RADIO & ELECTRONICS CONSTRUCTOR

MAY 1977

40p

Medium & Dual SHORT WAVE RADIO

PART 1 (2 PARTS)

RANGE
1 MHz-500kHz
250kHz-100kHz

CMOS CRYSTAL CALIBRATOR

ALSO FEATURED

THE BEGINNINGS OF ELECTRICITY

RADIO & ELECTRONICS CONSTRUCTOR

MAY 1977
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PAKS—PARTS—AUDIO MODULES

PANEL METERS

4" RANGE

Size 4¾" x 3½" x 1¾"

Value	No.	Price
0-50µA	1302	£4.50
0-100µA	1303	£4.50
0-500µA	1304	£4.50
0-1mA	1305	£6.00
0-50V	1306	£6.00

2" RANGE

Size 2½" x 1¾" x 1¼"

Value	No.	Price
0-50µA	1307	£3.50
0-100µA	1308	£3.50
0-500µA	1309	£3.50
0-1mA	1310	£3.50
0-50V	1311	£3.50

MR2P TYPE

Size 42 x 42 x 30mm

Value	No.	Price
0-50µA	1313	£4.80
0-1mA	1315	£3.20

EDGEWISE

Size 3½" x 1¼" x 2¼"

Cut out 2¾" x 1¼"

Value	No.	Price
0-1mA	1316	£4.05
0-500µA	1317	£4.05

MINIATURE BALANCE/ TUNING METER

Size 23 x 22 x 26mm

Sensitivity 100/0/100mA

No	Price
1318	£1.95

BALANCE/TUNING

Size 45 x 22 x 34mm

Sensitivity 100/0/100µA

No.	Price
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Size 23 x 22 x 26mm

Sensitivity 200µA

No.	Price
1320	£1.95

Vu METER

Size 40 x 40 x 29mm

Sensitivity 130µA

No	Price
1321	£2.00

MINI MULTI-METER

Size 60 x 24 x 90mm

Sensitivity 1000 ohms/V

AC VOLTS 0-10, 50, 250, 1000
DC VOLTS 0-10, 50, 250, 1000
DC CURRENT 0-1-100mA
Resistance 0-150kΩ

No.	Price
1322	£5.95

P&P

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AC127	0.14
AC128	0.12
AC128K	0.26
AC132	0.15
AC134	0.15
AC137	0.15
AC141	0.18
AC141K	0.30
AC142	0.18
AC176	0.12
AC176K	0.26
AC178	0.25
AC179	0.25
AC180	0.20
AC180K	0.30
AC181	0.20
AC181K	0.30
AC187	0.16
AC187K	0.26
AC188	0.16
AC188K	0.26
AD140	0.60
AD142	0.85
AD143	0.75
AD149	0.60
AD161	0.36
AD162	0.36
AD161/162 MP	0.75
AF114	0.20
AF115	0.20
AF116	0.20
AF117	0.20
AF118	0.40
AF124	0.30
AF125	0.30
AF126	0.30
AF127	0.32
AF139	0.58
AF180	0.58
AF181	0.58
AF186	0.58
AF239	0.38
AL102	0.95
AL103	0.95
AU104	1.00
AU110	1.00
AU113	1.00
BC107A	0.08
BC107B	0.08
BC107C	0.08
BC108A	0.08
BC108B	0.08
BC108C	0.08
BC109B	0.08

Type	Price
BC109C	0.08
BC147	•0.09
BC148	•0.09
BC149	•0.09
BC157	•0.12
BC156	•0.12
BC159	•0.12
BC167	•0.12
BC168	•0.12
BC169	•0.12
BC169C	•0.12
BC170	•0.10
BC171	•0.10
BC172	•0.10
BC173	•0.12
BC177	0.16
BC178	0.16
BC179	0.16
BC180	0.25
BC181	•0.25
BC182L	•0.10
BC183	•0.10
BC183L	•0.10
BC184	•0.10
BC184L	•0.10
BC207	•0.11
BC208	•0.11
BC209	•0.12
BC212	•0.11
BC212L	•0.11
BC213	•0.11
BC213L	•0.11
BC214	•0.12
BC214L	•0.12
BC237	•0.16
BC238	•0.16
BC251	•0.15
BC251A	•0.16
BC301	0.30
BC302	0.28
BC303	0.32
BC304	0.38
BC327	•0.16
BC328	•0.15
BC337	•0.15
BC338	•0.15
BC440	0.30
BC441	0.30
BC460	0.38
BC461	0.38
BC477	0.20
BC478	0.19
BC479	0.20
BC547	•0.12
BC548	•0.12
BC549	•0.12

Type	Price
BC550	•0.14
BC556	•0.14
BC557	•0.13
BC558	•0.12
BC559	•0.14
BD115	0.50
BD116	0.80
BD121	0.85
BD123	0.65
BD124	0.70
BD131	0.35
BD132	0.38
BD131/132 MP	0.80
BD133	0.60
BD135	0.36
BD136	0.36
BD137	0.38
BD138	0.45
BD139	0.54
BD140	0.60
BD139/140 MP	1.20
BD155	0.80
BD175	0.60
BD176	0.60
BD177	0.68
BD178	0.68
BD179	0.75
BD201/202 MP	1.70
BD203	0.80
BD204	0.80
BD203/204 MP	1.70
BDY20	0.80
BDX77	0.90
BF457	0.37
BF458	0.37
BF459	0.38
BF594	•0.15
BF596	•0.17
BFR39	0.25
BFR40	•0.25
BFR79	•0.28
BFR80	•0.28
BFX29	0.25
BFX30	0.30
BFX84	0.23
BFX85	0.24
BFX86	0.25
BFX87	0.22
BFX88	0.22
BFX90	•0.55
BFY50	0.14
BFY51	0.14
BFY52	0.14

Type	Price
BIP19	0.38
BIP20	0.38
BIP19/20 MP	0.80
BRY39	0.45
BU105	1.90
BU105/02	1.95
BU204	1.70
BU205	1.70
BU208	2.40
BU208/02	2.95
E1222	0.38
MJE2955	0.88
MJE3055	0.60
MJE3440	0.45
MP8113	0.45
MPF102	0.35
MPF104	0.39
MPF105	0.39
MPSA05•	0.20
MPSA06•	0.20
MPSA55•	0.20
MPSA56•	0.20
OC22	1.50
OC23	1.50
OC24	1.40
OC25	0.60
OC26	0.60
OC28	0.90
OC29	1.00
OC35	0.90
OC36	0.90
OC70	0.15
OC71	0.15
TIC44	•0.29
TIC45	•0.29
TIP29A	0.44
TIP29B	0.52
TIP29C	0.62
TIP30A	0.50
TIP30B	0.60
TIP30C	0.70
TIP31A	0.54
TIP31B	0.66
TIP31C	0.68
TIP32A	0.64
TIP32B	0.76
TIP32C	0.80
TIP41A	0.66
TIP41B	0.70
TIP41C	0.80
TIP42A	0.72
TIP42B	0.78
TIP42C	0.95

Type	Price
TIP2955	0.95
TIP3055	0.75
TIS43	0.22
TIS90	•0.18
UT46	0.20
ZTX107	•0.10
ZTX108	•0.10
ZTX109	•0.10
ZTX300	•0.12
ZTX500	•0.14
2N1613	0.20
2N1711	0.20
2N1889	0.45
2N1890	0.45
2N1893	0.30
2N2147	0.75
2N2148	0.70
2N2160	0.80
2N2192	0.38
2N2193	0.38
2N2194	0.38
2N2217	0.22
2N2218	0.22
2N2218A	0.20
2N2219	0.20
2N2219A	0.24
2N2904	0.18
2N2904A	0.21
2N2905	0.18
2N2905A	0.21
2N2906	0.16
2N2906A	0.19
2N2907	0.20
2N907A	0.22
2N2926G	•0.09
2N2926Y	•0.08
2N2926O	•0.08
2N2926R	•0.08
2N2926B	•0.08
2N3053	0.16
2N3054	0.40
2N3055	0.40
2N3414	•0.16
2N3415	•0.16
2N3416	•0.29
2N3417	•0.29
2N3614	0.85
2N3615	0.90
2N3616	0.90
2N3646	•0.09
2N3702	•0.08
2N3703	•0.08
2N3704	•0.07
2N3705	•0.07
2N3706	•0.08
2N3707	•0.08

Type	Price
2N3708	•0.07
2N3708A	•0.07
2N3709	•0.07
2N3710	•0.07
2N3711	•0.07
2N3819	0.20
2N3820	0.40
2N3821	0.60
2N3823	0.40
2N4058	•0.12
2N4059	•0.14
2N4060	•0.14
2N4061	•0.12
2N4062	•0.12
2N4284	•0.18
2N4285	•0.18
2N4286	•0.18
2N4287	•0.18
2N4288	•0.18
2N4289	•0.18
2N4290	•0.18
2N4291	•0.18
2N4292	•0.18
2N4293	•0.18
2N4921	•0.55
2N4923	•0.65
2N5135	•0.10
2N5136	•0.10
2N5138	•0.10
2N5194	0.56
2N5245	•0.28
2N5294	0.34
2N5296	0.35
2N5457	0.32
2N5458	0.32
2N5459	0.38
2N5551	•0.30
2N6027	0.32
2N6121	0.70
2N6122	0.70
40311	0.36
40313	0.95
40316	0.58
40317	0.36
40326	0.36
40327	0.45
40346	0.42
40347	0.55
40348	0.70
40360	0.38
40361	0.38
40362	0.38
40406	0.40
40407	0.28
40408	0.48
40409	0.52

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FULL SPECIFICATION GUARANTEED ALL FAMOUS MANUFACTURERS

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
7400	0.14	7409	0.15	7441	0.64	7482	0.85	7493	0.40	74122	0.50
7401	0.14	7410	0.14	7442	0.64	7483	0.95	7494	0.88	74123	0.70
7402	0.15	7411	0.23	7445	0.90	7484	0.98	7495	0.75	74141	0.80
7403	0.15	7412	0.23	7446	0.90	7485	1.20	7496	0.80	74154	1.30
7404	0.15	7413	0.27	7447	0.78	7486	0.30	74100	1.00	74180	1.10
7405	0.15	7414	0.58	7448	0.80	7489	2.90	74110	0.50	74181	2.00
7406	0.30	7416	0.28	7475	0.48	7490	0.42	74118	0.90	74190	1.50
7407	0.30	7417	0.28	7480	0.50	7491	0.75	74119	1.85	74198	2.00
7408	0.15	7440	0.15	7481	0.95	7492	0.45	74121	0.30	74199	1.90

CMOS IC'S

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
CD4000	0.14	CD4012	0.18	CD4022	0.95	CD4031	2.20	CD4046	1.30	CD4071	0.28
CD4001	0.18	CD4013	0.50	CD4023	0.18	CD4035	1.05	CD4047	1.10	CD4072	0.28
CD4002	0.18	CD4015	0.90	CD4024	0.72	CD4037	0.95	CD4049	0.55	CD4081	0.18
CD4006	0.98	CD4016	0.50	CD4025	0.18	CD4040	0.95	CD4050	0.55	CD4082	0.28
CD4007	0.18	CD4017	0.90	CD4026	0.98	CD4041	0.82	CD4054	1.20	CD4510	1.30
CD4008	0.95	CD4018	1.00	CD4027	0.60	CD4042	0.82	CD4055	1.20	CD4511	1.60
CD4009	0.55	CD4019	0.52	CD4028	0.85	CD4043	0.98	CD4056	1.40	CD4516	1.40
CD4010	0.55	CD4020	1.10	CD4029	1.15	CD4044	0.94	CD4069	0.40	CD4518	1.08
CD4011	0.18	CD4021	0.98	CD4030	0.55	CD4045	1.40	CD4070	0.40	CD4520	1.25

LINEAR IC'S

Type	Price
CA3011	•0.80
CA3014	•1.37
CA3018	•0.70
CA3020	•1.40
CA3028A	•1.10
CA3035	•1.30
CA3036	•1.35
CA3042	•1.15
CA3043	•1.65
CA3046	•0.50
CA3052	•1.60
CA3054	•1.94
CA3075	•1.50
CA3081	•1.60
CA3089E	•1.50
CA3090AQ	•4.25
CA3123E	•1.40
LM301AH	•0.47
LM304	3.00
LM308H	•0.95
LM309K	1.75

Type	Price
LM320-5V	2.00
LM320-12V	2.00
LM320-15V	2.00
LM320-24V	2.00
LM380N	•1.00
LM381AN	•1.15
LM3900N	•0.63
MC724P	1.50
MC1303L	•1.45
MC1304P	•3.50
MC1310P	•1.80
MC1312PQ	•1.50
MC1330P	•1.35

Type	Price
MC1339	•1.50
MC1350	•0.75
MC1351P	•0.85
MC1352P	•0.85
MC1456G	•0.85
MC1466L	3.95
MC1469R	2.50
MC1496G	•0.90
NE536	•2.00
NE515A	•2.10
NE540	•2.40
NE555	0.40
NE556	0.82
NE561	•3.25
NE562B	•2.95
NE565A	•2.00
NE566	•1.50
NE567	•2.50
UA702C	•0.46

Type	Price
72702	•0.46
UA703A	•0.25
UA709C	•0.25
72709	•0.46
72709P	•0.25
UA710C	•0.40
72710	•0.30
UA711C	•0.32
72711	•0.32
UA723C	0.50
72723	0.50
UA741C	•0.20
72741	•0.20

Type	Price
741P	•0.20
UA747C	•0.70
72747	•0.79
UA748	•0.35
72748	•0.35
72748P	0.35
SN76013N	•1.40
SN76023N	•1.40
SN76110	•1.50
SN76115	•1.90
SN76660	•0.75

Type	Price
SL403D	•1.75
SL414A	•1.75
TAA550B	0.35
TAA621A	•2.00
TAA661A	•1.50
TAD100	•1.30
TBA540Q	•2.50
TBA641B	•2.25
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TBA820	0.90
TBA9200	3.40
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MINIATURE MAINS Pri240V
with two independent secondary windings

No.	Type	Price
2024 MT280	0-6v, 0 6v RMS 280mA	£1.30*
2025 MT150	0-12v, 0-12v RMS 150mA	£1.30*

MINIATURE MAINS Pri 240v

No.	Secondary	Price
2021	6v-0-6v 100mA	£1.30*
2022	9v-0-9v 100mA	.85*
2023	12v-0-12v 100mA	£1.30*

1 amp MAINS Pri 240v

No.	Secondary	Price	
2026	6v-0-6v 1 amp	£2.70*	p&p 30p
2027	9v-0-9v 1 amp	£2.20*	p&p 30p
2028	12v-0-12v 1 amp	£2.60*	p&p 30p
2029	15v-0-15v 1 amp	£2.90*	p&p 30p
2030	30v-0-30v 1 amp	£3.80*	p&p 30p

STANDARD MAINS Pri 240v
Multi-tapped secondary mains transformers available in ½ amp 1 amp and 2 amp current rating Secondary taps are 0-19-25-33-40-50v.
Voltages available by use of taps:
4, 7, 8, 10, 14, 15, 17, 19, 25, 31, 33, 40, 50, 25-0-25 volts.

No.	Rating	Price	
2031	½ amp	£3.42*	p&p 30p
2032	1 amp	£4.40*	p&p 50p
2033	2 amp	£5.45*	p&p 85p

AUDIO OUTPUT Pri 1.2k Secondary 5 ohms 200mW Dimensions 20 x 16 x 15
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Pri 20k Secondary 1k Ratio 5:1
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LT717 MIN INPUT
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LT719 MIN INPUT
Pri 20k Secondary 1k 20 x 15 x 15mm
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Pri 10k Secondary 2k-C.T. 20 x 15 x 15mm
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LT724 MIN OUTPUT
Pri 1.2-C.T. Secondary 3 2 & 8 ohm 200mW Dimensions 20 x 15 x 15mm
Order no. 2045 £0 38*

LT726 MIN OUTPUT
Pri 500 ohm Secondary 3 2 & 8 ohm 200mW Dimensions 20 x 15 x 15mm
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LT728 MIN DRIVER
Pri 1k C.T. Secondary 500 ohm C T Dimensions 25 x 20 x 20mm
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LT729 MIN OUTPUT
Pri 200 ohm C T. Secondary 3.2 & 8 ohm 400mW Dimensions 25 x 20 x 20mm
Order no. 2048 £0.39*

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Pri 500 ohm C.T. Secondary 3.2 & 8 ohms 500mW
Order no. 2049 £0.42*

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Type	Size	Order no	Colour	Price
TIL209	125"	1501	RED	.12p
TIL211	125"	1502	GREEN	.25p
TIL213	125"	1503	YELLOW	.25p
FLV115	2"	1504	RED	.12p
FLV310	2"	1505	GREEN	.25p
FLV410	2"	1506	YELLOW	.25p

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A pack of standard sizes and colours which fail to perform to their very rigid specification, but which are ideal for experiments
Order no. 1507 £0.90

L.E.D. CLIPS

	Size	Order no.	Price
Pack of 5	.125"	1508/125	.15p
Pack of 5	.2"	1508/2	.30p

NUTS & BOLTS

BA BOLTS — packs of B.A. Threaded cadmium plated screws, slotted cheese head. Supplied in multiples of 100.

Type	No.	Price	Type	No.	Price
1"OBA	839	£1.12	1"4BA	845	£0.51
½"OBA	840	£0.83	½"4BA	846	£0.38
1"2BA	842	£0.69	¼"4BA	847	£0.33
½"2BA	843	£0.54	1"6BA	848	£0.50
¼"2BA	844	£0.63	½"6BA	849	£0.30
			¼"6BA	850	£0.33

BA NUTS — Packs of cadmium plated full nuts in multiples of 100.

Type	No.	Price	Type	No.	Price
OBA	855	£0.90	4BA	857	£0.42
2BA	856	£0.60	6BA	858	£0.36

BA WASHERS — flat cadmium plated plain stamped washers supplied in multiples of 100.

Type	No.	Price	Type	No.	Price
OBA	859	£0.19	4BA	861	£0.15
2BA	860	£0.15	6BA	862	£0.12

SOLDER TAGS — hot tinned supplied in multiples of 100.

Type	No.	Price	Type	No.	Price
OBA	851	£0.42	4BA	853	£0.30
2BA	852	£0.36	6BA	854	£0.30

INSTRUMENT CASES. In two sections, vinyl covered top and sides, aluminium bottom, front and back.

No.	Length	Width	Height	Price
155	8"	5¼"	2"	£1.40*
156	11"	6"	3"	£1.80*
157	6"	4¾"	1¾"	£1.25*
158	9"	5¼"	2½"	£1.60*

ALUMINIUM BOXES. Made from bright all., folded construction each box complete with half inch deep lid and screws

No.	Length	Width	Height	Price
159	5¼"	2¼"	1½"	£0.62*
160	4"	4"	1½"	£0.62*
161	4"	2¼"	1½"	£0.62*
162	5¼"	4"	1½"	£0.78*
163	4"	2½"	2"	£0.64*
164	3"	2"	1"	£0.44*
165	7"	5"	2½"	£1.04*
166	8"	6"	3"	£1.32*
167	6"	4"	2"	£0.86*

BRIDGE RECTIFIERS

SILICON 1 AMP

Type	Order No.	Price
50vRMS	BR1/50	£0.25
100vRMS	BR1/100	£0.28
200vRMS	BR1/200	£0.30
400vRMS	BR1/400	£0.35

SILICON 2 AMP

Type	Order No.	Price
50v	BR2/50	£0.40
100v	BR2/100	£0.45
200v	BR2/200	£0.50
400v	BR2/400	£0.55
1000v	BR2/1000	£0.65

FUSE HOLDERS & FUSES

Description	Order No.	Price
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1¼" x ¼" chassis mounting	507	£0.10*
1¼" car inline type	508	£0.20*
Panel mounting 20mm	509	£0.22
Panel mounting 1¼"	510	£0.24

QUICK BLOW 20mm

Type	No.	Type	No.	Type	No.
150mA	611	1A	615	3A	619
250mA	612	1.5A	616	4A	620
500mA	613	2A	617	5A	621
800mA	614	2.5A	618	ALL 5p EACH	

ANTI-SURGE 20mm

Type	No.	Type	No.	Type	No.
100mA	622	1A	625	2.5A	628
250mA	623	2A	626	3.15A	629
500mA	624	1.6A	627	5A	630

ALL 7p EACH

QUICK BLOW 1¼"

Type	No.	Type	No.	Type	No.
250mA	631	500mA	632	800mA	634

ALL 7p EACH

Type	No.	Type	No	Type	No.
1A	635	2.5A	638	4A	641
1.6A	636	3A	639	5A	642

ALL 6p EACH

SWITCHES

Description	No.	Price
D.P.D.T. miniature slide	1973	£0.10*
D.P.D.T. standard slide	1974	£0.12*
Toggle switch S.P.S.T. 1½ amp 250v AC	1975	£0.33*
Toggle switch U.P.D.T. 1 amp 250v AC	1976	£0.36*
Rotary ON-OFF mains switch	1977	£0.42*
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Push switch – Push to break	1979	£0.18*

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Description	No.	Price
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Miniature D.P.D.T. toggle 2 amp 250v AC	1960	£0.65*
Miniature D.P.D.T. toggle centre off – 2 amp 250v AC	1961	£0.85*
Push button S.P.S.T. 2 amp 250v AC	1962	£0.65*
Push button S.P.S.T. 2 amp 250v AC	1963	£0.68*
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4 pole 3 way	1968	£0.48*

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	Order No.	Price
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Button gives 1 pole change over action Rating 10 amp 250v AC	1970	£0.25

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50	4p	5p	6p	9p	13p	18p	25p	—
100	5p	6p	10p	12p	19p	20p	—	—
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7483	69p
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BRIDGE RECTIFIERS

Amp	Volt		
½	1,600	BYX10	30p
1	140	OSH01-200	26p
1.4	42	BY164	40p
0.6	110	EC433	6p
5	400	Texas	90p

RECTIFIERS

	Amp	Volt	
IN4004/5/6	1	4/6/800	5p
IN4007/BYX94	1	1250	5p
BY103	1	1,500	18½p
SR100	1.5	100	7p
SR400	1.5	400	8p
REC53A	1.5	1,250	14p
LT102	2	30	10p
BYX38-300R	2.5	300	40p
BYX38-600	2.5	600	45p
BYX38-900	2.5	900	50p
BYX38-1200	2.5	1,200	55p
BYX48-300R	2.5	300	26p
BYX49-600	3	600	35p
BYX49-900	3	900	40p
BYX49-1200	3	1,200	52p
BYX48-300R	6	300	40p
BYX48-600	6	600	50p
BYX48-900	6	900	60p
BYX48-1200R	6	1,200	80p
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BYX72-300R	10	300	45p
BYX72-500R	10	500	55p
BYX42-300	10	300	30p
BYX42-600	10	600	65p
BYX42-900	10	900	80p
BYX42-1200	10	1,200	95p
BYX46-300R*	15	300	£1.00
BYX46-400R*	15	400	£1.50
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BYX46-600*	15	600	£2.00
BYX20-200	25	200	60p
BYX52-300	40	300	£1.75
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*Avalanche type

TRIACS

Amp	Volt		
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25	900	BTX94-900	£4.00
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Mullard Data Book ... 40p

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Relay socket ... 10p
Take miniature 2PCO relay

B9A valve can ... 5p

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Diodes		Photo transistor	
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(VOLTIAC)

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ORANGE 14p
YELLOW 14p
RED 14p

PHOTO SILICON CONTROLLED SWITCH BPX66 PNPN 10 amp £1.00

.3" red 7 segment L.E.D. 14 D.I.L. 0-9+D.P. display 1.9v 10m/a segment, common anode ... 61p
DL747.6" ... £1.25
Minitron 3" 3015F filament ... £1.10

CQY11B L.E.D. Infra red transmitter ... £1
One fifth of trade

Plastic, Transistor or Diode Holder ... 1p
Transistor or Diode Pad ... 1p
Holders or pads 50p per 100

THYRISTORS

Amp	Volt		
1	240	BTX18-200	30p
1	400	BTX18-300	35p
1	240	BTX30-200	30p
15	500	BT107	£1
6.5	500	BT101-500R	90p
6.5	500	BT109-500R	£1.00
20	600	BTW92-600RM	£3.00
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30	1000	28T10 (Less Nut)	£3.00

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0.25MFD	800 volt	30p
1MFD	250 volt	15p
2MFD	250 volt	20p
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Car Aerial **9p**, Coax **3p**, 5 pin 180° **9p**, 5 or 6 pin 240° din **6p**, speaker din switched **5p**, 3.5 mm switched **5p**, stereo ¼" jack enclosed **10p**.

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SWG.	PER YD.
20-24	3p
26-42	2.5p

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GCS23T Crystal Stereo Cartridge ... 66p
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Copper coated board 10" x 9" approx 25p

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Nylon self locking 7" or 3½" ... 2p

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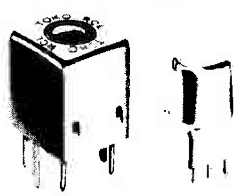

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MEDIUM AND SHORT WAVE

This simple a.m. radio is completely self-contained and covers the standard medium wave band together with short waves from about 1.6 to 15MHz. Unlike many home-constructed short wave receivers it does not require an external aerial, and it will operate satisfactorily with its own telescopic aerial. It will obviously not provide a performance equal to that of an expensive communications receiver but it will give reception of many interesting amateur and broadcast transmissions.

The approximate frequency coverage of each waveband is: Range 1, 550kHz to 1.8MHz; Range 2, 1.6 to 5.3MHz; and Range 3, 5.0 to 15.0MHz. Three ready-made coils are employed for the bands, these being Denco Red Transistor Tuning Coils range 2T, 3T and 4T respectively. The Denco range numbers should be quoted when ordering, and not the numbers 1, 2 and 3 which are used to designate the ranges in this particular receiver.

Part 1

In its basic form. the receiver requires only three transistors, and it offers an output which is suitable for 4,000Ω headphones, or any other medium to high impedance load such as the input of an a.f. amplifier. However, the set can itself be modified for loudspeaker operation if desired by the addition of its own single transistor output stage. Some constructors may like to have the option of employing a long external aerial, and another simple modification provides this option.

The receiver is not presented as a miniature design and the front panel measures 11½ by 4in. This enables the controls to be comfortably laid out for ease of operation. The depth of the case is about 5in., and there is more than adequate space inside for the component modules which make up the receiver.

