RADIO & ELECTRONICS CONSTRUCTOR

NOVEMBER 1976

35p

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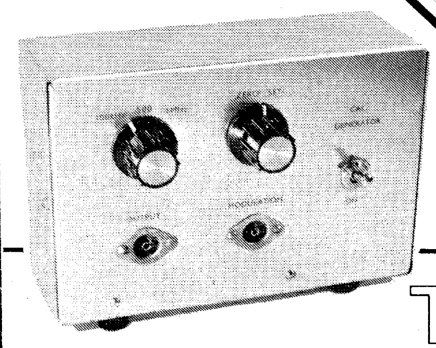
F·M·TUNER

PART 1
(2 PARTS)



T·T·L CALIBRATION GENERATOR

Wall CHART
DESIGN DATA
TABLES II

ALSO FEATURED

RADIO & ELECTRONICS CONSTRUCTOR

NOVEMBER 1976
Volume 30 No. 4

Published Monthly (1st of Month)
First Published 1947

Incorporating The Radio Amateur

Editorial and Advertising Offices
57 MAIDA VALE LONDON W9 1SN

Telephone 01-286 6141
Telegrams Databux, London

Annual Subscription: £5.00 (U.S.A. and Canada $11.00) including postage. Remittances should be made payable to "Data Publications Ltd". Overseas readers please pay by cheque or International Money Order.

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Correspondence should be addressed to the Editor, Advertising Manager, Subscription Manager or the Publishers as appropriate.

Opinions expressed by contributors are not necessarily those of the Editor or proprietors.

Production.—Web Offset.

Published in Great Britain by the Proprietors and Publishers, Data Publications Ltd, 57 Maida Vale, London W9 1SN

The *Radio & Electronics Constructor* is printed by Swale Press Ltd.

THE DECEMBER ISSUE WILL BE PUBLISHED ON 1st DECEMBER

SEMI-CONDUCTORS

TRANSISTORS

BRAND NEW — FULLY GUARANTEED

Type	Price
AC117K	*0.30
AC126	*0.18
AC126	*0.14
AC127	*0.11
AC128	*0.11
AC128K	*0.26
AC141	*0.19
AC141K	*0.80
AC142	*0.19
AC142K	*0.26
AC153K	*0.24
AC176	*0.11
AC176K	*0.26
AC180	*0.20
AC180K	*0.30
AC181	*0.20
AC181K	*0.30
AC187	*0.17
AC187K	*0.23
AC188	*0.19
AC188K	*0.23
AD140	*0.49
AD142	*0.55
AD143	*0.49
AD149	*0.45
AD150	*0.65
AD161	*0.36
AD162	*0.36
AD161 & AD162 (MP)	*0.69
AF114	*0.22
AF115	*0.22
AF116	*0.22
AF117	*0.22
AF118	*0.32
AF124	*0.28
AF125	*0.28
AF126	*0.26

Type	Price
AF127	*0.26
AF139	*0.31
AF178	*0.51
AF179	*0.51
AF180	*0.51
AF181	*0.51
AF186	*0.51
AF239	*0.38
AL102	*0.75
AL103	*0.75
BC107	*0.08
BC108	*0.08
BC109	*0.08
BC113	0.10
BC114	0.16
BC115	0.16
BC116	0.16
BC117	0.19
BC118	0.09
BC119	*0.31
BC120	*0.81
BC137	0.16
BC139	*0.41
BC140	*0.31
BC141	*0.31
BC142	*0.31
BC143	*0.31
BC145	0.46
BC147	0.09
BC148	0.09
BC149	0.09
BC150	0.19
BC151	0.20
BC152	0.18
BC153	0.29
BC154	0.20
BC157	0.11
BC158	0.11
BC159	0.11

Type	Price
BC160	*0.46
BC161	*0.51
BC167	0.10
BC168	0.10
BC169	0.10
BC169C	0.10
BC170	0.09
BC171	0.09
BC172	0.09
BC173	0.09
BC174	‡ 0.15
BC175	*0.22
BC177	*0.16
BC178	*0.16
BC179	*0.16
BC180	*0.25
BC181	0.25
BC182	0.09
BC182L	0.09
BC183	0.09
BC183L	0.09
BC184	0.09
BC184L	0.09
BC186	*0.29
BC187	*0.29
BC207	0.11
BC208	0.11
BC209	0.12
BC212	0.10
BC212L	0.10
BC213	0.10
BC213L	0.10
BC214	0.10
BC214L	0.10
BC225	0.26
BC226	0.36
BC251	0.10
BC301	*0.28
BC302	*0.25

Type	Price
BC303	*0.31
BC304	*0.37
BC327	0.12
BC238	0.12
BC337	0.12
BC338	0.12
BC440	*0.31
BC460	*0.37
BD115	*0.63
BD116	*0.81
BD121	*0.61
BD123	*0.67
BD124	*0.70
BD131	*0.36
BD132	*0.40
BD133	*0.67
BD135	0.41
BD136	0.41
BD137	0.46
BD138	0.51
BD139	0.56
BD140	0.61
BD155	*0.81
BD175	*0.61
BD176	*0.61
BD177	*0.67
BD178	*0.67
BD179	*0.71
BD180	*0.71
BD185	*0.67
BD186	*0.67
BD187	*0.71
BD188	*0.71
BD189	*0.77
BD190	*0.77
BD195	*0.87
BD156	*0.87
BD197	*0.92
BD198	*0.92

Type	Price
BD199	*0.98
BD200	*0.98
BD205	*0.81
BD206	*0.81
BD207	*0.98
BD208	*0.98
BDY20	*1.02
BF115	*0.15
BF117	*0.46
BF118	*0.71
BF119	*0.71
BF152	0.56
BF153	0.46
BF154	0.46
BF155	*0.71
BF156	*0.49
BF157	*0.56
BF158	0.56
BF159	0.61
BF173	*0.15
BF176	0.36
BF179	*0.31
BF180	*0.31
BF181	*0.31
BF194	0.10
BF195	0.10
BF196	0.92
BF197	0.12
BF198	0.12
BF199	0.12
BF257	*0.28
BF258	*0.36
BF259	*0.46
BF262	0.56
BF263	0.56
BF270	*0.36
BF271	*0.31
BF272	*0.81
BF273	0.36

Type	Price
BF274	0.36
BFX29	*0.25
BFX84	*0.19
BFX85	*0.25
BFX86	*0.22
BFX87	*0.22
BFX88	*0.22
BFY50	*0.13
BFY51	*0.13
BFY52	*0.13
BFY53	*0.13
BSY19	*0.16
BSX20	*0.16
BSY25	*0.16
BSY26	*0.16
BSY27	*0.16
BSY28	*0.16
BSY29	*0.16
BSY38	*0.19
BSY39	*0.19
BSY40	*0.29
BSY41	*0.29
BSY95	*0.13
BSY95A	*0.13
BU105	*1.90
MJE521	*0.56
MJE2955	*0.88
MJE3055	*0.57
MJE3440	*0.51
MPF102	*0.28
MPF104	*0.28
MPF105	*0.28
OC19	*0.36
OC20	*0.80
OC22	*0.47
OC23	*0.49
OC24	*0.57
OC25	*0.39
OC26	*0.38

Type	Price
OC28	*0.60
OC29	*0.60
OC35	*0.45
OC36	*0.51
OC41	*0.20
OC42	*0.25
OC44	*0.16
OC45	*0.13
OC70	*0.10
OC71	*0.10
OC72	*0.15
OC74	*0.15
OC75	*0.16
OC76	*0.16
OC77	*0.26
OC81	*0.16
OC81D	*0.16
OC82	*0.16
OC82D	*0.16
OC83	*0.20
OC139	*0.20
OC140	*0.23
OC169	*0.26
OC170	*0.26
OC171	*0.26
OC200	*0.26
OC201	*0.29
OC202	*0.29
OC203	*0.26
OC204	*0.26
OC205	*0.38
OCP71	*0.44
ORP12/ NSL4931	*0.48
ORP60	*0.41
ORP61	*0.41
TIP29	*0.40
TIP30	*0.45
TIP31A	*0.52

Type	Price
TIP32A	*0.60
TIP41A	*0.65
TIP42*	*0.72
TIS43	*0.25
UT46	*0.20
ZTX107	0.07
ZTX108	0.07
ZTX109	0.07
ZTX300	0.07
ZXT500	0.09
2N696	*0.10
2N697	*0.11
2N698	*0.20
2N699	*0.36
2N706	*0.08
2N706A	*0.09
2N708	*0.11
2N914	*0.15
2N918	*0.81
2N1131	*0.18
2N1132	*0.18
2N1302	*0.15
2N1303	*0.15
2N1304	*0.18
2N1305	*0.18
2N1306	*0.21
2N1307	*0.21

Type	Price
2N1308	*0.24
2N1309	*0.24
2N1613	*0.16
2N1711	*0.16
2N2147	*0.73
2N2148	*0.58
2N2218	*0.18
2N2218A	*0.19
2N2219	*0.18
2N2219A	*0.19
2N2220	*0.22
2N2221	*0.18
2N2222	*0.18
2N2368	*0.18
2N2369	*0.12
2N2369A	*0.12
2N2646	*0.34
2N2904	*0.14
2N2904A	*0.18
2N2905	*0.18
2N2905A	*0.18
2N2096	*0.12
2N2906A	*0.14
2N2907	*0.15
2N2907A	*0.16
2N2923	0.15
2N2924	0.15

Type	Price
2N2925	0.15
2N2926G	0.09
2N2926Y	0.09
2N2926O	0.08
2N2926R	0.07
2N2926B	0.07
2N3053	*0.15
2N3054	*0.40
2N3055	*0.40
2N3402	*0.21
2N3403	*0.21
2N3404	*0.29
2N3405	*0.43
2N3614	*0.69
2N3615	*0.76
2N3616	*0.76
2N3646	0.09
2N3702	0.09
2N3703	0.09
2N3704	0.08
2N3705	0.08
2N3706	0.08
2N3707	0.08
2N3708	0.08
2N3709	0.08
2N3710	0.09
2N3711	0.09

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Pak No.		Price
U50	100 Germ. Gold bonded OA47 diode	*0.60
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U53	150 diodes 75mA 1N4148	*0.60
U54	50 Sil Rect Top Hat 750mA	*0.60
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U56	50 400mW Zeners DO7 Case	*0.60
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U58	30 PNP Trans BC177/178 Plastic	0.60
U59	25 NPN TO39 2N697/2N1711 silicon	*0.60
U60	25 PNP TO59 2N2905 silicon	*0.60
U61	30 NPN TO18 2N706 silicon	*0.60
U62	25 NPN BFY50/51	*0.60
U63	30 NPN Plastic 2N3904 silicon	0.60
U64	30 PNP Plastic 2N3905 silicon	0.60
U65	30 Germ. OC71 PNP	*0.60
U66	15 Plastic Power 2N3055 NPN	*1.20
U67	10 TO3 Metal 2N3055 NPN	*1.20
U68	20 Unijunction trans TIS43	*0.60
U69	10 lamp SCR TO39	*1.20
U70	8 3amp SCR TO66 case	*1.20

Code No's mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

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2 Amp	TO5	*0.31	*0.51	*0.71
6 Amp	TO66	*0.51	*0.61	*0.77
10 Amp	TO48	*0.77	*0.92	*£1.12

GP300

115 WATT SILICON TO3 METAL CASE
Vcbo 100V. Vceo 60V, IC, 15A, Hfe, 20-100 suitable replacement for **2N3055 BDY11** or **BDY20**.

