout inside the case. S1 and VR1/S2 require standard ⅜in. diameter mounting holes. The Jackson 'Dilemin' capacitor specified for VC1 requires a $\frac{5}{16}$in. hole through which its spindle passes, and two 6BA clear holes for its two 6BA mounting screws. Two screws are supplied with the capacitor but these may be found a little too short for the present application. Also, they have round heads, whereas countersunk heads are preferable. The screws should therefore be replaced by two countersunk 6BA screws which will not pass further into the tapped holes in the capacitor than the original ones would. A suitable screw length should be ¼in.

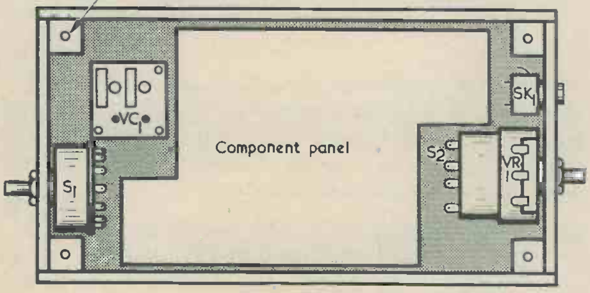


Fig. 5. General layout of the major parts inside the case

The component panel, complete with speaker, just drops into place inside the case. There is a space for the PP3 battery on the component panel. Some strips of sticky backed foam rubber or plastic (which is sold as draught excluder) can be fixed to the back of the case so that it will press down against the battery and the ferrite rod aerial. Screwing on the back of the case will then also hold the battery and component panel in position.

The leads between the component panel and the parts fitted to the case may now be connected up. They should be shortened as necessary. One lead from the speaker connects to the break contact of SK1. Its other lead connects to pin 1 of IC2 on the component panel.

If at any time in the future the set should require servicing, all the parts can be removed in their entirety without unsoldering any leads by removing the mounting nuts of VR1, SK1 and S1, and the mounting screws of VC1.

Once completed the set is ready for immediate use, no adjustments, apart from the possible fitting of CX, being required. ■

B.A.R.T.G. 1974 ANNUAL CONVENTION

The British Amateur Radio Teleprinter Group, held its annual Convention at Meopham, Kent, on Saturday, May 18th. This is the third such occasion held at this venue and was most successful.

The weather was perfect and the 'talk-in' station operated outdoors; so that visitors had plenty of room to watch its activities. The live RTTY station in the Village Hall produced much interest, especially to those who had not seen amateur radio RTTY before.

Two interesting lectures were arranged for the afternoon, and both were well attended. Doug Button, G8AEL, gave a useful talk on 'Getting Started', demonstrating what points to watch for when putting a Creed Type 7 Teleprinter into service, this being the model of teleprinter usually available to RTTY enthusiasts in this country. Bill Pechey, G4CUE, took his audience to the other end of the scale, in his talk on 'Advanced Terminal Units,' demonstrating with a T.U. of his own design, the application of integrated circuits and right up to the minute design features for an RTTY Terminal Unit. This talk was much appreciated by those with ambitions to keep their RTTY stations right up to date.

This event is fast becoming one of the priority dates in the amateur radio social diary. A.C.G.

SHORT WAVE NEWS
FOR DX LISTENERS

By Frank A. Baldwin

Times = GMT *Frequencies* = kHz

On the South American continent, bordering the Pacific Ocean, lies the Republic of Peru. Divided by two ranges of the Andes, with high altiplano lying between, with the dense rain forests of the west Amazon Basin in the east and with a long coastal desert belt in the west, Peru is one of the difficult countries to hear on the short wave bands. The reasons for this difficulty is that most of the stations have very low radiated powers, usually of the order of 1kW, and omnidirectional aerial arrays. The high Andean range must also play a part in shielding us here in the U.K. from many of the signals emanating from Peru. Nevertheless, just occasionally, conditions are such that this area of the world comes through very well on the 60m band.

Recently the writer had the good fortune to enter the shack just after 0300 to 'test' the 60m band, a not unusual occurrence, to find that signals from Peru and the nearby Colombia predominated over all others, clearly an LA session was called for and it produced the following.

● COLOMBIA

4865 0424 HJLZ Voz del Cinaruco, Arauca, local newscast in Spanish by OM announcer, many place names in Colombia mentioned, series of chimes and station identification at 0430. 1kW, schedule 1100 to 0500.

4755 0440 HJKC Emisora Nuevo Mundo, Bogota, talk in Spanish, station identification at 0442. 1kW Schedule 1100 to 0500.

● PERU

4788M OAX8F Radio Atlantida, Iquitos, Latin American music then OM with identification "Radio Atlantida" at 0324. 1kW, schedule 0900 to 0455.

5010 OAX8V Radio Eco, Iquitos, typical local music at 0340, identification by OM at 0352 "Radio Eco" then recorded announcement "Eco, Eco, Eco" followed by choral rendering of the National Anthem and off at 0355. 1kW, schedule 1200 to 0400.

4880 Radio Once Sesenta, Lima, OM with talk in Spanish from 0405, Lima mentioned several times, identification at 0416 uncertain but Lima definite, tentative logging. 1kW, schedule 1200 to 0500.

4815 OAX8X Radio Samaren, Iquitos, at 0443 with OM giving a talk in Spanish, station identification at 0456 "Radio Samaren", choral National Anthem and off at 0457. 1kW, schedule 1100 to 0500.

It is interesting to note, from the above, that most of the loggings were of stations in Iquitos, this being located east of the Andes which did not therefore, on this occasion, act as a barrier. The signal from Lima did have some of the Andes to surmount.

60 METRE BAND

Last month we conducted a brief survey of the 90 metre band and this month a report on the 60m band, which follows, will almost certainly prove of interest to many readers.

Latin America is always apparent on the band at night in some measure or another, some of the signals logged from this area of late have been.

● HONDURAS

HRVC Voz Evangelica, Tegucigalpa, on **4820** at 0355 when a religious talk in English was being radiated. For those who require a QSL card from Honduras, this station is your best bet, it closes at 0430 with full identification and all details.

● VENEZUELA

YVOI Radio Valera, Valera, on **4840** at 0400 signing off with hymn by small studio choir.

YVAO Radio Sucre, Cumana, on **4960** at 0328, identification amid LA music programme "R. Sucre Musica". Identification also at 0350 after trumpet fanfare.

YVOC Ecos del Torbes, San Christobal, on **4980** at 0200 with station and network announcements in English. This is one of the easiest LA's to hear on the band but is included here because of the language used at this time.

YVQE Radio Bolivar, Cuidad Bolivar, on **4770** at 0040 with LA songs, guitar music, OM in Spanish, ads and 'jingles'.

YVMG Radio Popular, Maracaibo, on **4810** at 0047 with LA music and Spanish songs.

YVWJ Radio Cristal, Barquisimeto, on **4820** at 2345 with identification followed by guitar music.

● COLOMBIA

HJGF Radio Bucaramanga on **4845** at 0403, OM with full identification, sign-off with National Anthem.

● ECUADOR

HCMQ1 Radio Atahualpa, Quito, on **4780** at 0320 with LA music, songs, identification at 0331.

HCWE1 Radio Nacional Espejo, Quito, on **4678** at 0606 with typical local music and song programme.

HCRQ1 Radio Quito, on **4923** at 0320, OM in Spanish with very exciting, apparently, sports commentary.

● **COSTA RICA**
TIHB Radio Capital, San Jose, on **4832** at 0120 with LA music, identification in Spanish then more music, songs. (This is in Central America/Caribbean area of course).

● **BRAZIL**
ZYG26 Radio Pioneira de Teresina, on **4887** at 2203 with OM in Portuguese with local newscast.

ZY121 Radio Poti, Natal, on **4934** at 2132 with talk in Portuguese..

AFRICA
Signals from this continent are often audible on the band from around 1730 onwards and the programmes are nothing if not varied, from discussions in English to local pop music sessions.

● **UGANDA**
Kampala on **4976** at 1907 with a newscast in English and on **5026** at 1939 with a programme of local music and s ngs – very rhythmic.

● **NIGERIA**
Lagos on **4990** at 1915, OM with identification after the news in English then into vernacular. Also heard at 2002 with news in English.

● **SOUTH AFRICA**
Johannesburg on **4830** at 2105, news in English, announcements then off with choral National Anthem at 2115.

● **MOZAMBIQUE**
Radio Clube Mozambique on **4890** at 1843 with talk in Portuguese followed by light music programme. Also on **4855** at 2057 with guitar music.

● **GAMBIA**
Banjul on **4820** at 2300 when signing-off with National Anthem.

● **DAHOMEY**
Cotonou on **4870** at 2205 local music, announcements in vernacular, African drums.

● **ANGOLA**
CR6RH Radio Clube da Huila on **5025** at 2140, OM in Portuguese, jingle and advert for "... cigarro" then light music.

● **LIBERIA**
ELWA Monrovia on **4770** at 1940, musical interlude then into vernacular with, presumably, gospel programme.

EAST AND FAR EAST
Although the 'season' for reception of signals from these areas is now past, occasional breakthroughs occur from time to time, although very much reduced in signal strength.

● **SRI LANKA**
Colombo on **4902** at 1855, continuous chanting of Buddhist monks on a full-moon day.

● **SINGAPORE**
On **5010** at 2318 with a programme of European-type light music with announcements in English.

● **MALAYSIA**
Kuala Lumpur on **4845** at 2330, 6 pips then OM in Tamil.

● **PAKISTAN**
Peshawar on **4950** at 1850, YL with Indian-type songs, local music, off suddenly at 1900 without National Anthem.

● **INDIA**
AIR Hyderabad on **4800** at 1701, local music, OM with songs, announcements by YL.

AIR Calcutta on **4820** at 1720, OM with songs in Hindi, local orchestra, off at 1730 without National Anthem.

● **AFGHANISTAN**
Kabul on **4775** at 1655, local music rendered on a guitar-like instrument, OM with announcements in vernacular.

● **CHINA**
R. Peking on **4800** at 2025, sign-off with "Internationale"; on **4883** at 2002 with "East is Red", identification in English by YL then into Asian dialect; on **4815** at 2243, Chinese music then into USSR dialect; PLA Fukien on **4840** at 2156, OM and YL alternately in Chinese dialect and Foochow on **4975** at 2323 with YL in Chinese dialect.

● **YEMEN P.D.R.**
Aden on **5060** at 1850, Arabic music, songs by OM, announcements in Arabic.

ANYTHING ELSE?
Well, there are one or two oddments left over, mostly overlooked when compiling the above, how about –

● **SOUTH AFRICA**
Johannesburg on **4975** at 0400, 6 pips, identification and announcement that broadcast is directed to East and Central Africa then the news, all in English. Unearthly hour 0400 but at least you will find that it is daylight at this time of the year – and the birds are singing!

● **ANGOLA**
R. Com de Angola on **4795** at 2040, programme of typical Portuguese music, channel is subject to much co-station QRM.

● **CAMEROON**
R. Yaounde on **4972** at 2203, Arabic-type music and chants, OM with announcements in vernacular.

● **UNIDENTIFIEDS**
On **5007** at 0128, unidentified Latin American, OM in Spanish, LA songs till 0133 when YL with "Radio ...", few short bars classical music then OM with echo-effect announcements. Heard several times.

On **4732** at 0345, an LA station with OM in Spanish, local music then lost in CW QRM, this one logged on three separate occasions.

On **4783** at 0140, OM in Spanish, LA music, many ads, jingles, no idents!

THE "WYVERN" 100 WATT INVERTER

By John R. Green, B.Sc., G3WVR

Intended primarily for amateur transmitter mobile or portable operation, this solid state inverter offers a high power output at 300 volts.