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)
R1 39kΩ
R2 10kΩ
R3 1.5kΩ
R4 5.6kΩ
R5 680Ω
R6 4.7kΩ
R7 5.6kΩ
R8 2.2MΩ
VR1 10k Ω Potentiometer, linear

Capacitors
C1 100μF electrolytic, 10 V. Wkg.
C2 0.047μF polyester
C3 0.047μF polyester
C4 0.01μF polyester
C5 0.0068μF polyester
C6 0.22μF type C280 (Mullard)
C7 100μF electrolytic, 10 V. Wkg.
C8 0.0022μF polystyrene
C9 10μF electrolytic, 10 V. Wkg.
C10 2.2μF electrolytic, 10 V. Wkg.
VC1 365pF variable, type 01 (Jackson)
VC2 50pF variable, type C804 (Jackson)

Inductors
L1,L2,L3 Transistor Tuning Coils, Red, Ranges 2T, 3T and 4T (Denco)

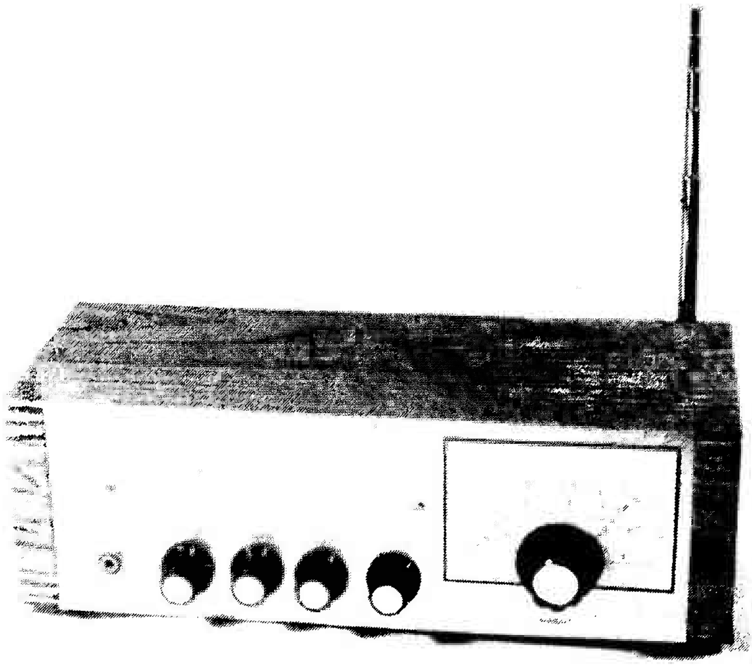
Transistors
TR1 BC107
TR2 BC109 or BC109C (see text)
TR3 BC109 or BC109C (see text)

Switches
S1(a)(b)(c) 4-pole 3-way miniature rotary
S2 s.p.s.t. rotary

Socket
SK1 3.5mm. jack socket with break contact (see text)

Miscellaneous
4 small control knobs
Large control knob
Telescopic aerial (see text)
3 B9A valveholders
Veroboard, 0.15in. matrix
6-way tagstrip (see text)
9-volt battery type PP3 (Ever Ready)
Battery connector
Materials for chassis and case (see text)
Bolts, nuts, solder tags, wire, etc.

DUAL RADIO



By P. R. Arthur

CIRCUIT DIAGRAM

The circuit diagram appears in Fig. 1. Here, S1(a)(b)(c) is the wavechange switch and, for clarity, only one of the three coils is shown. Of the three transistors, TR1 functions as a regenerative detector whilst TR2 and TR3 form a high gain audio amplifier.

The detector circuit will look very familiar to readers who have had experience of simple transistor superhet receivers, since coil L1, L2, L3 is connected to TR1 in the same manner as is the oscillator coil in a superhet mixer-oscillator stage. The three coils specified are, indeed, normally employed as superhet

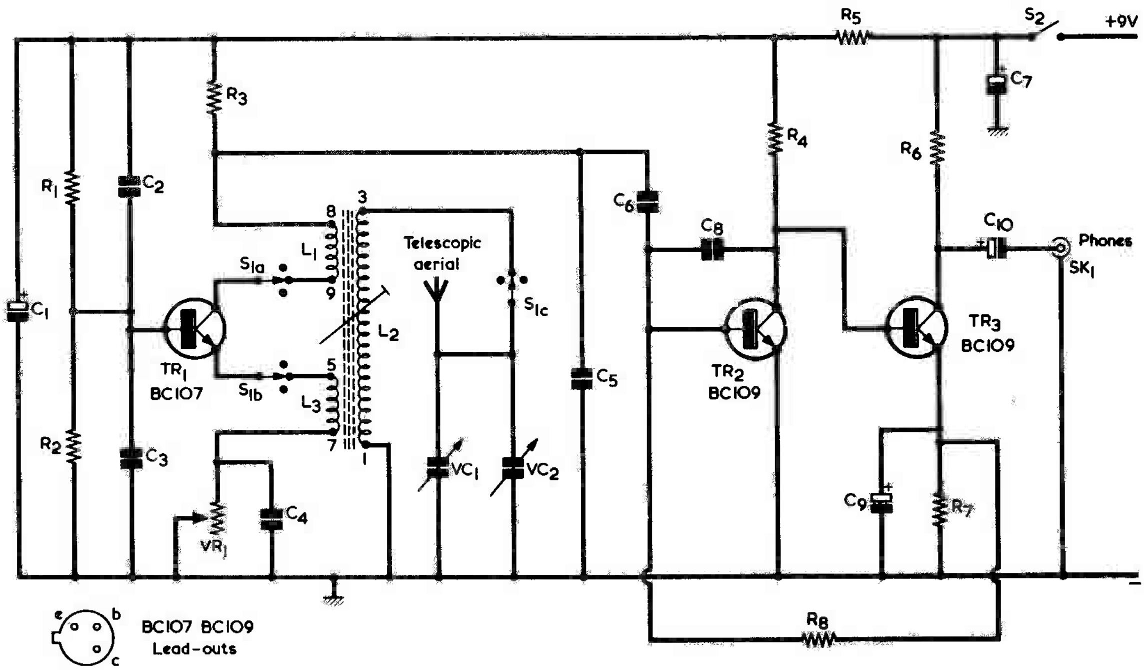


Fig. 1. The circuit of the medium and dual short wave radio. For clarity, only one of the three coils is shown

oscillator coils, with L2 functioning as the tuned winding and L1 and L3 as coupling windings to the collector and emitter of the transistor. In normal usage the coils would operate at frequencies which are higher than signal frequency by the superhet intermediate frequency of 465kHz. In the present circuit they are used without series padding capacitors and this fact, combined with the relatively wide inductance change offered by their adjustable iron-dust cores, enables them to cover the frequency ranges just mentioned.

Although the circuit may seem an unusual choice for the basis of a t.r.f. detector it is nevertheless a good one. This is because almost any reliable oscillator circuit lends itself well to operation as a regenerative detector if the feedback level is kept just below that at which oscillation takes place.

TR1 is employed in the common base mode with its base bypassed to chassis by C3. VC1 and VC2 connect to the tuned winding of the coil. VC1 has the higher capacitance and is the bandset tuning control, the lower value VC2 being the bandspread control. Since only a short telescopic aerial is employed it is important that a tight coupling be obtained to the tuned circuit. This is achieved by connecting the aerial direct to the non-earthy end of the tuned circuit.

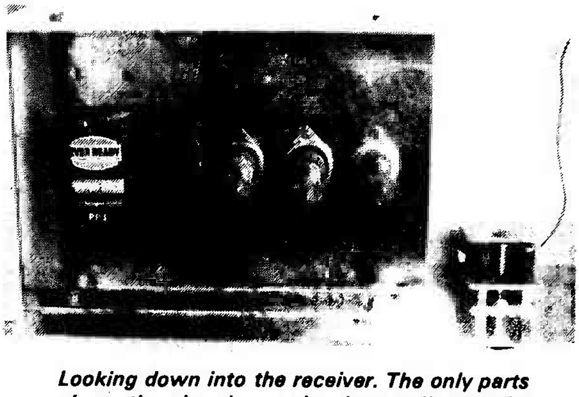
The coils are intended to be plugged into B9A valveholders, and one end of the tuned winding is connected to a different pin in each. This enables them, in their normal application, to be plugged into a single valveholder having different padding capacitors connected to the appropriate valveholder pins. In the present circuit it is merely necessary to remember that the connections to S1(c) are from pin 2 of the 2T coil, from pin 3 of the 3T coil and from pin 4 of the 4T coil. The coil shown in Fig. 1 is the 3T coil.

The gain of TR1 is controlled by VR1 in its emitter circuit. The voltage at TR1 emitter is largely controlled by the potential divider, R1 and R2, which connects to its base, whereupon the operating current of TR1 is controlled by VR1. TR1 gain increases with increasing operating current, and it is in this manner that VR1 controls the gain of the stage. VR1 is normally adjusted for a gain level just below that at which TR1 oscillates.

TR1 acts as a detector because it offers non-linear amplification. Positive-going half-cycles at its collector have received less amplification than negative-going half-cycles since they correspond to a lower collector current. Although the degree of non-linearity is small it is still in practice sufficient for signal detection, and the effect becomes more enhanced as regeneration is increased. The detected signal is built up across R3, with C5 functioning as a bypass capacitor for the remanent r.f. signal, and it is then applied via C6 to TR2.

The audio stages comprising TR2 and TR3 are quite straightforward, and the transistors appear in a direct coupled circuit with both in the common emitter configuration. C8 provides roll-off of the higher audio frequencies, giving a consequent improvement in stability and signal-to-noise ratio.

C1, C7 and R5 are supply decoupling components, and C10 provides d.c. blocking at the output. Total current consumption is only about 2mA, and many hours of operation can be obtained from a PP3 battery. The receiver will perform quite well with any BC109 transistors in the TR2 and TR3 positions. However, for optimum results it is preferable to use the high gain BC109C types.



Looking down into the receiver. The only parts above the chassis are the three coils and the PP3 battery

CASE AND CHASSIS

A home-made case and chassis are employed. The front and rear panels and the chassis are cut out from 18 s.w.g. aluminium sheet, and details of these are given in Fig. 2.

Making the front panel is quite straightforward apart from the three 4BA clear countersunk holes required for mounting VC1. These correspond with three 4BA tapped holes in the front plate of the capacitor, and a simple method of marking these out is to cut a small hole in the centre of a piece of paper and pass it over the spindle of the capacitor. The three tapped hole positions are then marked on the paper with a pencil, whereupon it becomes possible to use the paper as a template for marking out the holes in the panel. No dimension is given for the diameter of the mounting hole for SK1 as this depends upon the particular component used.

The rear panel is the same as the front panel except that it does not have the holes for the controls and SK1. There is instead a small hole at the bottom right (as viewed in Fig. 2) which allows the passage of a wire to the telescopic aerial.

The chassis has its two 1in. flanges bent up, towards the reader, and these are later secured with 6BA bolts and nuts at the corresponding holes in the front and rear panels. The three large holes in the chassis are for B9A valveholders. When mounted, these will have the orientation indicated in Fig. 4. The two 6BA clear mounting holes for each valveholder may be marked out with the aid of the valveholders themselves. Also required on the chassis are two 6BA clear holes for the component panel, two 6BA clear holes for the 6-way tagstrip and a hole for the battery leads. The 6BA clear holes are marked out with the aid of the component panel and the tagstrip, both of which will be described shortly. The precise positioning of these holes is not critical.

When all holes have been drilled the chassis may be assembled to the front and rear panels. The 1in. flanges of the chassis are above the chassis deck. Also above the chassis are the three coils, with the valveholder tags projecting below the chassis. The component panel and 6-way tagstrip are below the chassis. The PP3 battery will be situated above the chassis when construction and wiring are complete.

At this stage the controls, valveholders and SK1 may be mounted. A chassis solder tag is fitted at two of the valveholders, as shown in Fig. 4. VC1 is mounted by three 4BA screws which must have

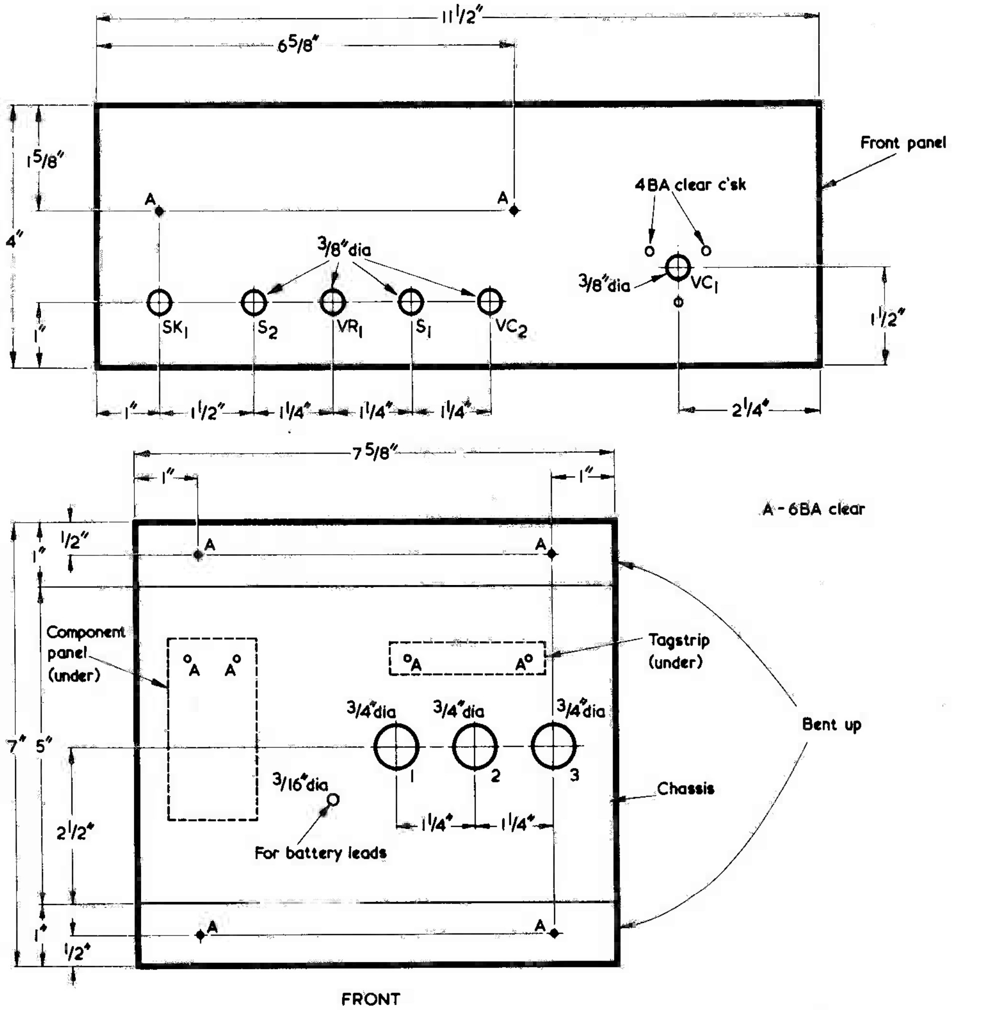


Fig. 2. Details of the front panel and chassis. These are cut out from 18 s.w.g. aluminium sheet

countersunk heads in order not to obstruct the control knob. The screws must be short, and care must be taken to ensure that their ends do not pass more than fractionally inside the front plate of the capacitor as they can then damage the capacitor vanes. It will be found helpful to fit spacing washers between the front panel and the capacitor front plate.

Two case sides may be made up with $\frac{3}{4}$in. timber, as shown in Fig. 3. They are covered with Fablon, or similar, and then two 5in. battens are nailed to each of them on the inside, also as illustrated. The side pieces are affixed to the front and rear panels by means of adhesive at the batten ends. The panel top and bottom edges project beyond the top and

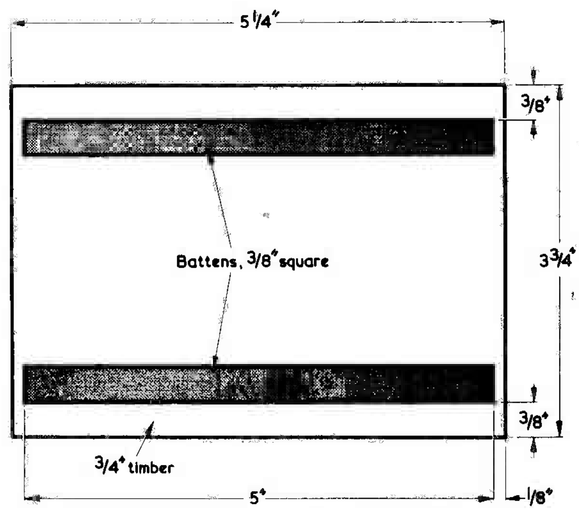


Fig. 3. The sides of the case consist of two pieces of thick timber. The two square-section battens are nailed to each on the inside

bottom edges of the timber side pieces by an equal amount. The top and base of the case consist of two pieces of hardboard, each measuring 13 by 5in. These are covered with the same self-adhesive plastic as the sides and are mounted by a small woodscrew at each end which passes into the appropriate side piece. The base is fitted with four rubber feet, these being secured near the corners. The top and base panels are fitted after wiring has been completed.

If the a.f. output stage or the modification for a long aerial is to be incorporated later it is necessary to drill further holes in the rear panel. Readers who anticipate undertaking these modifications may prefer not to affix the rear panel with adhesive at this stage or to devise an alternative means of securing the panel, say by means of small brackets and bolts and nuts.

DETECTOR WIRING

Most of the components in the detector stage are wired up on the 6-way tagstrip, as illustrated in Fig. 4. This tagstrip can be cut down from a 28-way tagstrip Type B, available from Doram Electronics. Cut out a section with 7 tags from one end of the strip, remove the seventh tag and drill the strip at this point to take a 6BA mounting bolt. Any other small 6-way tagstrip with mounting holes at each end and having horizontal tags may alternatively be employed.

First wire up all the components which connect directly to the tags and then mount the tagstrip under the chassis with 6BA bolts and nuts. Fit spacers over the bolts between the chassis and the tagstrip to ensure that the latter is clear of the chassis surface. Then wire the tagstrip to the valveholders and complete the wiring between the valveholders and switch S1(a)(b)(c). Note that this switch is a 4-pole component with 1 pole unused. Fig. 5 shows the connections at this switch. Some rotary switches may have the inner tag of each pole at a different position, relative to the three outer tags to which it connects, than is shown in Fig. 5. This point may be checked before wiring with the aid of an ohmmeter or continuity tester. All the wiring in the detector stage, including that to S1(a)(b)(c), should be kept as short and direct as is reasonably possible.

The connection to VR1 is to the track tag corresponding to full clockwise rotation of the spindle. C4, which is mounted at the potentiometer, is also soldered to this track tag. Its other lead is soldered to the potentiometer slider tag.

There is no need to make any connection to the moving vanes tags of VC1 and VC2 as this is automatically provided by way of the metal front panel. The lead from S1(c) arm tag connects to the nearer fixed vanes tag of VC2. A second lead from the remaining fixed vanes tag of VC2 connects to the nearer fixed vanes tag of VC1.

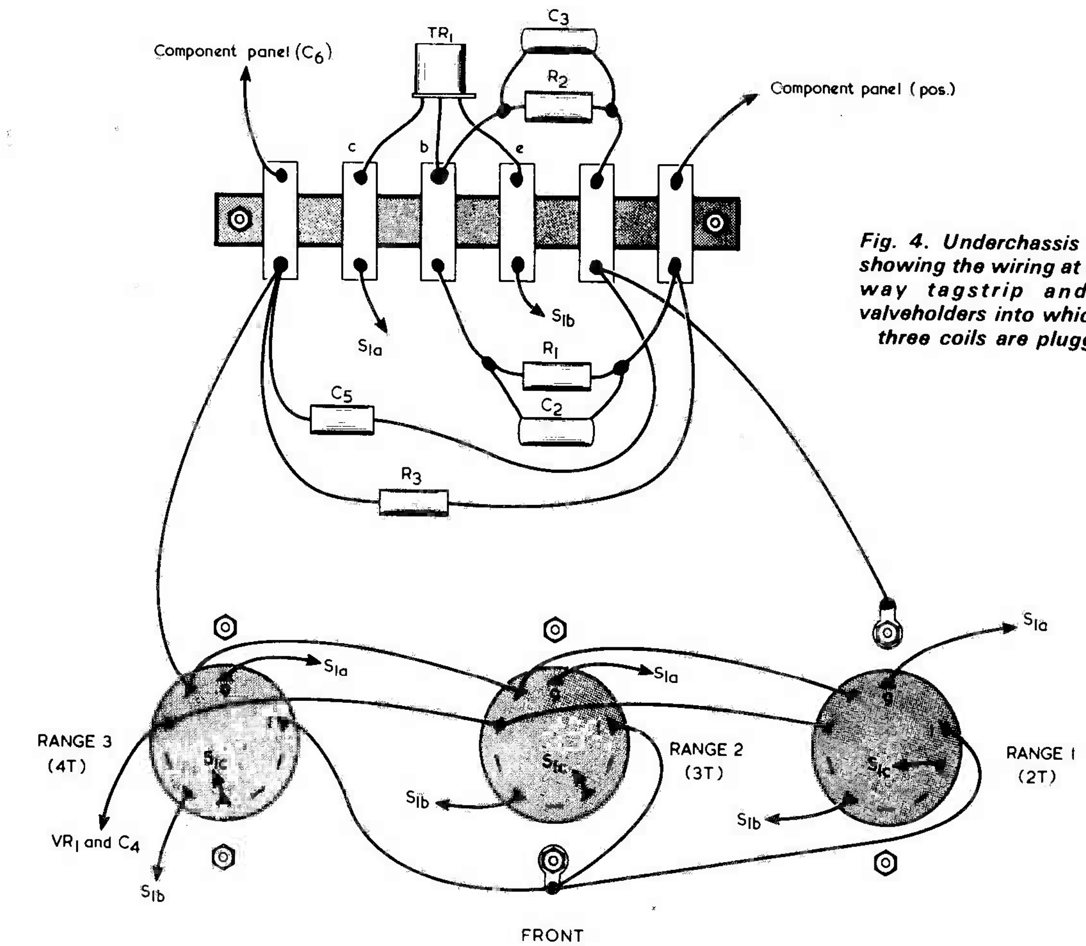
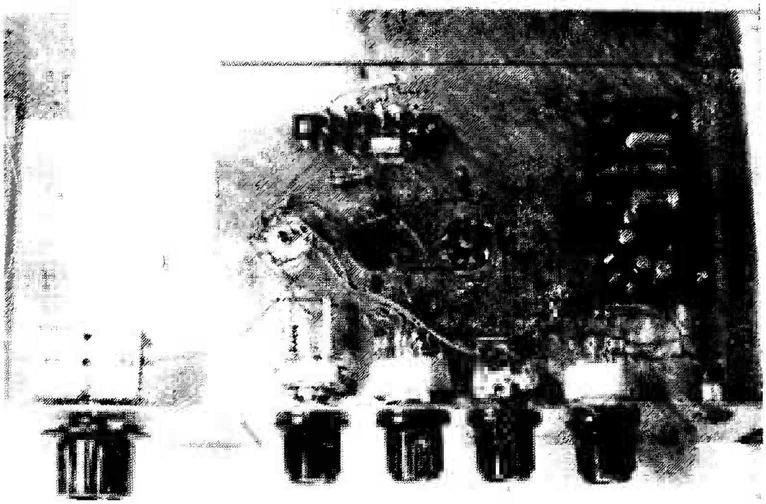


Fig. 4. Underchassis view, showing the wiring at the 6-way tagstrip and the valveholders into which the three coils are plugged.



Underneath the chassis. The three valve holders, the 6-way tagstrip and the component panel are all spaced out comfortably

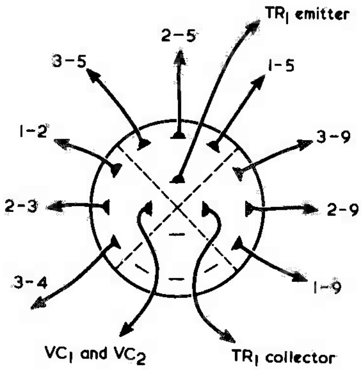


Fig. 5. The wiring to switch S1(a)(b)(c). Check the switch tag positioning as described in the text before making any connections

COMPONENT PANEL

The a.f. stages around TR2 and TR3 are assembled on a piece of 0.15in. Veroboard having 18 holes by 9 copper strips. The component side of this board is illustrated in Fig. 6.

First cut out the board to the required size, drill out the two 6BA clear holes and make the six breaks in the copper strips. Next wire in the components as shown in the diagram. The panel is mounted on the underside of the chassis as indicated in Fig. 2, but it should first have all its external connections completed. The lead to SK1 from the hole adjacent to C10 connects to the non-earthy (tip) contact of this socket, whilst the lead from the hole next to R7 connects to the earthy (sleeve) contact. SK1 is specified as a jack socket with a break contact which opens when the plug is inserted. A socket with a break contact is not necessary with the receiver as it stands, but is required if the audio output stage is added later. After all the external connections have been made the component panel is mounted to the chassis with 6BA bolts and nuts, using spacers to keep it clear of the chassis surface.

The few remaining connections are now completed. An insulated lead is connected between the earthy tag of SK1 and the slider of VR1, the connection being continued to the nearer chassis solder tag under the valveholder mounting nuts.

The battery clip leads pass through the chassis hole indicated in Fig. 2. The negative lead connects to VR1 slider and the positive lead to the unused tag of S2. In the prototype a multi-pole switch was employed for S2 with no connections made to the unused poles, but any small rotary switch offering the s.p.s.t. switching required can of course be employed.

The telescopic aerial used with the author's receiver had an extended length of 3ft. 7in. and a

The Veroboard panel on which the circuitry around TR2 and TR3 is assembled

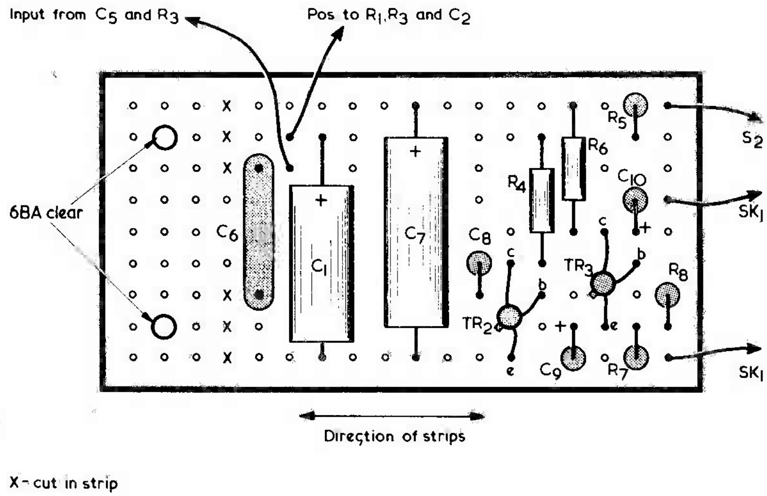


***Fig. 6.** The a.f. amplifier stages around TR2 and TR3 are assembled on a Veroboard panel. The component side of the panel is shown here*

collapsed length of 7in. Any telescopic aerial having approximately the same extended length will be suitable, and it is secured to the rear of the right hand case side (looking at the front of the receiver) by means of a simple bracket and two woodscrews. A wire from this aerial passes through the hole in the rear panel to the right hand fixed vanes tag of VC1.

A tuning scale taken from "Panel-Signs" Set No. 5 is applied to the front panel at VC1. The knob for this capacitor is fitted with a cursor which can consist of a piece of stiff wire glued to the knob underside. Legends taken from "Panel-Signs" Set No. 4 are also fitted to the front panel to indicate control functions. "Panel-Signs" are available from the publishers of this journal.

ADJUSTMENT AND USE

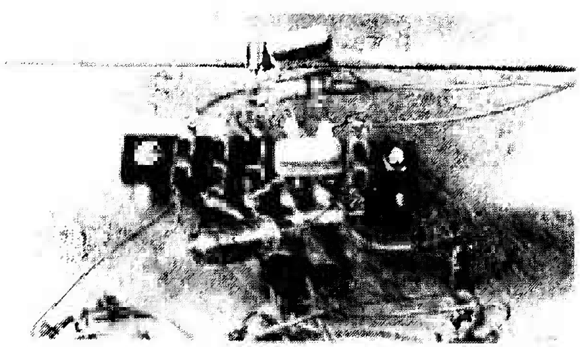
As supplied, the coils have their adjustable cores screwed right down for packing purposes. If a calibrated signal generator is available the cores can be adjusted so that the requisite frequency ranges are obtained. In the absence of a signal generator the cores can be adjusted in the following manner. The core of the Range 1 coil is set up so that about 2mm. (0.08in.) of the brass threaded section protrudes above the top of the former. The Range 2 coil is adjusted for a protrusion of approximately 6mm (0.24in.) and the Range 3 coil for a protrusion of about 10mm. (0.4in). These settings will allow approximately the correct frequency ranges to be obtained.

The receiver is fairly easy to operate although it will be necessary to obtain a little experience before optimum results are obtained. The best type of headphones to use are those with an impedance of 4,000Ω (2,000Ω per phone) but in practice the output will drive any type having an impedance of a few hundred ohms or more. The prototype even gave fairly acceptable results with headphones of 16Ω impedance. As mentioned at the beginning of this article, the output can also be connected to an external amplifier and speaker.