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PIV	0.6A TO18	0.8A TO92	1A TO5	3A TO66	5A TO66	5A TO64	7A TO48	10A TO48	16A TO48	30A TO48
10	*0.13	*0.15	—	—	—	—	—	—	—	—
20	*0.15	*0.18	—	—	—	—	—	—	—	—
30	*0.19	*0.22	—	—	—	—	—	—	—	—
50	*0.22	*0.28	*0.20	*0.25	*0.36	*0.36	*0.48	*0.51	*0.54	*£1.18
100	*0.25	*0.30	*0.25	*0.25	*0.48	*0.48	*0.51	*0.57	*0.58	*£1.43
150	*0.31	*0.38	—	—	—	—	—	—	—	—
200	*0.38	*0.44	*0.25	*0.30	*0.50	*0.50	*0.57	*0.62	*0.62	*£1.63
400	—	—	*0.30	*0.39	*0.55	*0.57	*0.62	*0.71	*0.77	*£1.79
600	—	—	*0.39	*0.48	*0.69	*0.69	*0.78	*0.89	*0.90	—
800	—	—	*0.58	*0.65	*0.81	*0.81	*0.92	*£1.22	*£1.39	*£4.07

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PIV	300mA (DO7)	750mA (SO16)		1 Amp Plastic	1.5 Amp (SO16)	3 Amp (SO10)	10 Amp (SO10)	30 Amp (TO48)
50	*0.05	*0.06	IN4001	*0.05	*0.07	*0.14	*0.19	*0.56
100	*0.05	*0.07	IN4002	*0.06	*0.09	*0.16	*0.21	*0.69
200	*0.06	*0.09	IN4003	*0.07	*0.12	*0.20	*0.23	*0.99
400	*0.07	*0.14	IN4004	*0.08	*0.14	*0.28	*0.35	*£1.25
600	*0.08	*0.16	IN4005	*0.09	*0.16	*0.33	*0.42	*£1.76
800	*0.11	*0.18	IN4006	*0.10	*0.18	*0.35	*0.51	*£1.94
1000	*0.13	*0.28	IN4007	*0.11	*0.23	*0.44	*0.60	*£2.31
1200	—	*0.32			*0.28	*0.54	*0.69	*£2.88

BI-PAK

P.O. BOX 6 WARE HERTS

SEMI-CONDUCTORS

Linear IC's

Type	1	25	100+	Type	1	25	100+	Type	1	25	100+
72702	0.46	0.44	0.42	SL701C	0.46	0.42	0.37	76003	£1.39	£1.34	£1.30
72709	0.23	0.21	0.19	SL702C	0.46	0.42	0.37	76023	£1.39	£1.34	£1.30
72709P	0.19	0.18	0.17	TAA263	0.74	0.65	0.56	76660	0.88	0.86	0.83
72710	0.32	0.31	0.28	TAA293	0.93	0.88	0.83	LM380	0.93	0.90	0.88
72741	0.28	0.27	0.26	TAA350	£1.71	£1.67	£1.57	*NE555	0.45	0.43	0.40
72741C	0.26	0.25	0.24	uA703C	0.26	0.24	0.22	*NE556	0.88	0.86	0.83
72741P	0.28	0.27	0.26	uA709C	0.19	0.18	0.17	TBA800	£1.39	£1.34	£1.30
72747	0.79	0.74	0.61	uA711C	0.32	0.31	0.28				
72748P	0.35	0.33	0.31	uA712C	0.32	0.31	0.28				
SL201C	0.46	0.42	0.37	uA723C	0.45	0.43	0.40				

(Quantities: 1, 25, 100+)

★ 74 Series TTL IC's

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Type	1	25	100+	Type	1	25	100+	Type	1	25	100+
7400	0.09	0.09	0.08	7448	0.80	0.78	0.76	74122	0.50	0.48	0.46
7401	0.10	0.09	0.08	7450	0.12	0.11	0.10	74123	0.58	0.56	0.54
7402	0.11	0.10	0.09	7451	0.12	0.11	0.10	74141	0.60	0.58	0.56
7403	0.11	0.10	0.09	7453	0.12	0.11	0.10	74145	0.96	0.94	0.92
7404	0.13	0.12	0.11	7454	0.12	0.11	0.10	74150	£1.30	£1.25	£1.20
7405	0.13	0.12	0.11	7460	0.12	0.11	0.10	74151	0.76	0.74	0.72
7406	0.25	0.24	0.23	7470	0.25	0.24	0.23	74153	0.95	0.93	0.91
7407	0.25	0.24	0.23	7472	0.22	0.21	0.20	74154	£1.50	£1.45	£1.40
7408	0.15	0.14	0.13	7473	0.26	0.24	0.22	74155	0.80	0.78	0.76
7409	0.15	0.14	0.13	7474	0.27	0.25	0.23	74156	0.80	0.78	0.76
7410	0.09	0.09	0.08	7475	0.48	0.46	0.44	74157	0.95	0.93	0.91
7411	0.23	0.22	0.21	7476	0.25	0.24	0.23	74160	£1.00	0.98	0.96
7412	0.25	0.25	0.24	7480	0.50	0.48	0.46	74161	£1.00	0.98	0.96
7413	0.26	0.25	0.25	7481	£1.02	£1.00	0.98	74162	£1.00	0.98	0.96
7416	0.28	0.27	0.26	7482	0.83	0.81	0.79	74163	£1.00	0.98	0.96
7417	0.28	0.27	0.26	7483	0.98	0.96	0.94	74164	£1.25	£1.20	£1.15
7420	0.12	0.11	0.10	7484	0.90	0.88	0.86	74165	£1.25	£1.20	£1.15
7422	0.28	0.27	0.26	7485	£1.25	£1.20	£1.15	74166	£1.48	£1.44	£1.39
7423	0.30	0.28	0.26	7486	0.32	0.30	0.29	74174	£1.00	0.95	0.90
7425	0.30	0.28	0.26	7489	£2.90	£2.80	£2.70	74175	0.95	0.93	0.91
7426	0.30	0.28	0.26	7490	0.37	0.35	0.33	74176	£1.16	£1.11	£1.06
7427	0.30	0.28	0.26	7491	0.60	0.58	0.56	74177	£1.16	£1.11	£1.06
7428	0.42	0.38	0.36	7492	0.43	0.42	0.41	74180	£1.16	£1.11	£1.06
7430	0.12	0.11	0.10	7493	0.43	0.32	0.41	74181	£2.00	£1.90	£1.80
7432	0.30	0.28	0.26	7494	0.43	0.42	0.41	74182	0.90	0.88	0.86
7433	0.39	0.37	0.35	7495	0.68	0.66	0.64	74184	£1.67	£1.62	£1.58
7437	0.30	0.28	0.26	7496	0.68	0.66	0.64	74190	£1.50	£1.45	£1.40
7438	0.30	0.28	0.26	74100	£1.00	0.98	0.96	74191	£1.50	£1.45	£1.40
7440	0.12	0.11	0.10	74104	0.40	0.38	0.36	74192	£1.15	£1.10	£1.05
7441	0.64	0.62	0.60	74105	0.40	0.38	0.36	74193	£1.15	£1.10	£1.05
7442	0.65	0.63	0.61	74107	0.36	0.34	0.32	74194	£1.15	£1.10	£1.05
7443	£1.10	£1.05	£1.00	74110	0.56	0.54	0.52	74195	0.80	0.78	0.76
7444	£1.10	£1.05	£1.00	74111	0.83	0.81	0.79	74196	£1.00	0.98	0.96
7445	0.95	0.90	0.85	74118	0.90	0.88	0.86	74197	£1.00	0.98	0.96
7446	£1.10	£1.05	£1.00	74119	£1.25	£1.20	£1.15	74198	£2.10	£2.00	£1.90
7447	0.67	0.65	0.63	74121	0.26	0.26	0.25	74199	£1.95	£1.90	£1.85

Devices may be mixed to qualify for quantity price. (TTL 74 series only). Data is available for the above series of IC's in booklet form. PRICE: 35p

★ DTL 930 Series

Type	1	25	100+	Type	1	25	100+	Type	1	25	100+
BP930	0.20	0.19	0.19	BP944	0.21	0.20	0.19	BP962	0.20	0.19	0.18
BP932	0.21	0.20	0.19	BP945	0.34	0.32	0.29	BP9083	0.48	0.46	0.44
BP933	0.21	0.20	0.19	BP946	0.30	0.19	0.18	BP9094	0.48	0.46	0.44
BP935	0.21	0.20	0.19	BP948	0.34	0.32	0.29	BP9097	0.48	0.46	0.44
BP936	0.21	0.20	0.19	BP951	0.71	0.66	0.61	BP9099	0.48	0.46	0.44

★ DIL Sockets

	1	25	100+
BPS8 8 pin type (low cost)	0.14	0.12	0.10
BPS14 14 pin type (low cost)	0.15	0.13	0.11
BPS16 16 pin type (low cost)	0.16	0.14	0.12
BPS24 24 pin type (low cost)	0.35	0.33	0.30

VAT

PLEASE ADD 8% TO ITEMS MARKED ★ REMAINDER ADD 12½%

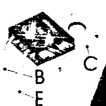
★ Voltage Regulators

TO.3 Plastic Encapsulation

μA.7805/L129 5V (equiv. to MVR5V)	£1.25
μA.7812/L130 12V (equiv. to MVR12V)	£1.25
μA.7815/L131 15V (equiv. to MVR15V)	£1.25
μA.7818 18V (equiv. to MVR18V)	£1.25

POW! POWER!!

R.C.A. 2N5295 NPN to 3 Plastic Power
VCE 50v.
VCB 60v.
P 36w. Ic 4A
hFE 30-120
ONLY
£1.50•
for 10



Untested LIN Paks

Manufacturers "Fall Outs" which include Functional and part Functional Units. These are classified as 'Out-of-spec' from the makers, very rigid specifications, but are ideal for learning about I.C.s and experimental work.

Pak No.	Contest	Price	
ULIC709 =	10 x 709	0.60	**Untested Audio Paks** Comprising 5, I.C.s:– 76003/76023 series **ONLY £1 per Pak** Complete with data
ULIC710 =	7 x 710	0.60	
ULIC741 =	7 x 741	0.60	**FM Stereo Decoder Pak** Comprising 5, I.C.s:– like MC1307 and SN 76110 **ONLY £1.50 per Pak** Complete with data.
ULIC747 =	5 x 747	0.60	
ULIC748 =	7 x 748	0.60	

Mammoth IC Pak

APPROX. 200 PIECES

Assorted fall-out integrated circuits, including: Logic, 74 Series, Linear, Audio and D.T.L. Many coded devices but some unmarked – you to identify.

OUR SPECIAL PRICE £1.20•

P&P

Postage and Packing add 25p unless otherwise shown. Add extra for air-mail. Minimum order £1.

★ Indicators

3015F Minitron 7 Segment Indicator **£1.11**

L.E.D. DISPLAYS

DL707 Common anode 0·3" **85p. DL747** Jumbo common anode 0·6" **£1.70. DL727** Double digit display, common anode 0·5" **£2.00**

L.E.D.'s

Available in 0·125" and 0·2" dia lenses
RED 19p. GREEN 17p. YELLOW 17p.
Mounting clips 2p each

NIXI TUBE ITT 5870S.
Character height 13·46mm.
SPECIAL OFFER 5 for £2

★ Untested TTL Paks

Manufacturers "Fall Outs" which include Functional and part Functional Units. These are classed as "out-of-spec" from maker's very rigid specifications, but are ideal for learning about I.C.'s and experimental work.

74G

100 Gates assorted
7400-01-04-10-50-60 etc
£1.20

174 SERIES IC PAKS
74F 30 Flip-Flops assorted
7470-72-73-74-76-104-109 etc.
£1.20

174 SERIES IC PAKS
74M 30 MSI Assorted Types
7441-47-90-154 etc. **£1.20**

BI-PAK

P.O. BOX 6 WARE HERTS
COMPONENT SHOP: 18 BALDOCK STREET, WARE. TEL: 61593

TRADE COMPONENTS

JUST A FEW BARGAINS ARE LISTED - SEND STAMPED ADDRESSED ENVELOPE FOR A QUOTE ON OTHER REQUIREMENTS. PAY A VISIT. OVER 90% OF STOCK BELOW QUANTITY WHOLESALE PRICE. RETURN POSTAL SERVICE UNLESS CHEQUE. ALL PRICES INCLUDE THE ADDITIONAL DISCOUNT IN LIEU OF GUARANTEE.

Goods sent at customer s risk, unless suficient payment for registration (1st class letter post) or compensation fee (parcel post) included.

VALVE BASES

Printed circuit B9A–B7G **5p**
Chassis B7–B7G **9p**
Shrouded chassis B7G–B9A–B8A ... **10p**
B12A tube ... **9p**

Speaker 6" x 4" 5 ohm ideal for car radio **£1.25**

TAG STRIP – 6 way **3p** 9 way **5p** Single **1p**

5 x 50pF or 2 x 220pF trimmers 20p

Car type panel lock and key **60p**
18 volt 4 amp charger, bridge rectifier **79p**
GC10/4B **£3.00**

Telescopic aerial
Closed $9\frac{1}{2}$", open $38\frac{1}{2}$"
Fitted right angle TV plug, **50p**

BOXES — Grey polystyrene 61 x 112 x 31mm, top secured by 4 self tapping screws **$32\frac{1}{2}$p**
Clear perspex sliding lid, 46 x 39 x 24mm **10p**
ABS, ribbed inside 5mm centres for P.C.B., brass corner inserts, screw down lid, 50 x 100 x 25mm orange **48p**; 80 x 150 x 50mm black **70p**; 109 x 185 x 60mm black **£1.10**

ALUMINIUM

				8" x 6" x 3"	**£1.02**
3" x 2" x1"	**39p**	4" x $2\frac{1}{2}$" x 2"	**44p**	10" x $4\frac{1}{2}$" x 3"	**£1.02**
$2\frac{3}{4}$" x $5\frac{1}{4}$" x $1\frac{1}{2}$"	**45p**	4" x $5\frac{1}{4}$" x $1\frac{1}{2}$"	**54p**	12" x 5" x 3"	**£1.20**
4" x 4" x $1\frac{1}{2}$"	**45p**	6" x 4" x 2"	**65p**	10" x 7" x 3"	**£1.22**
4" x $2\frac{3}{4}$" x $1\frac{1}{2}$"	**45p**	7" x 5" x $2\frac{1}{2}$"	**79p**	12" x 8" x 3"	**£1.50**

SWITCHES

Pole	*Way*	*Type*	
4	2	Sub. Min. Slide	**18p**
6	2	Slide	**20p**
2	2	Slide	**14p**
1	3	13 amp small rotary	**12p**
2	2	Locking with 2 to 3 keys	**£2.00**
2	1	2 Amp 250V A.C. rotary	**28p**