DESPITE THE GROWING POPULARITY OF SOLID STATE equipment, there are still many applications where valves offer an easier, cheaper, more rugged and more reliable circuit choice than do transistors. A prime example is given by the output stage of a high power a.m. or s.s.b. transmitter.

When it is contemplated using such equipment for mobile (or portable) applications, an inverter will be required to provide a suitable h.t. supply. The inverter presented here will happily produce 100 watts of h.t. from two car batteries, or 60 watts of h.t. from a single car battery.

The inverter will also be found useful for operating a valved receiver.

THEORETICAL POINTS

The circuit diagram of the complete inverter is shown in Fig. 1, and it will be seen from this that it is of the self-oscillating type. This offers the advantages over the driven type of being simpler and also short-circuit proof, provided that the rectifiers can withstand the instantaneous short-circuit current.

The heart of the inverter is the transformer, which is wound on a 35mm. Mullard transformer core pair type FX2242. Note that two cores should be ordered to make up the pair. Information on a retail source for these cores and other components not generally available is given at the end of this article.

The winding details listed in the Table will produce an oscillation frequency of around 5kHz for both versions. The secondary turns may be varied in either version if a different output voltage is required, but if it is desired to change the operating frequency then the number of turns on all windings must be changed in the same proportion. Increasing the number of turns will lower

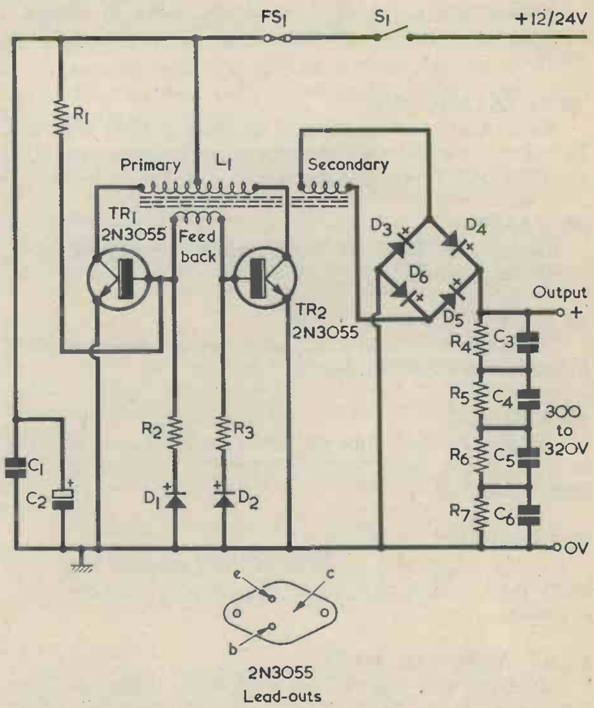


Fig. 1. The circuit diagram of the inverter

TABLE

Transfomer Winding Details

24 Volt 100 Watt Version

Primary:	14 turns + 14 turns (i.e. 28 turns centre-tapped) 22 s.w.g. enamelled copper.
Feedback:	4 turns 26 s.w.g. enamelled copper.
Secondary:	180 turns 30 s.w.g. enamelled copper (for 300 volts output).

12 Volt 60 Watt Version

Primary:	7 turns + 7 turns (i.e. 14 turns centre-tapped) 22 s.w.g. enamelled copper.
Feedback:	4 turns 26 s.w.g. enamelled copper.
Secondary:	180 turns 30 s.w.g. enamelled copper (for 300 volt output).

the operating frequency in proportion and decreasing the number of turns will raise the operating frequency in proportion. It should not be attempted to exceed 10kHz, however, unless faster transistors than 2N3055's are used.

The current gain versus collector current and the collector-emitter saturation voltage ratings of the 2N3055 tend to limit the capability of a pair of the devices, as used in the inverter, to 100 to 150 watts when inverting a 24 volt supply, and to 60 watts when inverting a 12 volt supply. Efficiencies in the order of 85% are to be expected from the higher power version, and 75 to 80% from the lower power version.

The drive feedback winding does not require a centre tap since the diodes D1 and D2 provide clamping of the drive waveform on the 'off' transistor side (forward bias on the diode) and a high resistance on the 'on' transistor side (reverse bias on the diode). The base current is limited by either R2 (for TR2 base) or R3 (for TR1 base) to the current drive required for full output. These diodes should be rated at 1 amp and only a low p.i.v. rating is required. although higher voltage diodes can be used if this is convenient.

The inverter operates as a square wave oscillator and the feedback must be correctly phased for oscillation. Should the inverter fail to oscillate then the connections to the feedback winding should be reversed.

The resistor R1 provides sufficient forward bias to take TR1 into conduction such that the inverter will self-start, and this resistor may require some reduction in value if the gain of the transistor is low.

A very low value in R1 would be required if the inverter is to self-start into a load given by a mains light bulb since the resistance of a cold light bulb filament is very much lower than that of a hot one. Hence a mains bulb presents an excessive load for the inverter and bulbs of greater than 40 watts are not recommended as loads.

The capacitors C1 and C2 across the supply lines are included to prevent excessive current spikes, which would introduce hash into other equipment, appearing in the supply leads.

The supply line fuse is included for the protection of the vehicle and its battery, since car batteries can produce spectacular firework displays when feeding into short circuited loads. The fuse will not provide any protection for the inverter components, as transistors burn up far faster than fuses; but the inverter is short-circuit proof at its output in any case since a short-circuit here will simply stop it from oscillating.

The rectifier diodes D3 to D6 require some special mention since, for a high frequency inverter of this type, 'just any old rectifiers' will not do. The storage time (i.e. the time a diode takes to switch off when changed from forward to reverse bias) of ordinary 50Hz rectifier diodes makes them totally unsuitable, in most cases, for high frequency inverters, and therefore 'fast recovery' rectifiers with very short storage times must be employed.

A suitable rectifier diode which may be used overall for D1 to D6 is the Mullard BYX70-500. The diodes which appear in the D3 to D6 positions in the photographs of the prototype are Texas Instruments type 1S107, but these are not recommended for use by constructors as they are specified only for operation at

COMPONENTS

Resistors

R1	2.7kΩ ½ watt 10%
R2, R3	10Ω 2 watts 10% (or 2X20Ω 1 watt 5% in parallel)
R4–R7	100kΩ ½ watt 5%

Capacitors

C1	4.7μF polyester or polycarbonate, 60 V. Wkg.
C2	8μF electrolytic, 40 V. Wkg.
C3–C6	4.7μF polyester, 100 V. Wkg.

Inductor

L1	Home-wound on 1–off former type DT2180 and 2–off Mullard cores type FX2242

Semiconductors

TR1, TR2	2N3055
D1–D6	BYX70–500

Switch

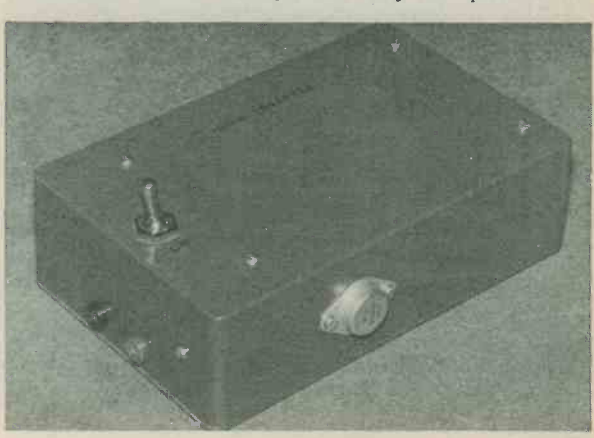
S1	s.p.s.t. switch, 5 amp (see text)

Fuse

FS1	5 amp fuse and holder (see text)

Miscellaneous

4 insulated sockets
Diecast box type 6827P (Eddystone)
Mica washers and insulating bushes (for TR1 and TR2)
Printed circuit board
Enamelled copper wire (see Table)



The completed inverter is housed in a small diecast box

2.5kHz maximum and it would be quite possible to pick up one or more 'marginal' specimens. Indeed, the 1S107's used by the author failed when checked experimentally at 10kHz, solely due to failure by overheating because of the high dissipation resulting from excessive storage time. The BYX70-500 rectifiers will, however, operate quite happily at the frequencies involved here and are more than adequate for the present application.

The output smoothing at 5kHz is very small in terms of microfarads, and the author used four 4.7μF 100 volt working polyester capacitors in series, giving an effective smoothing capacitance of just over 1μF. These capacitors are C3 to C6 and have voltage equalising resistors R4 to R7 connected across them. They reduced the twice frequency (i.e. 10kHz) ripple to a negligible level. There is no objection to using a single non-electrolytic 1μF 400 volt working capacitor if this is available. R4 to R7 are not then required, of course, but it would be a good idea to connect a 390kΩ 1 watt resistor across the single capacitor. This will act as a bleed and will discharge the capacitor if the inverter is switched off without a load connected. 4.7μF 100 volt working polyester capacitors are listed by Electrovalue Ltd., 28 St. Judes Road, Englefield Green, Egham, Surrey.

Large 400 volt working electrolytic capacitors may be used, but these will slow down the h.t. build-up and impose more of a surge on the rectifiers. An electrolytic capacitor may require a small high voltage polyester capacitor in parallel in any case, since the impedance of an electrolytic capacitor at the ripple frequency of 10kHz is quite high.

CONSTRUCTIONAL DETAILS

The construction of the inverter may be clearly seen from the photographs.

The majority of the components are mounted on a single printed circuit board measuring 6 by 3½in. This is shown full-size in Fig. 2, as seen from the component side. The transformer core, after winding (to be discussed shortly) has been completed, may be secured to the board either by means of a *brass* bolt passing through the centre or by two brass bolts passing down the outside grooves which are free of exit wires. Spring