VC1 is an ordinary tuning control covering the full range of whatever coil is switched in. It is suitable for tuning a.m. signals on Ranges 1 and 2. It will be difficult to tune to s.s.b. signals, or to signals on Range 3 with this control. The best procedure then consists of setting VC1 close to the required signal and then finally tuning with VC2. Since VC2 has a much lower value than VC1 it covers a smaller tuning range over its travel, giving the effect of an "electrical slow-motion" control.

Careful adjustment of the regeneration control, VR1, is needed for best results. When this control is turned fully anticlockwise the receiver is at its least sensitive, although it will still probably be possible to tune in a few stations on each range. Advancing the control clockwise will raise the volume and greatly increase the number of stations which can be received. However, if the control is advanced too far the detector will break into oscillation, this condition being indicated by a rise in background noise and by whistles of varying pitch as the receiver is tuned across a.m. signals. For optimum sensitivity and selectivity when receiving a.m. signals VR1 should be advanced to a setting just below the threshold of oscillation. VR1 will need to be readjusted if the receiver tuning is altered by any significant amount.

The set has been primarily designed for the reception of a.m. broadcast signals, but it will function quite well when used to receive 80 metre morse (c.w.) and single sideband (s.s.b.) signals. The 80 metre amateur band extends from 3.5 to 3.8MHz and will be found near the high frequency end (VC1 vanes



A closer look at the 6-way tagstrip

Looking towards the controls from the rear of the receiver

nearly fully unmeshed) of Range 2. Reception of c.w. and s.s.b. signals is given by advancing VR1 just beyond the threshold of oscillation. The set is then tuned to provide a beat note of comfortable pitch with c.w. transmissions or to resolve the modulation in the case of s.s.b. signals.

Broadcast a.m. signals should be readily picked up, as many of the transmitting stations are so powerful that they can be received with quite simple equipment.

NEXT MONTH

In next month's concluding article, details will be given of the additional a.f. output stage and the modification which allows the use of a long wire aerial.

(To be concluded)

U.S. RECORDING CENTENNIAL STAMP

By Michael Lorant

The United States Postal Service has issued a new 13 cent commemorative postage stamp to mark a century of progress in sound recording. The design of the stamp was unveiled this year during the 19th annual Grammy Awards telecast of the U.S. National Academy of Recording Arts and Sciences.

The colourful stamp, which depicts a stylised concept of early sound recording equipment, was issued on March 23rd in Washington D.C. during the Annual Cultural Award Dinner of the Recording Industries of America.

Sound recording was born one hundred years ago and the stamp points to the dramatic developments in recording techniques and equipment evolving from the earliest tin foil machine to today's sophisticated records and tapes.

The creator of the stamp was Walter Einsel, of Westport, Connecticut, who teamed with his wife to design four U.S. stamps marking *Progress in Electronics.*

This U.S. Commemorative postage stamp marks the fact that sound recording has now been in existence for a hundred years

The legend "USA 13c" appears in black in the upper right corner of the stamp design. Across the base of the recording device, in black lettering with a banner format, appears "Centennial of Sound Recording". ■

NEWS . . . AND .

ELECTRONIC PIANO USING GIM MICROCIRCUIT

The piano, now beyond the reach of many household budgets as a source of home entertainment, could once again be restored to popularity following the development of an electronic piano which could sell for as little as £100 it is claimed.

Key to this development is a new MOS microcircuit (AY-1-1320) designed by General Instrument Microelectronics, Glenrothes, Scotland, which simulates the sound and touch of hammer action instruments.

Unlike the electronic organ, in which volume is constant for all key depressions, the electronic piano incorporates circuitry which senses the key velocity as the pianist strikes each note, adjusts the output volume accordingly and produces a note which decays in amplitude in a manner similar to a hammer action instrument.

The instrument has other features which make it attractive. Firstly, it is extremely compact and can readily be accommodated in the smallest living room. Secondly, the volume can be set to any desired level so there need be no inconvenience to neighbours — alternatively, headphones can be used.

General Instrument Microelectronics has no plans to produce an electronic piano itself but plans to sell these microcircuits to electronic organ manufacturers.

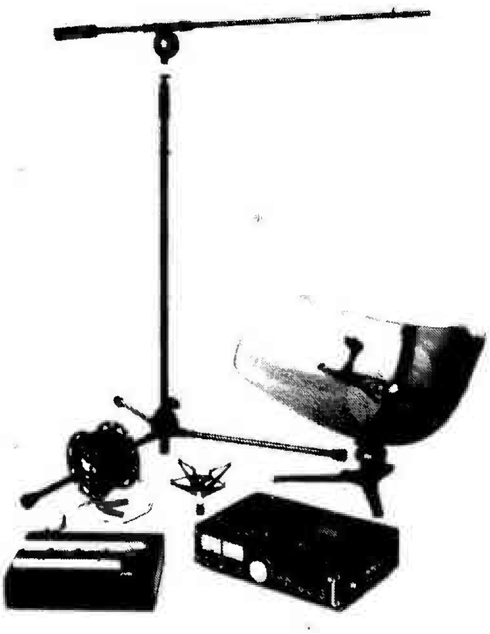
Technical Description

The MOS microcircuit, incorporates 12 separate envelope generation circuits, for octave tones and semi-tones. Thus a five octave instrument would require no more than five 40 pin dual-in-line devices of this kind.

Key velocity or touch is sensed by a switching arrangement which connects the input circuitry to the negative supply in the rest position and to the ground when the key is fully depressed. An on chip timer is initiated by removal of the negative supply and stopped when the key is grounded. The time to change state is thus inversely proportional to the key velocity and can be used to control the output volume.

The output from each keying circuit is a square wave of the required fundamental frequency. This is shaped by external voicing circuits to produce a piano like tone. The characteristics of the external voicing circuits are defined by the manufacturer and his skill in specifying them determines the eventual sound produced by the electronic piano.

BIG PRIZES FOR NATURAL HISTORY RECORDISTS



More than £500-worth of JVC 'sound safari equipment, including the model 1635 Mk II portable stereo cassette deck, is top prize in 3M's annual Scotch Wildlife Sound Recording Contest

Top prize in 3M's Scotch Wildlife Sound Recording Contest for 1977 is more than £500-worth of JVC "sound safari" recording equipment.

Entrants have until the end of October to record the sounds of the countryside for entry in the competition. There are classes — catering for both experienced and novice amateur recordists — for birds, mammals/insects, and outdoor habitat recordings, and special awards for the most original recordings, the best entry originating on cassette, and the best stereo entry.

The JVC prize, for the 3M Wildlife Sound Recordist of the Year, comprises a model CD-1635 Mk II portable stereo cassette deck with Super ANRS noise reduction; transparent collapsible parabolic reflector for accurate sound focusing; super-directional/uni-directional electret condenser microphone (worth £102) complete with multi-way boom stand and microphone suspension unit and 20 metres of stereo cable.

The 75W Monitor MA4 speakers will go to the entrant submitting the most original recording, and a pair of K.240 dynamic stereo headphones from AKG to the recordist with the best stereo entry. For the best recording originating on cassette there's 50 C90 Scotch High Energy cassettes. Each class winner receives a valuable prize and there are prizes for runners-up.

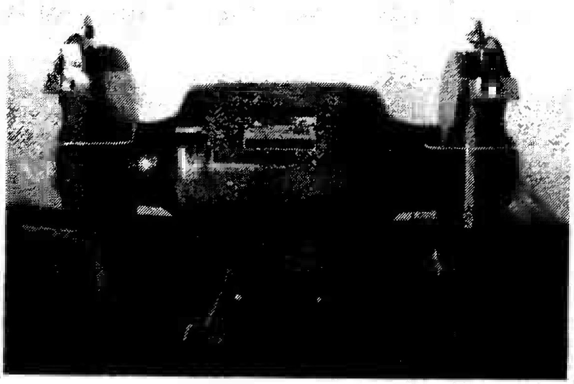
Rules and entry forms are available from Bill Bowles, Recording Materials Division, 3M United Kingdom Limited, 380/384 Harrow Road, London W9 2HU. There is no entry fee.

CO-DISCOVERER OF THE LASER AWARDED 1977 MARCONI INTERNATIONAL FELLOWSHIP

On April 25th in Stockholm, King Carl Gustav XVI of Sweden presented the $25,000 1977 Marconi International Fellowship to Professor Arthur L. Schawlow of Stanford University. Dr. Schawlow is the co-discoverer of the laser.

Dr. Schawlow was born in Mt. Vernon, New York. He moved to Toronto, Canada, at an early age and it was there he began his scientific studies. His research has been in the fields of optical and microwave spectroscopy, nuclear quadrupole resonance, super conductivity and lasers. In 1955, with C. H. Townes, Nobel laureate, he was co-author of "Microwave Spectroscopy" and in 1958 they published the first paper describing optical masers, which are now called lasers.

ELECTRIC BENCH GRINDER



This electric bench grinder is designed for the professional and "Do it Yourself" user. It incorporates a ¼ H.P. single or three phase motor with condenser starting and is fitted with two 6″ grinding wheels, one coarse and one fine, a safety pull/push on/off switch, safety plastic eye shields and the whole machine is built on generous and robust lines. The price is £45 plus £3 packing and carriage plus V.A.T. and is outstanding value for money. Further details from: Hadley Sales Services, 112 Gilbert Road, Smethwick, Warley, West Midlands B66 4PZ.

TWO INTERESTING RALLIES

- Northern Mobile Rally — 22nd May, 11.30-18.30 hrs at The Victoria Park Hall, Keighley, Yorks. Organised by the Otley Radio and Electronics Society.
- East Suffolk Wireless Revival — 29th May, 1100-1600 hrs at Civil Service Sports Ground, Straight Road, Bucklesham, Ipswich (near the Suffolk Show Ground). Organised by the Ipswich and Martlesham Radio Clubs.

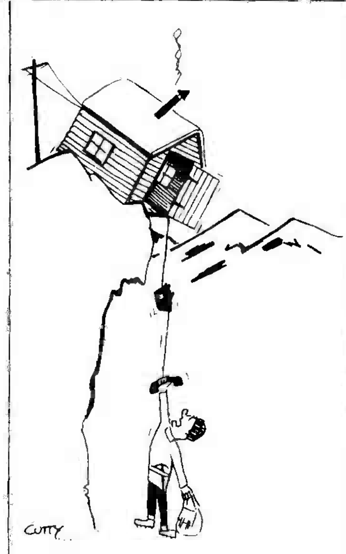
MOTOROLA RATIONALISES SEMICONDUCTOR RANGE IN IN EUROPE

In the last ten years, the well-established Motorola development programme has resulted in the design and introduction of hundreds of new devices each year. In Europe, this standard product range has included over 15,000 device types which, to many users and buyers, has often presented an overwhelming choice.

As a result of recent market research, Motorola Semiconductors in Europe have determined that 4,000 devices — now known as "preferred product" — will meet the vast majority of customers' needs. All Motorola product categories are fully represented and all potential applications should be covered by at least one device type.

Commenting on this announcement Piero Martinotti, Motorola's European Director of Marketing, said: "For some time I have felt that we have been making the end-user's life more difficult than it need be, by asking them to choose their requirements from too many thousands of semiconductor devices.

This product line-up of 4,000 devices has been published in a new catalogue, "The European Selection" and is available free-of-charge from Motorola distributors.



"I am hanging on!"

SUGGESTED CIRCUIT

UNIVERSAL BATTERY CHECKER

By G. A. French

It is often desirable, with battery operated test equipment, to have some means of checking the battery voltage. If this is not done it is possible for the battery voltage to fall to a level at which the test equipment gives a false or misleading performance, with the user being unaware that this is happening. For economic reasons it is usually undesirable to have a voltmeter built into the test equipment, and it is also undesirable to have a voltage indicating device which continually draws current unless that current is exceptionally low.

The battery voltage checker to be described in this article can be fitted in any item of battery equipment having a nominal battery supply voltage of 6 to 15 volts, and it can be pre-set to cause a light-emitting diode to be illuminated, at the press of a button, when the battery voltage has fallen to the critical level for the particular equipment concerned. Current is drawn from the battery only when the button is pressed. The l.e.d. cannot light up when the battery voltage falls to less than about 1.8 volts but, at such a low voltage, the performance of the equipment can be expected to be so poor as to automatically indicate an excessively low supply potential. Typically, the circuit would be set up such that the l.e.d. will light up when a 6 volt supply has fallen to 4 volts, a 9 volt supply to 6 volts and a 12 volt supply to 8 volts. However, any other voltage within reason can be chosen as that at which the l.e.d. becomes illuminated. An important feature is that the range of battery voltages between that at which the l.e.d. just ceases to be extinguished and that at which it lights up fully is very narrow.

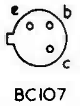
Apart from the push-button and the l.e.d., the circuit requires only two low cost transistors, a diode, three fixed resistors and a pre-set skeleton potentiometer.

CIRCUIT OPERATION

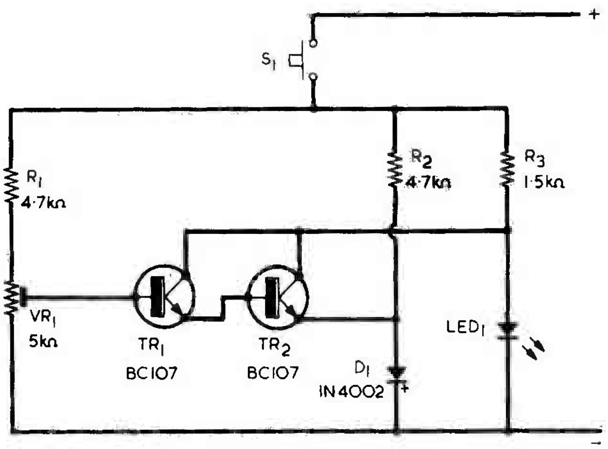
The circuit of the battery checker appears in the accompanying diagram and functions essentially by having a pair of transistors, TR1 and TR2, control the current available for a light-emitting diode. This is not a new idea and has been used in this journal in an earlier article ("Car Battery Monitor" in the February 1977 issue). In the present application the scheme has been developed to enable a wide range of voltages to be catered for, to give rapid switch-on of the l.e.d. with falling voltage and to offer a high degree of simplicity and economy in components.

Let us assume that the nominal battery supply voltage applied to the circuit is 9 volts and that the sensitivity control, VR1, is adjusted such that the l.e.d. will light up when that voltage has fallen to 6 volts. Push-button S1 is pressed whenever it is desired to make a check of the voltage.

For battery voltages above 6 volts a bias current flows from the slider of VR1 to the base of TR1, causing an



BC107 Lead-outs



The circuit of the battery voltage checker. This is connected across the positive and negative supply rails of the battery powered equipment in which it is installed amplified emitter current to flow into the base of TR2. TR2 provides further current amplification and a proportionately high current flows through R3, causing the voltage across LED1 to be below that at which it lights up. If we assume a forward voltage drop of 0.6 volt across a silicon p.n. junction, the voltage at the base of TR1 under these conditions is 1.8 volts. This is given by the sum of the series voltage drops in the base-emitter junctions of TR1 and TR2, and in diode D1. The collector-emitter potential of a conductive silicon transistor is of the order of 0.1 volt, and this voltage will appear between the collector and the emitter of TR1, whereupon the voltage across the l.e.d. becomes the sum of the collector-emitter voltage of TR1 (0.1 volt), the base-emitter voltage of TR2 (0.6 volt) and the voltage across D1 (0.6 volt), giving a total of 1.3 volts. This, incidentally, is the measured voltage given in practice with the prototype circuit and is too low to allow the l.e.d. to become illuminated.

If the battery voltage falls close to 6 volts the voltage at VR1 slider drops to slightly more than 1.8 volts. When the battery voltage is exactly 6 volts the voltage at the slider of VR1 becomes just too low to keep TR1 and TR2 fully turned on, and the voltage across the l.e.d. rises to around 1.5 volts. The l.e.d. gives a glow which is just discernible. As battery voltage falls further the glow in the l.e.d. rises rapidly in brilliance until it glows at its maximum brightness level, this condition corresponding to TR1 and TR2 being completely cut off. When the author's circuit was set up for 6 volts the l.e.d. was more than adequately lit at a battery voltage of 5.95 volts and was at maximum brightness at 5.85 volts.

Should the battery voltage decrease further, TR1 and TR2 remain cut off and the l.e.d. continues to be illuminated. The l.e.d. extinguishes when the battery voltage reaches a very low level well below 2 volts.

Similarly abrupt illumination of the l.e.d. with falling battery voltage is given at other settings of VR1. If this control is adjusted such that the l.e.d. just glows at 4 volts, it is adequately lit at 3.9 volts and fully lit at 3.8 volts. The corresponding voltages for 8 volts are 7.95 and 7.8 volts, and for 12 volts are 11.9 and 11.7 volts.

Thus, battery voltage in the equipment in which the circuit is fitted is checked by pressing S1. If there is then no glow in the l.e.d., battery voltage is above the critical level. Should there be a slight glow the battery voltage is at the pre-set level and if there is a bright glow the voltage is below that level.

OPERATING SPEED

The speed with which the circuit responds to falling battery voltage is boosted by the presence of D1 and R2. If the emitter of TR2 were returned directly to the negative rail the slider of VR1 would need to be adjusted to a lower setting along its track, whereupon a smaller fraction of the battery voltage would be applied to the base of TR1. In consequence the rate of change of TR1 base voltage with respect to falling battery voltage would be lower. Also, the presence of D1 results in the voltage across LED1, when it is extinguished, being only slightly below that at which it commences to glow. Resistor R2 causes a current to be maintained in D1 when the current due to the transistors reduces. In practice it provides a small but significant improvement in performance.

The current drawn by the circuit when the button is pressed varies with battery voltage. At 6 volts it is approximately 5mA, at 9 volts 7.5mA, at 12 volts 10.5mA and at 15 volts 13.5mA. Due to the action of the circuit there is little change in current consumption between the states when the l.e.d. is extinguished and when it is lit. These current consumption figures should not be excessive for most conventional items of test equipment.

The components are all readily obtainable. S1 is a push-button switch which closes when pressed, and R1, R2 and R3 are ¼ watt 5% resistors. VR1 is a standard size skeleton pre-set potentiometer having a rating of 0.15 watt or more. It can have a value of 4.7k Ω, if this is easier to obtain. Should it be desired to employ gain selected transistors, TR1 and TR2 can be BC107B or BC107C. The latter may give a slight increase in the rapidity with which the l.e.d. lights up as battery voltage falls. D1 is an ordinary silicon rectifier. LED1 can be any small red l.e.d. having a panel-mounting bush, and the author employed a Type 4 red l.e.d. obtainable from Doram Electronics. With this l.e.d. the anode lead-out (which connects to R3) is shorter than the cathode lead-out.

When the checker has been assembled, VR1 has to be set up. A voltage equal to that at which it is desired that indication should be given is applied to the circuit, this voltage being monitored by a testmeter switched to an appropriate volts range. VR1 is then adjusted such that the l.e.d. just glows. The circuit is installed in the test equipment with S1 and LED1 mounted on the front panel and the remaining components at any convenient position inside.

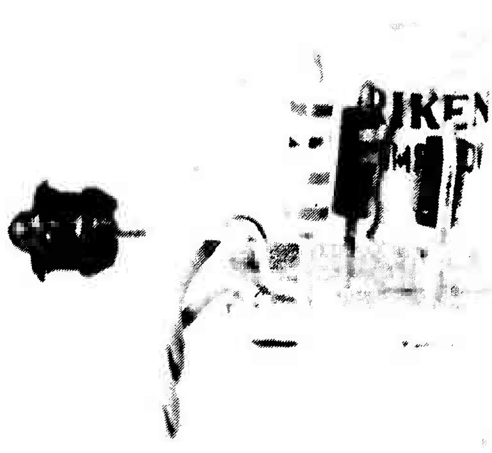
There is a very slight risk that if the forward voltage drops in TR2 base-emitter junction and the diode are at the top of their spread the l.e.d. will not be fully extinguished when the battery voltage is above the critical level. The writer checked the circuit with a number of transistors as well as several silicon diodes and no problems on this score were evident at all. In consequence it is very unlikely that the risk, which must of course be mentioned when discussing the circuit, will be encountered in practice. ■

SWITCH-OFF PILOT LIGHT

by A. P. Roberts

This simple circuit acts as a turn-off reminder by causing an l.e.d. to flash when the equipment in which it is installed is switched off.

When using battery operated equipment such as signal generators or electronic voltmeters, etc., there is always a risk of the apparatus being inadvertently left switched on unless some form of pilot light is fitted. The current consumption of an ordinary filament bulb is far too high for one of these to be used as an indicator with most equipment. On the other hand, light-emitting diodes have relatively low current requirements and are sometimes employed for this purpose. Even so, these require a current of at least several milliamps, which can be considered excessive with battery prices at their current high level.



Side view of the completed light assembly. The twisted leads connect to the supply rails of the associated equipment

Occasionally a flashing pilot lamp is used, and this has the advantage of consuming power at a significant rate only while the pilot light is on. If a charge storage circuit is used to provide the flash there is also a continual but very small current consumption.

A third and more novel method is available, and has been described in two previous articles in this journal. With this method, negligible current is consumed whilst the equipment is switched on, but a light flashes when it is turned off. In the first article, "Switch-Off Flasher" by S. A. Thomas in the February 1971 issue, the flashing light was a filament bulb. The second article, "Switch-Off Reminder" by T. Miles in the issue for August 1976, brought the idea up to date by having an l.e.d. flash instead of a filament bulb. In addition to their very small current consumption, the advantage behind these schemes is that there is a positive effect when the equipment concerned is switched off. Turning off an item such as an electronic voltmeter does not normally produce any perceptible result. If, however, the process of switching off the equipment causes a visible effect there is a psychological link in the mind which associates the effect with the act of switching off, and there is less likelihood of the equipment being left on.

ON-OFF SWITCH

The circuits given in the previous articles required that the single throw on-off switch incorporated in the equipment be changed for a double throw type. The circuit to be described here requires no alterations to the existing on-off switching arrangements, and it is simply wired across the supply lines of the equipment to which it is fitted. Since it is impossible to predict its performance with all items of equipment the circuit has to be considered as being in the experimental category, and constructors are advised to check it out

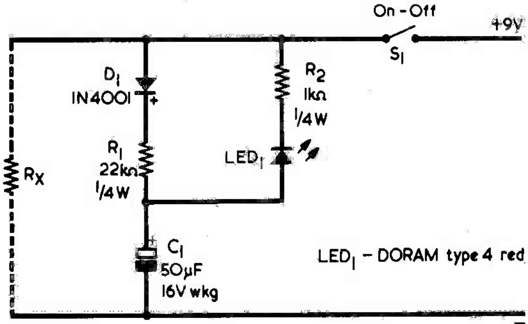


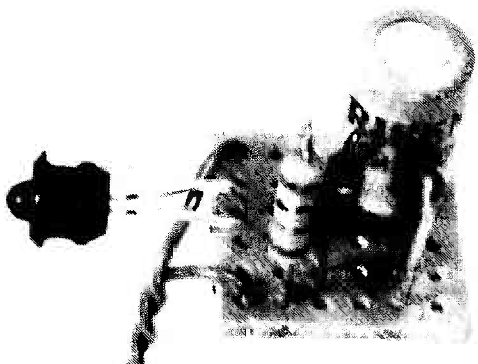
Fig. 1. The circuit of the switch-off pilot light. S1 is the existing on-off switch in the equipment, and RX represents the equipment circuit

in a temporary "lash-up" form before fitting it permanently into the equipment for which it is intended. In general the circuit should operate satisfactorily with any item whose current consumption is in excess of a few milliamps.

The circuit of the switch-off pilot light appears in Fig. 1. In this diagram S1 is the existing on-off switch whilst RX represents the equipment circuit which draws current from the battery. A 9 volt battery is assumed but the circuit will also function with a 6 or 12 volt supply. As can be seen, the pilot light components are connected across the supply rails after the on-off switch.

When S1 is closed, C1 charges up quickly via D1 and R1. The initial pulse of charging current, which at the outset is only about 0.4mA, soon ceases, after which the only current drain is a minute leakage current in C1. At the instant of switch-on the battery voltage appears as a reverse voltage across LED1. The l.e.d. specified is capable in practice of withstanding this voltage. After C1 has charged, the only voltage across LED1 and R2 is the 0.6 volt forward voltage dropped across D1.

At switch-off the 9 volt supply is disconnected, whereupon C1 discharges via LED1, R2 and RX. If RX is sufficiently low the result is a brief but visible glow in the l.e.d. If S1 is closed once more, C1 recharges, and the l.e.d. will again flash when the switch is opened.



Another look at the assembly. An idea of its very small size is given when it is appreciated that the Veroboard is of 0.1in. matrix

CONSTRUCTION

The circuit is assembled on a small piece of 0.1in. matrix Veroboard having 6 holes by 6 strips. The layout of this panel is shown in Fig. 2. There are no breaks in any of the copper strips.

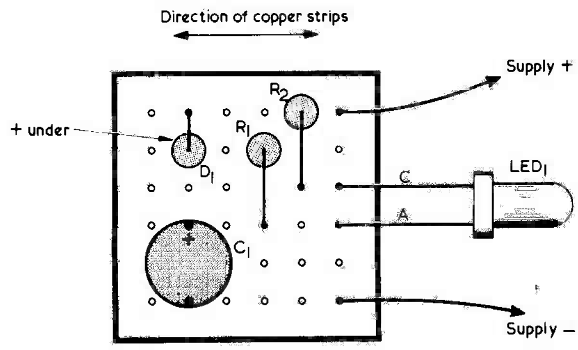


Fig. 2. The pilot light components are assembled on a Veroboard panel as illustrated here

Normally, it would be customary to first cut out the piece of Veroboard and then solder the components to it. In this case, however, due to the very small size of the board it will probably be found easier to wire in the components first at the corner of a larger board and then carefully cut away the excess.

The leads of LED1 are bent down at right angles before they enter the holes in the board. The l.e.d. can then be fitted to a front panel by means of its mounting bush, with the component board supported by its lead-outs. The Doram Type 4 l.e.d. is supplied with a mounting bush, and the shorter lead-out is that for the anode. Due to its small size it should not be found difficult to add the assembly to most existing pieces of equipment, even when the equipment is miniaturised.

There is some scope for experiment with component values. If the equipment draws only a very low current the flash in LED1 will be very dim or even non-existent. Under these circumstances it may be possible to increase the brightness by reducing the value of R2. This resistor should not be given a value lower than 150Ω. The duration of the flash will be lengthened by increasing the value of C1, which can have any capacitance up to some 500µF. As was stated at the beginning the circuit has to be treated as experimental, and the effects of changes in the values of R2 and C1 can be determined when it is initially checked in its temporary form, before the final assembly on the Veroboard panel.

SHORT WAVE NEWS
FOR DX LISTENERS

By Frank A. Baldwin

Times = GMT *Frequencies* = kHz

To provide a change of fare from the broadcast bands diet, the amateur band spreads have been visited to obtain a taste of the available Dx being dished up by prevailing conditions — and what a feast one can get at times!

As usual the choice of mode is cw, the first course being —

1.8-2.00 MHz (Top Band)

DJ6TK, DJ8WL, EI9J, F3AT, F8DB, GD3FXN, GI3JEX/P, GI6YM, GM3PFQ, GM3ZSP, GW3COI, GW3GWX, GW3KUY, HB9CM, ISOLYN, K2BQO, K2GNC, K4CYU, KV4FZ, LU1BAR/W3, OE1TKW, OE5KE, OH1MA OH2BC, OH2BFJ, OK1ATP, OL4ATY, OL8CHI, PAOINA, PAOLOU, PAOTA, ST2AY, VE3BMV, W1BB, W1HGT, W1HND, W2DXL, W3BUR, W3JSX, W4PRO, YU3EY, YV10B, YV4BK, 9H1CG.