Wafer Rotary, all types **30p**
S.P.S.T. 10 amp 240v. white rocker switch with neon. 1" square flush panel fitting **46p**
S.P.S.T. dot 13 amp, oblong, push-fit, rocker **20p**

AUDIO LEADS

5 pin din plug 180° both ends $1\frac{1}{2}$ Mtr., **80p**
3 pin din to open end, $1\frac{1}{2}$ yd twin screened **35p**
Phono to Phono plug, 6ft. **35p**

COMPUTER AND AUDIO BOARDS

VARYING PANELS WITH ZENER, GOLD BOND, SILICON, GERMANIUM, LOW AND HIGH POWER TRANSISTORS AND DIODES, HI STAB RESISTORS, CAPACITORS, ELECTROLYTICS, TRIMPOTS, POT CORES, CHOKES ETC.
3lb for **85p** + **85p** post and packing
7lb for **£1.95** + **£1.20** post and packing

Skeleton Presets
Slider, horizontal or vertical standard or submin. **5p**

3" Tape Spools **8p**
1" Terry Clips **4p**
12 Volt Solenoid **30p**

KNOBS

SILVER METAL PUSH ON WITH POINTER, OR WHITE PLASTIC, GRUB SCREW WITH GOLD CENTRE **8p** EACH

ENM Ltd. cased 7-digit counter $2\frac{1}{4}$ x $1\frac{3}{4}$ x $1\frac{1}{4}$" approx. 12V d.c. (48 a.c.) or mains **75p**

ZM1162A INDICATOR TUBE

0-9 Inline End View. Rectangular Envelope 170V 2·5M/A **£1**

REGULATED TAPE MOTOR
9v d.c. nominal approx $1\frac{1}{2}$" diameter **75p**

12v 8 amp Transformer **£2.50 (p&p 85p)**

Ferric Chloride, Anhydrous mil. spec. 1lb bag **40p**

RESISTORS

$\frac{1}{8}$-$\frac{1}{4}$-$\frac{1}{2}$ watt .. **1p**
1 watt **3p**
Up to 5 watt wire **11p**
10 watt wire wound **12p**
15 watt **12p**
1 or 2% five times price.

Semiconductor Data Book 263 pages. Covers 2N21 through to 2N5558 plus some 3N's. Type/connection/parameter details **£1.50** No VAT

POTS

Log or Lin carbon **16p**
Switched **31p**
Dual Pots **45p**
Dual & switch .. **60p**
Lin wirewound **25p**
Slider Pot .. **35p**
Dual Slider .. **50p**
1.5m Edgetype **8p**

THERMISTORS

VA1008, VA1034, VA1039, VA1040, VA1055, VA1066, VA1082, VA1100 **10p**
VA1077, VA1005, VA1026 **15p**

RELAYS

12 volt S.P.C.O octal mercury wetted high speed **75p**
P.O. 3000 type, 1,000 OHM coil, 4 pole c/o **60p**
Mains or 12v d.p.c.o heavy duty octal **£1**

Boxed GEC KT88 valve **£2**

JAP 4 gang min. sealed tuning condensers **New 35p**

ELECTROLYTICS MFD/VOLT. Many others in stock

MFD	Up to 10V	25V	50V	70–75V	100V	200–250V	300–350V	450–500V
10	4p	5p	6p	8p	10p	12p	16p	20p
25	4p	5p	6p	8p	10p	15p	18p	20p
50	4p	5p	6p	9p	13p	18p	25p	—
100	5p	6p	10p	12p	19p	20p	—	—
250	9p	10p	11p	17p	28p	—	85p	£1
500	10p	11p	17p	24p	45p	—	—	—
1000	13p	22p	40p	75p	—	£1.50	—	—
2000	23p	37p	45p	—	—	—	—	—

As total values are too numerous to list, use this price guide to work out your actual requirements

8/20, 10/20, 12/20 **Tubular tantalum 20p each** 16-32/275V. 32-32/275V. 100-100/150V. 100-100/275V **30p**; 50-50/385V, 12,000/12V, 32-32-50/300V, 20-20-20/350V **60p**; 700 mfd/200V **£1.00**; 100-100-100-150-150/320V **£2.00.**

RS 100–0–100 micro amp null indicator
Approx. 2" x $\frac{3}{4}$" x $\frac{3}{4}$" **£1.50**

INDICATORS

Bulgin D676 red, takes M.E.S. bulb **30p**
12 volt or Mains neon, red pushfit **18p**
R.S. Scale Print, pressure transfer sheet **10p**

CAPACITOR GUIDE – maximum 500V

Up to .01 ceramic **3p.** Up to .01 poly **4p.** .013 up to .1 poly etc. **5p.** .12 up to .68 poly etc. **6p.** Silver mica up to 360pF **8p,** then to 2,200pF **11p,** then to .01 mfd **18p.**
8p. .1/600: **12p.** .01/1000, 1/350, 8/20, .1/900, .22/900, 4/16. .25/250 AC (600vDC) .1/1500 **40p.** 5/150, 9/275AC, 10/150, 40/150.
Many others and high voltage in stock.

FORDYCE DELAY UNIT

240 volt A.C./D.C. Will hold relay, etc., for approx. 15 secs after power off. Ideal for alarm circuits, etc. **£1**

CONNECTOR STRIP

Belling Lee L1469, 4 way polythene. **6p each**

$1\frac{1}{4}$ glass fuses 250 m/a or 3 amp (box of 12) **24p**
Bulgin, 5mm Jack plug and switched socket (pair) **30p**

1" or $1\frac{1}{4}$" or 2" or $\frac{3}{4}$" CAN CLIPS 6p

MAINS DROPPERS

36+79 ohm **25p**
66+66+158 ohm, 66+66+137 ohm
17+14+6 ohm, 266+14+193 ohm **30p**
50+40+1k5 ohm
285+575+148+35 ohm
25+35+97+59+30 ohm **40p**

$5\frac{1}{4}$" x $2\frac{3}{4}$" Speaker, ex-equipment 3 ohm **30p**
2 Amp Suppression Choke **8p**
PAXOLINE
3 x $2\frac{1}{2}$ x $\frac{1}{16}$" **4p**
$4\frac{5}{8}$ x $\frac{1}{2}$ x $\frac{1}{8}$". **1p**
PCV or metal clip on MES bulb Holder **4p**
VALVE RETAINER CLIP, adjustable **2p**

OUTPUT TRANSFORMERS

Sub-miniature Transistor Type **25p**
Valve type, **40p**

Transformers 6 volt $\frac{1}{2}$A **£1.00**
Whiteley Stentorian 3 ohm constant impedance volume control way below trade at **80p**
Drive Cord ... ... **1p foot**
18 SWG multicore solder **$2\frac{1}{2}$p foot**

THE RADIO SHACK

161 ST. JOHNS HILL, BATTERSEA, LONDON S.W.11
Open 10 a.m. till 7 p.m. Monday to Saturday. VAT receipts on request
Terms: Payment with order Telephone: 01-223 5016

SEMICONDUCTORS

Full spec. marked by Mullard, etc. Many other types in stock

AC107	16p
AC128/176	8p
ACY28	19p
AD149	40p
AD161/2	33p
AF116	16½p
AF124/6/7	25p
AF139	20p
AF178/80/81	30p
AF239	30p
ASY27/73	30p
BC107/8/9 + A/B/C	6p
BC147/8/9 + A/B/C/S	6p
BC157/8/9 + A/B/C	6p
BC178A/B, 179B	12p
BC184C/LC	9p
BC186/7	20p
BC213L/214B	10p
BC216B	8p
BC327/8, 337/8	8p
BC547/8/8A	10p
BC557/8/9	9p
BCX32/36	12p
BCY40	50p
BCY70/1/2	12p
BD112/3	50p
BD115/6	31p
BD131/2/3	35p
BD135/7/9	30p
BD142	30p
BD201/2/3/4	80p
BD232/4/5	49p
BDX77	£1
BF115/167/173	15p
BF178/9	20p
BF180/1/2/3/4/5	15p
BF194/5/6/7	6p
BF194A, 195C	6p
BF200, 258	20p
BF202/3	30p
BF336	27p
BFS28 Dual Mosfet	£1
BFW10/11 F.E.T.	40p
BFW30	£1
BFW57/58	17p
BFX12/29/30	20p
BFX84/88/89	17p
BFY51/52	13p
BFY90	50p
BR101	30p
BRY39/56	26p
BSV64	30p
BSV79/80 F.E.T.s	80p
BSV91 Mosfet	90p
BSX20/21	14p
BSY40	27p
BSY95A	12p
BU105-01	50p
CV7042 (OC41/44 ASY63)	5p
GET111	40p
OC35	45p
ON222	20p
TIP30/3055	45p
TIS88A F.E.T.	23p
ZTX300/341	7p
2N393 (MA393)	30p
2N456A	50p
2N929	14p
2N987	40p
2N1507/2219	15p
2N2401	30p
2N2412	70p
2N2483	23p
2N2904/5/6/7/7A	15p
2N3053	14p
2N3055 R.C.A.	50p
2N3704	8p
2N3133	20p
2N4037	34p
2N5036 (Plastic 2N3055) down from 60p to	30p
2SA141/2/360	31p
2SB135/6/457	20p
40250 (2N3054) down from 54p to	30p

BRIDGE RECTIFIERS

Amp	Volt		
½	1,600	BYX10	30p
1	140	OSH01-200	26p
1.4	42	BY164	40p
0.6	110	EC433	15p
5	400	Texas	90p

RECTIFIERS

	Amp	Volt	
IN4004/5	1	400	5p
IN4006	1	6/800	7p
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
BYX49-300R	2.5	300	26p
BYX49-600	2.5	600	35p
BYX49-900	2.5	900	40p
BYX49-1200	2.5	1,200	52p
BYX48-300R	6	300	40p
BYX48-600	6	600	50p
BYX48-900	6	900	60p
BYX48-1200R	6	1,200	80p
BYX72-150R	10	150	35p
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
BYX46-300*	15	300	£1.00
BYX46-400*	15	400	£1.50
BYX46-500*	15	500	£1.75
BYX46-600*	15	600	£2.00
BYX20-200	25	200	60p
BYX52-300	40	300	£1.75
BYX52-1200	40	1,200	£2.50

*Avalanche type

TRIACS

Amp	Volt		
6	800	Plastic RCA	£1.20
25	900	BTX94-900	£4.00
25	1200	BTX94-1200	£6.00

12-0-12 50M/A Min. Txfmr. 90p

RS 2mm Terminals Blue & Black .... 5 for 40p

Chrome Car Radio facia .. 15p
Rubber Car Radio gasket .. 5p

DLI Pal Delayline 50p

Relay socket 25p
Take miniature 2PCO relay

B7G or B9A valve can ... 5p

0-30, or 0-15, black pvc, 360° dial, silver digits, self adhesive, 4½" dia. 10p

OPTO ELECTRONICS

BPX40	50p
BPX42	80p
BPY10	80p

(VOLTIAC)

BPY68, BPY69, BPY77 80p

Photo transistor

BPX29	80p
OCP71	44p

BIG L.E.D. 0.2" 2v 50m/A max.

RED	10p
ORANGE	17p
GREEN	14p
YELLOW	14p
CLIP	2p

Diodes
TIL209 Red 10p

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

Philips Iron Thermostat ... 15p
McMurdo PP108 8 way edge plug 10p

TO3 HEATSINK

Europlec HP1 TO3B individual 'curly' power transistor type. Ready drilled 12p

Tested unmarked, or marked ample lead ex new equipment

ACY17-20	8p
ASZ20	8p
ASZ21	30p
BC186	11p
BCY30-34	10p
BCY70/1/2	8p
BF115	10p
BY127	9p
HG1005	10p
HG5009	3p
HG5079	3p
L78/9	3p
M3	10p
OA81	3p
OA47	3p
OA200-2	3p
OC23	20p
OC71/2	5p
OC200-5	20p
TIC44	24p
2G240	£1
2G302	15p
2G401	15p
2N711	25p
2N2926	4p
2N598/9	6p
2N1091	8p
2N1302	8p
2N1907	£1
Germ. diode	1p
GET120 (AC128 in 1" sq. heat sink)	25p
GET872	12p
2S3230	30p

NEW B.V.A. VALVES

6BW7	60p
EB91	34p
ECH81	34p
ECL80	36p
EF80	34p
EF183	34p
EY86/7	34p
PC86	53p
PC88	53p
PC97	36p
PCC84	34p
PCC89	45p
PCC189	45p
PCF80	34p
PCF82	34p
PCF801	65p
PCL82	34p
PL81	35p
PY500A	80p
PY81/800	45p
R20/U26	50p

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
15	800	BTX95-800R Pulse Modulated	£8.00
30	1000	28T10 (Less Nut)	£3.00

PAPER BLOCK CONDENSER

0.25MFD	800 volt	30p
1MFD	250 volt	15p
2MFD	250 volt	20p
10MFD	500 volt	80p
4MFD	250 volt	20p

I.C. extraction and insertion tool 32p

CHASSIS SOCKETS

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**.