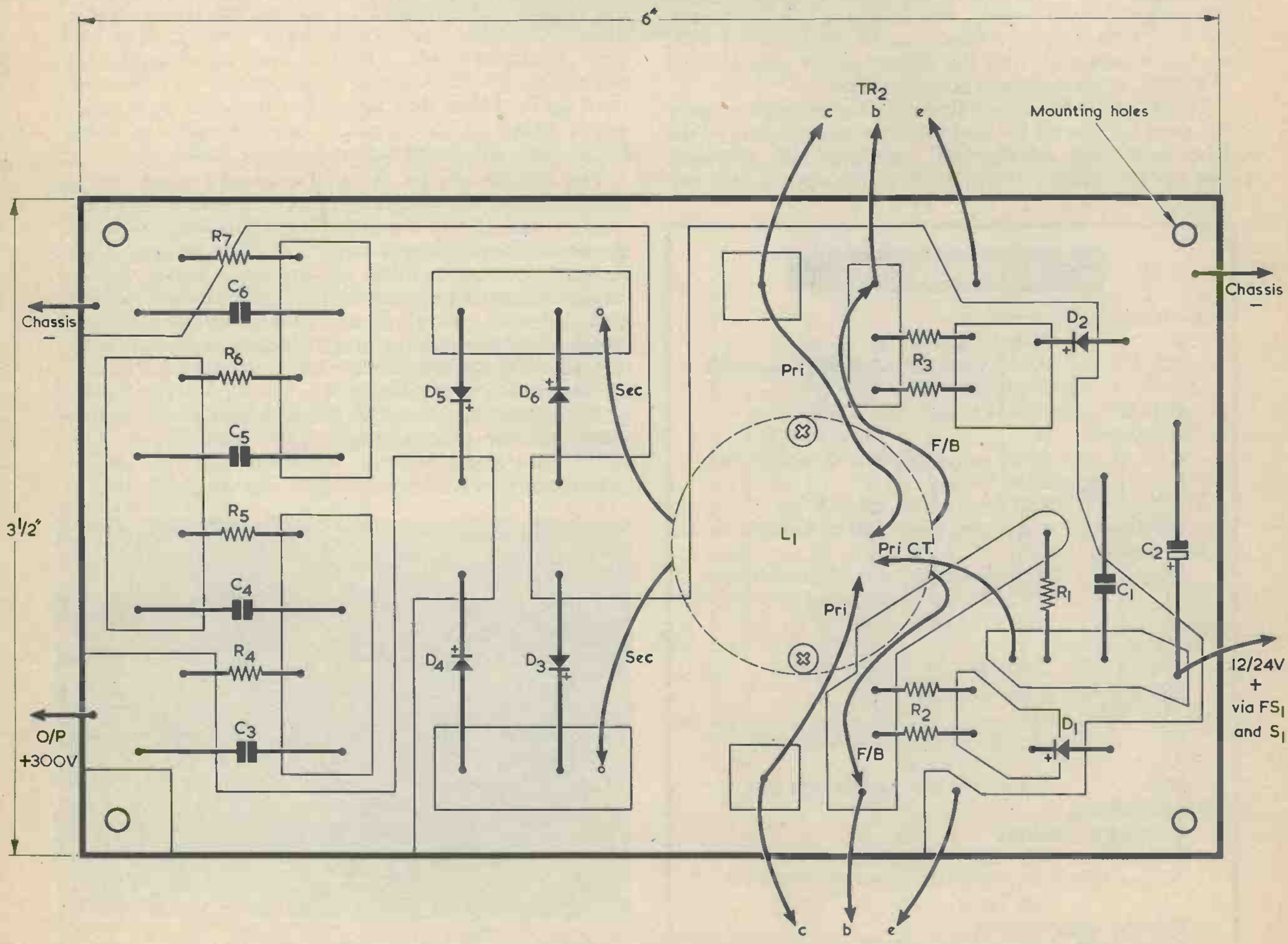


Fig. 2. The printed circuit board viewed from the component side R2 and R3 are each shown as two resistors in parallel. The board is reproduced full size and the diagram may be traced

washers or rubber grommets should be included to prevent damage to the brittle ferrite material.

The completed printed circuit board was fitted in an Eddystone diecast box type 6827P, this measuring approximately 7¼ by 4½ by 2in. This box is available from Home Radio under Cat. No. E845. An alternative is the slightly larger S.T.C. diecast box measuring 8¾ by 5¾ by 2⅓in. (Home Radio Cat. No. 8/Z140). Again, a suitable aluminium chassis of around the same dimensions could be employed.

The box also forms a heatsink for the two 2N3055 transistors which are fitted using insulating mounting kits. The heatsinking is absolutely necessary since the pair of transistors dissipate around 15 to 20 watts at full output.

The transformer core windings also dissipate a couple of watts in their resistive losses and the core will get quite hot. If it is contemplated that the inverter should run for more than 30 minutes continuously at full output then a heatsink in contact with the transformer core in the form of an aluminium plate would be useful.

The 12/24 volt input sockets were mounted at the same end of the box as the switch and fuse. The end of the board at which C2 is fitted is adjacent to the switch. The output sockets are mounted at the other end of the box. This layout helps to avoid the risk of plugging in the wrong leads at each end.

In the prototype the negative input and negative output were earthed to the diecast box. The experienced constructor should be able to modify the printed circuit board if alternative earthing arrangements are required. Such alternative arrangements have not been checked out by the author.

TRANSFORMER WINDINGS

The transformer windings are completely non-critical and there is no need to bifilar wind the primary. The windings must, however, be as neat as possible, otherwise it will be difficult to get all the turns on when the secondary is wound. It should be noted that the former type DT2180, which fits in the ferrite cores and which takes the windings, is not sectionalised.

The primary can be wound on first. Start by winding on half the turns, twist up about seven inches of wire for the centre tap, and then continue winding in the same direction for the second half of the primary. Bring out the start, centre-tap and finish neatly, and tape down the winding using a minimal quantity of *thin* tape. It is not necessary, incidentally, to 'cram' the primary into one layer.

The feedback winding is next. Wind 4 turns of the specified wire over the primary and bring out the start and finish. Ensure that the lead-outs will not be confused with those of the primary (although they should be different gauges in any case). Tape down and cover the winding with *thin* tape, again using a minimal quantity.

The secondary is wound on last, as neatly as possible, and the start and finish brought out. The final completed coil is well wrapped with tape.

Start and finish lead-outs should be left six inches long until they are connected into circuit. They are then cut to length and covered with sleeving, as required. The centre tap of the primary, after it has been cut to the desired length, must, of course, have *both* the twisted leads scraped clean and soldered to its circuit point.

Thin tape is specified as there is not a great deal of room on the former. Sellotape would be suitable, but if thin yellow Mylar tape can be obtained this is ideal.

TESTING

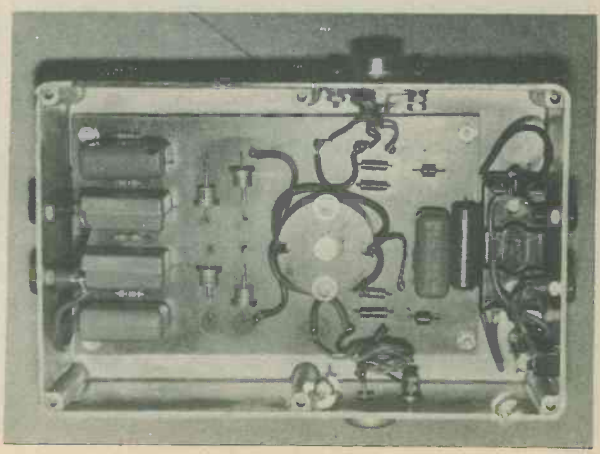
Initially the inverter should be tested off-load to check that it is oscillating. An audible steady whistle at twice the operating frequency emanating from the transformer core will confirm this.

If the unit fails to oscillate then the feedback connections should be reversed.

Once satisfactory oscillation is achieved the off-load h.t. voltage may be checked, after which a suitable resistive load can be introduced. The load could be 1kΩ 100 watts for the 24 volt version and 1.8kΩ 60 watts for the 12 volt version. Alternatively, the output may be presented to an item of equipment capable of drawing the requisite current. It should be noted that mains light bulbs do not make good test loads for the reasons mentioned earlier.

The frequency of oscillation of the inverter will gradually fall as the load is increased and will eventually break up into an unsteady 'warble' as the load becomes excessive. A short-circuit will stop the inverter completely and without damage; the inverter will re-start when the short-circuit is removed.

If it should be found that the power output capability falls short of the stated level then this will probably be due to the transistors having a low current gain and thereby requiring more base current drive. The values of R2 and R3 should be suitably reduced in this event.

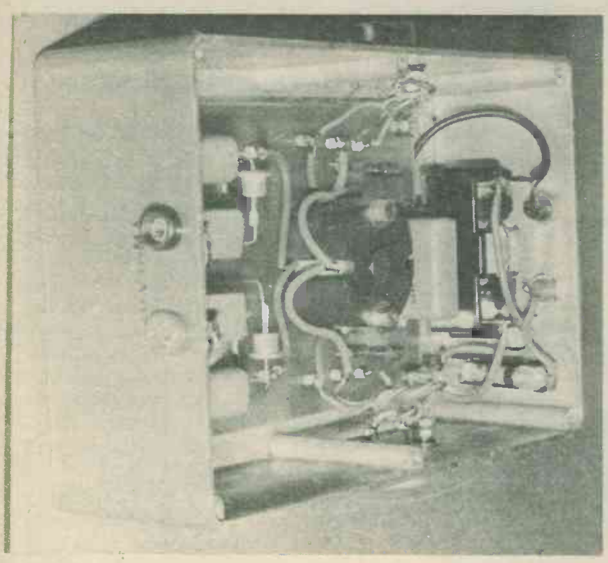


A printed circuit board enables the components to be laid out neatly inside the box. The two transistors are secured to the sides of the box, which functions as a heatsink

The 24 volt design assumes a collector 'on' current of 5 amps at maximum output and an hfe (current gain) of 10 times at this collector current, whereupon the drive is arranged to provide 0.5 amp of base current.

Note that the collector current is 6 amps for the 12 volt version, and a larger fuse may be required in addition to slightly more base drive if the full 60 watt output is required. S1 will also require a higher current rating to suit.

In the prototype, no problems of induced hash were experienced, and C1 and C2 provided adequate filtering to prevent 'audio' pick-up. Also, the 2N3055 transistors are too slow to produce much hash in the r.f. spectrum. in the event of any trouble, however, the values of C1 and C2 may be increased as necessary and a *small* inductance choke introduced into the non-earthy supply lead and fitted inside the box. A suitable choke would consist of, say, 20 turns of 20 s.w.g. enamelled wire wound on a 1 in. length of $\frac{5}{16}$ in. diameter ferrite rod, this being broken from a longer rod. Large inductances would prevent the inverter from working efficiently and should not be used.



A view inside the unit from the output socket end. The fuse in its holder, can be seen at the end further away from the reader

COMPONENTS

All the components are generally available with the exception of the two Mullard cores type FX2242, the coil former type DT2180 and the six rectifier diodes. The cores, coil former and diodes may all be obtained from Gurney's (Radio) Ltd., 91 The Broadway, Southall, Middlesex. ■

LOW —

By A. G. Blewett

Many conventional multimeters, when used to measure resistance, have the disadvantage that readings are taken on a non-linear scale, making the interpretations of intermediate readings difficult. They are also practically useless for measuring resistance values below a few ohms with any accuracy.

The unit to be described is designed specifically to measure low resistances, and has the additional advantage that readings are taken on a perfectly linear scaled meter.

CIRCUIT

The circuit of the unit appears in Fig. 1, in which TR1 functions as a constant current generator. Its base is held at a fixed potential by the forward voltage dropped across the two silicon diodes D1 and D2. The constant current flowing from TR1 collector is varied, for each range, by selecting one of the three resistors, R4, R5 or R6, by S3.

M1 is a Henelec 38 Series 0–100μA meter, as retailed by Henry's Radio Ltd. It has a nominal internal resistance of 900Ω, whereupon the voltage across its terminals at full-scale deflection is of the order of 90mV. It is employed here as a voltmeter which indicates the voltage across the resistance being measured. Since a constant current flows through the resistance, the voltage across it is directly proportional to its value and the meter is, in consequence, able to give a linear indication of resistance. Thus, on the 0–10Ω range, an indication of 100μA corresponds to 10Ω, an indication of 50μA to 5Ω, and so on.

Transistor TR2 is a germanium p.n.p. device which is connected here as a diode. It limits the voltage across the meter to a safe value if the test terminals should happen to be open-circuit or if the resistance being measured has a higher value than is anticipated.

The voltage dropped across D1 and D2 is of the order of 1.3 to 1.5 volts. Let us say that it is 1.4 volts. TR1 is a silicon transistor, and we can assume a voltage drop of 0.7 volt between its base and emitter. The resistors R4, R5 and R6 are then called upon to drop the remaining 0.7 volt at the various constant currents required on the three ranges.

If the 0–10Ω range is selected and a 10Ω resistor is connected across the test terminals, a current of 100μA is required to flow through the meter. When the meter internal resistance is at its nominal value of 900Ω a voltage of 90mV appears across it and across the 10Ω test resistance, whereupon 9mA flows in the latter. The collector current required of TR1 is therefore 9mA plus

VALUE LINEAR OHM METER

A simple instrument which allows the measurement of resistance values down to 0.05Ω

100µA, or 9.1mA. Very nearly the same current flows in the emitter circuit of TR1 with the result that R5 has to drop 0.7 volt at 9.1mA and requires a calculated value of 77Ω. However, a precise value for R5 cannot be specified because of the approximations (that the voltage drops across the diodes and the base-emitter junction of TR1 are each 0.7 volt, and that the meter internal resistance of the meter is exactly at its nominal value of 900Ω) which are inherent in the calculations just given. In consequence, the values specified in the Components List for R4, R5 and R6 are higher than the calculated values, and they are brought down to the desired values during calibration by experimentally putting fixed resistors of higher value across them until a resistor which causes the desired constant current to be given for each range is found. A close tolerance test resistor having a known value of 7 to 10Ω, preferably the latter, is required for the calibration process. Also needed is a stock of fixed resistors for the experimental shunting of R4, R5 and R6 during calibration.