One can have a plateful of not-so-tasty QRM on the next serving but digestable morsels can be selected, such as —

7.0-7.1 MHz (Forty)

CE3AWY, CO2CM, CO5GV, CM7FM, EP2VW, FM7AZ, HC2LT, HI8MOG, KP4WL, KV4CI, KZ5EK, PP2JT, PY1NEW, PY2FDM, PY2GZY, PY3CMH, PY4AVM, PY5CO, PY7ADL, PY7CCZ, PY7CPB, PZ1AH, UD6DFF, UF6FBL, UI8ADM, UJ8JCI, UL7CT, UL7TBG, UM8BMV, VE1CD, VP2SAH, VP9HO, W3DAD, YV5AGS, YV7PF, ZL2AYP, ZS5AY, ZS6OH.

Without waiting, one can soon commence to devour the sweets of —

14.00-14.35 MHz (Twenty)

KG4MW, KP4ESP, KV4CI, LU8ADK, VP2SZ, VP8AI, VP9UT, YS10, 5Z4NI, 8P6AU.

From which once can gather that the writer is no gourmet of the last offering.

Coffee sir?

CURRENT SCHEDULES

● **PORTUGAL**

"Radiodifusao Portuguesa," Lisbon, presents an External Service in English to Europe from 1800 to 1830 daily on **6025** and **9740** and from Mondays to Saturdays inclusive on **15340** and **17880.**

● **JAPAN**

"Radio Japan," Tokyo, beams a service in English to Europe from 0800 to 0830 on **15325** and **15430** and from 1830 to 1900 on **7195** and **9605.**

● **TAIWAN**

The "Voice of Free China," Taipeh, schedules a programme in English to Europe, Africa and the Middle East from 2130 to 2230 on **9510, 9600, 11860, 15225** and on **17720.**

● **EAST GERMANY**

"Radio Berlin International — the Voice of the German Democratic Republic," Berlin, operates an External Service in which an English programme for Europe is at 1830 until 1915 on **6080, 6115, 7185 7300** and on **9730** and at 2115 until 2200 on **7260.**

● **SWITZERLAND**

The "Overseas Service of S.B.C.," Berne, features programmes in English for Europe and other target areas from 0700 to 0730 on **3985, 6165, 9535, 9560, 11775, 11950** and on **15305**; from 1100 to 1130 on **3985, 6165, 9535, 15140, 15430, 17830** and on **21520**; from 1315 to 1545 on **3985, 6165, 9535, 9735, 11745, 11870, 15140** and on **15430**; from 1530 to 1600 on **3985, 6165, 9535, 9590, 11870** and on **15430** and from 2100 to 2130 on **3985, 6165, 9590, 11720** and on **11870.**

● **SPAIN**

"Radiotelevision Espanola," Madrid, lists programmes in English to Europe daily (except Sunday) from 2030 to 2230 on **6100** and on **9505.**

● **NORTH KOREA**

"Radio Pyongyang" broadcasts in English to Europe daily from 2000 to 2150 on **3890, 6575** and on **9420.** An English programme to the Middle East and Africa is on the air from 1800 to 2000 on **3560, 6338** and on **9977.**

● **TUNISIA**

The Domestic National Programme from Tunis may be heard from 0430 sign-on to 2200, in Arabic, on **7275, 11970** and on **15225.** From 2200 until sign-off at 2345 the **7275** frequency is the only short wave channel in use.

● **INDIA**

"All India Radio," Delhi, radiates in English to the U.K., West Europe and Australasia from 2045 to 2230 in the General Overseas Service on **7145, 7225, 9525, 9912, 11620** and on **11740.**

● **CHILE**

"La Voz de Chile," Santiago, has programmes in English to Europe, the Middle East and the Americas from 2030 to 2050 and from 2250 to 2310 on **9566** and **15150**; from 0110 to 0150 and from 0210 to 0230 on **9566.**

● **PHILIPPINES**

"Radio Veritas," Manila, lists programmes in English from 0100 to 0200 on **11875** and **15280**; from 1400 to 1500 on **9645, 11780** and on **15260**;

"Radio Filipinas, the Voice of the Philippines," Malolos, has an English transmission to Europe from 1655 to 1855 (often variable) on **9580.**

"Far Eastern Broadcasting Company," Manila, can probably best be heard here in the U.K. during the following transmissions — English to S.E. Asia from 1215 to 1630 on **15440**; from 1400 on **11920**; from 2315 to 0230 to South and S.E. Asia, Far East and Australasia on **11890** (from 2315 to 0100); on **15235** (from 2345 to 0230); on **15440** (from 2330 to 2400).

AROUND THE DIAL

● **NORTH KOREA**

Radio Pyongyang on **6770** at 1435, local-type orchestral music, YL with song in Korean in the French transmission directed to S.E. Asia scheduled from 1400 to 1550.

Radio Pyongyang on a measured **9977** at 1600, announcements by OM and YL in commencement of the Korean Service to the Middle East and Africa, scheduled from 1600 to 1650.

Radio Pyongyang on a measured **6338** at 1855, YL with identification, orchestral and choral music in the English programme for the Middle East and Africa, scheduled from 1800 to 2000.

● **POLAND**

Warsaw on **11840** at 1205, OM in Italian to Europe, this programme being scheduled from 1200 to 1230.

● **ETHIOPIA**

ETLF Addis Ababa on **11910** at 2030 with identification and sign-off after the English programme for West Africa, scheduled from 1945 to 2030.

● **MADAGASCAR**

Radio Nederland (relay) on **11730** at 2114, OM in programme entitled "African Scene" in English to Africa.

Radio Nederland (relay) on **11740** at 1903, OM in Arabic to the Middle East, North Africa and Europe, scheduled from 1830 to 1950.

● **FINLAND**

Helsinki on **11755** at 1910, YL with interview in the English programme to Europe, the Middle East and West Africa, scheduled from 1900 to 1930.

● **SOUTH AFRICA**

Johannesburg on **11800** at 1953, interval signal, identification then French programme to West Africa and Europe, scheduled from 2000 to 2050, also in parallel on **11905.**

● **TURKEY**

Radio Ankara on **11880** at 1550, a programme of local music in the Bulgarian transmission scheduled from 1530 to 1600 on this channel.

● **GREECE**

Athens on **11730** at 1548, typical local music in the Greek programme for North America, scheduled from 1500 to 1550. Also logged on **11925** at 1847, similar programming.

● **SWITZERLAND**

Berne on **11870** at 1544, OM in the English programme directed to the Near and Middle East, Africa and Europe, scheduled from 1530 to 1600.

● **WEST GERMANY**

Cologne on **11905** at 1957, OM with identification and a newscast in the English programme to West Africa, scheduled from 1930 to 2000.

● **ISRAEL**

Jerusalem on **11630** at 1921, OM in Hebrew to Europe, South Africa and the Middle East, scheduled from 1800 to 1930.

● **KUWAIT**

Radio Kuwait on **9580** at 1858, YL with news of local affairs and events in English.

● **CHINA**

Radio Peking on **6860** at 2135, OM with a newscast to Europe in the English programme, scheduled from 2130 to 2230, also logged in parallel on **6270** and **7590.**

Radio Peking on **6560** at 2145, OM in the French programme directed to Africa and Europe, scheduled from 2130 to 2230.

Radio Peking on **7620** at 1909, OM in Hausa to West Africa, scheduled from 1900 to 1930 and also in parallel on **9900.**

Lanzhou on **4865** at 1416, OM and YL in a Chinese drama programme. The schedule is from 2150 to 0600 and from 0950 to 1600.

Radio Nanning on **4915** at 1414, OM in Chinese in a relay of the Home Service 1 programme from Peking. The schedule is from 2130 to 1600.

● **VENEZUELA**

R. Continente, Caracas, on **5030** at 0415, Latin American music with announcements in Spanish. Schedule is from 1000 to 0500 and the power is 10kW.

Radio Valera, Valera, on **4840** at 0400, OM with identification, sign-off with choral rendition of the National Anthem.

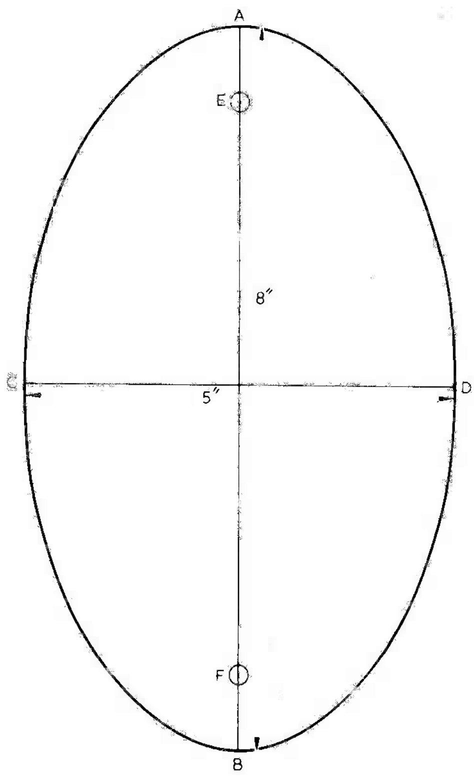
● **BOLIVIA**

Radio Riberalta on a measured **4696.5** at 0330, sign-off after station identification and National Anthem. (Acknowledgements to B. Walsh of Romford for this item).

ELLIPTICAL CUT-OUT MARKING

by V. C. Tondelier

An elliptical speaker merits an elliptical aperture. Here is a simple means of marking out the ellipse required.



Marking out an ellipse. In this example the ellipse is 8 by 5in., but the method can be employed for any other size of ellipse

The D.I.Y. enthusiast when making up his electronic equipment from components, is almost certain at some time or other to wish to cut an elliptical opening for a loudspeaker unit. How can he mark out a perfect ellipse of any desired size? True, there are complicated mathematical means of plotting the perfect ellipse; but how many people know the method? You don't have to. The answer to the problem is simplicity itself and can be achieved by anyone who can use a pencil and possesses a school ruler — it isn't even necessary to have a pair of compasses. All that is required (apart from the pencil and ruler) are two pins and a piece of thread and, if you haven't got compasses, a piece of cardboard.

MARKING OUT

Let us suppose you wish to mark out an ellipse measuring 8 by 5in. (the method is the same for any other size, the dimensions being adjusted accordingly). First you draw a vertical line 8in. long and a horizontal line 5in. long, each line bisecting the other at right angles. In the diagram these are lines AB and CD respectively.

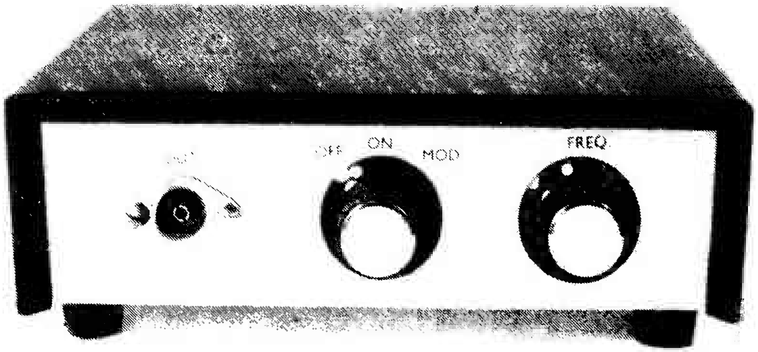
With your compasses set to mark a distance of 4in. (half the length of AB), strike an arc from point C (or point D — it doesn't matter which) so that it cuts the line AB at points E and F. If compasses are not available use a strip of cardboard about 6in. long and mark on it two points 4in. apart; one point is pierced to accept a pin while the other is pierced to take the point of a pencil: this is your compass.

Fix a pin at A and another at F, then tie a loop of thread so that it is taut between these pins. Next, shift the pin at A to point E, still keeping the thread over the two pins. You are now ready to draw your ellipse. Place the pencil point against the thread near the pin at E and, keeping the thread taut, follow the restricted outline which the thread allows until you reach B; then "change sides" and complete the ellipse from B to A.

Alternatively, the two pins could have been at B and E, with that at B transferred to F.

The writer can take no credit for originating this method, having encountered it in his schooldays. But the scheme is not generally known, and his main desire is to help others to wrestle successfully with this kind of problem. ■

CMOS



Crystal Calibrator

by R. A. Penfold

Single frequency crystal calibration generators offering a fundamental frequency and harmonics for the accurate calibration of short wave receivers are always of value to the amateur. The generator described in this article takes the process several steps further and incorporates a CMOS divider to give fundamentals at 1MHz, 500kHz, 250kHz and 100kHz. Another facility is the provision of a separate oscillator which can generate a 5MHz fundamental and can also be used for checking crystals.

Calibration of a home constructed short wave receiver can be something of a problem unless one possesses either an accurately calibrated r.f. signal generator or some form of spot marker generator. The latter provides outputs at numerous points throughout the short wave frequency spectrum, and is often crystal controlled so that a very high degree of accuracy is obtained. Because of its superior accuracy when compared with an average r.f. signal generator, a crystal controlled calibration oscillator is generally considered to be the most satisfactory instrument for use in short wave receiver calibration.

Such an instrument is also suitable for checking the calibration of even quite sophisticated commercially manufactured receivers.

The unit which forms the subject of this article is a relatively simple but nevertheless comprehensive crystal calibration oscillator having fundamental output frequencies of 100kHz, 250kHz, 500kHz and 1MHz. It has a harmonic output which extends beyond the upper frequency limit of the short wave spectrum (at about 30MHz).

In conjunction with an external crystal the unit can provide higher fundamental output frequencies. This is helpful in identifying the harmonics produced by the main circuitry, and it also enables the unit to be used in conjunction with a short wave receiver as a crystal checker.

OPERATING PRINCIPLE

The block diagram which appears in Fig. 1 shows the various stages which comprise the unit. The heart of the unit is the 1MHz crystal oscillator, and this has its output fed to a simple amplifier stage which ensures that there is sufficient signal amplitude to reliably operate the subsequent stage.

This is a frequency divider stage, but it does not provide a single division ratio. Instead, by using a CMOS presettable divide-by-N counter, it gives switched division ratios of 1, 2, 4 and 10. Thus, the combination of the single crystal oscillator and the divider stage enables fundamental output frequencies to be produced at 1MHz, 500kHz, 250kHz and 100kHz respectively.

An audio oscillator operating at a frequency of about 400Hz can be switched in to modulate the crystal oscillator. This is a helpful feature as it enables the marker signals to be easily and quickly picked out from any other signals which happen to be received during the calibration process.

When calibrating a newly constructed receiver, one problem that usually arises is that of determining the actual frequency of a harmonic. This is not usually a difficult matter on the lower frequency bands where the 1MHz marker signals are well spread out and the marker frequency is fairly obvious. However, on the high frequency bands even the 1MHz markers will be

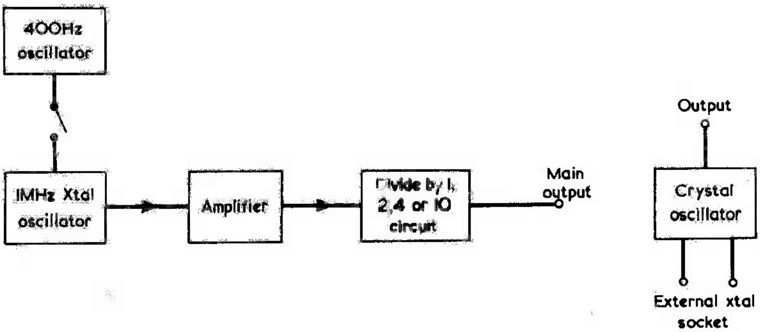
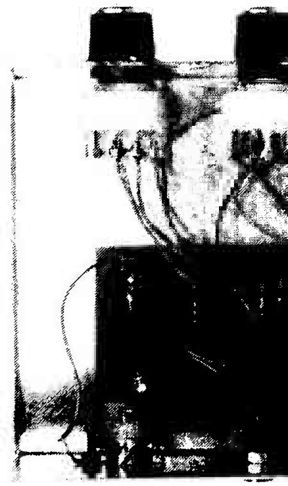


Fig. 1. Block diagram illustrating the various stages in the calibration generator



Inside the case, layout is ... ding of parts. The majori... are assembled on a per...

rather closely spaced around the dial of a general coverage receiver.

The unit has therefore been fitted with a second crystal oscillator which does not use an internal crystal. Instead, a crystal socket (or sockets) is provided at the rear of the calibrator. By plugging, say, a 5MHz crystal into this socket, calibration markers at 5MHz intervals will be provided. Even on the high frequency bands these signals will be sufficiently well spaced out for them to be recognised as a 10MHz signal, a 15MHz signal, and so on.

The idea is not to use these signals as calibration markers, but merely as signals which will enable the frequencies of the more accurate harmonics from the main calibrator to be identified. Since the separate oscillator will function with a wide range of crystal frequencies, it can also be employed as a crystal checker.

THE CIRCUIT

The complete circuit of the calibration oscillator is given in Fig. 2. In this, TR2 appears in the main crystal oscillator stage, which is of the Pierce type. Trimmer C6 enables the oscillator to be set to precisely 1MHz, using a simple procedure which will be described later.

A phase shift oscillator incorporating TR1 provides the audio modulation signal. This signal is applied to the base of TR2 via R5 when S1(a) is in the "Mod." position. As the modulating voltage swings positive and negative the base current, and hence the collector current, of TR2 varies in sympathy. Despite its simplicity, this method of modulating the crystal oscillator is perfectly satisfactory for the present application.

The output of the 1MHz oscillator is coupled via C8 to TR3, which functions as a common emitter amplifier. The collector of this transistor connects directly to the clock input of IC1, a CD4018 CMOS divide-by-N counter. The clock input requires a signal having a peak-to-peak value which is virtually equal to the supply voltage and it is the function of TR3 to provide such a signal.

The CD4018 is a rather complex device and its method of operation will be described here in broad terms only. Many of its pins are unused in the circuit, and these are either left unconnected or are connected to the negative supply rail. The terminals which are of importance here are the clock input (pin 14), the data input (pin 1) and outputs not-Q1, not-Q2 and not-Q5 (pins 5, 4 and 13 respectively).

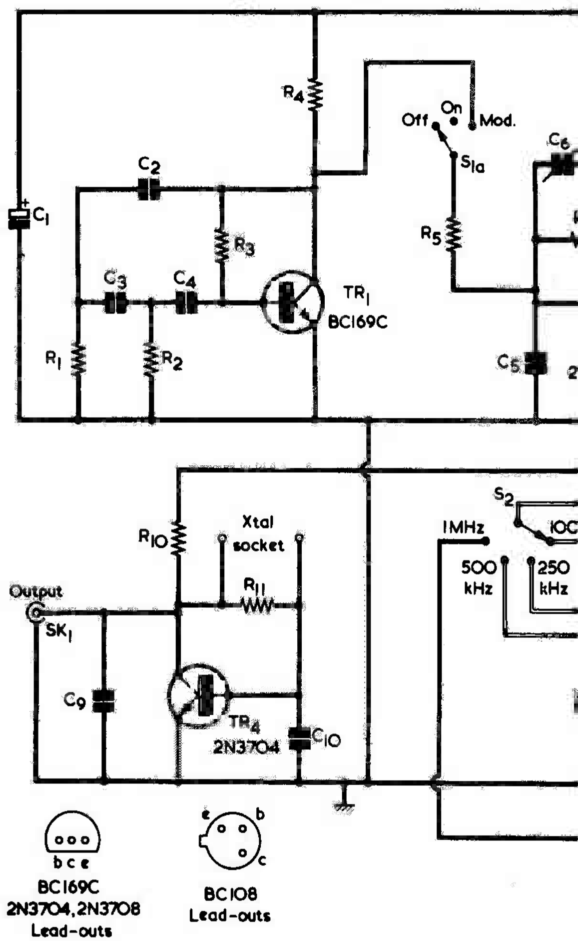


Fig. 2. The circuit of the CMOS crystal calibrator. T... quired for the outputs at 50...

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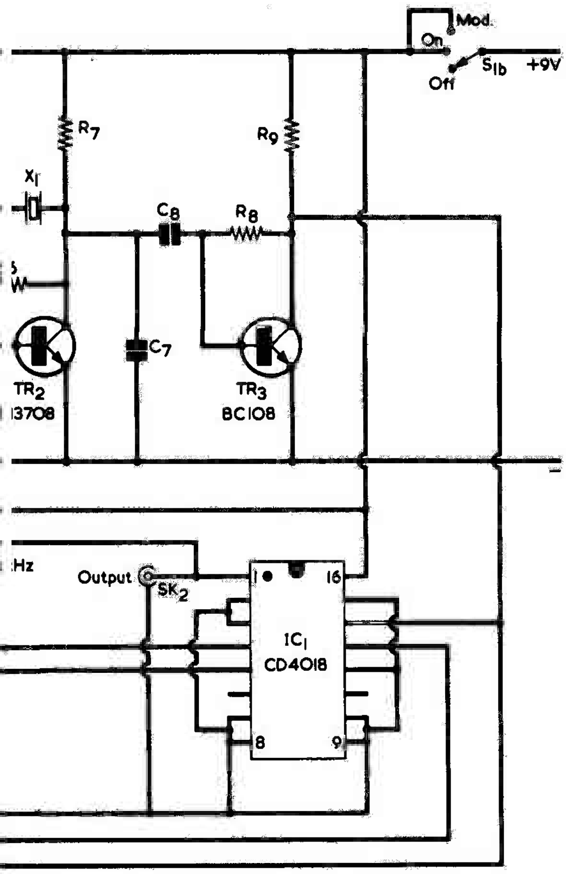


he CD4018 i.c. provides the frequency division re-
)kHz, 250kHz and 100kHz

COMPONENTS

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

R1 15k Ω
R2 15k Ω
R3 1.2M Ω
R4 6.8k Ω
R5 120k Ω
R6 560k Ω
R7 4.7k Ω
R8 1.2M Ω
R9 3.3k Ω
R10 2.7k Ω
R11 470k Ω

Capacitors
C1 4.7 or 5μF electrolytic, 10 V. Wkg.
C2 0.01μF type C280 (Mullard)
C3 0.01μF type C280 (Mullard)
C4 0.01μF type C280 (Mullard)
C5 470pF ceramic or silvered mica
C6 10-60pF ceramic trimmer
C7 150pF ceramic or silvered mica
C8 0.015μF type C280 (Mullard)
C9 150pF ceramic or silvered mica
C10 150pF ceramic or silvered mica

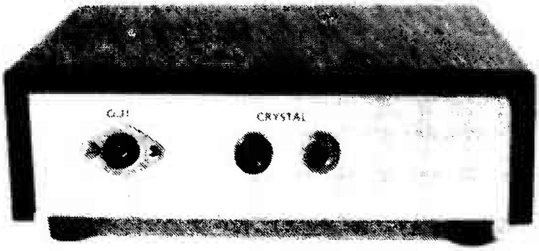
Semiconductors
IC1 CD4018AE
TR1 BC169C
TR2 2N3708
TR3 BC108
TR4 2N3704

Switches
S1 4-pole 3-way rotary
S2 3-pole 4-way rotary

Crystals
X1 1MHz crystal, HC6/U
Higher frequency crystal (see text)

Sockets
SK1 flush mounting coaxial socket
SK2 flush mounting coaxial socket

Miscellaneous
Instrument case type BV3
Battery type PP3 (Ever Ready)
Battery connector
Crystal holder, HC6/U
Crystal holder for external crystal (see text)
Plain perforated s.r.b.p. board, 0.1in. matrix
2 control knobs
4 rubber feet
Wire, solder, etc.



The rear panel of the unit. The output socket is for the subsidiary crystal oscillator, the crystal for which plugs into the sockets at the centre

S2 selects the desired division ratio, and when this is in the "100kHz" position the data input is coupled to the not-Q5 output. After every five clock pulses the not-Q output changes state and latches in that state, since it is connected to the data input, for the next five clock pulses. Thus, ten input cycles are required to produce one complete output cycle, and the i.c. functions as a divide-by-ten device.

With S2 in the "250kHz" position the data input is connected to the not-Q2 output and the output changes state with every two clock pulses, thereby giving a division ratio of four.

A division ratio of two is obtained with S2 in the "500kHz" position since the data input is connected to the not-Q1 output, which changes state with successive input pulses. In effect the i.c. is then functioning as a conventional flip-flop binary counter.

The i.c. has no effect when S2 is set to "1MHz" because the 1MHz output of TR3 is then connected direct to the output socket. The fact that the data and clock inputs of the i.c. are left connected to the output is of no consequence.

The final part of the circuit is the second crystal oscillator incorporating TR4. This is another conventional Pierce oscillator.

CONSTRUCTION

The calibrator is housed in a metal instrument case type BV3 having dimensions of 6 by 4¾ by 1¾in. This case is available from Bi-Pak Semiconductors.

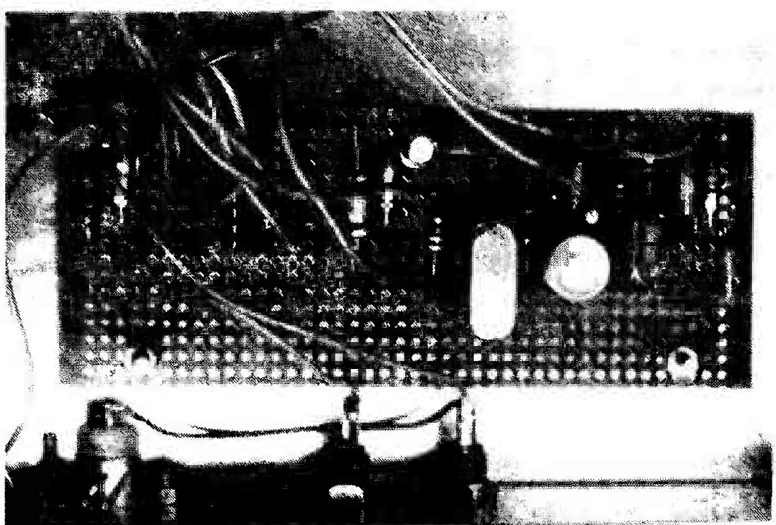
Reference to the accompanying photographs will reveal the general layout of the unit. On the front panel, S1(a)(b) is mounted in the centre with S2 to the right and SK2 to the left. Note that S1(a)(b) is a 4-pole 3-way switch with only 2 poles used and that S2 is a 3-pole 4-way switch with only 1 pole used. SK2 is a flush mounting coaxial socket. There should be adequate space between its left hand mounting nut and the adjacent case side to allow a PP3 battery on its side to be positioned between them.

SK1 is another flush mounting coaxial socket, and it is mounted on the rear panel opposite S2. A solder tag is fitted under its right hand securing nut. Also fitted to the rear panel is a crystal socket to take the crystal in the TR4 circuit. This should be of a type suitable for whatever crystal (or crystals) is to be employed here. If the unit is intended to have extensive use as a crystal checker in addition to its function as a calibration generator, several sockets of different type wired in parallel may be mounted on the rear panel. In the prototype two separate single sockets with spacing suitable for a 10X crystal were fitted.

All the small components are wired up on a plain perforated s.r.b.p. ("Paxolin") panel of 0.1in. matrix having 42 by 17 holes. Details of the component layout and underside wiring are shown in Fig. 3.

First cut out a board of the required size with the aid of a small hacksaw. Next drill out the two 6BA clear mounting holes. Two holes need to be slightly enlarged to take the crystal holder pins, which will normally be spaced by 0.5in. C6 is a small ceramic trimmer and its lugs pass through the holes indicated. A suitable trimmer is available from Doram Electronics, as also is an HC6/U crystal holder and 1MHz crystal.

The components are next mounted on the board and, apart from those of the crystal holder, all the lead-outs are bent flat against the board underside. With the i.c., some pins are bent inwards and some outwards, as shown in the diagram. No attempt should be made to bend the terminals of the crystal holder as, in most instances, these will be very rigid.