8 way Cinch standard 0.15 pitch edge socket 30p

U.E.C.L. 10 way pin connector 2B6000 OA1P10 10p

U.E.C.L. 20 way pin connector 2A60000A1P20 20p

U.E.C.L. 10 way pin socket 2B606001R10 10p

U.E.C.L. 20 way pin socket B260800A1R20 20p

3.5mm STEREO PLUG Metal screened 35p

Philips electronic engineer kits add on series E1004 £1.00 each

RS Yellow Wander Plug Box of 12, 25p

OTHER DIODES

1N916	6p
1N4148	2p
BA145	14p
Centercel	24p
BZY61/BA148	10p
BB103/110 Varicap	15p
BB113 Triple Varicap	37p
BA182	13p
OA5/7/10	15p
BZY88 Up to 33 volt	7p
BZX61 11 volt	15p
BR100 Diac	15p

INTEGRATED CIRCUITS

TAA700	£2.00
723 reg (TO99)	45p
741 8 pin d.i.l. op. Amp	20p
TAD100 AMRF	£1
CA3001 R.F. Amp	50p
TAA300 1wt Amp	£1
NE555v Timer	35p
TAA550 Y or G	22p
TAA263 Amp	65p
7400/10	9p
7402/4/20/30	12p
7414	56p
7438/74/86	24p
7483	69p
LM300, 2-20 volt	£1
74154	90p

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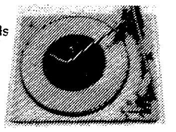
NEW BSR HI-FI AUTOCHANGER
STEREO AND MONO



Plays 12", 10" or 7" records Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. AC 200/250v. Size 13½ x 11¼in.
Above motor board 3¾in.
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PORTABLE PLAYER CABINET £4.50
Modern design. Size 16" x 15" 7" approx, Post 50p
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Size 16 x 13¾ x 7in. £6.95 Post 75p

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Size: 20in. x 19½in. x 9in. CALLERS ONLY **£19.50**

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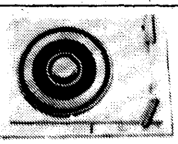
Sizes: 'A' - 14½in. x 12½in. x 4¼in., £2.50. 'B' - 20⅜in. x 12¾in. x 4½in., £3. 'C' - 17⅜in. x 13⅜in. x 3¾in., £3.25.
Ideal for record decks, tape decks, etc. Post 75p



R.C.S. DISCO DECK SINGLE RECORD PLAYER
Fitted with auto stop, compatible cartridge. Base-plate. Size 11in. x 8½in. Turntable. Size 7in. diameter. A/C mains. 220/250V motor has a separate winding 14 volt to power a small amplifier.
3 speeds plays all size records. **£6.95** Post 45p
Two for £13.

COMPLETE STEREO SYSTEM
Two full size loudspeakers 13¾ x 10 x 3¾in. Player unit clips to loudspeakers making it extremely compact. Overall size only 13¾ x 10 x 8½in. 3 watts per channel, plays all records 33 rpm 45 rpm. Separate volume & tone controls 240v AC mains.

Attractive Teak finish Weight 13lbs. Bargain Price **£22.50** 85p carriage

GARRARD MINICHANGER

Plays all size records, 3 speed. Size 12 x 8½in. Complete with stereo/mono cartridge.
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CASSETTE RECORDER MOTOR ONLY. 6 Volt. Will replace many types. Ideal for models. **£1.25**

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ALUMINIUM ANGLE BRACKET 6in long x ¾ x ¾ **15p.**

1½inch DIAMETER WAVECHANGE SWITCHES **45p.** EA.
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1 p.1 2-way, or 4 p. 2-way, or 4 p. 3-way.
TOGGLE SWITCHES, sp. 20p; dp. 25p dp. dt. 30p.
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Many types TOGGLE SWITCHES in stock

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER BRITISH MADE
Ideal for Mike, Tape P.U., Guitar, etc. Can be used with Battery 9-12v. or H.T. line 200-300V. D.C. operation. Size 1¾" x 1¼" x ¾". Response 25 c.p.s. to 25 Kc/s, 26 db gain.
For use with valve or transistor equipment. Post
Full instructions supplied. Details S.A.E. **£1.45** 30p

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4/350V	20p	500/25V	20p	50+50/300V	50p
8/350V	22p	100+100/275v	65p	32+32/450V	75p
16/350V	30p	150+200/275v	70p	100+50+50/350V	85p
32/500V	50p	8+8/450V	50p	32+32+32/350	75p
25/25V	10p	8+16/450V	50p	30,000/25V	95p
50/50V	10p	16+16/450V	50p	4700/63V	95p
100/25V	10p	32+32/350V	50p		

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22, 25, 50, 68, 150, 470, 500, 680, 1500, 2200, 3300, mfd all 6 volt 10p ea.
22, 25, 68, 100, 150, 200, 220, 330, 470, 680, 1000, 1500, 2200, mfd all 10 volt 10p ea.
220, 330, 1000, 4700, mfd all 4v. 10p ea.
1 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V 10p.
500mF 12V 15p ; 25V 20p ; 50V 30p.
1000mF 12V 20p ; 25V 35p ; 50V 47p ; 100V 70p.
2000mF 6V 25p ; 25V 42p ; 50V 57p ; 4700/63V 95p.
2500mF 50V 62p ; 3000mF 25V 47p ; 50V 65p.
5000mF 6V 25p; 12V 42p; 35V 85p; 50V 95p.
500V-0·001 to 0·1 10p; 0·25 12p; 0·47 25p
CERAMIC 1pF to 0·01mF, 5p. Silver Mica 2 to 5000pF, 5p.
PAPER 350V-0·1 7p; 0·5 18p; 1mF or 2mF 150V 15p.
MICRO SWITCH single pole changeover 20p.
MICRO SWITCH sub min 25p.
TWIN GANG. "0-0" 208pF + 176pF £2. TWIN 365pF 50p.
Slow motion drive 365pF + 365pF with 25pF + 25pF 65p.
500pF standard twin gang 75p. 120 PF twin gang 50p.

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10 WATT, 8 OHM. CERAMIC MAGNET. **£3.45**

NEON PANEL INDICATORS, 250V Red or Amber, 30p
RESISTORS, ¼w., ½w., 1w 20%, 2p; 2w. 8p. 10 to 10M.
HIGH STABILITY, ½ w. 2% 10 ohms to 10 meg., 12p.
Ditto 5%, Preferred values, 10 ohms to 10 meg., 5p.
WIRE-WOUND RESISTORS, 5 watt, 10 watt, 15 watt, 10 ohms to 100K, 12p each; 2w 0.5 ohm to 8.2 ohms 15p.
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MAINS TRANSFORMERS
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250-0-250 80mA. 6·3v 3·5a, 6·3v 1a or 5v 2a	£4.60
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300-0-300 120mA. 6·3v 4a C.T.; 6-3v 2a	£7.00
220v 45mA. 6·3v 2a.	£1.75

HEATER TRANS. 6·3v 3 amps. £1.45 ½amp. 95p
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1 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60, £4.60
2a, 6, 8, 12, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 £7.00
3a, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 £8.70
5a, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 £11.25
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12v 300mA £1. 12v 500mA £1. 12v 750mA £1.
40v 2a tapped 10v or 30v £2.95. 20v 3a £2.
40v 2a £2.75 30v 5A and 34v 2A ct. £3.50
20-0-20v 1a £2, 30v 1½a £1.75. 20v ½a £1.75, 1a £2
AUTO TRANSFORMERS. 115v to 230v or 230v to 115v 150w £5; 250w £6; 400w £7; 500w £8.
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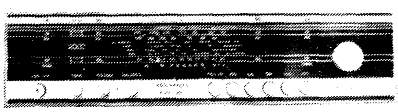
FULL WAVE BRIDGE CHARGER RECTIFIERS: 6 or 12v outputs 1½a 40p; 2a 55p; 4a 85p.
1 amp Transformer, mounted on panel with input and output fuses supplies 0,20v,40v,60v or 20-0-20v £3.50

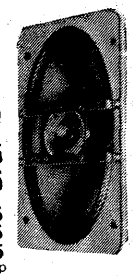
R.C.S. STABILISED POWER PACK KIT
All parts including printed circuit and instructions to build this unit. Voltages available: 6v, 7·5v, 9v, 12v. Up to 100mA output.
Please state voltage required. **£2.95** Post 45p

STEREO FM/AM TUNER AMPLIFIER CHASSIS BY KUBA



This all transistor chassis has push button selection for long, medium, short and V.H.F. wave bands. Features A.F.C. on V.H.F. band with automatic stereo beacon light. Volume tone and Balance controls with push button mains on/off switch. Amplifier accepts ceramic cartridge and has record/playback socket fitted. Four watts per channel output.
Chassis size - 17 x 4 x 5in. **£38.50** POST £1.50

E.M.I. 13½ x 8 in. SPEAKER SALE!



With tweeter And crossover, 10 watt State 3 or 8 ohm **£5.25** Post 45p
15 watt version 8 or 15 ohm **£7.95**
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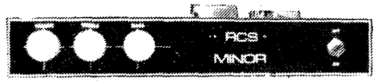
as illustrated
Bass units only 20W **£6.95**
Bass units only 15W **£5.95**
Bass units only 10W **£4.25**
Post 65p

Bookshelf Cabinet £7.50
Teak Veneer. For above units .... Post 75p

R.C.S. 10 WATT AMPLIFIER KIT



This kit is suitable for record players, tape play back, guitars, electronic instruments or small P.A. systems. Two versions are available. A mono kit or a stereo kit. The mono kit uses 13 semiconductors. The stereo kit uses 22 semiconductors with printed front panel and volume, bass and treble controls. Spec. 10 watts output into 8 ohm, 7 watts into 15 ohms. Response 20 cps to 30K/cs. Input from 20mV high imp. Size 9½in x 3in x 2in.
Mono kit **£11.25** *Stereo kit* **£17.50** post 45p

LOUDSPEAKERS P.M. 3 ohms, 7 x 4in. £1.25; 6½in. £1.50; 8 x 5in. £1.60; 8in. £1.75; 10 x 6in. £1.90; 10in. £2.50.
SPECIAL OFFER LOUDSPEAKERS! All Brand New. 3 ohm, 2½in; 2⅝in; 3½in; 5in. 8 ohm, 2¼in; 2¾in; 5 x 3in; 5in. 15 ohm, 3½in; 5in; 6 x 4in; 5 x 3in; 7 x 4in; 25 ohm, 2¼in, 3in, 5 x 3in, 7 x 4 in; 35 ohm, 3in; 5in. 80 ohm, 2¼in; 2¾in. 120 ohm, 3in. **£1.25** EACH

TWEETER VOLUME CONTROL 15 ohm 10 watt with 1in. long threaded bush for wood panel mounting. Will suit all tweeters 75p

RICHARD ALLAN TWIN CONE LOUDSPEAKERS, 8in. diameter 4W £2.50; 10in. diameter 5W £2.95; Post 25p. 12in. diameter, 6W £3.50; 3 or 8 or 15 ohm models.
SPEAKER COVERING MATERIALS. Samples Large S.A.E.
Horn Tweeters 2-16Kc/s. 10W 8 ohm or 16 ohm £3.60.
De Luxe Horn Tweeters 2-18 Kc/s, 15W, 8 ohm £6.80
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3-WAY CROSSOVER 850 cps and 3000 cps (25 watt) £2.20

GOODMANS CONE TWEETER £3.25
18,000 cps. 25 watts. 8 ohm.
5½in. Woofer 10 watt. Price £4.95.

ELECTRO MAGNETIC PENDULUM MECHANISM
1·5v d.c. operation over 250 hrs continuous on SP2 battery, *fully adjustable swing and speed. Ideal displays teaching* electro magnetism or for metronome; strobe etc. 95p. Post 20p

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P50/1AC	60p	RA2W	85p	Twin Gang	£2
P50/2CC	40p	OPT1	65p	Printed Circuit	85p
P50/3CC	40p	LFDT4	65p		

COAXIAL PLUG 10p. PANEL SOCKETS 10p. LINE 18p.
OUTLET BOXES, SURFACE MOUNTING 40p
BALANCED TWIN RIBBON FEEDER 300 ohms, 5p yd.
JACK SOCKET Std. open-circuit 20p, closed circuit 25p; Chrome Lead Socket 45p. Phono Plugs 10p. Phono Socket 8p.
JACK PLUGS Std. Chrome 30p; 3·5mm Chrome 15p. DIN SOCKETS Chassis 3-pin 10p, 5-pin 10p; DIN SOCKETS Lead 3-pin 18p; 5-pin 25p; DIN PLUGS 3-pin 18p; 5-pin 25p. VALVE HOLDERS 5p; CERAMIC 10p; CANS 5p.

R.C.S. 100 WATT VALVE AMPLIFIER CHASSIS

Professional model. Four inputs, Treble, Bass, Master Volume Controls. Ideal disco, P.A. or groups. 5 speaker outputs, very robust job
S.A.E. for details **£85** plus £2.50 carr.

NEW MIXER/AMP 150 WATT
PROFESSIONAL TRANSISTOR AMPLIFIER **£68**
4 inputs, 3 outputs, separate volume treble Carr. **£1.50**
and bass controls. Ideal disco or group, P.A. amplifier
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T.T.L. CALIBRATION GENERATOR

By A. P. ROBERTS

This unusual design employs an LC oscillator which is set to correct frequency by zero-beating with the long wave Radio 2 transmission on 200kHz. Another novel feature is the use of a t.t.l. decade counter to obtain division by 2 and by 10 of the oscillator frequency.