Due to the shunting effect of the meter, there will be inaccuracies at the higher end of the 0–100Ω range. At

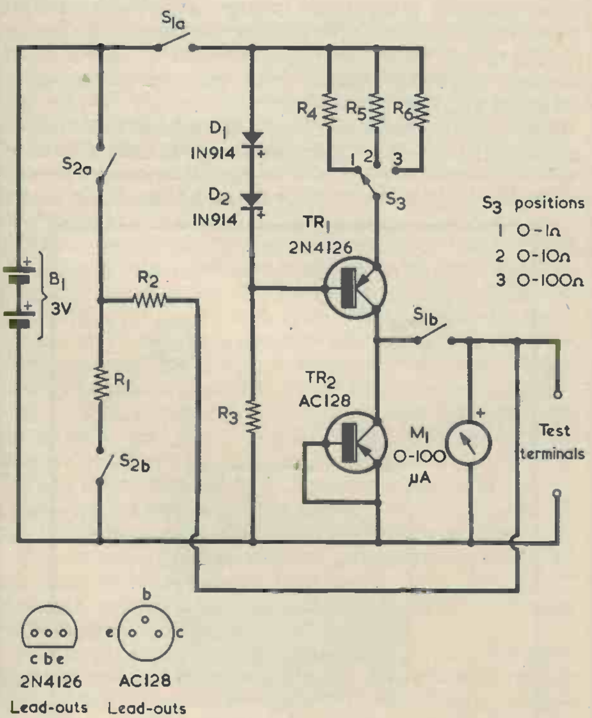


Fig. 1. The circuit of the low-value linear ohmmeter

COMPONENTS

Resistors
(All ½ watt)

R1	33Ω 10%
R2	39kΩ 5% or better
R3	120Ω 5%
R4	10Ω (see text)
R5	100Ω (see text)
R6	1kΩ (see text)

Semiconductors

TR1	2N4126
TR2	AC128
D1, D2	1N914

Switches

S1(a)(b), S2(a)(b)	2 pole push-buttons, press to make
S3	Maka-Switch shafting assembly, with spacers and break-before-make 4-pole 3-way wafer

Meter

M1	0–100µA meter, 38 Series (Henelec)

Battery

B1	2-off U11 cells (Ever Ready)

Miscellaneous
2-off test terminals
Pointer knob
2-off 1in. Terry clips
10-way groupboard
Case

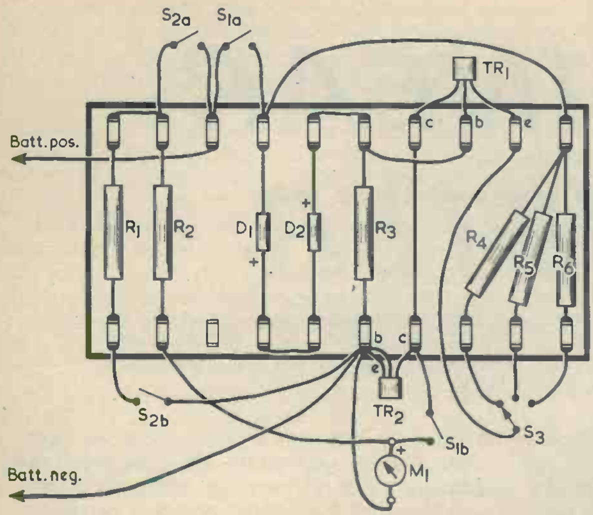


Fig. 2. Layout of components on the 10-way groupboard

worst, readings will be about 10% low for a test resistance of 100Ω. The 0–100Ω range is retained, nevertheless, because the inaccuracies with test resistances up to 50Ω are reasonably acceptable and resistances above this level fall into the accurate range of most multimeters.

Depressing the 'Battery Check' button S2 places a load of about 100mA across the 3 volt supply to simulate operational conditions, and the battery voltage is measured on the meter using R2 as a multiplier to give an f.s.d. of 4 volts. An assessment of battery condition can therefore be made 'on load'.

CONSTRUCTION

Any form of construction can be used, and the author's unit was built in a ready-made aluminium box using a small 10-way groupboard for the components. The layout of this is illustrated in Fig. 2, and the front panel is shown in Fig. 3. Because of the intermittent nature of use and the relatively large cells employed (two Ever Ready type U11) the battery life is very long. For this reason it was decided to solder the cells into circuit, using Terry clips to hold them in position.

It is recommended that the switch used in the S3 position should be an R.S. Components 'Make-Switch' type. Ordinary low cost 'wavechange switches' could present a varying contact resistance and thereby affect accuracy. A single 'Make-Switch' wafer is required, this being break-before-make 4-pole 3-way. Three of the poles are unused. S1 and S2 are 2-pole push-buttons in which both poles close when the button is pressed. Alternatively, spring biased double pole toggle switches, biased to 'off', may be employed.

The internal wiring in the unit, and particularly that in the collector and emitter circuits of TR1, should be made using relatively heavy wire. The wiring between M1 and the test terminals could consist of 5 amp mains cable.

CALIBRATION

The unit is calibrated by first finding the constant current required on the 0–10Ω range and then setting up R4 to give a constant current 10 times greater, and R6 a constant current which is one-tenth of that given by R5.

Select the 0–10Ω range, connect the known 10Ω resistor across the test terminals and press S1. The meter should give a reading which is lower than full-scale deflection. Experimentally apply higher value fixed resistors across R5 until one is found which causes the meter to give an f.s.d. reading. Solder this resistor into circuit across R5.

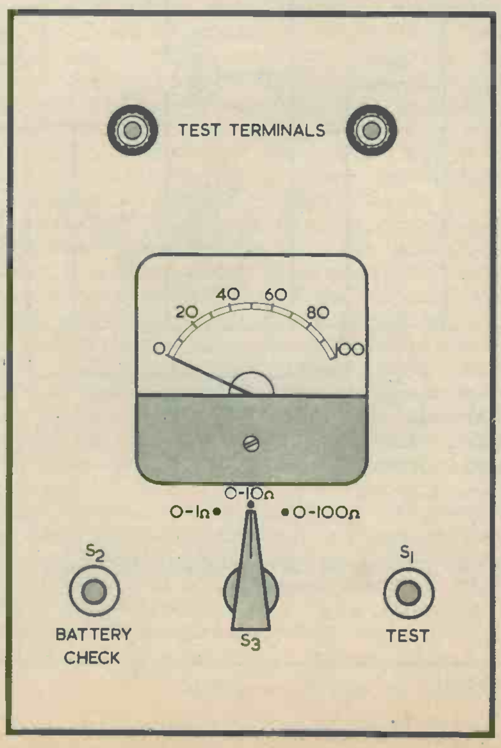
If the known test resistor used for calibration has a value lower than 10Ω, then R5 is adjusted to give the corresponding reading in the meter. Should the resistor be 8.2Ω, for instance, then the corresponding indication in the meter is 82μA.

Next, remove the known test resistor and disconnect the collector of TR1 from the remainder of the circuit. Connect a 1.5 volt cell and a multimeter switched to read current to the collector of TR1 and the negative supply rail in the manner illustrated in Fig. 4, then switch on again at S1, and note the reading given in the meter. This should normally be of the order of 8 to 10mA. Switch the multimeter to a current range which will enable it to read 10 times the present value, then set S3 to the 0–1Ω range. With S1 pressed, but parallel resistors, as required, across R4 until the multimeter indicates a current 10 times that given on the 0–10Ω range. Solder in the parallel resistor.

Finally, select the 0–100Ω range by means of S3 and experimentally put parallel resistors across R6 until the meter reads one-tenth the constant current given on the 0–10Ω range. When the required value for the parallel resistor has been found, this may be permanently soldered into circuit.

Calibration is now complete. The multimeter and the additional 1.5 volt cell are removed and the collector of

Fig. 3. A suitable front panel layout



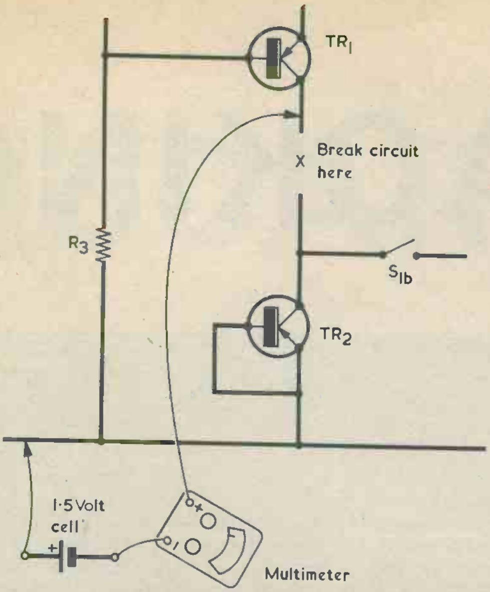


Fig. 4. A multimeter and an additional 1.5 volt cell are connected to the unit during calibration

TR1 is reconnected into circuit, as in Fig. 1. It is desirable to have the additional 1.5 volt cell during calibration because some lower cost multimeters drop quite high voltages across their universal shunt circuits when reading current, whereupon a supply of 3 volts only could result in insufficient voltage being available for the collector of TR1.

OPERATION

Connect the unknown resistance to the test terminals and, with S3 in the 0–100Ω position, press S1. If the reading is greater than full-scale the resistance is larger than 100Ω or is, alternatively, an open-circuit. The use of a conventional multimeter will decide which. If no reading or a very low reading is obtained, switch S3 down a range and try again. If still no reading, or a low one, is given, set S3 to the 0–1Ω range and finally read off the value.

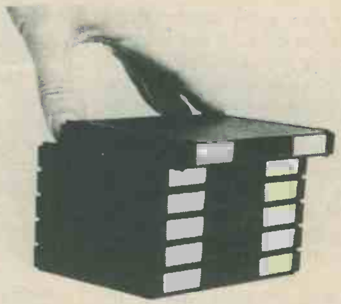
If there is still no reading on the lowest range this will indicate that the resistance is so low as to be negligible, almost a short-circuit in fact. With the prototype the first indication on the unit is 0.05Ω. It should be mentioned here that even a short-circuit across the test terminals may allow a just discernable forward movement of the meter needle to be given on the 0–1Ω range. This is due to the inevitable resistance between the meter and the test terminals, and emphasises the desirability of using thick wire in this part of the circuit. The test terminals should be reasonably large types with a threaded section which is 4BA or thicker in size, in order to keep the circuit resistance to a minimum.

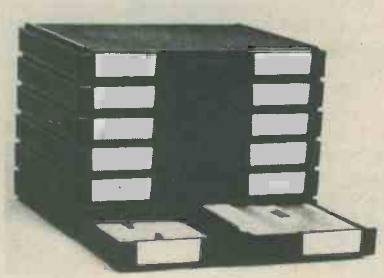
To test the battery condition, simply press switch S2 and read off the voltage, bearing in mind that meter f.s.d. is 4 volts. The cells should be changed when they read lower than 2.6 volts.

Where possible, test resistances should be connected direct to the test terminals, which must be screwed up tight. Where this cannot be done, thick flexible multimeter-type leads can be connected to the terminals, with their remote ends applied to the resistance being measured. If this is very low, first find the resistance of the flexible leads by short-circuiting their ends together, then apply them to the resistance. The value of the latter is then equal to the resistance indication in the meter minus the resistance of the test leads. ■

TRADE NEWS...