A closer look at the component board. The 1MHz crystal and its ceramic trimmer are mounted on this

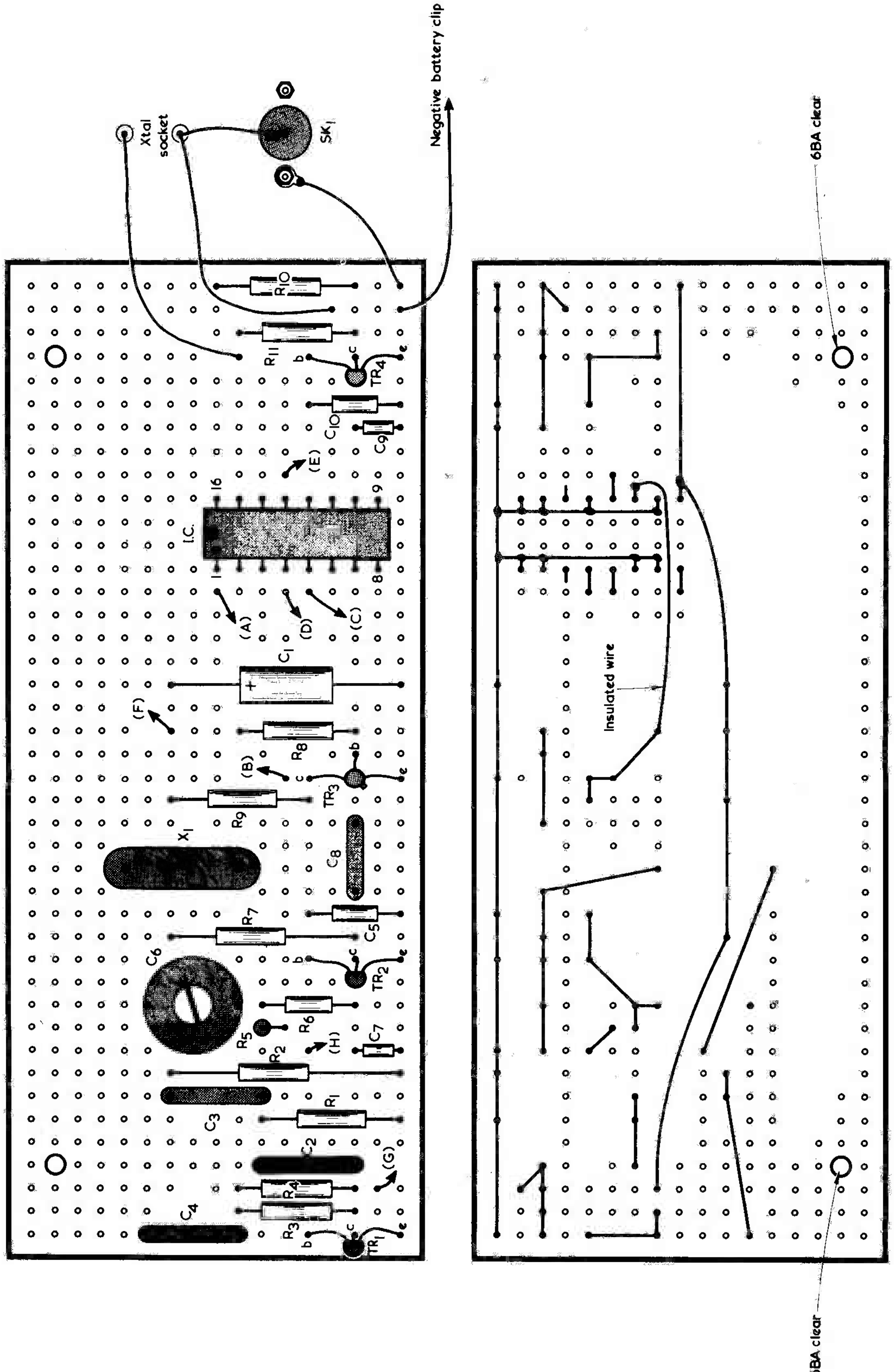


Fig. 3. The components are assembled on a plain perforated s.r.b.p. board. This diagram illustrates the component and wiring sides of the board

Next comes the wiring beneath the board. To prevent damage to the i.c. it is essential to use a soldering iron which has a reliably earthed bit. The wiring is carried out as shown in Fig. 3, tinned copper wire of around 22 s.w.g. being employed for long runs or where lead-outs are too short to reach their connection points. One wire on the underside has to be covered with sleeving, this being the wire between pin 14 of the i.c. and R8. Alternatively, a length of single strand p.v.c. covered wire may be employed.

The crystal holder is held in place by winding the connecting wire several times around each pin and then using plenty of solder on the joints. This will maintain the holder in position with adequate firmness. If the holder pins extend excessively beyond the solder joints they should be snipped short.

Flexible p.v.c. covered wires connect the board to the external components, and these are next added before the board is finally mounted in the case. The connections to the sockets on the rear panel are shown in Fig. 3. The chassis connection to the case is made via the solder tag under the securing nut for SK1. Fig. 4 shows the connections to the front panel components, the wiring to the switches here and in Fig. 3 being identified by the letters "A" to "H." Before wiring to the switches, confirm the outer tags which correspond to the inner tags by means of an ohmmeter or continuity tester. With some rotary switches their relative positioning may differ from that shown in the diagram.

Two 6BA clear holes are required in the base of the case for mounting the board. This is positioned, as shown in the photograph of the interior, with the i.c. and transistors nearer the front. There should be room for the PP3 battery between the front of the case and the front surface of the board; this battery is also shown in the photograph. The board is mounted by means of two 6BA bolts 1in. long with ¼in. spacing washers between the board underside and the case bottom to ensure that the wiring is well clear of the inside surface of the case. Four rubber feet are affixed with adhesive near the corners of the case underside. Finally to be fitted are the control knobs. With the prototype, legends taken from "Panel-Signs" Set No. 4 were applied to the front and rear panels to indicate control and socket functions. "Panel-Signs" are available from the publishers of this magazine.

The battery will be found to be a loose fit in its position behind the left hand end of the front panel. It may be held in place more securely by fixing a strip of foam rubber or plastic to the underside of the case lid at the appropriate place by means of adhesive. This will then keep the battery in position when the cover of the case is screwed on.

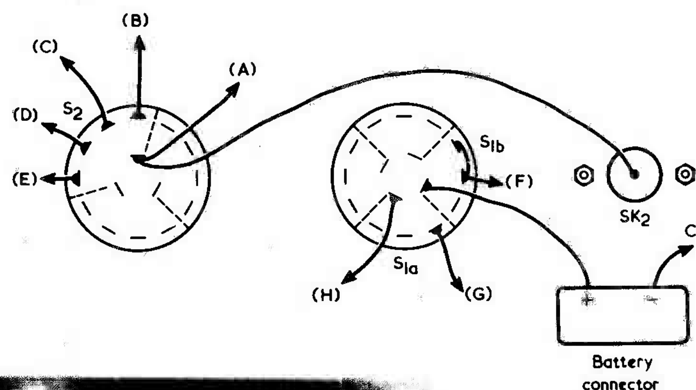
Battery life will be long, as the current consumption of the calibrator is only about 4mA.

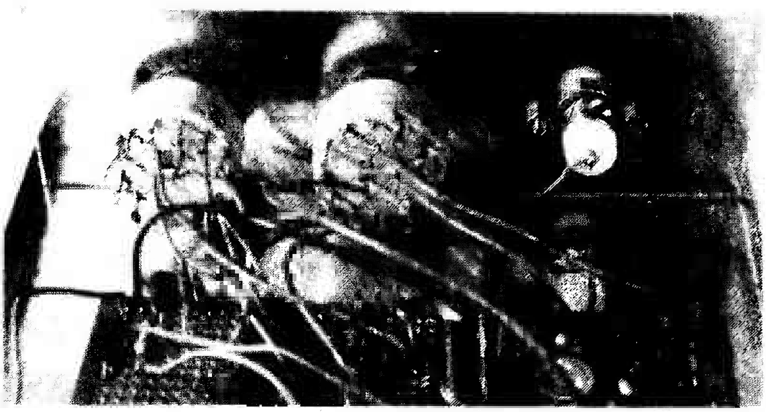
ADJUSTMENT AND USE

The only adjustment required is the setting up of C6 to bring the crystal frequency as close to 1MHz as is reasonably possible. What is probably the easiest way of carrying out the adjustment is to zero-beat the oscillator against the B.B.C. Radio 2 transmission on 200kHz (1,500 metres). The unit is switched on and S2 set to the "100kHz" position; then an unscreened lead from SK2 is placed near a receiver tuned to the Radio 2 transmission.

This set-up should produce a beat note from the receiver as the 200kHz second harmonic from the

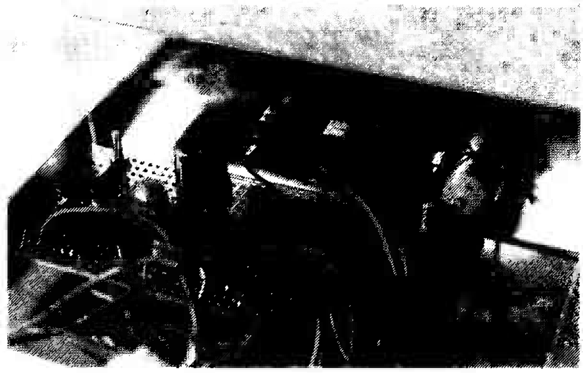
Fig. 4. Details of the wiring to the switches and to output socket SK2. These components are mounted on the front panel





Detail showing the wiring to the switches and main output socket

A View into the rear of the calibration generator

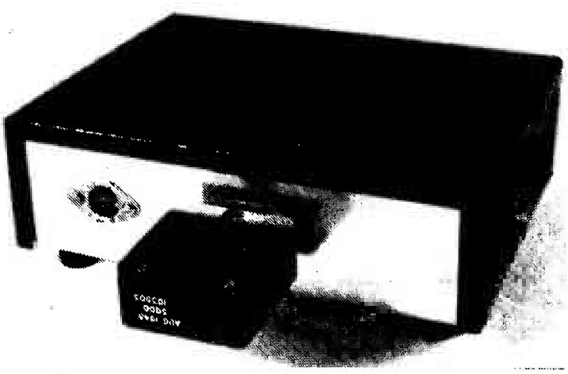


calibrator reacts with the 200kHz Radio 2 carrier. However, the beat note may be rather difficult to detect as it will only be at a very low frequency (possibly no more than a few Hz) and the output waveform of the unit is such that the even harmonics (200kHz, 400kHz, 600kHz, etc.) are not as strong as the odd harmonics (300kHz, 500kHz, etc.). It may help to vary the coupling between the calibrator and the receiver, and to reduce the strength of the Radio 2 signal. Since the receiver is almost certain to have a ferrite rod aerial, pick-up of the Radio 2 signal can be varied by rotating the set.

C6 is adjusted to produce the lowest beat note, and it should be possible to obtain a beat frequency of less than 1Hz. The calibrator is then ready for use.

When using the unit to calibrate a short wave receiver only a fairly loose coupling between the two should be necessary. One simple method of coupling is given by connecting a 12in. length of unscreened insulated wire to SK2 and a similar lead to the aerial terminal of the receiver. At the lower frequencies sufficient coupling should be given by placing the two leads close to each other, whilst at high frequencies it will probably be necessary to twist the wires together.

The unit will then provide marker signals at harmonics of whatever fundamental frequency is selected. Thus if the 1MHz fundamental signal is selected, harmonics at 2MHz, 3MHz, 4MHz, and so on to beyond 30MHz will be received. The unit can therefore be used to provide calibration points at 100kHz, 250kHz, 500kHz and 1MHz intervals.



Here, a 5MHz crystal is inserted into the sockets on the rear panel

When calibrating a receiver it is normally best to start by marking in the calibration points on the dial at whole numbers of MHz, and then use the lower fundamental frequencies to enable intermediate points to be marked in. On the lower frequency bands it will probably be possible to calibrate the dial at 100kHz intervals, but it will usually be found that on the higher frequency bands the dial calibration becomes too cramped to permit this. The 250kHz and 500kHz signals can then be employed.

As was mentioned earlier, it can often be a problem to determine the actual frequency of a harmonic when calibrating the higher frequency bands of a short wave set. In some cases, transmissions of known frequency can help, but in most instances it is more convenient to use the second crystal oscillator in the calibrator.

In the author's unit a 5MHz crystal is plugged, when required, into the socket on the rear panel, and this provides harmonics at SK1 of 10MHz, 15MHz and so on. These are sufficiently well spaced out on the receiver dial for their frequency to be readily assessed. No attempt is made to trim this second crystal to precisely 5MHz, as it does not matter if its frequency is very slightly removed from the more accurate harmonic of the main 1MHz crystal.

Also, it is not necessary to employ a 5MHz crystal, and any crystal having a frequency around 5MHz will be satisfactory. If, for example, a 5.7MHz crystal is used, its second harmonic of 11.4MHz can be located on the receiver. The 1MHz signal from the calibrator can then be coupled to the receiver, after which the set is tuned higher in frequency until the first 1MHz harmonic is found. This will be the 12th harmonic, at 12MHz. The harmonics above must then be 13MHz, 14MHz, etc., and those below it 11MHz, 10MHz and so on. As can be seen, any crystal having an operating frequency of around 5MHz can be used, provided of course that its actual operating frequency is known.

The coupling between SK1 and the receiver can be the same as was just described for the output at SK2, this applying both for the crystal fundamental frequency and its harmonics.

Since the second oscillator will operate with any reasonably active crystal having a frequency between several hundred kHz and around 10MHz, it can be used in conjunction with a suitable receiver to test crystals which fall within this frequency range. It is merely necessary to plug in the crystal, switch on and loosely couple the output from SK1 to the aerial terminal of the receiver. The receiver is then tuned around the nominal crystal frequency whereupon, if the crystal is serviceable, it should be possible to pick up the oscillator signal. ■

The Beginnings of Electricity

by D. P. Newton

The birth of the Battery, Capacitor, Resistor and Inductor

THE ORIGIN OF THE BATTERY

As is often the case, Nature anticipates man in his discoveries. In this instance, Nature equipped the electric ray or torpedo fish of Fig. 1 with its own power supply millions of years before man existed, but man was quick to take advantage of this natural power station. The Romans used it to "cure" gout by standing the sufferer barefoot on the live fish; surely one of the earliest examples of electrotherapy.

Fifteen hundred years later, John Walsh (c1725-1795) used the torpedo fish in an electrical circuit, as in Fig. 2. As the final person in the line dipped his hand in water, they all received a shock.

However, this set men like Luigi Galvani (1737-1798) on the wrong track. In his well-known experiment with frogs' legs he noticed that they twitched when an electrostatic generator was used nearby and he thought he had discovered "animal electricity." This special kind of electricity was to be found only in animals and was different to all other kinds of electricity. And so he missed the point of another experiment which must be the first low-voltage make and break device. A frog's leg is suspended over a silver plate as in Fig. 3 so that the brass hook touches the plate as well as the toes of the dampened leg. The leg twitches repeatedly, jumping up and down on the plate. He failed to see that it was the contact of the two dissimilar metals which generated electricity. The frog's leg simply completes the circuit and its muscles contract as electricity passes through, causing it to leap and break the circuit. However, Galvani's nephew travelled over Europe popularising his theory. In Newgate prison he passed current through a fresh corpse and made it jerk and twitch; and so we have the phrase "galvanised into action" to remember him by.

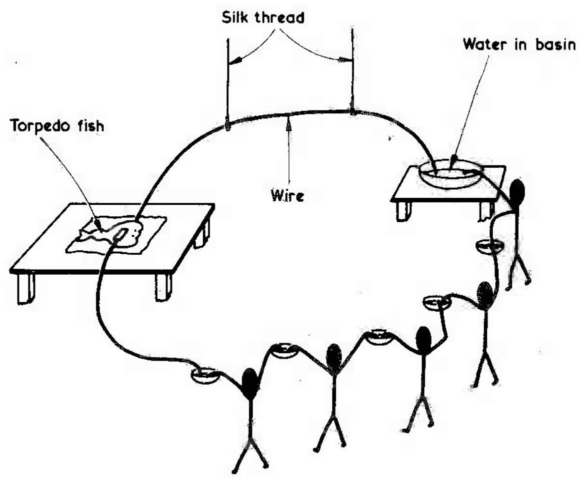


Fig. 2. When the last person in the chain places his hand in water, all the people receive a shock

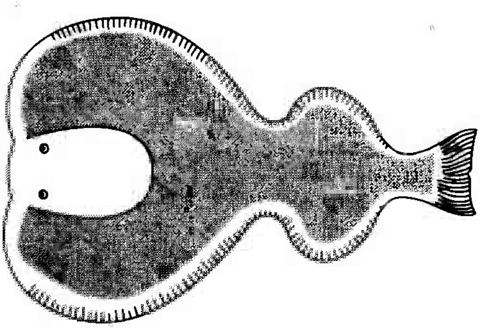


Fig. 1. Nature's power supply. This is the electric ray or torpedo fish

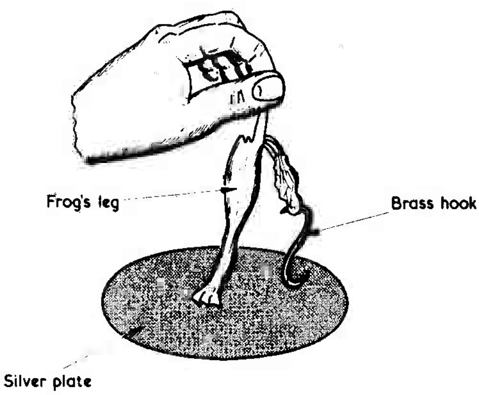


Fig. 3. Galvani's famous frog's leg experiment

A contemporary of Galvani was Alessandro Volta (1745-1827) who, fortunately, did not make Galvani's mistake. Seeing that electricity was generated by the contact of dissimilar metals, it was simply a matter of using a silver and brass coin as in Fig. 4 to produce a voltage.

To convince people that this was the same electricity as could be obtained by other methods, he had a series of demonstrations, of which some do not bear repeating. One was simply to place dissimilar coins over and under the tongue so that they touched in front. A strange taste was produced which we now know to be due to electrolysis. However, another experiment was not so innocuous. Placing tin-foil *under* the eyelid so that the edge protruded, he touched it with a silver candlestick and "saw" flashes of light as the current passed along the optic nerve.

To increase the voltage, batteries of stacked cells soon developed, known as voltaic piles. The Royal Institution of London made a battery in 1819 from 2,000 double plates of zinc and copper with dilute nitric and sulphuric acid as the electrolyte. From this, many discoveries in electrolysis were made, including new chemical elements.

The standard modern dry battery differs but little. Two dissimilar materials are separated by a paste-like electrolyte which contains a chemical to absorb any gases given off. And so we have caught up with Nature.

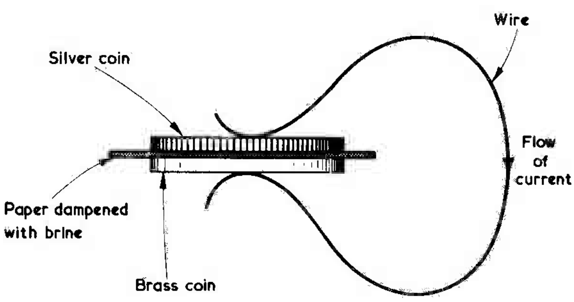


Fig. 4. A simple cell is produced by two dissimilar metals and an electrolyte

THE ORIGIN OF THE CAPACITOR

Electricity has always intrigued amateurs and professionals alike and it was quite often the amateur who made the important invention or discovery. E. G. von Kleist, a Prussian clergyman, was such an amateur from before the days of the battery. In those days, electricity was thought of as a liquid so, in 1745, von Kleist decided to "condense" and trap it in a bottle to store it for future use. He could not know how successful this would be or what an indispensible contribution to electronics he was about to make.

Into a bottle he placed a small amount of water and a nail, as in Fig. 5. Then he passed a charge in from an electrostatic generator. On touching the nail he obtained a shock and so he knew he had "filled" the bottle with electricity.

Soon, others found that the water could be replaced by mercury, alcohol or lead shot and that these were more effective. A French scientist discharged such an electric phial, as it was known, through a line of monks from a local monastery to see them jump in unison. The other reactions of the monks is not recorded!

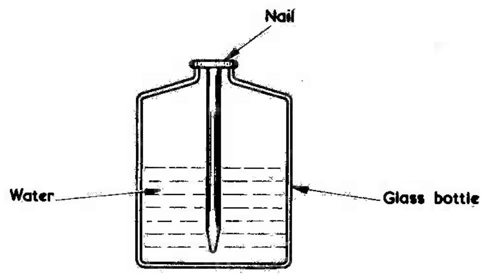


Fig. 5. An early device for "condensing" electricity

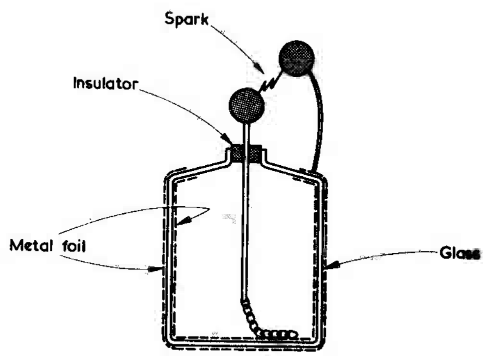


Fig. 6. A Leyden jar can produce a spark when it discharges

Pieter van Musschenbroek of Leyden, also in 1745, improved the condenser by lining the bottle inside and out with metal foil, as in Fig. 6. There are still a few of these Leyden jars about, used to store static charges from Wimshurst or van de Graaff generators.

The modern capacitor is but a short step from here. In the Leyden jar the two plates are the inner and outer layers of foil, separated by a glass insulator. By replacing the glass with plastic foil the condenser, or capacitor as it is now called, can be made into a small, convenient cylinder, like a Swiss roll. The thinner the insulator, the higher the capacitance and the greater the charge which can be stored. Electrolytic capacitors use an insulator which is created by electrolysis and need only be a few molecules thick. Such capacitors can have a very large capacitance.

Should you experiment with any of the earlier designs, take care! They can deliver an unpleasant, even dangerous shock, especially if used with a high voltage.

THE ORIGIN OF THE RESISTOR

The discovery of resistance was nowhere near as colourful as that of the battery and capacitor. It was Georg Simon Ohm (1787-1854) who made the decisive experiments which were to culminate in Ohm's Law in 1827, but earlier scientists had been near. Because the batteries of the time were somewhat erratic and irregular in e.m.f. and internal resistance, Ohm used a thermocouple as his constant voltage supply. See Fig. 7. The constant temperature difference between the two copper-bismuth junctions generates a small e.m.f. which causes a current to pass through the galvanometer G. Ohm connected wires of the same length but of different materials between X and Y and saw the meter reading alter. Hence resistance depended on the material used, a property we now know as resistivity. Similarly, with wires of the same material but differing in length, he showed that resistance was proportional to length. It was then a simple matter to show that increasing the thickness of the wire decreased the resistance.

With this basic, but essential, information wires of a known material and size could be coiled into resistors and, of course, these resistors were measured in ohms.

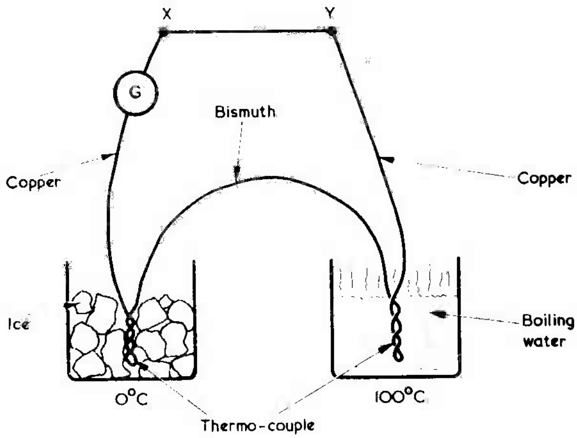


Fig. 7. The basic apparatus which was used to initially determine Ohm's Law

THE ORIGIN OF THE INDUCTOR

Another effect, given by a coiled wire, was not long in following Ohm's discoveries and was just about as prosaic.

When we disconnect a battery from a coil, such as in the primary circuit of an iron-cored transformer, a spark appears across the switch contacts as the circuit is broken. The odd thing about this spark is that even with a 1.5 volt cell it is far bigger, more intense and longer lasting than it should be for such a low voltage.

This peculiar spark was brought to the attention of no less a person that Michael Faraday in about 1834 by a William Jenkin, an amateur scientist. Although Faraday investigated the effect successfully, the credit must go to the American, Joseph Henry (1797-1878), whose exhaustive study showed that the spark was produced by the coil itself. As the circuit is broken, the coil appears to try to prevent the current dying away by developing its own, very large, back e.m.f. Large coils do this better than small ones, so we say they have the greater inductance.

Henry was able to show that the spark was oscillating, that is, it consisted of a to and fro movement of electricity between the switch contacts. This proved to be the foundation for the production of radio waves. The inductor, along with the capacitor, resistor and power supply became an indispensible part of radio and, naturally, inductance was measured in henrys. ■

BACK NUMBERS

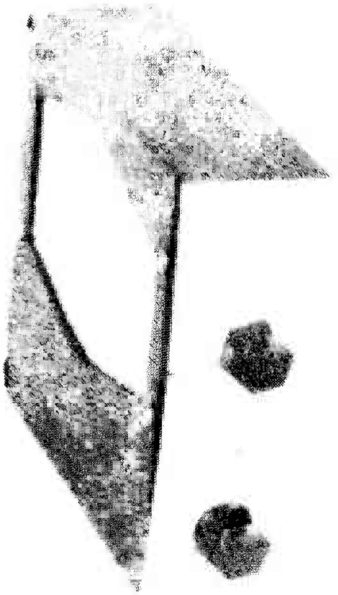
For the benefit of new readers we would draw attention to our back number service.

We retain past issues for a period of two years and we can, occasionally, supply copies more than two years old. The cost is 40p plus 11p postage.

Before undertaking any constructional project described in a back issue, it must be borne in mind that components readily available at the time of publication may no longer be so.

We regret that we are unable to supply photo copies of articles where an issue is not available. Libraries and members of local radio clubs can often be very helpful where an issue is not available for sale.

THE "M5"



POCKET RECEIVER

Part 2

By Sir Douglas Hall, K.C.M.G.

In this concluding article, constructional details of this pocket sized medium wave receiver are completed, after which the process of setting up is described.

In last month's issue, the preceding article introduced this medium wave receiver and described its circuit functioning. Preliminary constructional details were then given, and these will now continue. When following the instructions it will be necessary to refer to Figs. 2 and 3, which were published last month.

TAGSTRIP

Take up the 28-way tagstrip and cut a section with 8 tags away from it, leaving 20 tags. Drill out the last of these 20 tags, counting from the end of the strip with a hole in it. This will leave the strip with 19 tags and a hole at each end. It will be found that these holes fit over the two lower 1in. 4BA speaker mounting bolts, as in Fig. 3. Fit the tagstrip to these bolts with a 4BA nut above and below at each end. See Fig. 4(a). There is also a 4BA solder tag under the upper nut at the right hand end of the tagstrip.

Turn next to the output transformer T2 and, if this is the specified Repanco TT56 component, remove its clamp. As was mentioned last month, the author initially used an R.S. Components transformer type T/T7; if the reader has one of these transformers the clamp need not be removed. As can be seen in Fig. 3 the two secondary leads are connected directly to the speaker tags. In this view the two primary leads are underneath the transformer. Connect two short flexible leads to the upper (as in Fig. 3) primary lead and one short flexible lead to the lower primary lead. No connection is made to the centre primary lead. If applicable, tin the core of the transformer as described later in this paragraph then, with the transformer fully prepared, connect its secondary leads to the speaker tags. Take great care, during this operation, to ensure that no part of the transformer or its leads damages the speaker cone. Anchor the transformer in position by soldering its clamp (T/T7) or core (TT56) to the 4BA solder tag at the end of the 19-way tagstrip. With the TT56 it will be necessary to scrape off the enamel from the appropriate part of the core to allow this soldering to be carried out. It is best to scrape away the enamel and preliminarily tin the core before connecting the transformer to the speaker tags.