In order to accurately calibrate the tuning dial of a home-constructed receiver or to properly correct the tuning calibration of a commercially produced receiver that has been in use of a period, some form of calibration generator is required.

The highest quality types of calibration generator use several crystal controlled oscillators, or a crystal controlled oscillator and frequency divider chain to produce several highly accurate and stable calibration frequencies. A more simple type of generator employs an LC oscillator with several switched coils to provide the required calibration frequencies. This has the advantage of comparative cheapness, but it is not as stable or accurate as the crystal controlled type of calibrator. However, if one has a general coverage receiver the read-out accuracy of the tuning dial rarely warrants the greater accuracy afforded by a crystal controlled unit.

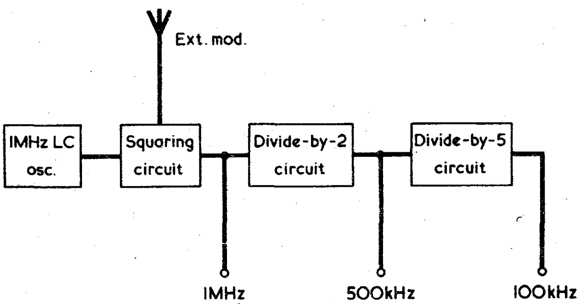


Fig. 1. The basic line-up of the calibration generator

Since the majority of short wave receivers are of the general coverage type, the simple LC calibration oscillator described in this article will satisfy most people's requirements. The unit has three output frequencies, these being at 1MHz, 500kHz and 100kHz. With the current low cost of t.t.l. digital integrated circuits it was decided to use a 1MHz oscillator with a frequency divider i.c. to obtain the two lower frequency outputs, rather than to use a separate coil for each range. This method is probably a little cheaper than using a different coil for each frequency, and in the author's opinion it is more convenient from the constructional point of view.

BLOCK DIAGRAM

The circuit breaks down into four main sections, as shown in the block diagram of Fig. 1. The 1MHz signal is generated by an LC oscillator. This has a fairly high output amplitude at about 2.8 volts peak-to-peak, but with an output waveshape that is virtually a pure sine wave. For calibration purposes an output that is rich in harmonics is essential, as will be explained later. The output of the oscillator is therefore fed to a squaring circuit which produces a hard square wave output offering harmonics throughout the short wave frequency spectrum.

A secondary function of the squaring circuit is to provide the interface between the oscillator and the t.t.l. frequency divider, the latter requiring a high amplitude driving signal at comparatively low impedance.

Some calibration generators incorporate an a.f. generator to modulate the r.f. output in order that the generator signal can be distinguished from other signals picked up by the receiver. No a.f. generator is provided in the unit being described, but an external a.f. modulating signal can be applied to the squaring circuit, if desired.

A divide-by-two circuit provides a 500kHz output from the basic 1Mhz signal, and a divide-by-five circuit futher divides this signal to produce a 100kHz output.

THE CIRCUIT

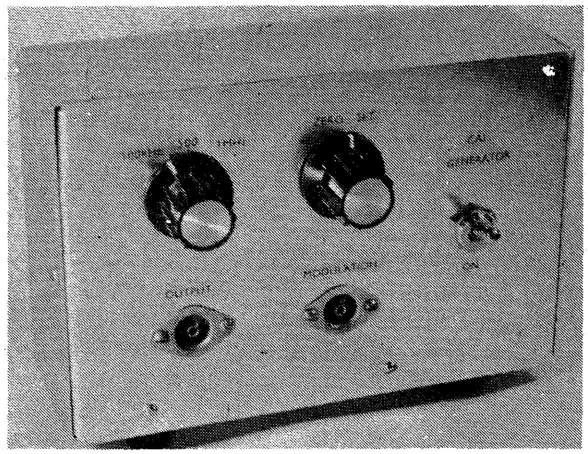
The complete circuit diagram for the calibration generator is given in Fig. 2. The oscillator circuit is of the type employed in the mixer-oscillator stage of conventional transistor superhet radios. Indeed, the oscillator coil, L1, is primarily intended for use in this stage in medium and long wave broadcast receivers.

The grounded base transistor, TR1, is the oscillator amplifier and L1 provides positive feedback from its collector to its emitter. The frequency of oscillation is determined by the tuned circuit. This is adjusted to approximately 1MHz by trimmer TC1, with VC1 (a front panel control) being used for precise frequency adjustment. R1, R2 and R3 are the usual base bias and emitter resistors, and C2 is the emitter bypass capacitor. C1 provides an a.c. path to chassis at r.f. for the base of TR1.

C3 couples the output of the oscillator at TR1 collector to the base of TR2, which is connected as a common emitter amplifier. This stage clips the 1MHz signal and provides the requisite squaring action.

An a.f. modulating tone can be fed to the base of TR2 via d.c. blocking capacitor C4 and current limiting resistor R6. The audio signal cuts TR2 off on negative peaks and produces a rather crude form of amplitude modulation, but one that is quite satisfactory for the present application. An a.f. tone of about 4 volts peak-to-peak is required for 100% modulation.

An SN7490 i.c. provides the frequency divider circuitry. This is a decade counter, or divide-by-ten circuit, but it actually consists of a divide-by-two and a divide-by-five circuit. The three output signals are fed to S2 which selects one of these and passes it to the output socket via d.c. blocking capacitor C5.



The calibration generator is housed in a metal case to provide screening and prevent unwanted radiation

A supply of 5 volts is required for the SN7490, and for good stability the supply to the oscillator should be stabilized. The battery supply is fed to the circuit by way of a conventional emitter follower series regulator incorporating TR3, R7, D1 and C6. This has an output voltage about 0.6 volt less than the zener voltage, giving in consequence an output of 5 volts.

S1 is the on-off switch. Current consumption is a little under 30mA.

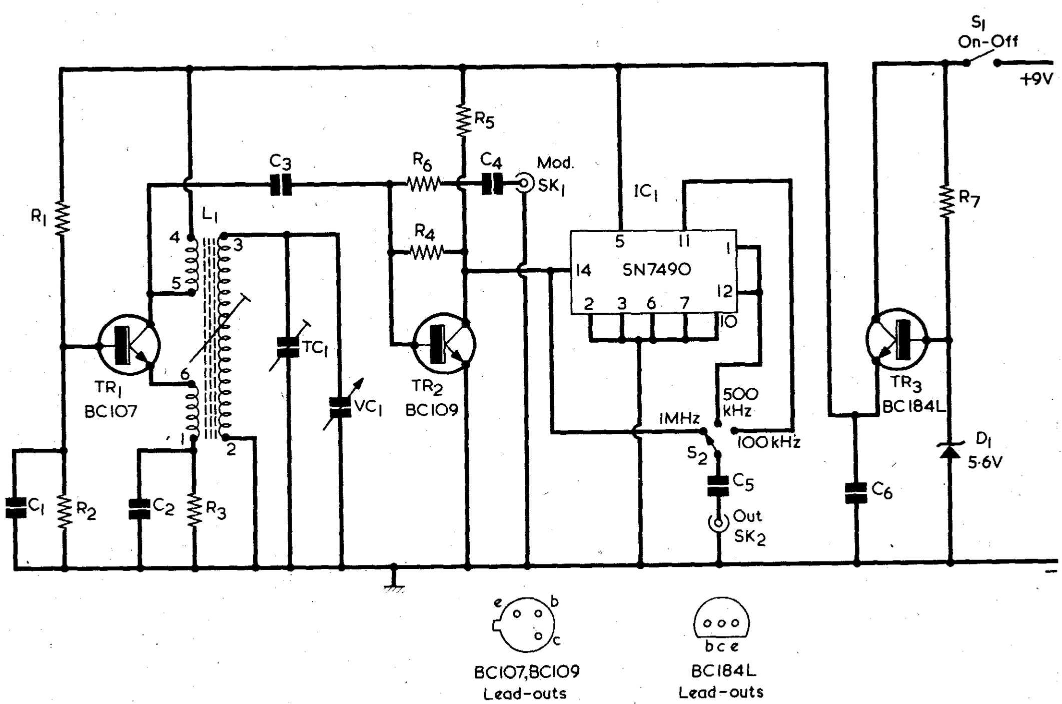


Fig. 2. Complete circuit of the t.t.l. calibration generator. Frequency division is given by a digital decade counter

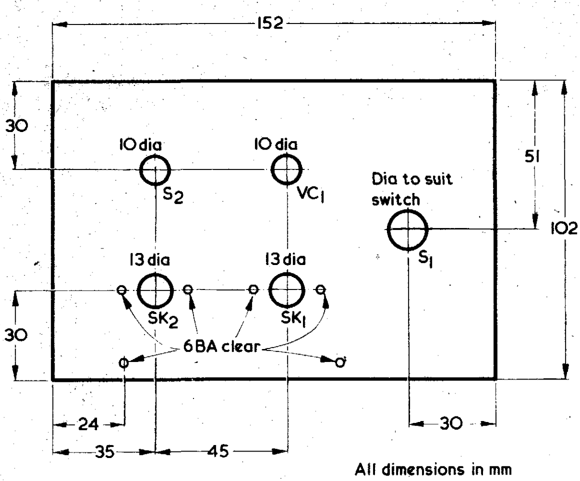


Fig. 3. Drilling details for the front panel. The two bottom 6BA clear holes are marked out with the aid of the component board and should be positioned such that the board clears the inside surfaces of the case bottom and left hand side.

METAL CASE

It is essential that a metal case be used for the calibration generator as this will screen the circuitry and prevent radiation of the 100kHz signal when the 500kHz output is in use, and radiation of both the 100kHz and 500kHz signals when the 1MHz output is selected. The author used an aluminium box type AB13 with a modified lid as the case for the prototype. This case measures approximately 6 by 4 by 2in. (152 by 102 by 51mm.) and there are several other metal cases of about this size currently available, any of which would be suitable. The circuitry requires more space than might be imagined, and a case having significantly smaller dimensions than those just given cannot be used.

Details of the front panel layout (assuming that the panel is 6 by 4in.) are given in Fig. 3. Four small cabinet feet are glued or bolted to one long side of the box, which now becomes the bottom.

Two 6BA clear holes for mounting the component board are also required in the front panel. These can be marked out with the aid of the board after it has been cut out and drilled.

COMPONENT BOARD

Most of the components are wired up on a plain 0.1 in. matrix perforated s.r.b.p. board. The required board size is 36 by 21 holes, and this must be cut from a larger piece using a hacksaw. Care must be exercised in cutting as this type of board is rather brittle.

Details of the component layout and underside wiring of the board are show in Fig. 4. Apart from the two 6BA clear mounting holes, it is also necessary to enlarge the holes for the pins of L1 using a drill of about 2.5mm (0.1in.) diameter. TC1 requires a single 4.5mm. (0.18in.) diameter mounting hole.

The trimmer specified is a type 'TP' and is available from Doram Electronics or Home Radio.

L1 and TC1 are fitted to the board first, after which the remaining components are mounted. Their lead-out wires are bent over flat on the underside of the board and are then soldered together as indicated in Fig. 4. Bare tinned copper wire of around 22 s.w.g. is

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)
R1 22kΩ
R2 10kΩ
R3 680Ω
R4 270kΩ
R5 1kΩ
R6 33kΩ
R7 2.2kΩ

Capacitors
C1 0.01μF type C280 (Mullard)
C2 0.047μF type C280 (Mullard)
C3 470pF Polystyrene
C4 0.1μF type C280 (Mullard)
C5 8.2pF ceramic
C6 0.1μF type C280 (Mullard)
VC1 25pF variable, type C804 (Jackson)
TC1 20-250pF trimmer, mica, type TP (see text)

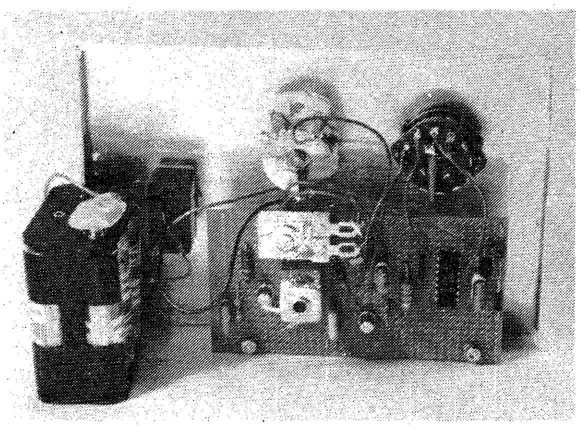
Inductor
L1 Oscillator coil type TOC.1 (Denco)

Semiconductors
IC1 SN7490
TR1 BC107
TR2 BC109
TR3 BC184L
D1 5.6V zener diode type BZY88C5V6

Switches
S1 s.p.s.t., toggle
S2 1-pole 3-way rotary (see text)

Sockets
SK1, SK2 coaxial sockets, flush mounting

Miscellaneous
2 Control knobs
Metal case, 6 x 4 x 2in. (See text)
Plain perforated s.r.b.p. board, 0.1in. matrix
6 HP7 cell (Ever Ready)
Plastic battery holder for cells
Battery connector, PP3 type
Nuts, bolts, wire, etc.