CASSETTE STORAGE SYSTEM





Each Stak Pak in the Capitol Stak Pak system holds two cassettes and is complete with sliding drawer, index cards and title card for fronting the drawer. The individual Stak Pak drawers link together by means of slides, building into a neat, compact and highly efficient storage system that not only looks good, but protects precious cassettes from damage or spoilage. A chest of drawers in miniature.

Stak Pak containers can be purchased individually as empty units for storage of existing tapes, or complete with a pair of Capitol 2 iron oxide blank cassettes.

In empty form, Stak Pak is priced at 44p each or £2.40 for six (+VAT). Imported from USA by the sole UK concessionaire, Musitapes (Wholesale) Ltd of 402, Edgware Road, London W2 1ED, it is distributed to the audio and Hi-Fi trade by that company, and to the auto accessory and auto electrical trades by Musitape's newly formed specialist distribution company, M.I.M.A. (Musitapes International Motor Accessories Ltd), 6 Stortford Road, Dunmow, Essex.

TRACKING

By Arthur C. Gee, G2UK

FROM WHAT HAS BEEN WRITTEN IN this journal to date on the subject of communicating via OSCAR, most readers will have gathered that some form of directional beam aerial must be used to aim signals at the satellite to gain access to it. It will be recalled that in the case of OSCAR 6, the one in orbit at the time of writing, transmission to it is made in the 2 metre amateur band, and reception from it, takes place in the 10 metre amateur band.

At first, it was thought that a 10 metre rotational beam would be required to receive the down link signals, but experience has shown that this is not necessary and that an omnidirectional 10 metre receiving antenna is quite adequate. (See, "Listening to Oscar", March 1974, "R. & E. C.", p. 490). In relation to transmission however, particularly if the transmitter is of limited power output, a directional beam antenna is a necessity. For this, some means of "orbit prediction" is required.

The mechanics of the problem are briefly as follows.

The satellite is ejected into an orbit in space from its launching vehicle, and subsequently travels round and round the earth, held in its orbital path, by the force of gravity keeping it towards the earth, and centrifugal force, keeping it trying to fly outwards. The balance of these two forces primarily determines the characteristics of its orbit.

Beneath this fixed orbit in space, the earth rotates with its one revolution per day. To an observer on the earth's surface, the orbit seems to be moving, and each time the satellite comes up over the horizon, it reappears some distance further west than on its previous orbit. The amount of this apparent difference depends on how fast the satellite is orbiting.

In the case of OSCAR 6, it does one complete orbit round the world, ie., over the north pole, down over the equator, under the south pole and back up over the equator in approximately 115 minutes of time. The orbit is actually not truely 'polar' in the way suggested but is inclined at an angle of a few degrees to the equator. During this time, a point on the equator which was directly beneath the satellite in its ascending path, would be 28.8 degrees east of its first position, as the satellite passes on its way up and over the north pole. The number of degrees is obtained by dividing 360 degrees – the rotation of the earth in 24 hours – by the fraction of the orbit time – 115 minutes – of 24 hours.

So the first point to note is that the satellite appears either east, or overhead, or west of the observation site each time it orbits in the vicinity, and that with each successive orbit, it appears to move 28.8 degrees of longitude further west.

The actual track of the satellite, in relation to places on the earth's surface, needs to be known, with some degree of accuracy, if we are to be able to direct our beam antenna at it. How is this done? It is done by means of an Orbit Predictor, and numerous forms of gadgetry for doing this have been devised. The one most commonly used in this country is that described by W. Browning, G2AOX, in his booklet "Keeping Track of Oscar", published by the RSGB and available from them for 10 pence in stamps. The construction of this is fully described in this booklet and those who wish to make one up for themselves, should get a copy. That made up by the author is shown in the accompanying illustration. As can be seen, it consists of a map of the world, of the northern half of the globe, centred on the north pole, extending down to the equator. The track of OSCAR 6 is shown by the curved cursor, which is pivoted at its centre and rotates round the north pole. The degree of its curve is important and full instructions for making it are given in the booklet. The author made his from a length of copper brazing rod, pulled into the required curve by a length of thin flexible wire (from twin flex) and fixed and soldered to make a permanent joint. In this case, the cursor is attached to the board by a short length of screwed rod, fixed into the board and with a large terminal nut fixing the pivot of the cursor. By just releasing the nut, the cursor can be twisted round and temporarily fixed by retightening the nut.

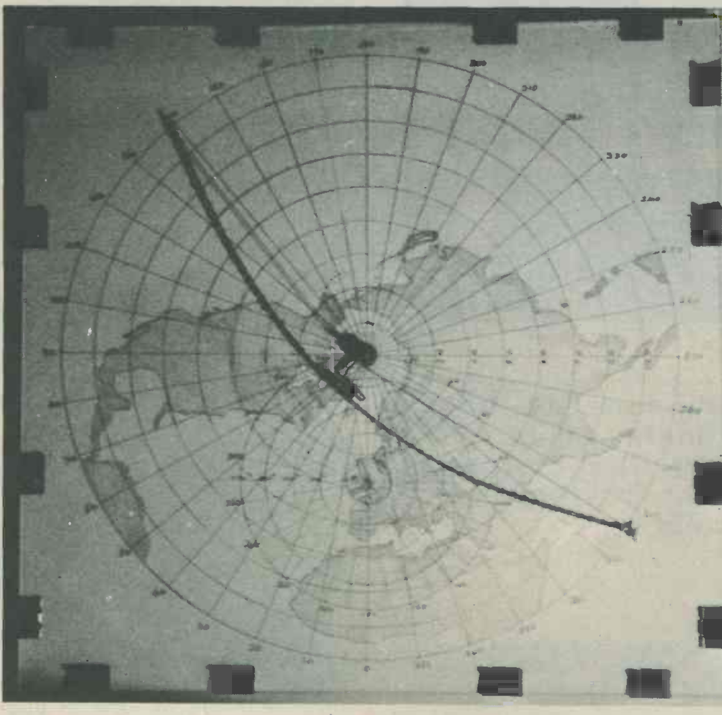
The cursor rod itself is divided into 57½ equal parts – half of 115 – and these divisions then represent one minute of time each and thus indicate the time taken by the satellite in its passage in orbit. The writer found a convenient way to make these division marks, was to cut some insulating tape into very narrow strips – about $\frac{1}{16}$ inch – and then roll a short length round the cursor rod. In this way, they can be adjusted to fill the cursor rod at equal distances. This takes time and patience, but great accuracy is not essential. It is a good idea to make every 5th mark a different colour, and every 10th one can be a different colour as well; this helps in counting the marks. Once the marks are in their proper position, they can be permanently fixed with a dab of adhesive. A direction indicator to indicate which way the satellite is going, in the form of an arrowhead of thin brass or plastic sheet, soldered or cemented to the cursor rod, is also needed, as shown.

The drawing of the map itself again needs time and patience. If you do not have an atlas with sufficient detail of the northern hemisphere, you may be able to borrow one from your local library. It makes it easier to use a map more or less the same size as your predictor base board. You then only have to trace the map on to tracing paper, and then redraw this back on to the predictor base board, using carbon paper. If you cannot find a suitably sized map, you will have to do the best you can by freehand.

The baseboard itself is made of plywood, covered with a piece of thick drawing board, the author's being 20 inches square.

Once the map is drawn, the circumference representing the equator is divided into degrees of longitude. The writer found a division into 36 parts, representing 10 degrees of longitude, quite a convenient arrange-

OSCAR



ment. The next stage is the means for obtaining information showing in which direction to point the beam.

Centred on the point of our location, another "compass rose" of circles is drawn, in the form of a series of concentric circles. For convenience, these can represent distances of 500 miles each, from our location. As explained in W. Browning's booklet, the greatest distance likely to be covered by the usually used 2 metre transmitter and rotary beam aerial is 2500 miles, and so the concentric circles are drawn up to this distance.

This circle is also marked up into 36 divisions, zero being at the top – ie north – and 360 degrees being marked round in the usual clockwise manner. Each division then represents 10 degrees of a circle. These of course are compass bearings.

It must now be becoming apparent to the reader, just how to get the desired direction of the beam.

Prediction charts are available from numerous sources, giving the time each orbit appears over the equator and the longitude of this appearance. From our prediction chart, we read for instance that on 6th May, orbit 7115 will appear over the equator at 1.8 degrees west (of our "0" point ie Greenwich Meridian) at 2055 hours GMT. So we swing our cursor round so that it registers with longitude 1.8 degrees West. We see however, that we shall not hear the satellite until it is within the 2500 miles range. So we have to count up the minutes of time from its appearance over the equator to where it cuts our 2500 mile circle. This we find to be 5 minutes. So we add five minutes to our prediction chart time, giving us 2100 hours GMT. So if we turn our beam antenna towards the point at which the satellite cuts the 2500 mile radius at 2100 hours GMT, we should hear it and be able to gain access to it. Our beam will be directed in the right direction. However, as the satellite travels on its orbit, the bearing of the beam for continued contact changes. By counting up the minutes along the cursor, a table can be drawn up showing time against beam bearing. In the example given, this would be as follows:–

6th May, Orbit 7115. 2055 hrs GMT. Long 1.8 degrees W.

Access of Signals + 5 mins., = 2100 hrs. Long 1.8 degrees cursor cuts 2500 mile circle at 190 degrees on the beam circle.

190	degrees	@ 2100	GMT.
200	,,	@ 2102	,,
210	,,	@ 2104	,,
220	,,	@ 2106	,,
230	,,	@ 2107	,,
240	,,	@ 2108	,,
250	,,	@ 2109	,,
260	,,	@ 2110	,,
270	,,	@ 2111	,,
280	,,	@ 2112	,,
290	,,	@ 2113	,,
300	,,	@ 2114	,,
310	,,	@ 2115	,,
320	,,	@ 2117	,,
330	,,	@ 2119	,,
340	,,	@ 2122	,,

At 2122 hours GMT, the satellite passes over the 2500 mile radius circle on a bearing of 340 degrees from the location and is lost to reception, ie, "L.O.S." – Loss Of Signals. In this programme of bearings, we have taken the times for every 10 degrees of bearing variation. It is not necessary to go into quite such detail, perhaps, with the average amateur beam antenna, but it is a convenient way to work things out. By altering the beam heading every two or three minutes or so, one can keep tracking the satellite.

It will be appreciated that there is a lot to do during an orbit! Tuning the receiver, working the transmitter, sending morse code – most transmissions via OSCAR are in this mode – and keeping the beam rotating in step with the changing times, one can be assured of a pretty lively session! Incidentally a digital display clock is a great help in keeping the beam in step with the changing time.

Prediction Charts from which the basic information is obtained for using this Predictor, are now being published by numerous amateur radio journals, month by month. Orbital predictions are also given in the RSGB's News Bulletins given out over the air from GB2RS at 0930 hours local time on 3600 KHz each Sunday. The American amateur radio magazine HAM RADIO issues a nice booklet giving predictions up to November 1974, and the OSCAR NEWSLETTER produced by G3IOR and G3WPO also gives prediction tables. (See "R. & E. C." April 1974, p. 536; 'News and Comment'.)

The writer's Orbital Predictor was finished off by fixing a sheet of perspex over the map to afford protection, by means of a series of large paper clips as shown in the illustration. It hangs on the wall where it can be very conveniently seen and used.

The booklet, "Keeping Track of OSCAR" from which all the details for constructing the cursor, etc., can be obtained, is available from the RSGB, 35 Doughty Street, London WC1N 2AE at 10 pence. ■

In your workshop

There is, for once, a peaceful interlude in the affairs of the Workshop, and Smithy takes advantage of this to demonstrate to Dick the design techniques employed in current low power a.f. amplifier circuits

"AH," STATED DICK WITH SATISFACtion, "that should just about see this job off."