The secondary leads of T2 have a soldered section which appears above the bobbin. Three leads will later be soldered to this upper section of the lower secondary lead.

Take up the section which was just cut from the main tagstrip and cut it so as to leave the hole at one end plus 4 tags. The 4-way tagstrip is shown in Fig. 3 after mounting, but first solder to its two outer tags the feet of the clamp of transformer T1 so that the transformer takes up the position shown in the diagram. Next solder the leads of T1 to the tags of the strip, again as in Fig. 3. Note that, with one winding, connections are made only to the centre tap and one end, the remaining winding end not being connected. Next take the Lektrokit spring clip and drill out its hole 4BA clear. Then fit the tagstrip and the spring clip over the remaining 1in. speaker mounting bolt, as in Figs. 3 and 4(b). In Fig 3 a part of the ferrite rod is shown cut away so that the 4-way tagstrip is visible, whilst in Fig. 4(b) the view is looking down at the top edge of the speaker. When the ferrite rod aerial is fitted, its coil is away from the clip. Make sure that T1 is so positioned that it will not touch the speaker cone. Its position can be changed by bending the tags to which it is soldered.

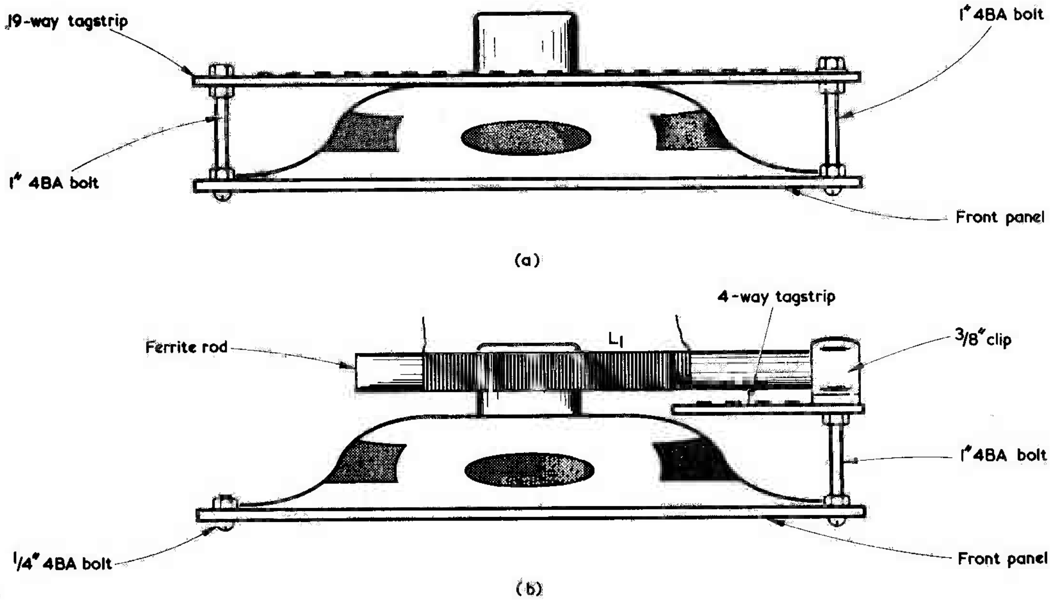


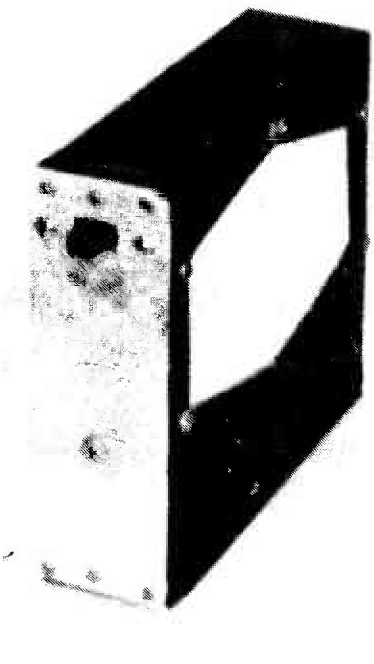
Fig. 4(a). Illustrating how the 19-way tagstrip is secured by two of the speaker mounting bolts (b). The spring clip for the ferrite rod and the 4-way tagstrip are fitted on a third speaker mounting bolt

WIRING

Mount and wire in all the components on the spaker panel, as shown in Fig. 3. The lead-outs of L2 need to be a little longer than they would normally be, as this choke is orientated for best results during setting up. For clarity, TR1 and TR2 are shown as being at the side of the 19-way tagstrip but in practice they are below it with their lead-outs passing upwards through the centre holes of the appropriate tags. Their bodies are kept clear of the speaker cone and also of the battery space, i.e. the space which will be taken up by the two HP2 cells. No connections are made to the shield lead-outs of these two transistors. TR3 and TR4 are mounted above the tagstrip, but still clear of the battery space.

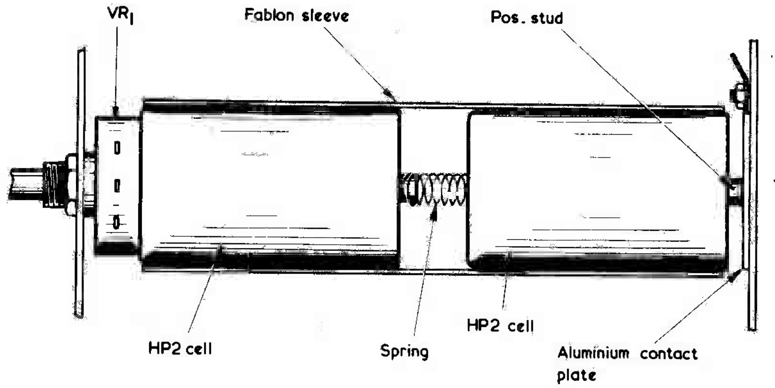
Screw the completed side panels to the top and bottom panels, as indicated in Fig. 2, then complete all the wiring shown in Fig. 3. Note that C2 and D1 are wired between the left hand side panel and the speaker panel. Only one pole of switch S1 is used, and no connections are made to its remaining tags.

The two cells which make up the battery are fitted in a sleeve made of Fablon, the general mode of assembly being shown in Fig. 5. Take a piece of Fablon measuring 9 by 4½in., and leave on all the backing paper except for a ½in. strip along one of the shorter edges. Roll the cells into this Fablon with the exposed ½in. strip going on last, so that it secures the resultant cylinder in shape. The cylinder should be loose enough for the cells to be easily removable. A small compression spring is required between the two cells, and this spring should have an internal diameter of ¼in. and a length of ¾in. One end is opened out very slightly with a pair of pliers so that it fits firmly onto the positive stud of one of the cells. The cells are inserted in the Fablon cylinder as illustrated



The on-off slide switch is mounted on the panel at the other end of the receiver

Fig. 5. The two cells are inserted in a sleeve made of Fablon. The negative battery connection is to the metal case of VR1 and the positive connection is to the aluminium contact plate



in Fig. 5, and the resultant battery can then be put in the receiver with the positive end fitting into the partially drilled $\frac{3}{8}$in. hole in the aluminium contact plate and the negative end pressing against the metal cover of VR1. The spring between the two cells makes the fitting easy and ensures that good contact is made. Before the battery is inserted, however, the next and final step in construction has to be carried out.

In the side panels there are two holes, marked "X" and "Y" in Fig. 2, which have not yet been used. A $5\frac{7}{8}$in. length of 6BA studding is cut and passed through the receiver at these holes. The studding has a $5\frac{3}{8}$in. length of insulated tubing, or sleeving, passed over it between the panels and is held in position by two 6BA nuts at the outside. If possible, the nuts should be dome types to give a good appearance. The studding prevents the s.r.b.p. panels from bulging outwards when the battery is fitted and will just clear the lower speaker mounting bolts.

SETTING UP

After fitting two control knobs the receiver is ready for setting up. New HP2 cells should be employed. First adjust VR1 so that its slider is at the end of the track which connects to T1, i.e. control knob fully anti-clockwise. Next, adjust VR2 such that its slider is at the negative end of its track; this is fully clockwise as shown in Fig. 3. It is next necessary to monitor the current passed by TR4. If a testmeter is available capable of giving a clear reading of 55mV, which presupposes a range with an f.s.d. of 0.25 or 0.5 volt, connect this across C5 with the same polarity as that of the capacitor. Adjust VR2 for a reading of 55mV. (This voltage reading takes in the current drawn by TR1 and TR2.) If a testmeter with a suitable voltage range is not to hand, select a current range which will give a clear indication of 23mA, disconnect the lead between T2 and the emitter of TR4 and insert the meter with the positive test lead connected to T2. VR2 is then adjusted for a current of 23mA, after which the lead is re-connected. The procedure, employing either method of checking TR4 current, should be repeated after the battery has had about 20 hours use, in order that maximum life may be obtained from it. After this, VR2 can be left alone. It does not require further adjustment when new cells are fitted later.

Next, seek a station towards the low wavelength (high frequency) end of the tuning range. Radio 1 on 247 metres will be satisfactory, and this should be received with VC1 set to around 40 degrees from the minimum capacitance end of its travel. Keep VR1 adjusted so that there is no excessive distortion. The "hiss point" represents the most sensitive setting for this control. Having received the signal satisfactorily, search for a station near the high wavelength (low frequency) end of the range, such as Radio 3 on 464 metres. It may be found that VR1 has to be re-set considerably for best results, or that the oscillation point is impossible to obtain even with VR1 fully advanced. L2 should then be twisted, on its lead-out wires, such that the most sensitive setting of VR1 with the high wavelength station is the same as that for the low wavelength station. The orientation of L2 has little effect at the low wavelength end of the scale but has a large effect at the high wavelength end. Try reversing the leads of L2 at the tagstrip if the correct orientation is difficult to obtain.

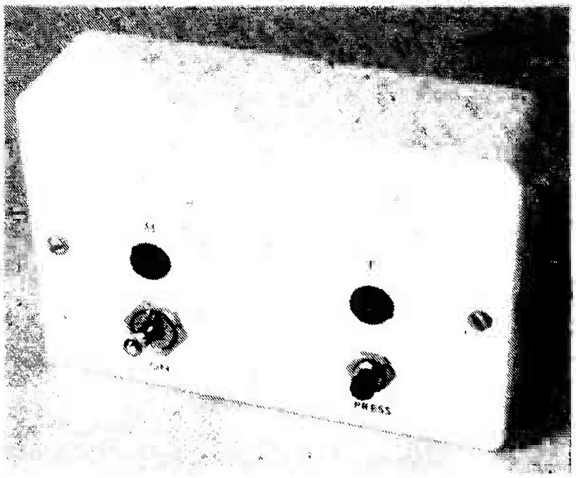
By careful positioning of L2 it is possible to arrange that the maximum sensitivity setting for VR1 remains virtually constant throughout the range except for wavelengths around 200 metres. At these low wavelengths it will probably be necessary to set back VR1 a little to avoid oscillation. VR1 will, of course, need to be used as a volume control with the more powerful stations, or when a low output is required. Several stations in daylight, and a large number after dark, will be found to give good programme volume at a level consistent with a small receiver.

It is possible that distortion, or even instability, which cannot be controlled by VR1 is present. In this event, either a mistake has been made in assembly or the winding of L1 is such that it interacts with T1. Transposing the two top leads of T1, as shown in Fig. 3, will correct matters. In some instances, distortion may also be cleared by reversing the connections to T2 primary.

All that now remains is to make a back for the receiver. This can consist of a piece of $\frac{1}{16}$in. s.r.b.p. measuring $5\frac{3}{8}$in. by $3\frac{7}{8}$in., and it is covered with Fablon of the appropriate colour. The back will slip inside the case and is kept in position by two small solder tags screwed to the case bottom and a third small solder tag, free to swivel, screwed to the case top.

(Concluded)

SIMPLE RANDOM SELECTOR



By R. A. Penfold

A 2-way gaming device which is free of bias and requires very few components.

This simple device electronically simulates the tossing of a coin and it can provide much amusement.

Basically the unit consists of a box having two lights on the front panel. When a push-button is pressed both the lights come on, but when the button is released only one light remains on. It is purely a random matter as to which of the lights stays on, and by labelling one lamp "heads" and the other "tails" the required simulation is provided.

The circuit of the device is extremely simple and it takes advantage of two low cost integrated circuits. Few other components are required.

BASIC OPERATION

Fig. 1 shows the unit in block diagram form, and this helps to explain its operation. It comprises two main stages, a pulse generator and a J-K flip-flop.

A J-K flip-flop is a divide-by-two circuit, and every time a pulse is received at its clock input the outputs change state. The outputs are designated Q and not-Q (the letter Q with a bar above it) and have opposite states. Thus, when Q is high not-Q is low, and vice versa. A lamp is driven from each output and lights up when that output is in the high state.

When the push-button is pressed a series of regularly spaced pulses is applied to the flip-flop, causing the outputs to continually change with each pulse. Since the pulse generator output is at about 600Hz the consequent flashing of the lamps is much too fast to be observed, and the impression is given that both lamps are continually lit. Releasing the push-button allows the flip-flop to stay in the state it held at the instant of release, and only one lamp stays alight.

It is impossible to judge what state the flip-flop outputs are in when the push-button is released and, since the pulses from the pulse generator are regularly spaced, the choice of lamp remaining alight is completely random. There is no bias towards one lamp or the other.

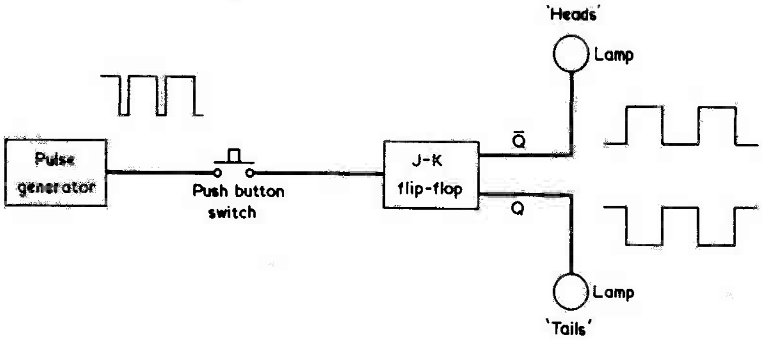


Fig. 1. Block diagram illustrating the basic functioning of the unit

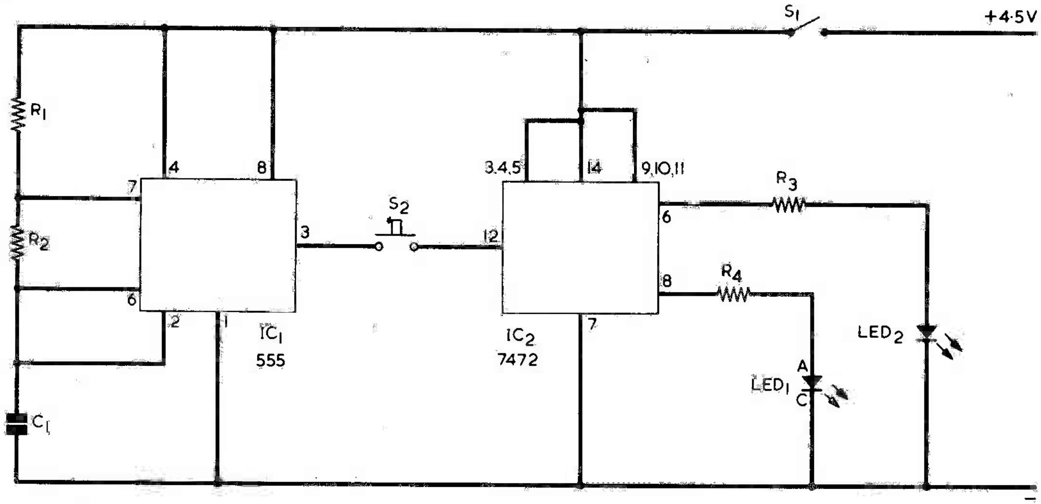


Fig. 2. The complete circuit of the unit. This requires an extremely small number of discrete components in addition to the two integrated circuits

THE CIRCUIT

The full circuit of the unit appears in Fig. 2. The pulse generator is a 555 timer i.c. connected as an astable multivibrator. The operation of this circuit is now so well-known that it merely suffices to state first that on one half-cycle C1 charges via R1 and R2 and that on the other it discharges via R2 and, second, that the output at pin 3 is high when C1 charges and that it is low when C1 discharges. Pin 3 couples to the clock input at pin 12 of IC2 when push-button S2 is closed.

IC2 is a 7472 t.t.l. integrated circuit, and its three J and three K inputs are all taken up to the positive rail. Its Q and not-Q outputs are at pins 8 and 6 respectively. The two indicator lamps consist of light-emitting diodes, and these are coupled to the flip-flop outputs via R3 and R4.

S1 is the on-off switch and power is obtained from a 4.5 volt battery. Current consumption is approximately 9mA, this rising slightly when S2 is closed. In consequence, the three HP7 cells which make up the battery have a long life.

CONSTRUCTION

The prototype was housed in a plastic box measuring 115 by 75 by 35mm. deep, and any plastic box of similar or slightly larger dimensions can be used. The front panel layout is shown in Fig. 3. The dimensions in this diagram apply to a box of the size used by the author and may be amended, as required, for other boxes.

The two holes for the l.e.d.'s are drilled to take the particular components employed, and these should be obtained with panel bushes. An attractive display will be given by l.e.d.'s of different colours, and the author used a red l.e.d. for LED1 and a green l.e.d. for LED2.

COMPONENTS

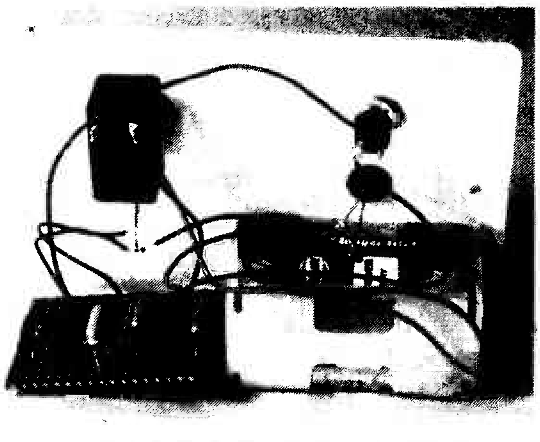
Resistors
(All ¼ watt 5%)
- R1 39kΩ
- R2 2.2kΩ
- R3 680Ω
- R4 680Ω

Capacitor
- C1 0.047μF type C280 (Mullard)

Semiconductors
- IC1 555
- IC2 SN7472
- LED1 light-emitting diode with panel bush
- LED2 light-emitting diode with panel bush

Switches
- S1 s.p.s.t. toggle
- S2 push-button, press to make

Miscellaneous
- 3 HP7 cells
- Battery holder (see text)
- Battery connector, PP3 type
- Perforated s.r.b.p. board, 0.1in. matrix
- Plastic case (see text).



The components behind the front panel are assembled on a perforated board

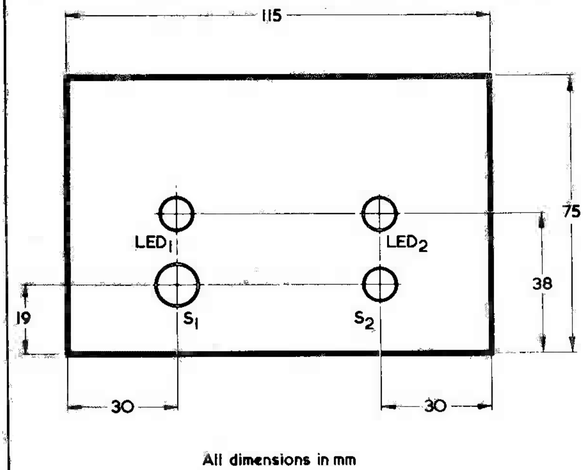
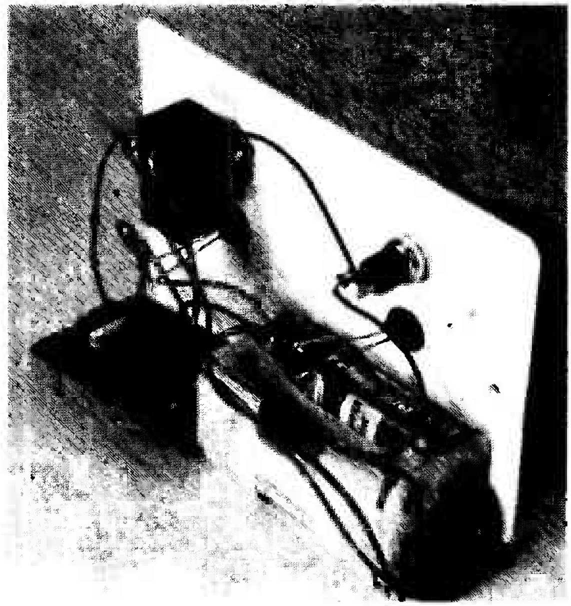


Fig. 3. Front panel layout of the prototype. Hole diameters depend upon the l.e.d. and switch types employed



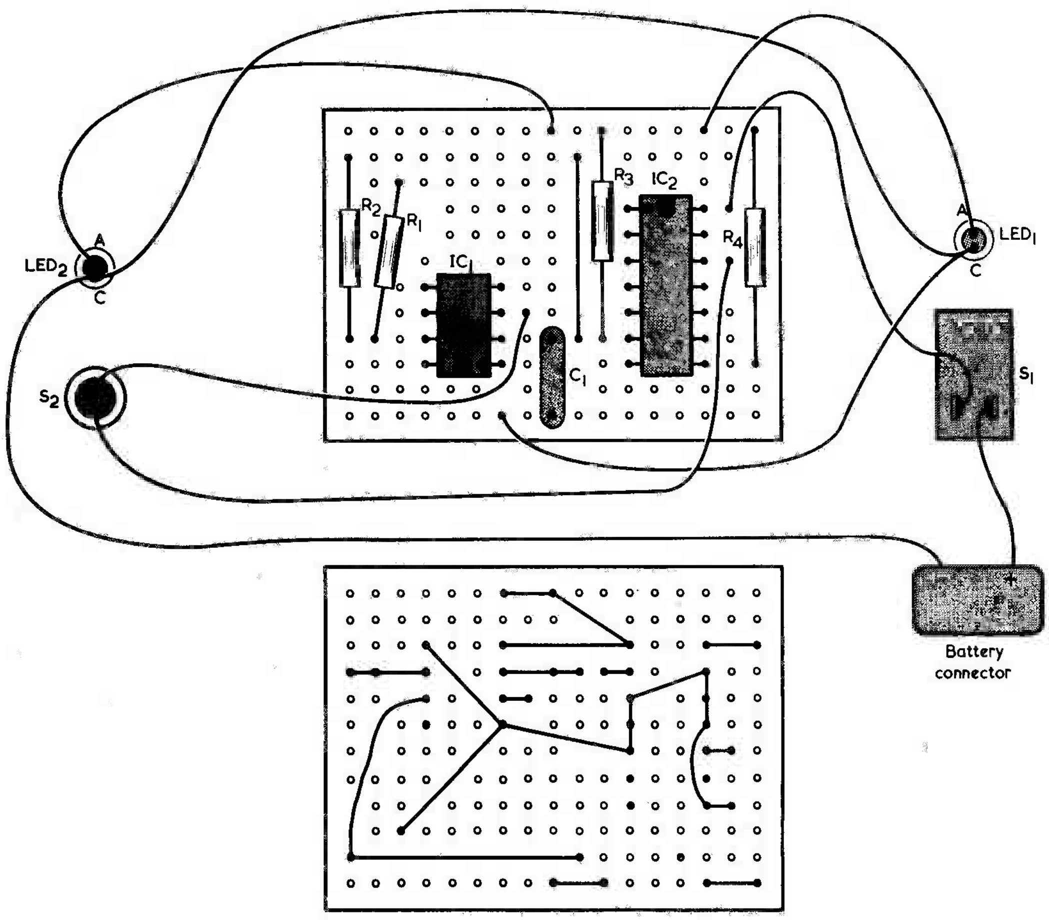


Fig. 4. Complete wiring diagram, showing both sides of the perforated s.r.b.p. board and the external connections which are made to it

Suitable l.e.d.'s are widely available, including the l.e.d.'s Type 4 listed by Doram Electronics. These are supplied with panel bushes and can be obtained in red and green. With these the short lead-out is that for the anode (which connects to R3 or R4 as applicable).

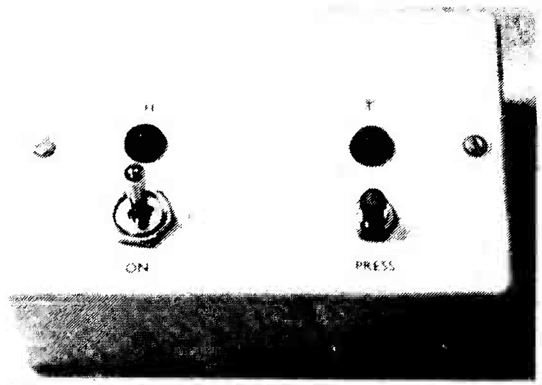
The remaining components are wired up on a piece of plain perforated board of 0.1in. matrix. This has 17 by 12 holes and is cut down from a larger piece by means of a hacksaw. The components and the link wire are fitted to the board as indicated in Fig. 4, the leads under the board being bent at right angles to complete the wiring as shown. Where component leads are too short, extension pieces consisting of tinned copper wire of around 22 s.w.g. may be added. The i.c. pins are gently bent outwards under the board after these have been inserted.

The board is then wired up to the external components and the battery by means of thin flexible insulated wires. This wiring is also shown in Fig. 4.

Power is obtained from three series-connected HP7 cells. These are fitted in a holder which is intended to take four cells and it is a simple matter to short-circuit the unoccupied cell position. The battery holder is coupled to the circuit by way of an ordinary PP3 type battery connector.

The board is positioned at the top left hand side of the case (as viewed in Fig. 3) and in the prototype it was simply held in place by the leads connecting to it. A more positive method of mounting can, of course, be devised should the constructor so desire. For instance, a hole in a clear section of the board can be drilled out 6BA clear before wiring is commenced. A 6BA screw passing through the case side can then be fitted, the board being spaced off slightly from the inside surface of the case.

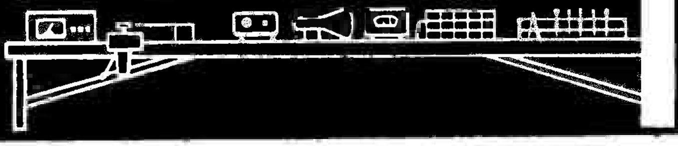
After a final check of the wiring, the unit is ready for use. The constructor should not be surprised if he



The letters "H" and "T", taken from Panel Signs Set No. 4, are affixed to the front panel above the l.e.d.'s to indicate "Heads" or "Tails"

obtains recurrent illumination of one l.e.d. over quite a few successive operations of S2; this can also happen when a coin is tossed a similar number of times. To check for absence of bias towards either l.e.d. it is necessary to carry out about a hundred operations, recording each result as it is given. The results, when added, should then be approximately equal. ■

In your workshop



This month Dick embarks on what he considers to be a very simple repair job. But it turns out to have some slightly surprising symptoms and, as always, the assistance of Smithy has to be called in.

With a careless gesture, Dick pushed all the debris on his bench to the back, up against the mains sockets, then positioned the record player in its exact centre. He next walked back to the "For Repair" rack and returned with the player's two small speakers. He carefully set one speaker to the left of the record player and the second speaker to its right, precisely positioning the latter so that all three units were laid out with perfect symmetry. There was an unexpectedly finicky trait in Dick's character concerning the positioning of things: he was a compulsive straightener of pictures and rearranger of umbrellas in hall stands, and in his view the left hand speaker of a stereo system had to be exactly balanced spatially by the complementary right hand speaker.