The component board is fitted to the rear of the front panel

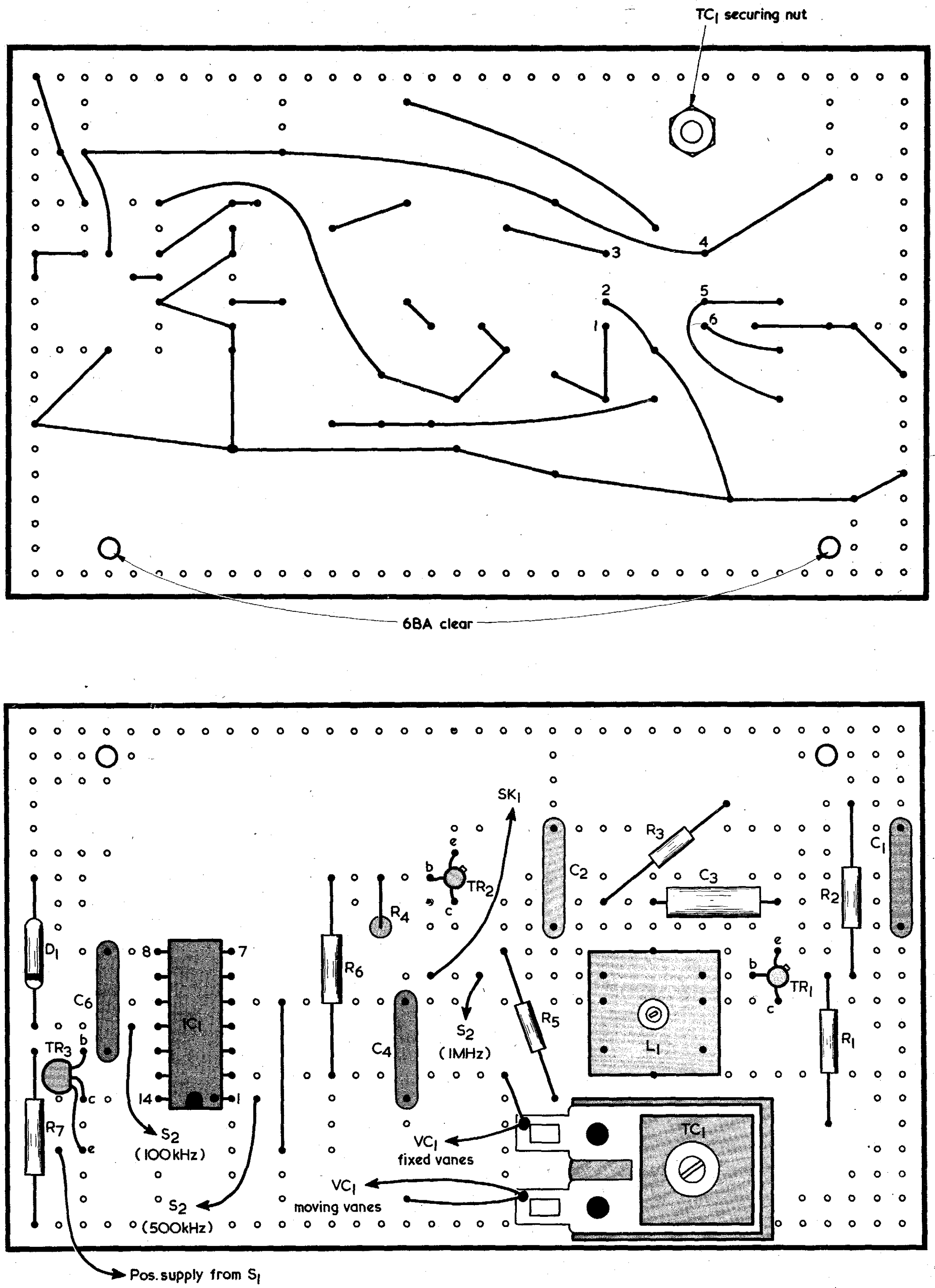


Fig. 4. Most of the components are assembled on a plain perforated board. Illustrated here are the wiring and component sides

employed to extend leads where necessary. Note that the two mounting lugs of L1 are used to complete the negative supply wiring. There are several places where wires run close to each other. One of the leads at such points should be covered with sleeving to prevent accidential short-circuits.

The completed board is mounted on the front panel behind SK1 and SK2, and just below VC1. The wiring side faces the front panel and spacing pillars, or extra nuts, are employed on the mounting bolts to space it back from the front panel. It may be necessary to clip off a portion of the centre conductor tags of the sockets to ensure that the component board can be positioned sufficiently forward for the assembly to fit into the case. The component board is not finally mounted until it has been wired to the front panel components. This Wiring is carried out with thin flexible p.v.c. covered wire. The board picks up its chassis connection to the case via the moving vanes tag of VC1.

S2 is wired such that 100kHz is selected when its spindle is rotated anti-clockwise, 500kHz is selected at its central position and 1Mhz at its clockwise setting. The switch is specified as 1-pole 3-way, but it will be found most convenient to obtain a 4-pole 3-way switch and use only one pole of this. A miniature type should be employed. Capacitor C5 is not on the component board and is wired directly between the arm of S2 and socket SK2. The final connections are to the battery connector, which is of the PP3 type. The negative battery connector lead connects to the moving vanes tag of VC1 and the positive lead to S1.

Power for the unit is obtained from six HP7 cells contained in a plastic battery holder, which fits into the space above S1. Connection to this holder can be made by way of a PP3 type connector.

When all the wiring is completed it should be checked carefully. The component board may then be finally mounted behind the front panel.

ADJUSTMENT

The only adjustment required is to set up trimmer TC1 such that an oscillator frequency of 1MHz falls within the tuning range of VC1. The oscillator coil core is not adjusted and is left in the position given to it at the factory. TC1 is adjusted with the unit out of the metal case. First, VC1 is set to about half its maximum capacitance, S2 is set to select 100kHz and the calibrator is switched on. A portable receiver tuned to Radio 2 on 200kHz (1,500 metres) long waves is then placed near the calibrator, and TC1 is adjusted until a whistle is heard in the receiver. This whistle should be the beat note between the 200kHz Radio 2 carrier and the second harmonic of the calibrator 100kHz output signal. Alter the tuning of the receiver to see if this varies the pitch of the whistle. If it does, this means that a harmonic of the generator output is beating with the receiver i.f. or image frequency, whereupon TC1 must be further adjusted to find the correct beat note.

When the correct setting has been found, adjust TC1 to give a beat note of the lowest possible frequency. The unit is then set up and may be fitted in its metal case.

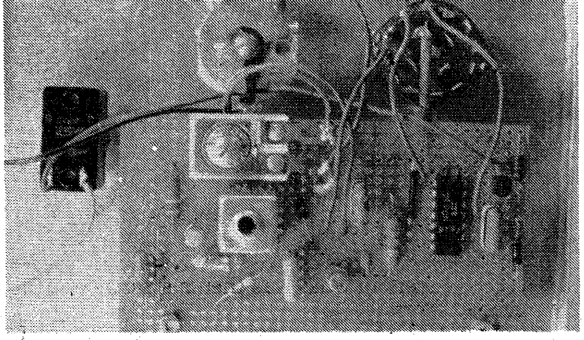
Whenever the calibration generator is used, VC1 is primarily adjusted, with the aid of a portable radio, for zero beat with the 200kHz Radio 2 transmission. It should be quite easy to obtain a beat of only a very few Hertz, and the resultant accuracy is more than adequate for most requirements. When the unit is in its case it will probably be necessary to connect a short length of wire to SK2 and position this near the portable radio to obtain sufficient coupling.

When using the unit to calibrate a short wave receiver it will usually only be necessary to loosely couple the generator to the receiver by placing a lead from SK2 near the receiver aerial socket. No direct connection will normally be required.

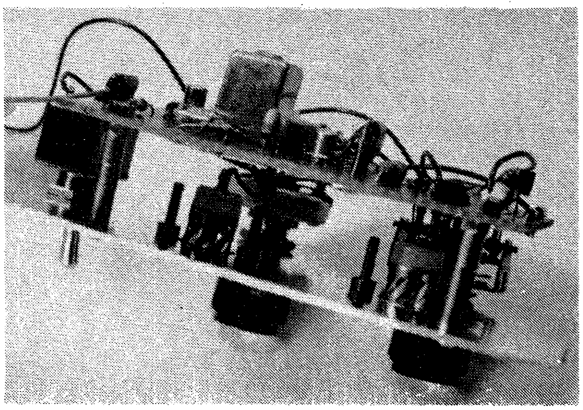
HARMONICS

The calibration generator produces a square wave, which is very much richer in harmonics of the fundamental frequency than would be a sine wave or near-sine wave. Marker signals at fundamental frequency harmonics are provided throughout the short wave frequency spectrum up to and beyond 30MHz. Thus, the 1MHz output gives marker signals at 2, 3, 4, 5MHz and so on. The 500kHz signal will provide outputs at these frequencies and, more important, at frequencies between (e.g. 1.5, 2.5, 3.5, 4.5MHz, etc.). The 100kHz signal will provide markers at 100kHz intervals, at 1.1, 1.2, 1.3, 1.4MHz, etc. In consequence, it is possible to use the generator to calibrate a receiver tuning dial at 100kHz intervals throughout the short wave frequency range.

One difficulty which might be encountered on the higher frequency bands is that of knowing which harmonic is being picked up. A solution consists of using any transmission of known frequency, or approximately known frequency, to help identify the harmonics. For instance, if a 20 metre amateur band transmission is tuned in on the receiver and the 1MHz



Illustrating the component board in greater detail



The board is mounted by means of two 6BA bolts, with spacing pillars to give clearance for the coaxial sockets

output of the calibrator is coupled to its aerial, tuning the receiver lower in frequency until a calibrator harmonic is picked up will identify that harmonic as being at 14MHz. This must obviously be the case as the 20 metre band extends from 14 to 14.35MHz.

Other harmonics on the receiver band concerned are then easily identified by simply counting up and down from the known harmonic. The first harmonic above 14MHz must be 15MHz, and the one above that 16MHz; whilst the first harmonic below 14MHz will be 13MHz, and so on.

Of course, any amateur band or broadcast station of known frequency can be used to help with the initial identification of one of the harmonics. Once the 1MHz points have been marked on the receiver dial it is a simple matter to use the 500kHz and 100kHz signals to fill in the gaps between, a similar counting method being employed to identify the harmonics. ■

ANTIQUE WIRELESS EXHIBITION

By
Ron Ham

Of considerable interest to devotees of early wireless has been the exhibition of antique and wartime equipment held this year in the Hargood Room at the Municipal Museum in Chapel Road, Worthing. The period covered ranged from 1900 to 1955.

In the military part of this large collection, lent to the Museum by the author, were wireless sets used by the R.A.F., the U.S.A.A.F. and the Luftwaffe. The Museum Curator, John Norwood, utilised a selection of water colour paintings of wartime scenes in Worthing to back up the exhibits. It is fitting that Army equipment such as the Wireless Sets type 18, 19, 38 and 46 should be displayed in a town which played an important role in the preparations for the D-Day Landings where these sets were extensively used.

The turn of the century was illustrated by contemporary telegraph keys, to be followed by the Audion valve, with World War 1 being represented by a 50 watt Trench Set and a ship's wireless receiver, both made by the Marconi Company.

Visitors have been fascinated to see the B2, MCR1, and other sets used by the S.O.E., and to hear the performance of a Civilian Wartime Receiver which is still working well after 35 years.

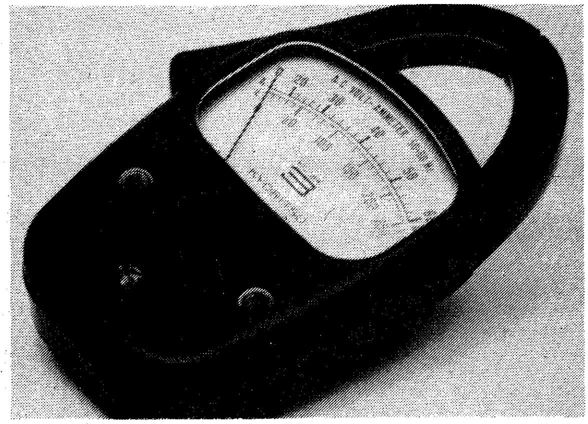
Crystal sets and home-made sets represented the twenties, while early factory-made receivers by Philips and Marconi showed the state of the art in the thirties. A 1937 HRO communications Receiver and the Muirhead morse key used by the late Nell Corry (and described in *Radio & Electronics Constructor* for August) flew the flag for amateur radio.

With the knowledge of present day transistor sets in mind, younger visitors have been shocked at the size, weight and power requirements of the selection of "portable" receivers made by Marconi, Pye, Ever Ready and Vidor, spanning the valve era from 1925 to 1955.

A fascinating exhibition which shows, by comparison, how far advanced we are in the late 1970's and which also emphasises the drive which impelled the early pioneers in what was then a strange and unmapped territory. ■

NEWS . . . AND .