He carefully adjusted the last i.f. transformer core in the medium and long wave portable transistor radio on his bench and then swung the tuning control of his signal generator on either side of the centre intermediate frequency. The i.f. band-pass response was nicely flat-topped and pleasingly symmetrical.

"Yep," continued Dick, warming to his theme. "This little set should now be ready to give all it's got."

"You seem," remarked Smithy, from his bench on the other side of the Workshop, "to be remarkably pleased with yourself."

COMPLEMENTARY OUTPUT STAGE

"So I should be," replied Dick cheerfully, as he switched the set off and disconnected the signal generator output from it. "I've just beaten off another assault by the Phantom Fiddler!"

"Have you?" queried Smithy, interested. "We haven't had much trouble with him recently, have we?"

"He's made up for it with this radio," stated Dick. "When it came in, all the trimmers were screwed up tight and all the coil and i.f. transformer cores were miles out of position."

"I wonder what makes people do things like that," mused Smithy. "In most cases, a transistor radio can go through life with all its trimmers and coil cores in just the same positions that they had when the set left the factory. Yet, when the set develops a fault some ham-handed Henry gets hold of it and adjusts everything that's adjustable in the fond hope that this will clear the snag. In normal fault-finding work there are quite a lot of other things to look for before you start playing around with trimmers and coil cores."

"True enough," agreed Dick. "Anyway, the actual fault in the set was dead easy. The upper base bias resistor to the second i.f. transistor had gone high in value and it just needed to be replaced." (Fig. 1.)

"Good," commended Smithy. "And how did you find that?"

"By checking the emitter voltages of the i.f. transistors," explained Dick. "The a.f. stages seemed reasonably all right because I could hear a slight crackle as I turned the volume control and there was a noticeable background hiss at full volume level. So I thought I'd just have a quick prod around in the i.f. section. And straightaway I found that there was hardly any voltage at all across the emitter resistor of the second i.f. transistor. I then switched the set off, took a few resistance measurements and located the bias resistor which had gone high."

"That was a good approach," said Smithy approvingly. "If there's no immediately obvious fault in these transistor portables, it's always a good idea to check up on the voltages at the transistors in the suspected stages. Quite often you'll be lucky enough to find that it's just a simple d.c. snag which is causing the trouble. I.F. amplifier transistors usually draw something like 0.75 to 2mA or so, and it's easy to measure transistor current by checking the voltage across the emitter resistor. If you remember that 1mA through 1kΩ gives 1 volt you can quickly assess the current flowing in any particular emitter resistor."

"Exactly," agreed Dick. "Well, I replaced the faulty bias resistor, tried the set out and then found it was right out of alignment. So I went and got its service sheet."

Smithy's eyebrows shot up.

"Are you telling me," he questioned incredulously, "that you actually went of your own accord and without any prompting from me to consult a service sheet?"

"Of course I did," replied Dick carelessly. "I must admit that I don't, perhaps, use service sheets as often as you'd like me to, but I felt that this was a case in which it would be best to have a look at the manufacturer's data and stuff. For a start, the i.f. transformers were so badly out of bonk that I didn't have a clue what the correct i.f. should be. Anyway, I got the i.f's and the signal frequency circuits all lined up as per the service sheet, and I was just giving the last i.f. transformer a final tickle-up when you started nattering to me."

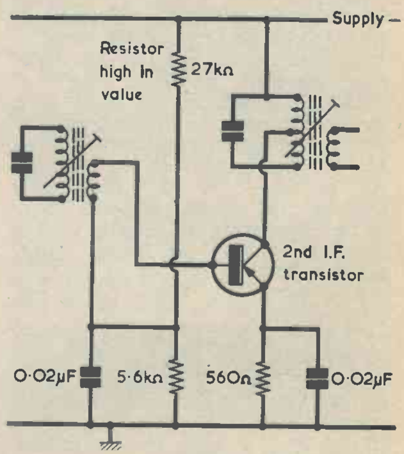


Fig. 1. In the receiver serviced by Dick the upper bias resistor for the second i.f. transistor had gone high in value. Component values here and in Figs. 2 to 7 are representative of commercial practice

"Well," commented Smithy. "Seeing that you've put so much work into that set, I think I'll come over and see how it performs."

He placed his soldering iron on its rest and walked over to his assistant's side. Eagerly, Dick switched on the receiver, set the volume to a low level and selected medium waves. He adjusted the tuning knob over its range. The receiver was very lively and picked up the local stations and quite a few other transmissions as well. Exultantly, Dick switched to long waves, to find that the set continued to give an excellent performance on this band as well.

"How about that, then?"

"Very good," remarked Smithy. "Try it at a higher volume level."

Dick tuned in a station and turned up the volume. The reproduction was acceptable in quality up to volume levels of about a quarter of the maximum to be expected from the receiver. Above that level the sound distorted badly.

ADJUSTABLE BIAS

Dick's face fell.

"Darn it," he snorted. "It looks as though there's still another snag in this set."

"It's possible," remarked Smithy mildly, as he glanced at the circuit in the receiver service sheet, "that our friend the Phantom Fiddler has messed up the a.f. section as well."

"How could he do that?"

"There's an adjustable component in the a.f. amplifier stages which he has probably spotted and you haven't," stated Smithy. "If you look at the circuit you'll see that there's a pre-set 800Ω pot in the emitter circuit of the transistor which precedes the driver transistor."

Smithy indicated the potentiometer in question. (Fig. 2.)

"Blimey," exclaimed Dick. "What does that do?"

"It sets up the voltage on the two output transistor emitters," said Smithy. "In the absence of signal, these emitters should be at or near half the supply voltage, to enable them to have maximum swing in the positive and negative directions when they're handling a signal. That pre-set pot sets up the collector potential of the first a.f. transistor and, in consequence, the base potential of the driver transistor. This, in turn, controls the collector potential of the driver transistor and, as a result, the potential at the output transistor emitters."

"Stap me," said Dick. "There's quite a chain of voltages there before you get to the final one at the output emitters. Well, let's see if that pot has been adjusted wrongly by our Phantom Fiddler mate."

Dick turned down the receiver volume, switched his testmeter to its 0–10 volt range and clipped its test leads to chassis and the junction of the two 2.2Ω current limiting resistors between the output transistor emitters. The testmeter needle indicated 8 volts.

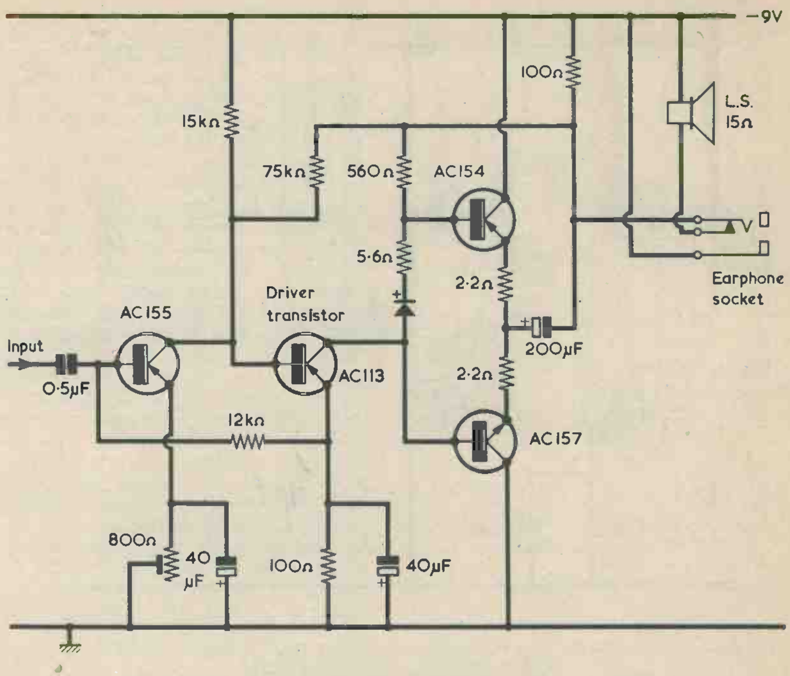


Fig. 2. Typical a.f. amplifier circuit in which a pre-set variable resistor is set up to give the required potential at the two output transistor emitters

"There's the cause of your distortion," stated Smithy. "Since the supply voltage is 9 volts these output emitters can only swing negative by 1 volt, after which they clip the signal. What you have to do now is to adjust that pre-set pot so that the output emitters are just a little higher than 4.5 volts. Say, just below 5 volts."

"Why not have them exactly at 4.5 volts, Smithy?"

"Because with this particular circuit they can't swing fully positive towards the chassis potential," replied Smithy. "That's because of the voltage dropped across the emitter bias resistor for the driver transistor. There'll be about half a volt dropped across that resistor, and this will restrict the positive excursion of the driver collector."

Dick chuckled.

"I love that word 'excursion'," he grinned. "Just when you're in the middle of reading some dry old technical article you bump into a voltage 'excursion'; and it raises no end of mental images of coaches coming back from Blackpool, all full of people singing and crates of beer and stopping at convenient fields every half-hour or so!"

Smithy shuddered.

"I prefer," he remarked primly, "to take my pleasures in a more restrained manner. Anyway, let's get back to this radio and try the effect of adjusting that pre-set pot."

Dick soon located the potentiometer on the printed circuit board of the receiver, and he adjusted it carefully. The voltage indicated by his testmeter reduced obligingly and he withdrew his screwdriver from the potentiometer when the testmeter indicated 4.8 volts. He next unclipped the testmeter leads and turned up the volume of the receiver. The distortion at high volume had now disappeared and the receiver output had quite an acceptable quality at this level.

"Well, that's finally got this set fixed," he remarked happily. "This business of setting the output emitters to half battery voltage by means of a pot is a new one on me, though."

"Actually," remarked Smithy, "this is a fairly old circuit and it was the sort of thing that appeared in the earlier sets having Class B output stages without a.f. transformers. Later circuits have automatic means of giving half-supply voltage at the output emitters and they don't need any setting up. Our present circuit does, however, have the bootstrap coupling back to the collector load of the driver transistor which is a common feature in the later versions."

Smithy pointed at the components

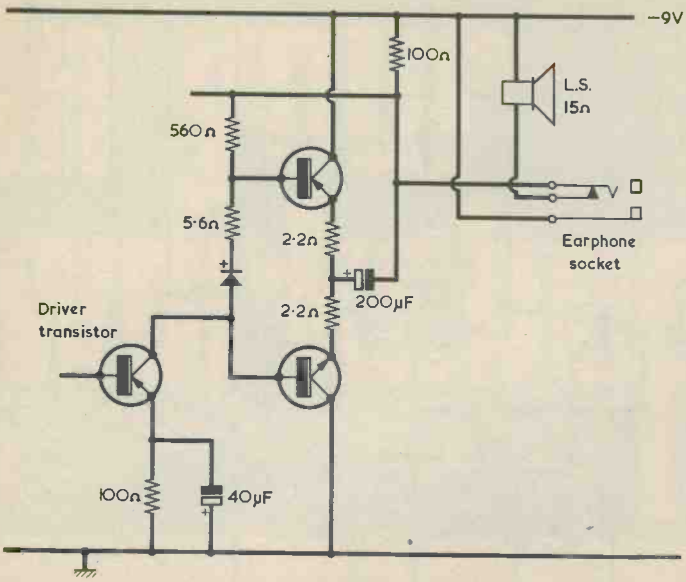


Fig. 3. Illustrating the bootstrap coupling to the upper end of the driver transistor collector load

in question. (Fig. 3.)

"The driver transistor collector load," he went on, "is the 560Ω resistor going up to the lower side of the speaker. This resistor couples to the output emitters via the 200μF electrolytic capacitor which feeds the speaker, with the result that when a signal causes the output transistor bases to go positive so also does the top end of the 560Ω resistor. The same happens when the signal causes the output transistor bases to go negative. So, there is a signal at the top end of the 560Ω resistor which is nearly the same as that at its bottom end. The consequence is that, whilst the resistor has quite a low value at d.c. and can allow the driver transistor to have a reasonably high collector current, its effective value at a.c. is much higher, whereupon there is a consequent increase in the voltage gain offered by the driver transistor."