He plugged the two speakers into the record player then cleared an area at the rear of his bench in order to fit its plug into a mains socket. He turned the volume control experimentally, to be rewarded by the click of the on-off switch and the optimistic glow of a little red pilot lamp on its control panel.

ONE CHANNEL ONLY

Reaching up, he took an l.p. from the stack of battered discs on the shelf above his bench, placed it on the turntable, actuated the pick-up arm to start the motor then lowered the stylus onto the lead-in groove of the rotating record. After some moments the sound of Led Zeppelin became audible from the right hand speaker. Dick placed his head close to the left hand speaker. The left hand channel was being reproduced at an extremely low level.

Dick scratched his head, then turned back to the record player and adjusted its balance control. As he rotated it to favour the left hand channel the amplitude of the sound from the left hand speaker rose very slightly, then commenced to distort with only a small further increase in volume.

"Hey, Smithy!"

"Hullo," came Smithy's preoccupied voice from the other side of the Workshop.

"I've got a dead easy one here," called out Dick confidently. "It's a stereo player with one channel up the spout."

"Bully for you," retorted Smithy drily, as he looked into the chassis of the television receiver on his bench. "It's about time we had a few simple snags in here."

Undeterred by Smithy's reaction, Dick disconnected the record player from the mains, removed the record, clipped the pick-up arm to its rest then unfastened the screws securing the base plate. After a struggle he was able to remove its printed circuit board so that it rested against the bottom of the record player case, with the latter on its side. Working through the wiring from the left hand speaker socket he checked back to what was patently the output d.c. blocking electrolytic capacitor for the left hand channel amplifier on the board. There were no obvious visible faults. He unplugged the left hand speaker and, switching his testmeter to an ohms range, checked that the output capacitor was not short-circuit. The testmeter needle rose rapidly to a low resistance reading then fell to the left hand end of its scale as the electrolytic capacitor, obviously serviceable, charged up from the battery inside the meter.

Dick put down the test prods, stood up and walked over to the filing cupboard.

"Service manual already?" queried Smithy from his bench. "I thought you said you had a dead easy one."

"I have got an easy one," retorted Dick. "All I want to do is check up on a few little points in its circuit."

"And very commendable, too," stated Smithy. "Five minutes with the service sheet can save hours of aimless digging around."

Dick found the manual he required, then returned to his bench and opened it out at the circuit diagram. (Fig. 1.)

Smithy's voice became audible once more.

"The first thing you want to do," he remarked, "is to check that the full supply voltage is getting to the left hand channel amplifier."

"That," said Dick irritably, "is just what I'm going to do."

"And then," continued Smithy inexorably, "see if the output transistor emitters are sitting at about half the supply voltage."

"Dash it all," expostulated Dick, "that's exactly what I intend doing."

Irately, Dick reconnected the left hand speaker, plugged the record player into the mains again, switched his testmeter to a voltage range and clipped its negative lead to the player chassis. After studying the service manual he located the copper area on the printed board which carried the supply to the left hand channel amplifier and applied the positive testmeter prod to it. (Fig. 2(a).)

The meter gave a reading of 24 volts.

With a grunt of satisfaction, Dick removed the prod and applied it to the positive lead-out of the d.c. blocking electrolytic capacitor he had checked previously. This lead-out coupled to the two output emitters. (Fig. 2(b).)

The testmeter needle moved slightly to the right. Dick selected a lower voltage range and tried again. The testmeter indicated 1.1 volts. He switched the record player off, then tentatively applied the back of a finger to the TO-1 can of each output transistor in turn. Both the output transistors were perfectly cool. Dick scowl-

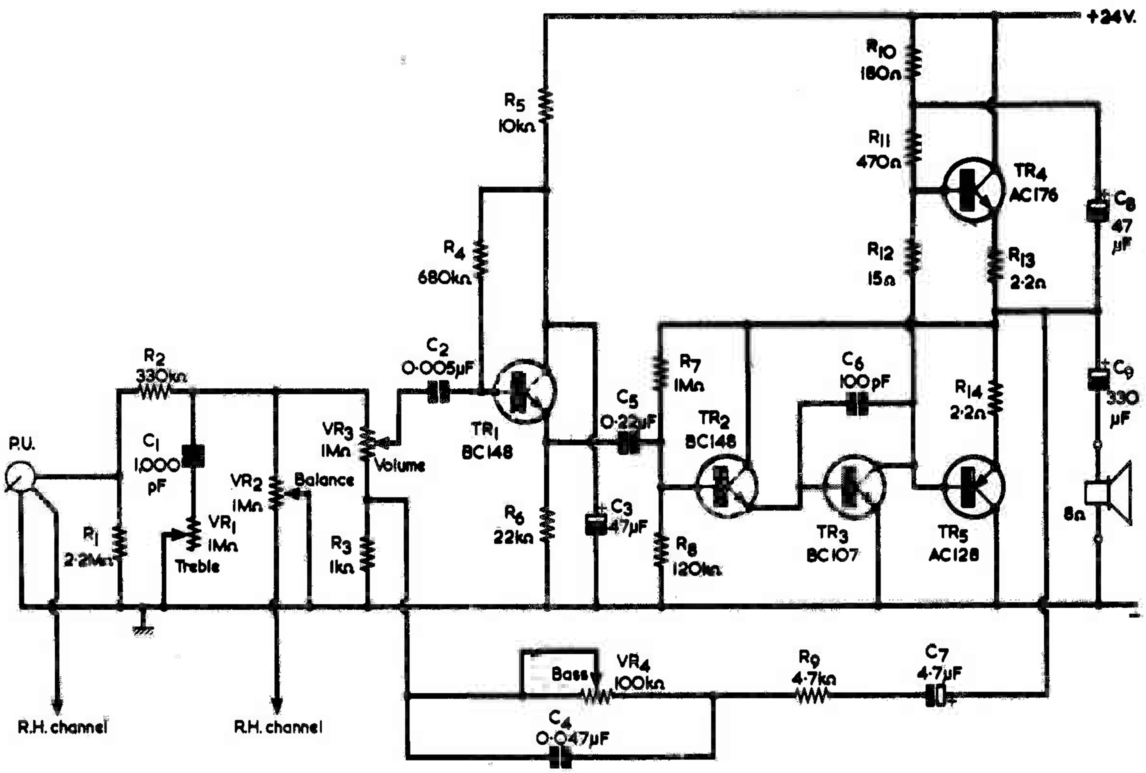


Fig. 1. The left hand chanel amplifier of the record player serviced by Dick. The treble, volume and bass controls are ganged with similar controls in the right hand channel. This circuit is based on that employed in the Philips 13GF829 record player

ed at the printed board then selected a resistance range on his meter and applied the positive test prod once more to the electrolytic capacitor positive lead-out. The meter gave an indication slightly in excess of 6k Ω.

LOW VOLTAGE

"Hey, Smithy!"

"Blimey, what is it now?"

"There's something queer here. The output emitters in this record player are only just over a volt positive, and yet there are no shorts or low resistances to chassis and the output transistors aren't even running warm."

"You and your dead easy ones," grumbled Smithy. "I should have guessed that you'd get stuck in the first few minutes. Hang on a jiffy and I'll come over."

He completed the solder joint he had been engaged in making, put his soldering iron on its rest, then walked over to Dick and took a quick glance at the service manual circuit.

"Here's the last check I did," said Dick eagerly, applying the test prod to the electrolytic capacitor again. "See, there are no shorts to chassis."

"Fair enough," commented Smithy. "The actual resistance reading you are getting there doesn't signify anything in particular because there are a

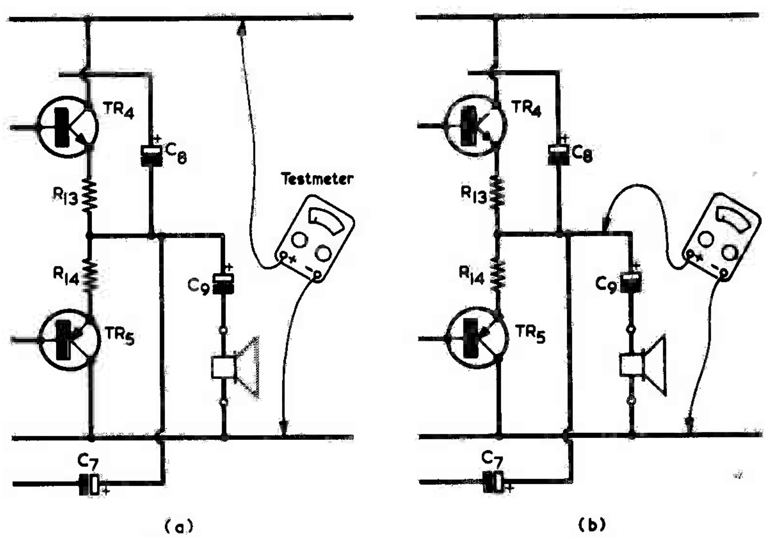


Fig. 2(a). First, Dick checked the supply voltage applied to the left hand channel amplifier

(b). He then measured the voltage at the transistor output emitters. The very low voltages dropped across R13 and R14 can normally be ignored

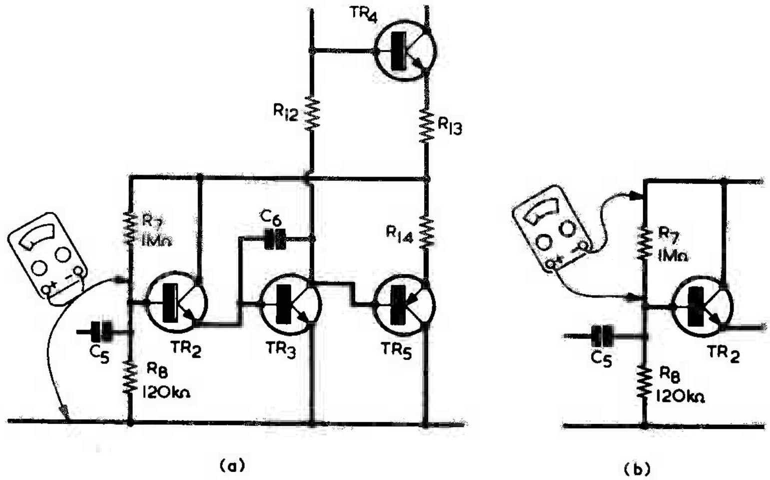


Fig. 3(a). At Smithy's bidding, Dick checked the resistance of R8

(b). The next component to be checked was R7

number of semiconductor junctions in the circuit through which the testmeter current can pass. If these are silicon junctions each one drops around 0.6 volt, so that quite misleading resistance readings can be given. But I'll certainly agree that there are no obvious shorts or low resistances to chassis. The fact that there is a standing voltage at the output emitters of slightly more than a volt would indicate, at first sight anyway, that both the output transistors are passing a quiescent current. So let's have a look at the circuit before them which controls the standing output voltage. This is given by TR2, TR3, R7 and R8."

Dick frowned.

"I don't quite see how they can cause the trouble," he remarked. "For instance, those two transistors are just an a.f. amplifier and a driver transistor for the output stage."

"Look," said Smithy wearily, "just take a few resistance measurements for me, will you? For a start, put that positive test lead of yours on the base of TR2. Your negative clip is already connected to chassis, and this will check the 120kΩ resistor, R8."

"Dick did as he was bid, and they both looked at the meter. It indicated slighly more than 6kΩ. (Fig. 3(a).)

"That's funny," remarked Dick. "It's the same resistance reading that I got at the output emitters."

"It should have been around 120kΩ" stated Smithy thoughtfully, "Connecting the positive lead of your testmeter to TR2 base should mean that the negative terminal of the internal meter battery is coupling through the meter circuitry to that base. No current should then flow in the base-collector or base-emitter junctions of the transistor and so you'd get a reasonably true reading for the resistance of R8."

"Well we didn't, so something wrong has happened."

"I know it has," agreed Smithy. "The obvious thing to do next is to see what resistance reading you get across the 1MΩ resistor, R7."

"Does it matter which way round I connect the testmeter leads?"

"I have a hunch," said Smithy, "that in this case it won't."

Dick unclipped the negative meter lead from the chassis and then applied the two test leads to the 1MΩ resistor. The meter indicated zero ohms. (Fig. 3(b).)

"There you are," said Smithy briskly. "That's your trouble. There's a dead short across the 1MΩ resistor. That explains also, of course, why the resistance to chassis at TR2 base was the same as that at the output emitters. Since it's a complete dead short I would suspect that the base-collector junction of TR2 has broken down."

"What about the 1MΩ resistor?"

"That's less likely," stated Smithy. "Even if it went low in value, a 1MΩ resistor wouldn't normally go all the way down to zero ohms. So it's a new transistor that you want there, Dick boy."

EXPLANATION

"As always," said Dick ruefully, "you were right in suggesting where the trouble in this amplifier would be. Anyway, I can see now how that short-circuit caused the standing output emitter voltage to go low."

"Good show," stated Smithy, pleased. "I'm glad you've at last been able to work out how this circuit works."

"It's obvious," said Dick cheerfully. "If there is a short between the collector and base of TR2, then you have the output emitter point connected to chassis via the base-emitter junctions of TR2 and TR3 in series. These act like two forward biased silicon diodes, and they simply pull down that output emitter point to a little over a volt by pure brute force!"

Smithy's jaw dropped.

"And *that*," he queried wonderingly, "is your explanation of what's been happening in this amplifier?"

"But of course," replied Dick airily. "When you're as clued up as I am, it doesn't take long to visualise what a short-circuit can do."

Smithy cast a despairing eye towards the ceiling.

"I must," he confessed dolefully, "have heard everything now. You just don't have the vaguest idea of how the circuit works, do you?"

"Of course I have," retorted Dick indignantly. "As I said earlier, the two transistors are an a.f. amplifier and an output transistor driver. And I've explained how that collector-base short caused the output emitter voltage to be low."

"Look," said Smithy doggedly, "let me start by giving you a brief rundown on the circuit when it's in proper working order. Okay?"

"As you like," responded Dick carelessly. "I suppose that this will only be embroidery on what I've already said."

"When the circuit is working properly," grated Smithy, "an input a.f. signal goes from the emitter of TR1 to the base of TR2 via C5. TR2 is an emitter follower and so the signal appears at its emitter without any voltage amplification and is then passed to the base of TR3, which is a common emitter amplifier. This provides voltage amplification, and the signal at its collector is out of phase with the signal at its base."

"Which is what I said. TR2 is an a.f. amplifier and TR3 is the driver for the output transistors."

Smithy cast a furious glance at his assistant.

"Now," he went on, "the collector of TR3 couples to the bases of TR4 and TR5. These are emitter followers and their emitters couple via the two 2.2 Ω resistors to the positive side of the output coupling electrolytic. Which is the point we have been referring to as the emitter output point."

"Let me put in a little further detail," interjected Dick. "Those two 2.2 Ω resistors are in series with the emitters to prevent thermal runaway in the output transistors. You didn't mention that bit, Smithy."

"I shouldn't have to," snarled Smithy, "it's flaming obvious. Now, the emitter output point voltage will be close to the voltage at the collector of TR3, and the emitter output point also provides the collector voltage for TR2."

"Right!"

"Further," fumed Smithy, "the 1M Ω resistor R7 connects to that emitter output point and it forms part of a potential divider in conjunction with the 120k Ω resistor, R8. If no current is drawn from the junction of these two resistors the voltage applied to the base of TR2 is about one-ninth of the voltage at the emitter output point." (Fig. 4(a).)

"Very well put," stated Dick condescendingly. "I couldn't have described the situation better myself."

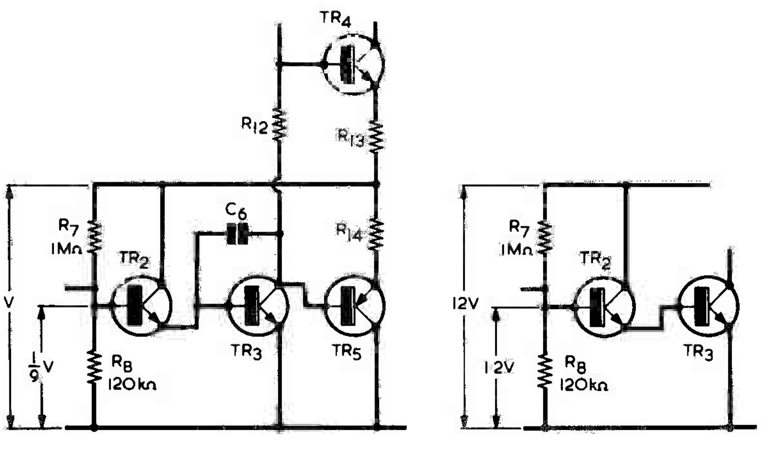
"Will you," spluttered Smithy, "keep quiet?"

"I'm only making the odd helpful remark, that's all."

"Then don't."

"Blow me, there's no need to get all uptight about it."

"Belt up!"



(a) (b)

Fig. 4(a). One-ninth of the total voltage across R7 and R8 appears across R8

(b). The circuit stabilizes at the approximate voltages shown here

Dick opened his mouth, caught Smithy's baleful gaze, then closed it abruptly.

"So," said Smithy, his voice trembling, "the voltage at the base of TR2 is about one-ninth of that at the emitter output point. Let's next see what happens if, for some reason, the voltage at the emitter output point is low and then starts to rise. This could conceivably happen immediately after switch-on, as the output coupling electrolytic charges. When the emitter output point voltage is low, so also is that at the base of TR2, and this transistor is cut off. In consequence, TR3 is cut off as well and it passes no collector current. The voltages at the output emitter bases then rise, taking the emitter output point with them. When this point reaches a certain level the voltage at TR2 base has risen sufficiently to make this transistor conduct and pass emitter current to the base of TR3. TR3 also turns on and starts to draw a collector current, whereupon the rise in voltage at the emitter output point ceases. The circuit then settles into a state of equilibrium in which the current flowing into TR2 base is just sufficient to cause TR3 to hold the output emitter point steady and prevent it going further positive."

This time it was Dick's jaw which dropped. He turned to the circuit diagram and feverishly traced out the circuit path from the output emitter point back to the base of TR2.

"Now," said Smithy triumphantly, we can start to impart a little common sense to this circuit. TR2 and TR3 are both silicon transistors with a forward voltage drop of about 0.6 volt in their base-emitter junctions. In consequence, these two transistors only become conductive when the base of TR2 goes up to approximately 1.2 volts. The circuit then stabilizes, and the input current into TR2 base will be extremely small because of the amplification which follows it. If the base current were negligibly small, the total voltage across R7 and R8 would be 9 times that across R8, which is 1.2 volts. This works out at about 11 volts. In practice, some current does flow into TR2 base and the actual voltage at the emitter output point will be a little higher, say at about 12 volts." (Fig. 4(b).)

SHORT-CIRCUIT CONDITION

Smithy ceased his explanation and looked at his assistant who, mouth now closed, returned his gaze mournfully.

"Gee Smithy," said Dick contritely, "I hadn't realised that the circuit worked in quite that fashion."

"Well, it does," returned Smithy shortly. "In addition to the d.c. negative feedback given by the 1M Ω and 120k Ω resistors, there is also a.c. negative feedback. When the base and collector of TR2 were short-circuited the a.c. feedback became 100%, which is why there was so little gain in the left hand channel of the record player amplifier. And, of course, you got distortion at anything above a very low output level because of the clipping of negative half-cycles in the output stage. In addition, of course, to any distortion caused in the TR2 circuit itself."

"But," protested Dick, "that still doesn't upset my explanation that the two base-emitter junctions of TR2 and TR3 pulled down the output voltage when the collector of TR2 shorted over to its base."

"Of course it does, you steaming nit! When TR2 went faulty the emitter output point connected directly via the base-emitter junction of TR2 to the base of TR3. Under these conditions, TR2 base-emitter junction is just the same as a silicon diode." (Fig. 5.)

"I suppose it is, really."

"Right," said Smithy. "This time, when the voltage at the output emitter point rises it turns TR3 on when it reaches about 1.2 volts. TR3 once more conducts and its collector current prevents the voltage rising further. It's TR3 collector current which was holding the voltage down, not the brute force effect of two base-emitter junctions, as you claimed."

"Blimey of course, I can see it all now! Your explanation is an even better one than the one I gave!"

Smithy regarded his assistant stonily.

"What baffles me," he remarked eventually, "is how on earth you get that great head of yours through the Workshop door each morning."

"Hey," replied Dick, stung. "There's no need to get personal. After all, this is only a technical discussion."

Smithy flapped his arms against his sides in a gesture of hopelessness.

"I give up," he said resignedly. "Just put in a new transistor whilst I get back to my own work."

"Okey-doke," returned Dick brightly. "I'll soon be getting this record player back into working order again. Now, if we were living in an ideal world all I'd have to do next is get our friendly robot to fetch me a new transistor from the spares cupboard."

Smithy raised his eyebrows.

"Robot?"

"Robot. If other establishments can have a robot," pronounced Dick darkly, "we should be able to have one, too."

Smithy grinned.

"I'll have to work on that," he chuckled. "In the meantime let's get back to earning a little bunce."

His good humour restored, Smithy returned to his bench whilst Dick, robot-less, made his own way to the spares cupboard and selected a new BC148 transistor. Back at the record player Dick carefully applied his iron to the lead-outs of the transistor on the printed board, removed it and satisfied himself that its base and collector were quite definitely short-circuited together. He fitted the new transistor, switched on and once more checked the voltage between chassis and the emitter output point.

Incredulously, he stared at the meter needle, then once more gave voice.

"Hey, Smithy!"

"Hello!"

"I've got a really weird fault now."

"It couldn't," stated Smithy, "have happened to a nicer chap."

"No, seriously Smithy. I'm in right trouble this time."

"What's wrong?"

"You remember that the emitter output point in this record player amplifier was only about 1.1 volts positive of chassis."

"I do."

"I've put in a new transistor," wailed Dick, "and that output point is now just short of 23 volts positive of chassis. This time it's about 1.1 volts negative of the positive rail!"

Smithy rose once more, came over to Dick's side and checked the meter. This was, indeed, giving a reading of slighly less than 23 volts. He switched off the record player then, turning to the board, examined the new transistor and the solder joints connecting

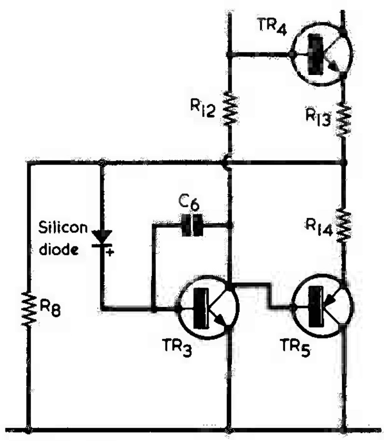


Fig. 5. A rearrangement of the circuit to illustrate a fault condition

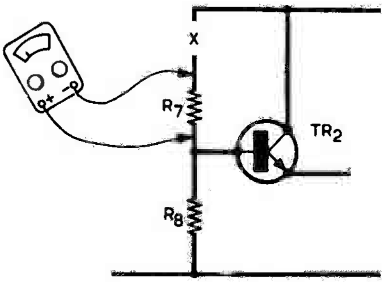


Fig. 6. One of the leads of R7 has to be disconnected from the circuit before its resistance can be measured accurately

it to the copper pattern. As was always the case with Dick's handiwork, the latter were immaculately finished.

"This is a turn-up for the book," he remarked slowly. "Let's try a little deduction. I think it's still pretty safe to assume that the driver and output transistors are behaving themselves, because they previously caused a low voltage to be given at the emitter output point when the collector and base of TR2 were short-circuit. You've fitted a new transistor and done nothing else and now the output emitter voltage has gone high. It seems very probable that there is a second fault in the network comprising R7, R8 and TR2. It can't be in TR2 because this is a new transistor, so it's either in R7 or R8."

"If," suggested Dick, "R8 went low in value, there'd be a smaller fraction of the output emitter voltage going to the base of TR2. Could that cause the output emitter point to go high?"

"It could," confirmed Smithy. "The same result would also be given if R7 went high. It's more likely that a 1M Ω resistor will go high than a 120k Ω resistor will go low, so we'll start with R7. We can't measure its resistance while it's in circuit because of all the other components it's connected to. So, unhook one of the R7 leads and check its resistance then."

Dick took up his iron and, applying it to the printed board, deftly removed one of the resistor lead-outs. Selecting a high resistance range he then connected his testmeter across the resistor. (Fig. 6.)

"You've hit it first go, Smithy," he exclaimed jubilantly, "this resistor's gone up to about 2.5M Ω ."

"That figures," commented Smithy, pleased. "With the resistor at that value about one-twentieth of the output emitter voltage is being applied to the base of TR2 and so the output emitter voltage will be roughly 20 times 1.2 volts. I'll see this through to the bitter end now, so solder in a new 1M Ω resistor and check the result."

Dick soon had the new resistor fitted. He then switched on the record player and applied his testmeter between chassis and the output emitter point. The testmeter indicated 12 volts.

"That's that, then," he announced happily. "It's funny that there should have been two faults in the same part of the circuit. Could one have caused the other, Smithy?"

"It's reasonably possible," said Smithy. "What could have happened was that the resistor went high first, whereupon that transistor had more than 20 volts permanently applied across its collector and base. The collector-base junction should be able to stand up to this voltage but, if it was in any case on the verge of breaking down, the continuous voltage may have been what finally did the trick. Humph, quite an interesting little progression of faults."

ALL WORKING

"I think," said Dick slowly, "that from now on I'll keep my big mouth shut about dead easy faults and things like that."

Smithy turned a quizzical eye on his assistant.

"You will?"

"Definitely," stated Dick with conviction. "And I really mean that, Smithy. Oh well, let's get this record player back together again and give it its final check."

As Dick re-installed the printed board in the record player case, Smithy walked thoughtfully back to his own bench. He pondered on the future vista of a Workshop in which Dick was neither bombastic, braggart, boastful, blustering, bigoted nor even generally big-headed. It would be a pallid scene. His thoughts were punctuated by the strains of Led Zeppelin, now manifestly reproduced by both channels of the record player and, later, the sounds of the player and its speakers being transported to the "Repaired" rack. These were followed by Dick's subsequent steps towards the "For Repair" rack.

Gloomily, Smithy turned his attention to the television chassis on his bench.

"Hey, Smithy!"

"Hello."

"I've got a real honey here. It's an a.m.-f.m. radio which won't work on f.m. This is going to be a real piece of cake."

"Dead easy?"

"Nothing simpler."

Smithy grinned happily. Every thing was back to normal. ■

"Do you know you're too Hi with your Fi — turn it down!"

MINIMISING MAINS HUM

By D. Snaith

A simple dodge which can significantly reduce mains hum pick-up in a.f. amplifiers

When transistors first ousted valves one design difficulty in a.f. amplifiers disappeared from the scene almost completely. This was the problem of capacitive pick-up of hum in mains-driven amplifiers. Those old valve amplifiers had control grid a.f. input circuits with impedances to chassis of the order of 250kΩ to 1MΩ or more, and quite a little care had to be taken to ensure that these did not pick up hum due to stray capacitive couplings with mains power supply circuits and wiring. On the other hand, the earlier transistor amplifiers had low impedance base input circuits, and were much less liable to pick up hum due to capacitive coupling.

Now, with input Darlington pairs, CMOS devices and field-effect transistors, the high a.f. input impedances have all come back again.

F.E.T. INPUT

Fig. 1 shows a possible high input impedance circuit for an a.f. amplifier. The f.e.t. has a source bias network consisting of R2 and its bypass capacitor C2, and the input is applied to the gate via the d.c. blocking capacitor C1. This could have a value of the order of 0.022μF. A screened wire couples the gate to an input socket or pre-amplifier output elsewhere. The gate has a bias resistor, R1, which can typically have a value of 1MΩ. If the stage is fairly close to a mains transformer and the mains input wiring it becomes susceptible to capacitive hum pick-up in the gate circuit.