Clamp meters from Eagle



The KEW 3 pocket sized clamp meter

The latest additions to Eagle International's comprehensive range of test equipment are three new clamp meters the KEW 103, KEW 3 and KSN 7 for clip-on, read-off duties. Simply by clipping around the conductor these compact meters make current readings without disturbing the installation.

The photograph shows the KEW 3 which has been designed as a low price pocket sized AC clamp meter for general service use. Having an internal jaw diameter of approx. 18mm. it measures AC current 0-60 amps and (with probes) AC voltage 0-250v on an easy-to-read rotary scale. Its small size 113 x 70 x 25mm. makes the KEW 3 a very convenient general purpose instrument both to carry and use.

All Eagle clamp meters are complete with carrying cases and leads/probes and are accurate to at least 3% on all scales. Further details can be obtained from Eagle International, Heather Park Drive, Wembley, HA0 1SU.

Precise time for ships' navigators

A British company is producing a clock which keeps the time correctly to within six seconds a year. It is a chronometer for use on board ships, where accurate time is needed for navigation. BBC World Service described the clock in a recent broadcast. The timekeeping element in the Quartz Digital Chronometer is a quartz crystal. This vibrates at a fixed high frequency which is divided electronically to give seconds, minutes and hours. The time is displayed as a row of illuminated figures. The chronometer is mains-operated but also has its own internal battery which is kept charged. If the mains fail the battery can keep the clock going for at least 30 days. The critical parts of the electronic circuit are housed in a thermostatically controlled compartment to prevent outside temperature changes from upsetting the accuracy. The Quartz Digital Chronometer costs £465 in Britain.

Anti-static groovac record cleaner

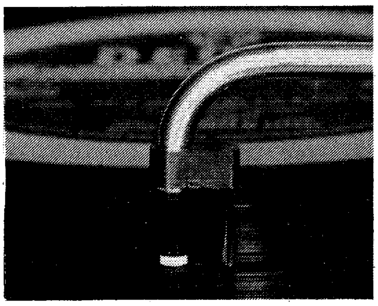
An anti-static device has been incorporated into the Groovac vacuum record cleaner manufactured by RI Audio. Not only does this device discharge static on records but also the new cleaner, Groovac III, is very effective in removing dust.

By providing vacuum cleaning combined with static elimination, the Groovac III is offering complete record care in one unit which operates efficiently and quietly while the record is playing.

The new device consists of a small carbon fibre brush attached to the Groovac arm near its suction cleaning nozzle, and connected to earth via electrical connectors inside the arm. Static electricity on the record is discharged by the carbon fibres which track across the record just ahead of the suction nozzle and pick-up stylus. In addition to eliminating static, the carbon fibre brush also gathers surface dust which would otherwise collect on the suction nozzle hairs and impair tracking.

To cause wear on records and stylii, dust particles must be small enough to get between the tip of a stylus and the groove walls. Since record grooves are only about 60 microns wide, these dust particles have to be about 10 microns in size — too small to see by eye! This microdust is efficiently removed with Groovac III because static electrical charges no longer attract these small dust particles to the record, and consequently they can be removed very efficiently by vacuum cleaning.

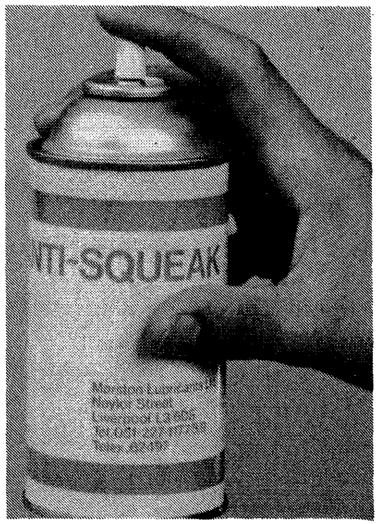
Price: £17.95 including VAT, p&p 80p. Delivery 2-4 weeks. Available from RI Audio, Kernick Road, Penryn, Cornwall.



Combined vacuum record cleaner and an anti-static device

. . . COMMENT

Aerosol stops squeaking indefinitely



An entirely new lubricant available in handy aerosol cans will eliminate for an indefinite period squeaking noises produced by any two types of surfaces rubbing together, claim the makers Marston Lubricants Limited of Naylor Street, Liverpool.

Called 'Anti-Squeak', the new product has wide application in industry, particularly in vehicle manufacture and maintenance.

Where the exact sound source cannot be traced, application of Anti-Squeak in the general area of the noise will eliminate it, say the manufacturers.

In the home the product can be applied to any surface movement that produces a noise, from curtain rails, to door hinges and squeaking floorboards.

A feature of Anti-Squeak is that it is non-toxic, will not stain leather, PVC or fabric or adversely affect rubber or paintwork.

It is designed for maximum penetration and contains lanoline which gives the product its long-lasting effect.

Another area of use, suggested by the makers, is the maintenance of garden tools, lawn mowers and sporting tackle and guns.

Available in handy 10oz. aerosols, retailing at 90p plus VAT, Anti-Squeak is available direct from the manufacturers or their distributors.

Presentation of Queen's Award to Industry to Marconi Communication Systems Ltd.

The Queen's Award to Industry was formally presented to Marconi Communication Systems Limited, a GEC-Marconi Electronics company recently, at the company's Waterhouse Lane factory in Chelmsford. The presentation was made on behalf of the Queen by the Lord Lieutenant of Essex, Sir John Ruggles-Brise, and received by Mr. Tom Mayer, the Managing Director of Marconi Communication Systems Limited.

The company won the award for technological achievement in designing the B3404 telecine — the first in the world to have a film transport system designed specifically for television broadcast operation.

Telecine is a means of converting film material into a form suitable for broadcast television. The B3404 represents a significant advance in this type of equipment which, hitherto, relied on film transport systems derived from models produced for cinema projection purposes. This presented, at best, an approach to the problems of film on television which compromised with the very different problems of film in the cinema.

The B3404 first entered full-scale production in 1973. Since that time export sales alone are almost £4 million and equipment is currently in use or on order in Australia, Barbados, Canada, Egypt, France, Iran, Malaysia, New Zealand, Nigeria, Thailand, the United States, the Soviet Union and Yugoslavia as well as the United Kingdom. It has already won recognition from the Royal Television Society for its outstanding technical qualities, having won the 1975 Geoffrey Parr Award.

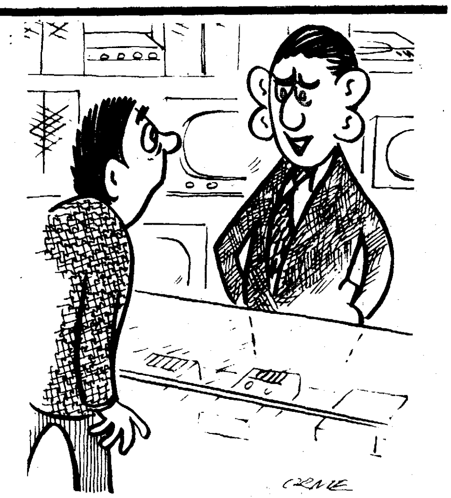
Since the inception of the Queen's Award to Industry in 1966, companies which today form part of GEC-Marconi Electronics have won a total of 18 awards, nine of which were for technological innovation and nine for export achievement.

B.A.E.C. Exhibition

The eleventh B.A.E.C. Amateur Electronics Exhibition was held recently and was even more successful than the previous ones.

Members sold a record number of raffle tickets for the B.A.E.C. Raffle 1976, so that together with the proceeds from the exhibition and various donations they handed over a record £607.30 to the Cancer Research Campaign.

Well done!



"Well, don't look so flabbergasted – You've heard of quadraphonics haven't you?"

ELECTRONIC EGG TIMER

by P. R. ARTHUR

Although ostensibly described as an egg timer, this handy little unit may be employed for any other timing application where the delay required is in the range of 2 to 6 minutes.

There are many simple electronic household gadgets that can prove to be extremely useful and worth-while constructional projects. They can also make an interesting diversion for enthusiasts whose main preoccupation is with another branch of electronics. This article describes a typical device, the project concerned being an electronic egg timer.

This unit is designed to turn on a two-tone audible alarm some 2 to 6 minutes after the device is switched on, the time delay being continuously variable over the 2 to 6 minute range. There are only two controls, and these are the on-off switch and the potentiometer which sets the required time delay. The timer can therefore be easily operated by a non-technical user.

The timer is completely self-contained in a small plastic box, and construction is extremely simple. Apart from its intended purpose there are other possible uses for the device, and the prototype has been found to be an extremely useful piece of household equipment.

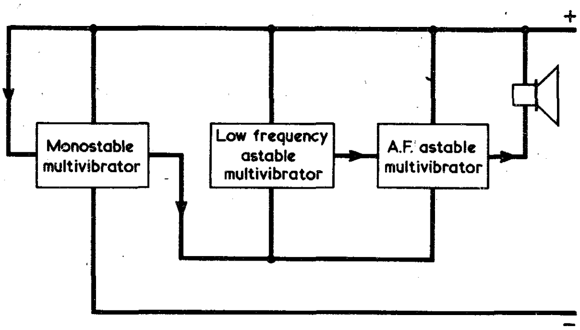


Fig. 1. Block diagram illustrating the basic operation of the electronic egg timer

CIRCUIT OPERATION

The circuit consists of three main sections, these being a monostable multivibrator and two astable multivibrators. These are interconnected as shown in the block diagram of Fig. 1.

The monostable multivibrator produces a positive pulse when it receives a trigger pulse at its input. In the present design the trigger input is coupled to the positive supply rail so that the monostable is triggered the moment the supply is connected to the circuit. The length of the output pulse is variable from about 2 to 6 minutes.

The output drives two astable circuits, both of which are powered from the positive supply rail and the output of the monostable. Thus, when the output of the monostable is positive no power is applied to the astable, but at the end of the output pulse when the output goes negative the astables commence to operate.

One astable oscillates at a frequency of a few hundred Hertz, and its output is fed to a speaker. The other astable operates at a low frequency of about 1 Hertz, and modulates the frequency of the higher frequency astable to produce a two-tone output. A two-tone alarm is employed as this attracts attention more readily than does a single continuous tone, and it is also more pleasing to listen to. The alarm will continue to sound until the unit is turned off. The timer is then ready for use again.

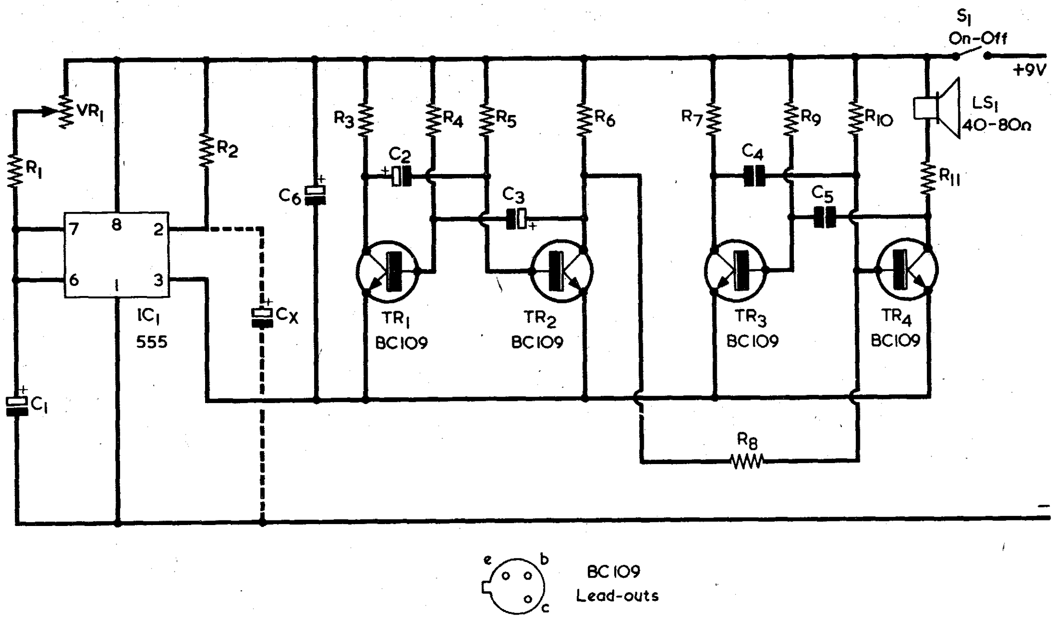


Fig. 2. The full circuit of the timer. The capacitor shown as CX may be required with some versions of the unit

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)
R1 470kΩ
R2 10kΩ
R3 4.7kΩ
R4 39kΩ
R5 39kΩ
R6 4.7kΩ
R7 4.7kΩ
R8 150kΩ
R9 39kΩ
R10 180kΩ
R11 100Ω
VR1 2MΩ potentiometer, linear

Capacitors
C1 100μF electrolytic, 10 V. Wkg.
C2 2.2μF electrolytic, 10 V. Wkg.
C3 2.2μF electrolytic, 10 V. Wkg.
C4 0.047μF type C280 (Mullard)
C5 0.047μF type C280 (Mullard)
C6 100μF electrolytic, 10 V. Wkg.
CX 10μF electrolytic, 10 V. Wkg. (See text)

Semiconductors
IC1 555
TR1 BC109
TR2 BC109
TR3 BC109
TR4 BC109

Speaker
LS1 40-80 Ω (see text)

Switch
S1 s.p.s.t., toggle

Miscellaneous
Plastic case (see text)
Veroboard, 0.1in. matrix
Speaker fret or fabric
Battery type PP3 (Ever Ready)
Battery connector
Control knob

FULL CIRCUIT

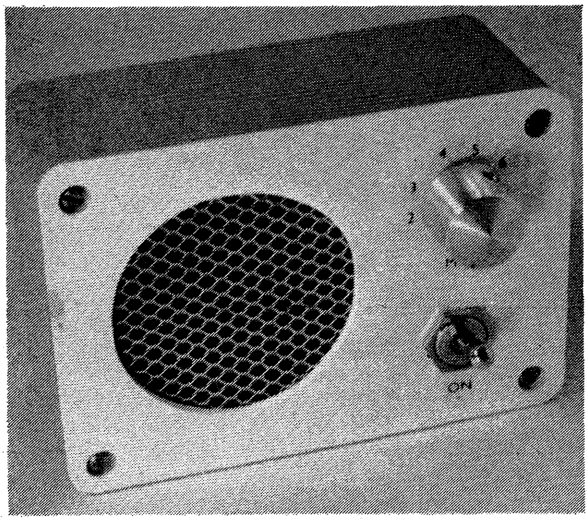
The full circuit of the timer appears in Fig. 2. In this, the monostable function is provided by a 555 timer i.c. together with its associated components.