ALTERNATIVE CIRCUITS

"Blimey, that's neat," remarked Dick. "Incidentally, I see that there's a 75kΩ resistor from the lower side of the speaker to the base of the driver transistor. Is that a bootstrap connection, too?"

"Oh no," said Smithy, "that resistor just gives negative feedback."

Dick absorbed this information.

"What," he resumed, "are those other circuits you were talking about in which the half-supply voltage at the output emitters is given automatically?"

"Half a tick," said Smithy, "and I'll show you."

He walked over to the filing cabinet and selected a dozen service manuals at random. He returned, placed them on Dick's bench and started to look through them.

"I should," he remarked, "be able to find a few examples of what I mean amongst these. Ah, here we are!"

Smithy opened out one of the manuals and placed it on the bench with the circuit uppermost. He indicated its a.f. section. (Fig. 4.)

"Here's an example of one very common approach," he stated. "The output transistors are wired up in much the same manner as in the last circuit we looked at. In this case, though, the two 2.2Ω emitter current limiting resistors are omitted, and this is a feature you'll find in the output stage of quite a few portable transistor receivers. Omitting these components saves the price of two resistors and means that a wee bit more of the available audio power finds its way to the speaker. On the other hand, the lack of current limiting resistors means that the two output transistors are more likely to burn out if, say, the diode or other voltage dropping component between the two output bases goes open-circuit."

Dick frowned.

"That looks as though you need to take a little extra care in playing around with the output stage if you're doing any fault-finding there."

"You do, rather," agreed Smithy. "Anyway, the two output transistors are driven by a grounded emitter driver transistor in the same way as in the previous circuit, and there is the same bootstrapping back to the top of the driver transistor collector load. The

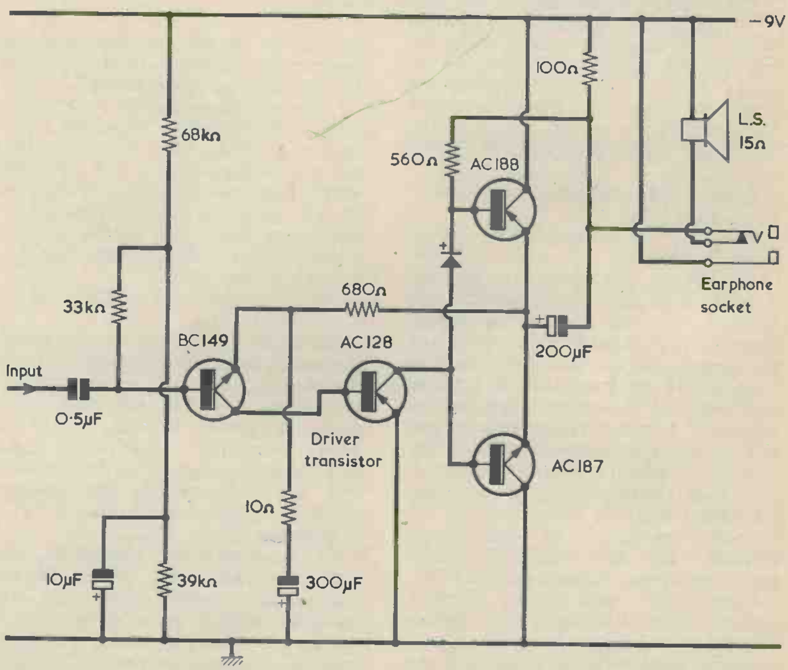


Fig. 4. A typical a.f. amplifier in which the potential at the output emitters is governed by the base potential of the transistor preceding the driver transistor. This transistor and the driver transistor are both silicon types whilst the two output transistors in this example of the circuit are germanium

base of the driver transistor is fed by the first transistor in the a.f. amplifier section and the base of this first transistor is held at a reference voltage fairly close to half the supply voltage by the potential divider given by the 68kΩ and 39kΩ resistors."

"But there's a 33kΩ resistor between their junction and the base of the first transistor."

"There is," concurred Smithy, "and that resistor is included to allow a.f. to be fed into the base. The base current required by the first transistor is very low and there will be only a small voltage dropped across the 33kΩ resistor. Now let's look first at the d.c. feedback loop in the circuit."

"Come again?"

"The d.c. feedback loop," repeated Smithy patiently. "The junction of the two output emitters in this circuit couples back to the emitter of the first transistor via a 680Ω resistor. This gives d.c. negative feedback. If, for any reason under no-signal conditions, the output emitters try to go positive they cause the emitter of the first transistor to go positive, too. If we say that, because of what is nearly a fixed potential at the base, the first transistor is now acting as a grounded base device, its collector will go positive also, as will the base of the driver transistor. The driver transistor is in the grounded emitter mode, which means that its collector is out of phase with its base, and its collector goes negative. So also do the output bases and emitters, thereby cancelling out their original attempt to go positive. If the output transistors try to go negative the d.c. feedback loop comes into operation again and the collector of the driver transistor goes positive to counteract the attempt."

Dick looked keenly at the circuit.

"It's easy to see how this works," he said excitedly. "The overall effect is that the output emitters stay at a voltage which is governed by the voltage applied to the base of the first transistor."

"That's right," confirmed Smithy. "The circuit stabilizes at a voltage on the output emitters which allows just sufficient base current in the first transistor to keep it conductive. That current is the base current required by the driver transistor divided by the current gain of the first transistor and will probably be in the order of tens of microamps. Since the first transistor is a silicon type, its emitter will be 0.6 volt negative of its base. This fact, together with the very small base current it draws through the 33kΩ and 39kΩ resistors, explains why the lower part of the potential divider is smaller, at 39kΩ, than the upper part, which is 68kΩ. These values allow the half-supply voltage to appear at the emitter of the first transistor. So you've now seen a circuit in which the output emitters are automatically held at half the supply potential by means of d.c. negative feedback."

"It's quite cute, isn't it?" remarked Dick, as he continued to gaze at the circuit. "Here, hang on a minute, Smithy! There are two components you haven't mentioned yet. There's a 10Ω resistor and a 300μF capacitor."

"I was wondering how long it would be before you got round to noticing those," grinned Smithy. "Well now, you've just seen that there is a very high degree of d.c. feedback. Without that 10Ω resistor and 300μF capacitor, there would be a similarly high level of feedback at audio frequency as well and the a.f. gain of the amplifier would be very low indeed. When the 10Ω resistor and 300μF capacitor are added, there is no change in the d.c. conditions because of the capacitor. At audio frequencies, however, the capacitor offers a very low impedance, and the audio frequency at the output emitters is applied to a potential divider given by the 680Ω and 10Ω resistors in series. In consequence, only about one-seventieth of the a.f. voltage at the output emitters is passed back to the emitter of the first transistor and this is a much lower level of feedback than occurs under d.c. conditions. The a.f. feedback is such that the amplifier will have an overall voltage gain of about 70 times, this gain being governed by the 680Ω and 10Ω resistors."

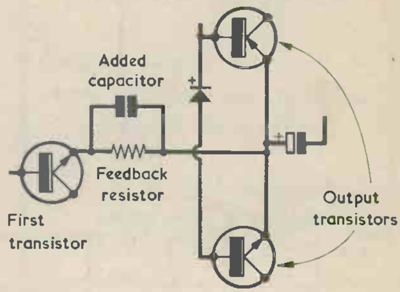
FORWARD VOLTAGE DROP

"Is this sort of circuit used a lot, Smithy?"

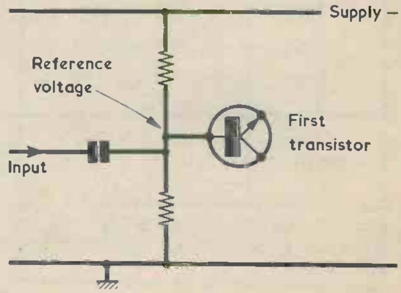
"Oh definitely," replied Smithy. "Rough check, I'd say it's the most popular amongst set makers for low power amplifiers. It doesn't always appear in exactly the form I've shown you, of course, and there are quite a few variations. You may find, for instance, that the polarity of all the transistors is changed and the upper supply rail is positive instead of negative. In some sets, too, you'll find a small capacitor in parallel with the feedback resistor which goes from the output emitters back to the emitter of the first transistor. Also, the reference voltage at the base of the first transistor may be provided by two resistors only, instead of the three resistors and the electrolytic capacitor we saw in our circuit." (Figs. 5(a) and (b).)

"What would the capacitor across the feedback resistor do, Smithy?"

"It provides increased feedback at the higher frequencies," said Smithy. "Normally, this would be to provide treble cut. Despite their simplicity, amplifiers of this type are capable of offering quite good quality. There is direct coupling throughout, from the input base to the output emitters, and there's quite a reasonable level of a.f. negative feedback. You can recognise the circuit by looking for a resistor going back from the output emitters to the emitter of the transistor which precedes the driver transistor, and then seeing if the base of that transistor is held at around half-supply voltage by a potential divider across the supply rails."



(a)



(b)

Fig. 5 (a). A capacitor may be connected across the feedback resistor of Fig. 4 in order to give treble cut. A typical value is 2,000pF
(b). A potential divider circuit simpler than that shown in Fig. 4 may be used to provide the reference base voltage for the first transistor

Smithy chose another service manual and indicated its circuit to his assistant. (Fig. 6.)

"This isn't the a.f. amplifier in a radio," commented Dick, surveying the circuit critically. "It's the circuit of a record player amplifier."

"That's right," agreed Smithy. "The basic circuit is used fairly frequently in small amplifiers powered by the mains,

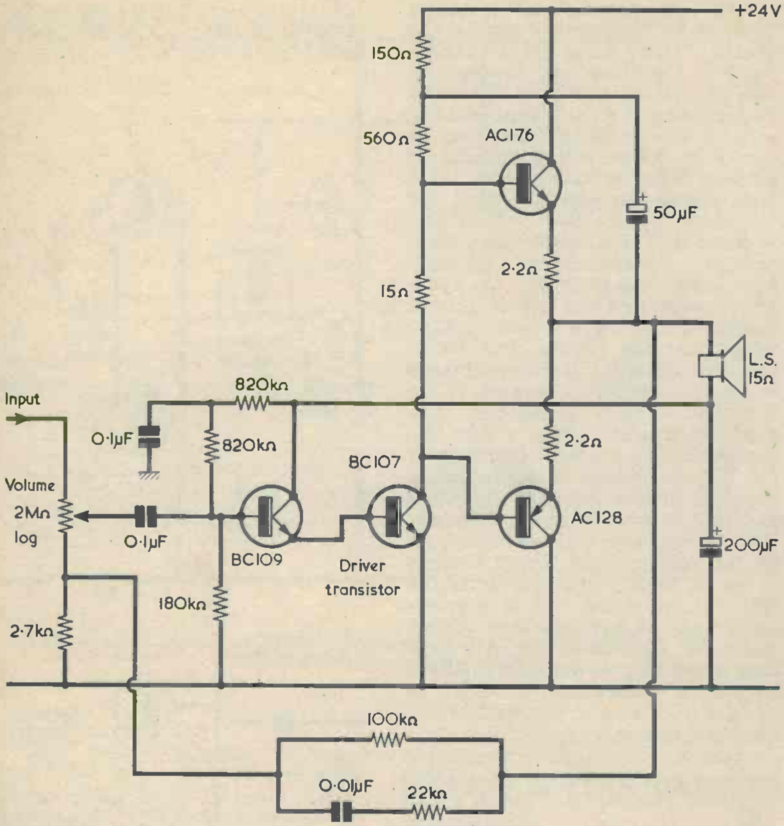


Fig. 6. A basic a.f. amplifier cicuit encountered in mains-driven record players. In this version the first transistor and the driver transistor are silicon and the output transistors are germanium

and it employs quite a different approach towards having the output transistor emitters at half-supply potential. To start off with, the first transistor is an emitter follower, whereupon the input is at a high impedance. Also, the first transistor and the driver transistor are silicon types."