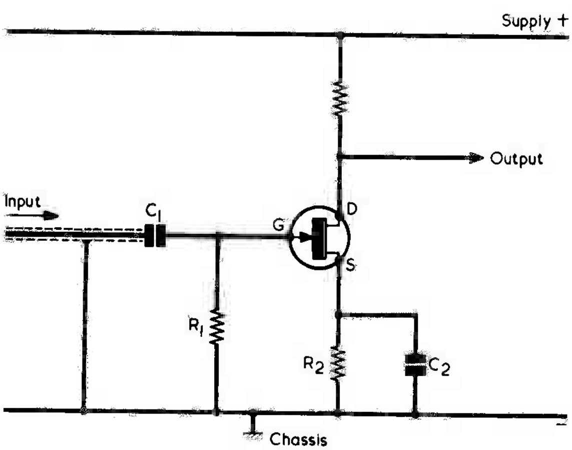
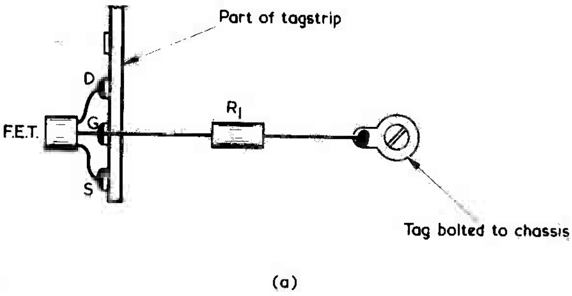


Fig. 1. A high impedance input in an a.f. amplifier could be given at the gate of an f.e.t.

The hum pick-up can be kept to a low level by keeping the unscreened metal area connecting to the gate as small as is reasonably possible. All of the metal under the coating of capacitor C1 is capable of picking up hum and so it pays to employ a capacitor which is small in physical size. The smallest capacitors are, in general, disc ceramics, but these are not normally recommended for a.f. coupling applications because of their wide tolerances on capacitance and because their values change with temperature. What is probably the best choice is a small low voltage polyester capacitor, such as the Mullard C280. Both its lead-outs should be kept short.

The gate bias resistor has next to be considered and, here, it is possible to employ a little trick. The lead-out of this resistor which connects to chassis cannot pick up hum capacitively, but the lead-out which connects to the gate can. Inside the resistor the susceptability to hum pick-up increases along the length of its body, being minimum near the earthy end and maximum at the gate end. However, a modern miniature ¼ watt component, which is all that is required here, is so tiny that a consideration of different hum pick-up levels along its body length becomes virtually academic.

The dodge is to wire up the resistor so that the lead-out connecting to the gate is short and the lead-out connecting to chassis is long. Fig. 2 (a) illustrates the resistor neatly wired up in conventional fashion between the gate and chassis points, whilst Fig. 2(b) shows it wired up with the body much closer to the gate point. Hum pick-up can be significantly lower in Fig. 2(b) than it is in Fig. 2(a).



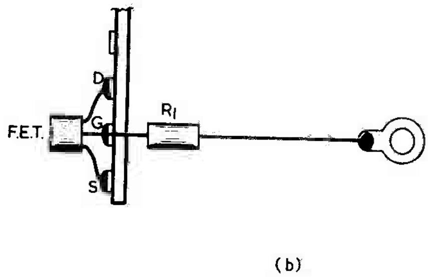


Fig. 2(a). A wiring layout for the f.e.t. and R1 in which the body of R1 is mid-way between the gate lead-out and the chassis connection

(b). Capacitive hum pick-up is reduced if R1 is wired so that its body is close to the gate lead-out.

There is no need to use these techniques when the high impedance a.f. input is well clear of mains wiring and components. But they can be surprisingly helpful when the input circuit is definitely liable to pick up a noticeable hum. They can also reduce the risk of instability in cases where there is a stray capacitive coupling between an in-phase amplifier output voltage and its high impedance input. ■

LETTERS . . .

FOR THE TRUE CONSTRUCTOR

Would you very kindly forward the enclosed letter to Mr. A. P. Roberts?

In passing I would like to mention how much I enjoy 'R. & E.C.' and hope that it will remain what it has always been — a true constructor's magazine. Most things seem to change these days whether we want them to or not.

Hoping that you can assist me in getting in touch with Mr. Roberts.

D. Haggerstone,

Christchurch.

'BRITISH VOLUNTEER PROGRAMME'

I am writing to you on behalf of the 'International Voluntary Service' in the Seychelles. We are part of the 'British Volunteer Programme' which is a voluntary organisation formed with a view to training technicians, etc., in the developing countries. At present the College in which I am teaching has a City and Guilds of London 235A and 235B Electricians Course, we are trying to start a **Basic Electronics Course.**

The Islands, I should explain, have just received independence, and of course have a limited budget, therefore we have problems in supplying texts for our students and component parts for building circuits. I would add that a lot of British technology is exported to the Islands but only a limited training is available. Part of the plan is to expand this training, so I would like to appeal to you and your readers, to help in as many ways as possible, one very practical way would be with back issues of your magazine which I feel would be a tremendous help in the work. Also old or used texts would certainly be gratefully received and, of course, what we call in the Trade Junk, old PCBs, Resistors, Diodes, Transistors (not too old Capacitors, etc.)

The students are hard working and would be grateful for any help in developing the skills of our industry. My colleagues and I, some of whom are directly employed by the Seychelles Government, all feel that the possibilities that exist are excellent. The British people have given political independence to the Seychellois, and we can give them economic independence by giving as generously as possible the technical training that they need. If anyone would like further information on our school please write and I would be only to willing to forward it.

G. Catto,

Seychelles Technical School,
Education Department,
P.O. Box 48,
Victoria,
Mahe,
Seychelles.

NEW TRANSISTORISED OSCILLOSCOPE

As a matter of interest I have built the oscilloscope as described in your journal by Mr. R. A. Penfold and apart from one question which he answered satisfactorily I found his method of explanation quite superior to many and I have noticed that in all his designs he appears to give very simple and concise instructions and is worthy of commendation.

One further point, your practice of sending queries direct to the designer has always appealed to me as one gets the answer direct from the 'horse's mouth' so to speak and is one reason I have been satisfied for years with the journal.

W. J. Tilbury,

Salisbury.

Radio Topics

By Recorder

In design work it is advisable never to take anything for granted. Two recent experiences of mine can demonstrate the sort of trap into which one can so readily fall if attention isn't paid to the odd unseen detail.

A recent circuit I made up was intended to turn on a silicon transistor when a supply voltage, which was available at a low source impedance, went above a certain predetermined level. The circuit I used couldn't have been simpler. A pre-set potentiometer and a zener diode were connected in series across the supply so that a proportion of the supply voltage appeared across the potentiometer track. The slider of the potentiometer connected to the base of the transistor, whose emitter coupled to the same supply rail as the potentiometer.

LIKE A BOMB

The circuit went like a bomb and did everything that was demanded of it. Until, that is, someone idly adjusted the potentiometer so that its slider was right at the end of the track which connected to the zener diode.

The result? A circuit in which a low impedance supply was connected to a zener diode, a few ohms of resistance in the potentiometer track and a forward biased transistor base-emitter junction. Naturally, the potentiometer track burned out over the small section through which the consequential heavy current flowed, whereupon one red-faced Recorder had to fit a new potentiometer *and* a series current limiting fixed resistor between its track and the zener diode. Thus modified the circuit worked just as well as before, but this time there was no risk of potentiometer burn out whatever the position of its slider.

My other experience is really an oldie in reverse. Whenever you make up experimental circuits with the aid of a bench power supply, always check the circuit with the power supply it will eventually have when it is to be used in practice. Bench power supplies offering variable voltages, short-circuit proof outputs and the like are ideal for trying out new ideas in practice. But if the circuit being designed is intended finally to work from a battery or its own mains supply, always check it out with the correct battery or supply before you finally pronounce its performance as being satisfactory.

WHEATSTONE BRIDGE

In my own case I was knocking up a d.c. Wheatstone bridge in which the d.c. null was indicated with the aid of a 741 operational amplifier. The idea is that one arm of the bridge connects to the op-amp inverting input and the other arm to the non-inverting input. The 741 is offset null adjusted and, when the two inputs have the same potential, the output swings rapidly from high to low and low to high. This scheme was used some time ago by Dick and Smithy in "In Your Workshop" in the October 1975 issue.

When a 741 is employed as an open loop amplifier without feedback it is very nearly impossible, with standard potentiometers, to bring its output to a potential mid-way between the supply rails. The voltage gain is so high that the exact input voltages required virtually cannot be resolved.

Not so with this 741. The op-amp output dutifully went high and low at the balance point, but in a most leisurely fashion. In fact I could swing the output quite readily to any voltage between the low and high extremes with very little difficulty.

And what caused this unusual behaviour? An unearthed bench power supply! There was no undue ripple on its output but it did have a capacitive coupling to the mains via the secondary and primary of its mains transformer. At the same time the components and wiring connected to the 741 inputs had a tiny but nevertheless significant capacitance to earth. The result was an extremely small mains hum pick-up in the 741 input circuits, this being enough to override the d.c. voltages at the inputs and to upset the operation of the circuit. The trouble cleared dramatically when I used a battery (as was intended eventually) instead of the bench power supply, as it did also when, later, I connected the power supply to a reliable earth.

One thing about electronic design work is that there is quite often some little unseen factor which can cause the failure of a circuit. One just has to keep an eye open for all eventualities, however hidden these may be.

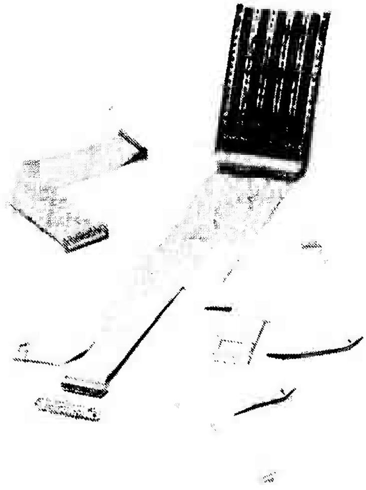
FLAT CABLE

In the accompanying photograph can be seen items from the Vero Electronics Interconnection System incorporating "Scotchflex" flat multi-core cable. "Scotchflex" is a Registered Trade Mark of the 3M Company.

The flat cable forms the heart of the Interconnection System, and offers savings in both weight and cable space requirements. It is easier to handle than a multitude of individual wires, and this fact makes wiring errors less likely to occur. Cables may be bent or folded without damaging either the insulation or the conductors. Connections between cable and plug provide high reliability, since U-contacts in the plug pierce the cable insulation and grip each conductor in a corrosion resistant, gas-tight joint. This jointing is achieved without the need to pre-strip the cable.

Connectors are available in a range of sizes from 10 to 64 contacts, on a 2.54mm. pitch. Vero also offer 14, 16 and 24 way dual-in-line plugs which are compatible with standard integrated circuit sockets. A unique feature of the Vero "Scotchflex" system is the Delta connector which is compatible with other "D" type subminiature connectors used throughout industry.

Progressively, Vero Electronics plan to extend their service by establishing an assembly facility covering all "Scotchflex" items. Initially, however, this will only relate to items carried in stock. Further details may be obtained from Vero Electronics Limited, Industrial Estate, Chandler's Ford, Eastleigh, Hampshire.



Typical items in the Vero Electronics Interconnection System incorporating "Scotchflex" multi-core cable. Connections between cable and plugs is achieved automatically without the necessity of pre-stripping the insulation

CAPACITANCE

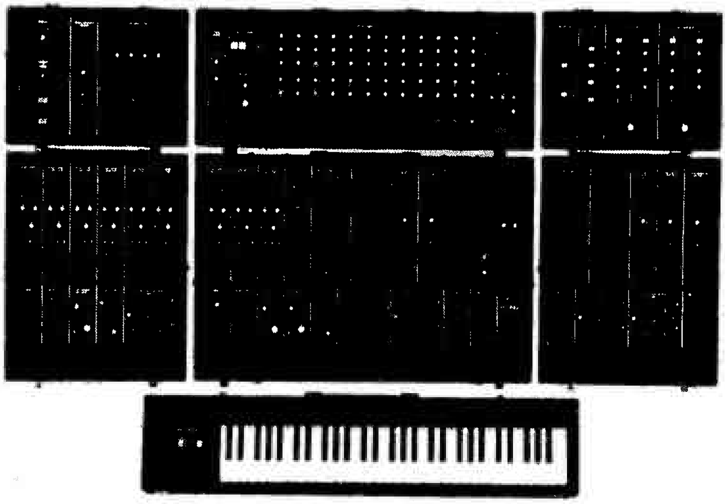
Take a high value electrolytic capacitor, connect across it an electronic voltmeter then charge it up to, say, 9 volts by applying a battery to it for a short while. Then take the battery away. If the capacitor is a modern component with very little leakage current and the voltmeter has a very high input impedance the latter will continue to indicate 9 volts (or thereabouts) for a sufficiently long period to enable the experiment to be carried out.

Next, connect another electrolytic capacitor of the same value across the first one. The voltage will immediately drop to about 4.5 volts, and stay there. If you connect a third capacitor of the same value across the two the voltage across all three will drop to about 3 volts, and so on.

In practice, you don't even need an electronic voltmeter. An ordinary testmeter having a sensitivity of 20,000 ohms per volt on its voltage ranges will be satisfactory if the electrolytic capacitors have values in the order of 2,000μF or more. The voltage across the capacitor or capacitors will fall with time as a discharge current flows through the meter, but the gradual decrease in voltage is not so fast as to prevent a meaningful experiment being carried out.

What happens, of course, is that the charge initially held by the first capacitor is shared by two capacitors when the second capacitor is added across the first, and then by three capacitors as the third is added. The charge (in coulombs) is equal to capacitance multiplied by voltage, and so if capacitance is doubled the voltage is halved.

The effect can be useful if you want to find the value of an electrolytic capacitor whose markings have become smudged or erased, but this time an electronic voltmeter will be essential. First charge up a capacitor of known value, then connect the unknown capacitor across it and note the new voltage. Multiply the known capacitance by the fall in voltage, then divide the result by the new voltage. The answer will be the value of the unknown capacitor.



The Roland System 700 Synthesizer. This has an exceptionally comprehensive specification and can be employed in company with any professional audio equipment

ROLAND SYNTHESIZER

The second photograph shows the new Roland System 700 Synthesizer, claimed by its manufacturer to be "the latest in up-to-the-minute technology". First introduced to the U.K. at the London Trade Show on August 6th of last year, this highly sophisticated piece of equipment could well be the ultimate in synthesizers. It offers an extremely large variety of applications for use by musicians and composers, recording studios, for audio research and for the teaching of acoustics.

The System 700 is a modular console type synthesizer with five optional sections. There are 47 modules to choose from for making any desired arrangement. The inputs and outputs of the modules are compatible with all professional audio equipment, so they may be used in any existing installation. In the main console the modules are logically arranged according to the signal paths. The System 700 has DIN connections for two separate 61 key manuals, together with provisions for control by external musical instruments.

Except for very fine adjustments, the positions of the potentiometer sliders on the console give a graphic representation of the balance between audio signals and control voltages. The general arrangement for each module is: upper, signal input mixers; middle, module function controls; lower, control voltage input mixers.

All modules have input and output jacks for free use of patch cords, these employing standard phone jack plugs. Also, each module contains its own input mixer, which means that the signal levels in the patch cords are high, giving less leakage and a better signal-noise ratio.

The output of each module incorporates l.e.d.'s to show signal flow through units, and the system is engineered so that external amplifiers, tape decks, etc., can be used for any manner of dubbing and recording. The inbuilt test oscillator produces a 1kHz, sine wave as well as square waves at 110Hz 220Hz, 440Hz and 880Hz. Sound can be moved around and manipulated in space by means of the reverberation unit, phase shifter and the audio delay line. Further, the system can be controlled by external musical instruments or even by singing voices.

As illustrated in the photograph, the complete system is priced at over £9,000. It can also be supplied as a modular unit, and the basic assembly starts at around £2,700 at the time of writing. Demonstrations can be arranged at Freedmans Music Centre, 629 High Road, Leytonstone, London E11.

MARCONI EXPORTS

I see that Marconi Communication Systems Limited, a GEC-Marconi Electronics company, is to supply a further two colour television transmitters for use by CBC, the Canadian Broadcasting Corporation.

Under the terms of new contracts one u.h.f. transmitter is to be supplied to CBC's station at Sarnia, Ontario, and one v.h.f. transmitter to its station at Prince Albert, Saskatchewan. In both cases the new equipments will be used to establish French language services in the areas concerned. The contracts, which were placed with the Canadian Marconi Company, also include the provision of engineering and installation services.

It may not be generally realised that Marconi Communication Systems has an unparalleled history of involvement in the growth of Canadian broadcasting. Its u.h.f. and v.h.f. broadcast transmitters are operating in places as far afield as Vancouver, Montreal, and Regina in Saskatchewan. In Toronto alone more than a million dollars' worth of the company's equipment is installed in the world's tallest self-supporting building, the CN Tower. Additionally, the company has supplied Canadian broadcasters with some 67 colour television cameras, a number of its Queen's Award winning telecine systems and a great variety of ancillary television studio equipment.

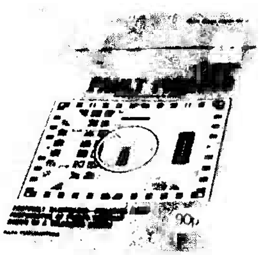
This is certainly another export achievement on the part of GEC-Marconi which deserves special credit.

METRIC MINUTE?

I dropped a minor clanger in the March issue when I referred to a digital clock changing from 09.99 to 10.00 hours. The first time should, of course, have been 09.59. My thanks to reader L. A. Chinnery for pointing out the slip and for conceiving the felicitous phrase "Metric Minute" to describe the situation. ■

TV

FAULT FINDING MANUAL for 405/625 LINES



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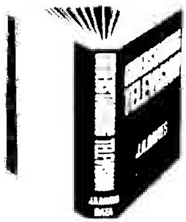

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(Continued on page 645)

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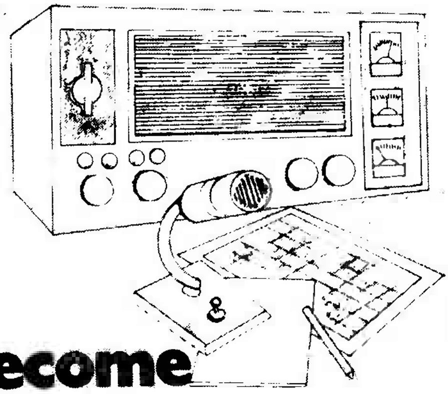
(Continued on page 647)



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(Continued from page 645)

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FOR THE BEGINNER

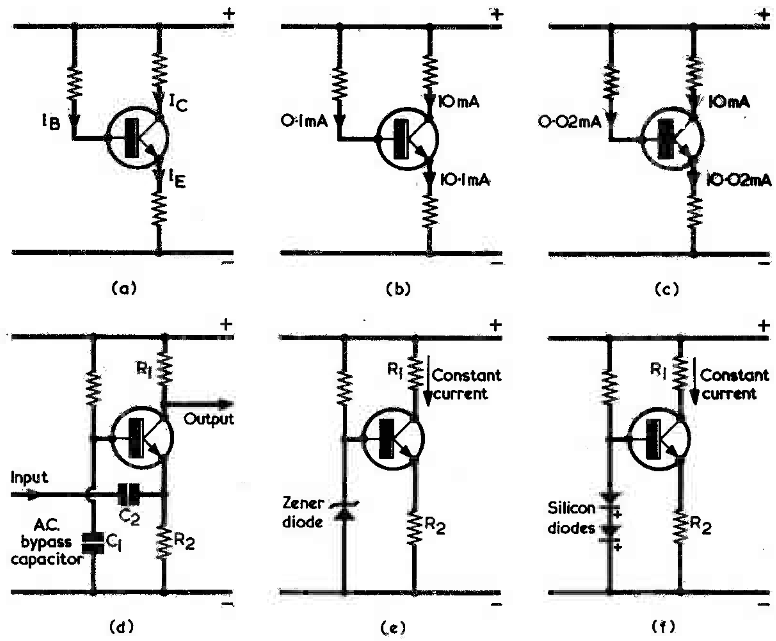
EMITTER AND COLLECTOR CURRENTS

In (a) a current, IB, flows into the transistor base, producing an amplified collector current, IC. IC is equal to IB multiplied by the current gain of the transistor. Both collector and base currents flow out of the transistor emitter, whereupon IE is equal to IC plus IB. IE is slightly greater than IC and can, with only a small error, be considered as being equal to IC.

To demonstrate this, the transistor in (b) has a current gain of 100 times. The base current is 0.1mA, the collector current is 10mA and the emitter current is 10.1mA. Transistor current gain in (c) is 500 times, and 0.02mA base current produces a collector current of 10mA. Emitter current, at 10.02mA, is even closer to the collector current value.

An a.c. signal is applied via C2 to the transistor emitter in (d). Since virtually the same current flows in R1 and R2 (and ignoring input signal source impedance) the a.c. voltage gain is R1 divided by R2. If R1 is 10 times R2, the voltage gain is 10 times. The circuit is a common base amplifier.

In (e) a fixed voltage (zener voltage minus transistor base-emitter voltage drop) appears across R2, whereupon this resistor passes a constant current. Virtually the same constant current flows in R1 for all resistance values from zero to the maximum which allows the current to flow. The same principle is used in (f) where the base voltage is held steady by two forward connected silicon diodes. Due to the lower base voltage, less voltage is wasted in R2 and a greater range of voltages is available in R1.



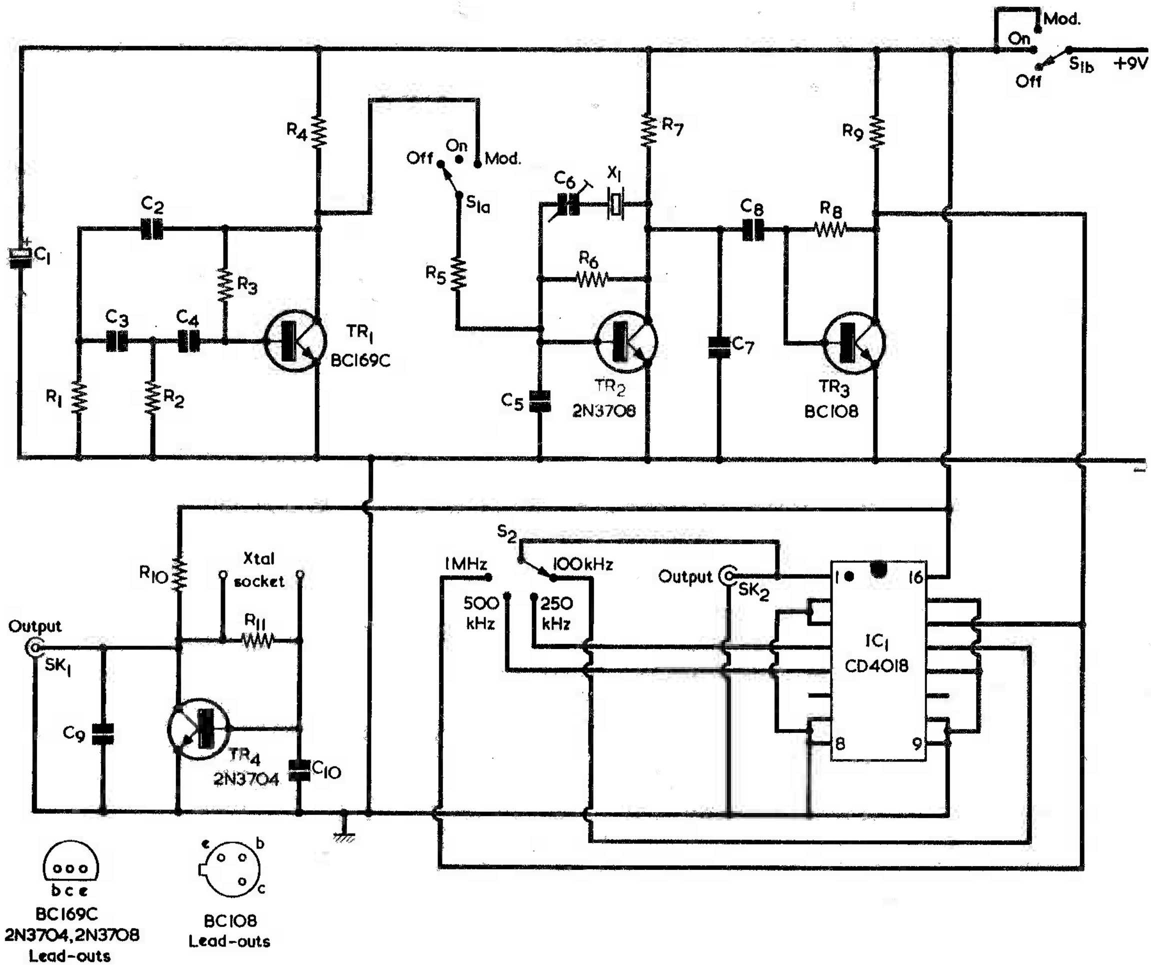
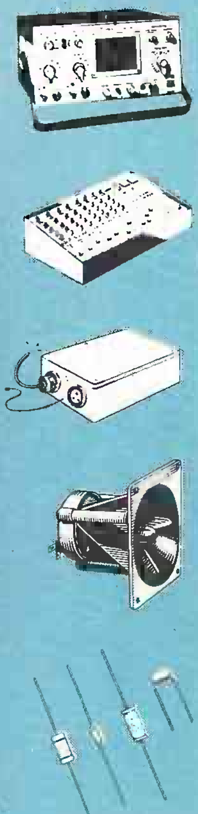


Fig. 2. The circuit of the CMOS crystal calibrator. The CD4018 i.c. provides the frequency division required for the outputs at 500kHz, 250kHz and 100kHz

MAPLIN



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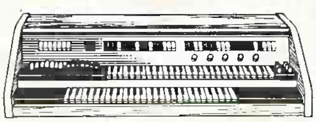

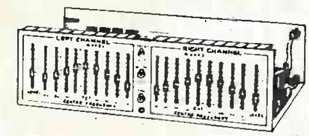

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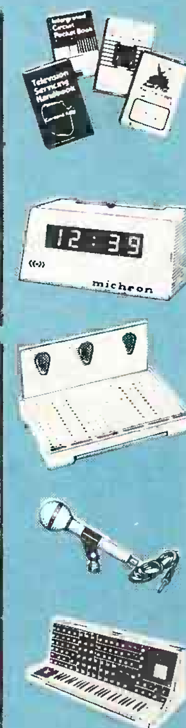

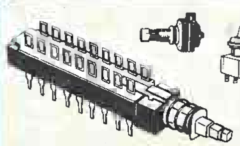

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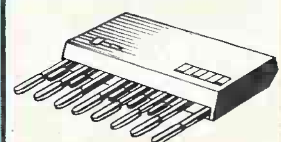

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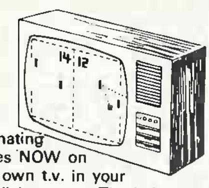

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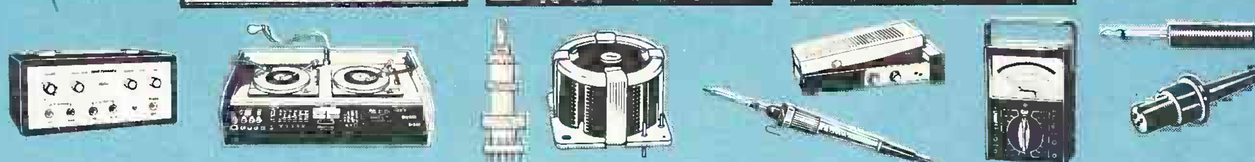

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