"Where's the d.c. feedback resistor?" asked Dick. "The only resistors I can see going back to the input are the 100kΩ and 22kΩ ones between the output emitters and the bottom of the volume control."

"Forget about them for the moment," advised Smithy. "And have a look at the two 820kΩ resistors from the lower side of the speaker going back to the base of the first transistor. Now, the lower side of the speaker is at the same potential as the output emitters so far as d.c. is concerned, whereupon we have a potential divider set up between this point and chassis. The upper section consists of the two 820kΩ resistors in series and the lower section consists of the 180kΩ resistor between the input base and chassis."

Smithy traced out the potential divider with his finger. (Fig. 7.)

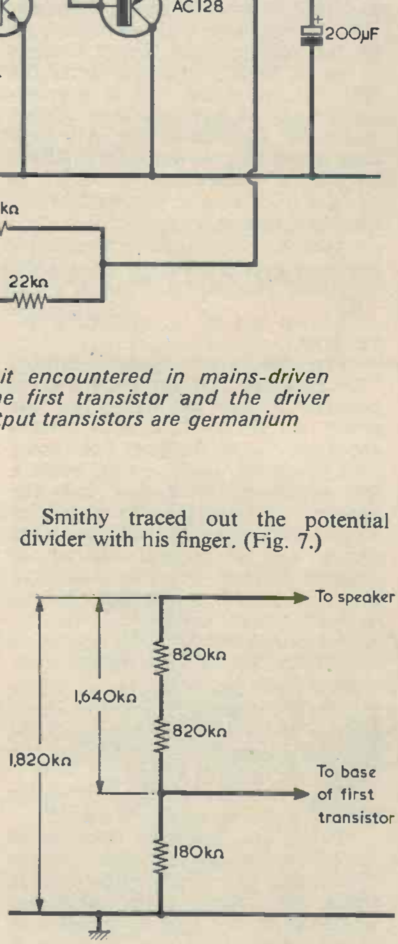


Fig. 7. The potential divider given by the two 820kΩ and the 180kΩ resistors of Fig. 6. About one-tenth of the voltage on the speaker is applied to the base of the first transistor

"Now," he went on, "since the input transistor and the driver transistor are both silicon types, each has a forward voltage drop of about 0.6 volt across its base-emitter junction. The circuit then stabilizes when the voltage applied to the base of the input transistor is about 1.2 volts positive of chassis."

"I think I can see what happens here," said Dick, frowning. "The upper arm of the potential divider is twice 820kΩ which is 1,640kΩ and the lower arm is 180kΩ. This means that about one-tenth of the voltage on the lower side of the speaker will be applied to the base of the input transistor."

"Which is," broke in Smithy, "the same as saying that the voltage on the lower side of the speaker will be about 10 times that on the input transistor base. In consequence, the circuit will stabilize when the voltage on the lower side of the speaker is approximately 10 times 1.2 volts, or 12 volts, which is just half of the 24 volt supply. Actually, the voltage may be a little higher in order to allow sufficient bias current to flow into the input base to keep the input transistor conductive. This bias current will be quite small, as with the other circuits we have looked at, because of the current gain provided by the input transistor and the grounded emitter driver transistor which follows it. The driver transistor gives phase reversal and so the feedback is truly negative. If the output emitters try to go positive, so also do the bases of the input and the driver transistors. The collector of the driver transistor then goes negative to counteract the change."

"Why," asked Dick, "is there a 0.1μF bypass capacitor at the junction of the two 820kΩ resistors?"

"To remove any a.f. which may be present at the lower side of the speaker," replied Smithy. "The 200μF electrolytic going down to chassis won't completely remove all the a.f., and particularly not bass frequencies, and the 0.1μF capacitor prevents these getting back to the base of the input transistor."

"I suppose," remarked Dick, "that the 100kΩ and 22kΩ resistors I thought provided d.c. feedback are actually the a.f. feedback components."

"That's right," confirmed Smithy. "They form another potential divider in company with the 2.7kΩ resistor at the bottom of the volume control. An interesting feature of the circuit is that a.f. negative feedback increases as volume is reduced."

Smithy put the service manual to one side and took up another one.

"Now here," he chuckled, "is a really simple circuit. Have a look at this one."

Smithy indicated the circuit diagram. (Fig. 8.)

"Now, you couldn't," he continued, "have anything simpler than that. Since the two output transistors are

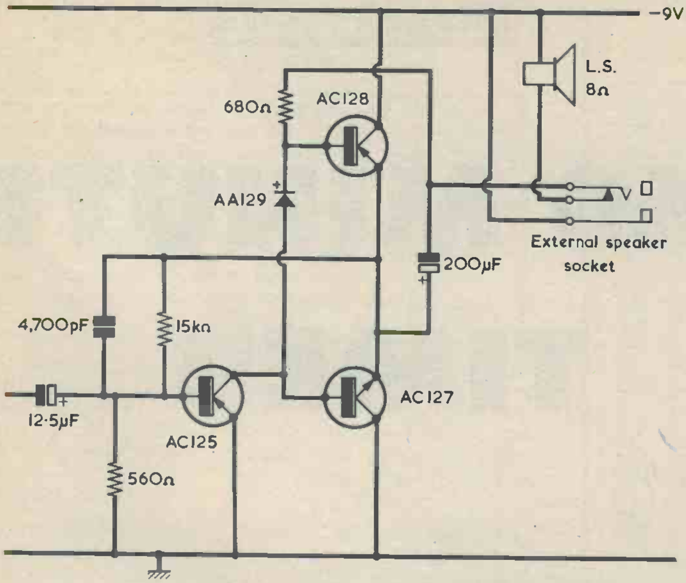


Fig. 8. A very simple driver and complementary output stage. This is employed in the Bush DC70 tape and disc player

emitter followers, the d.c. conditions in the circuit are pretty well the same as in a grounded emitter amplifier where the base bias resistor is taken from the collector."

"There doesn't," remarked Dick, "seem to be any circuit arrangement which will cause the output emitters to be exactly at half-supply voltage."

"Well," said Smithy, "there isn't as precise a degree of voltage control as in the previous circuits we've seen. Nevertheless, the circuit still settles down with a voltage at the output emitters which is approximately equal to half-supply voltage. This voltage will change somewhat for different values of current gain in the driver transistor, but the component values are such that these changes will not be excessive over the spread in this transistor."

NEW RECEIVER

"These various a.f. amplifier and output stages are really interesting, aren't they, Smithy?"

"They are," agreed the Serviceman. "And they're all nice and easy to understand once you've picked up their basic modes of operation. Oh well, I suppose I'd better get back to my own bench now."

Smithy gathered up the service sheets, returned them to the filing cabinet, then went back to his bench.

Dick carried the transistor radio to the 'Repaired' rack. Surveying the remaining receivers in for repair, he selected an impressive portable which boasted medium and long wave bands, two short wave bands and a v.h.f.–f.m. band. As he carried it over to his bench he noticed a mechanical rattling from its interior. Perplexed, he put the radio on his bench, removed its back and held it with the front panel upwards.

Eleven iron-dust cores rolled out.

"Oh no," groaned Dick.

Feverishly, he picked up his screwdriver and located the various aerial and oscillator trimmers inside the set. There were eight of them. And they were all screwed up tight.

"This just *can't* be true," he moaned. "Not two sets in a row."

He turned round, to see the Serviceman, who had been attracted to his side by the sounds of woe and who had watched him checking the trimmers.

Smithy leaned forward and peered at the dislodged dust cores and the maladjusted trimmers.

"This is Fate, Dick," he declaimed in a sepulchral tone. "You just cannot fight against it."

He pointed dramatically at the receiver, while Dick watched him open-mouthed.

"And there's your evidence," Smithy intoned thunderously. "The Phantom Strikes Again!" ■

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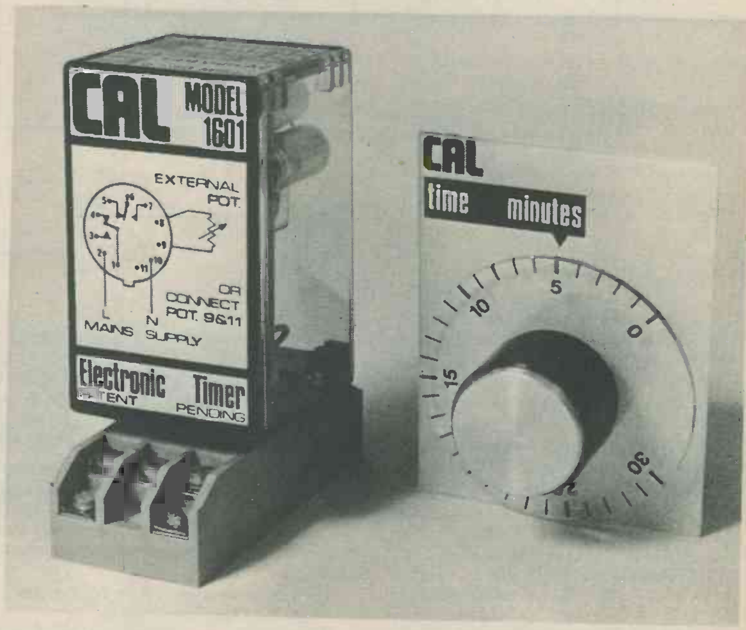

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(Continued on page 767)

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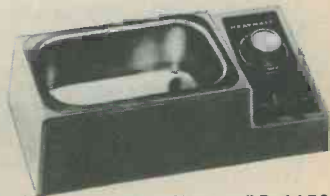

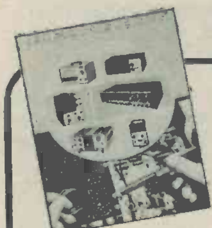

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(Continued from page 765)

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(Continued on page 769)

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TEST EQUIPMENT

CR CHARGE/DISCHARGE TIMES

The Table lists the voltage across a 1μF capacitor when charging to V volts via a series 1MΩ resistor, or when discharging from V volts via a parallel 1MΩ resistor, after periods of time up to 5 seconds. Multiply time by microfarads and megohms for other values of C and R. Thus, the voltage across a 10μF capacitor charging via a 2MΩ series resistor will rise to 45%V after 0.6 × 10 × 2 = 12 seconds.

Time (Secs)	%V (Charge)	%V (Discharge)	Time (Secs)	%V (Charge)	%V (Discharge)
0	0	100	0.9	59	41
0.05	5	95	1.0	63	37
0.1	10	90	1.2	70	30
0.15	14	86	1.4	75	25
0.2	18	82	1.6	80	20
0.25	22	78	1.8	83	17
0.3	26	74	2.0	86	14
0.4	33	67	2.5	91	9
0.5	39	61	3.0	95	5
0.6	45	55	4.0	98	2
0.7	50	50	5.0	99	1
0.8	55	45			

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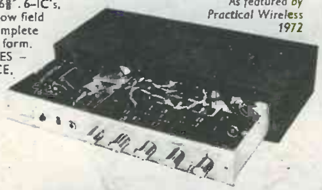

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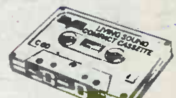

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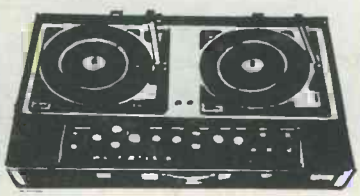

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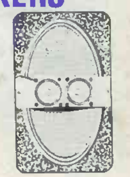

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