Pin 2 is the trigger input of the i.c., and this is connected to the positive supply rail via R2 so that the circuit is triggered the instant the on-off switch is closed. C1 is normally short-circuited by an internal transistor of the i.c., but the short-circuit is removed when the circuit has been triggered. Also, the output at pin 3 goes positive. C1 now gradually charges up through R1 and VR1. When the voltage across C1 reaches two-thirds of the supply potential the timing period comes to an end, and the output at pin 3 of the i.c. drops and becomes close to the negative supply rail potential. The output thus provides power to the astable circuits, which sound the alarm.

At the end of the timing period C1 becomes short-circuited once more by the internal transistor of the i.c., and it is held in this state until another trigger pulse is received at pin 2. This does not occur, of course, until the device has been switched off and then on again.

The trigger pulse at pin 2 of the 555 should be negative, but in practice the circuit works reliably as so far described. Due to variances between different 555 timers, there is a slight possibility that some i.c.'s may not always trigger on closure of the on-off switch, whereupon the alarm will sound without a delay. Should this occur the capacitor shown as CX may be added to the circuit, and it will ensure that pin 2 potential is lower than pin 8 potential immediately after switch-on. The prototype circuit works reliably every time the on-off switch is operated and the possible necessity of adding CX is mentioned merely to ensure that all aspects of circuit functioning are covered.

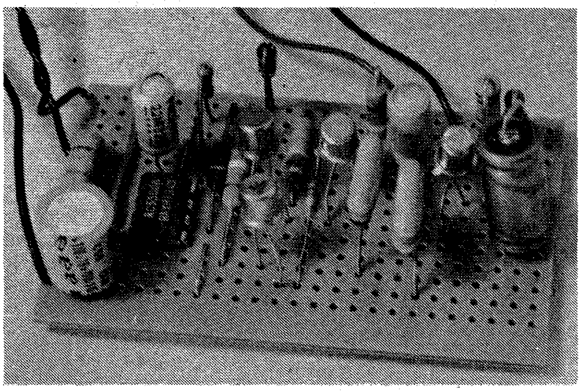
The length of the timing period is varied by altering the setting of VR1. The actual range obtained will be somewhat wider than 2 to 6 minutes; this is necessary as the timing components, including C1 in particular, have relatively wide tolerances on value. The actual range will, in consequence, vary with different units made up to the circuit but should still encompass the 2 and 6 minute periods.



The timer has a simple front panel layout, with only the on-off switch and the timing control to adjust

TR3, TR4 and their associated components form the higher frequency astable multivibrator, and this is quite conventional. The collector load for TR4 consists of the speaker and the current limiting resistor R11 in series.

TR1 and TR2 appear in the low frequency astable multivibrator, and the circuit here is also quite conventional. The collector of TR2 is coupled to the higher frequency multivibrator by way of R8. The result is that during the periods when the collector of TR2 is high the cross-coupling capacitor C4 charges more rapidly, via R8 and R6, than it does during the periods when TR2 collector is low. In consequence the frequency of the tone generating multivibrator increases when TR2 collector goes high, and there is an overall attention-catching warble effect.



The components are laid out without cramping on the Veroboard panel

The transistors in the two multivibrators are taken beyond their reverse base-emitter voltage ratings during parts of the cycles. This point has no practical significance in the present circuit.

S1 is the on-off switch and C6 is the supply bypass capacitor for the multivibrators. The current consumption of the unit is approximately 4.5mA during the delay period, rising to about 20mA when the alarm is sounding.

CONSTRUCTION

The egg timer can be housed in a plastic case measuring 110 by 73 by 47mm. (4.3 by 2.9 by 1.9in.) and a suitable type is the Albol box No. 1005, available from Home Radio. Any other similar plastic case may be employed provided that it is not significantly smaller in any of the dimensions.

Fig. 3 shows the drilling required on the front panel. The speaker cut-out can be made by means of a

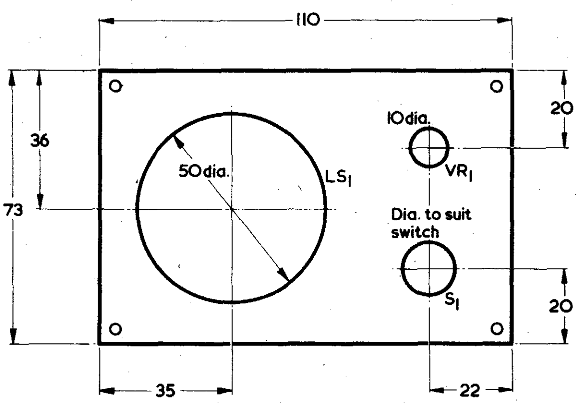


Fig. 3. Drilling and cut-out details for the front panel. Hole positioning can be amended to suit if a case having a larger front panel is employed

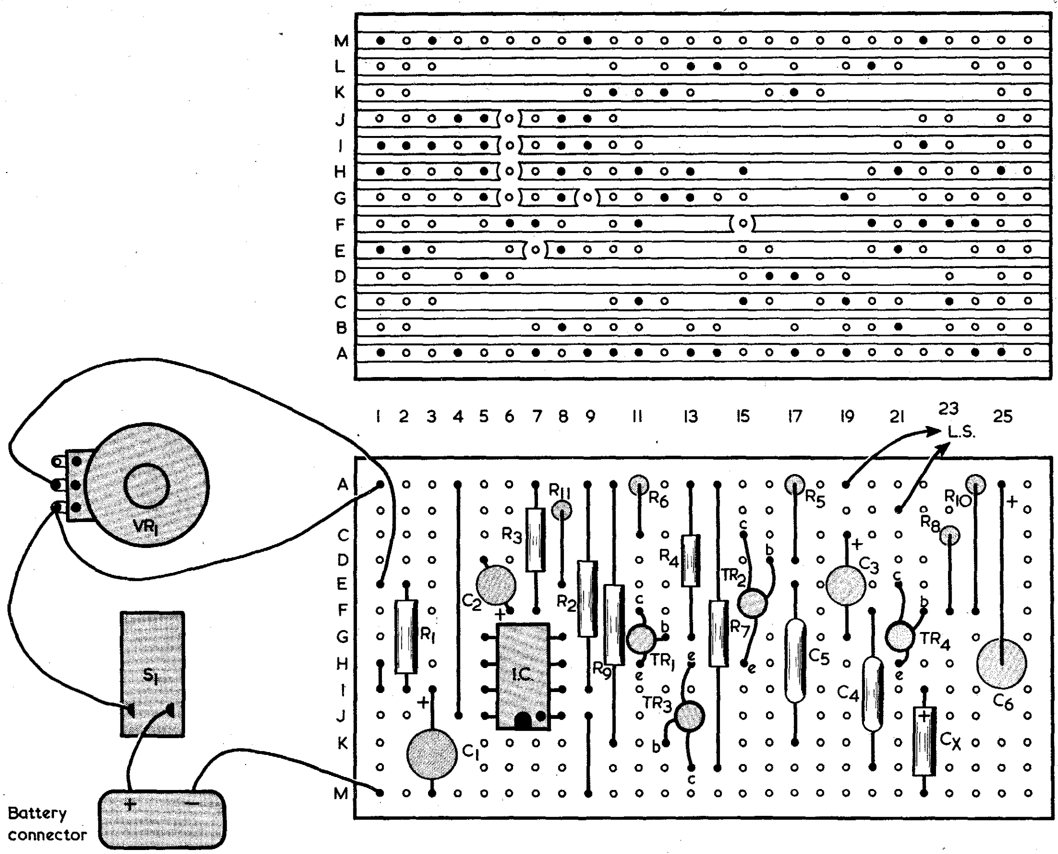


Fig. 4. Illustrating how the components are wired up on the Veroboard panel

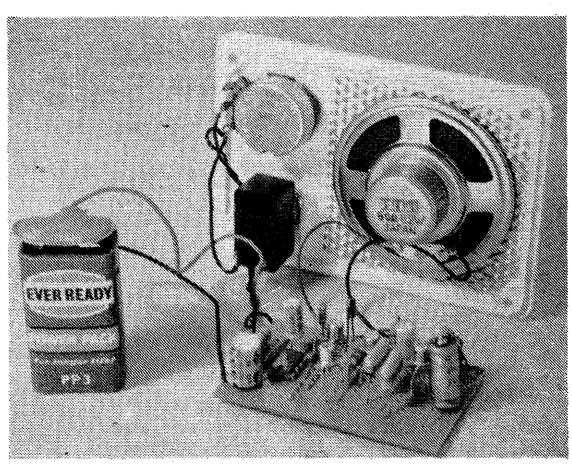
fretsaw or a miniature round file. A piece of speaker fret is glued to the back of the cut-out, using a good general purpose adhesive such as Bostik No. 1. The speaker is then carefully glued in place on the speaker fret. Take care to ensure that none of the glue gets on to the speaker cone or its surround. If the speaker has mounting holes, some constructors may prefer to fit it by means of four screws passing through the front panel and the speaker fret.

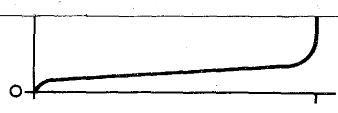
The speaker employed in the author's unit has an impedance of 50Ω and a diameter of 2¼in. (57mm.) but any speaker that is physically small enough to fit into the case and which has an impedance in the range of 40 to 80Ω can be used.

COMPONENT BOARD

All the small components are wired up on a Veroboard panel of 0.1in. matrix having 13 strips by 26 holes. The component and copper sides, together with external wiring, are illustrated in Fig. 4. The

Here, the Veroboard assembly is wired to the front panel components and the battery

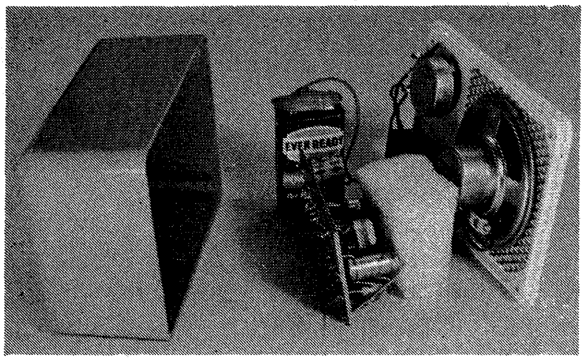




In Fig. 2(a) a constant current source is used in a circuit which measures the hFE of an n.p.n. transistor. The source has been pre-set to

the source is low. A low value is therefore applied to the emitter follower and the l.e.d. does not light.

The variable resistor is next ad-



A piece of soft foam rubber or plastic maintains the Veroboard assembly in position when the case is closed

panel is cut from a larger piece, and the seven breaks in the strips are then made, using a Vero spot face cutter or a small twist drill held in the hand.

The components are then soldered to the board. It is best to start with the three link wires, proceed to the resistors and capacitors and then finally solder in the transistors and the integrated circuit. The capacitor shown as CX is not fitted.

The completed timer seen from a different angle

The board is wired to the switch, the potentiometer and the speaker by means of thin flexible p.v.c. covered wires approximately 100mm. long. The wiring to the battery connector clip is also completed.

The component board is situated in the case behind the speaker, and the battery fits behind VR1 and S1. A piece of soft foam rubber or plastic is placed between the speaker and the component board, and this holds the board in position when the front panel is screwed in place. A smaller piece of foam rubber or plastic may be interposed between the switch and the battery.

CALIBRATION

It is a good plan to monitor the current consumption after the unit has been completed, and this should be in the region of 4.5mA. If the links at H1-I1 and A4-J4 are temporarily bridged with a 1kΩ resistor, the two-tone alarm should sound almost at once, with a corresponding increase in current consumption to some 20mA. If the unit does not function correctly it should be switched off immediately and the wiring thoroughly checked for mistakes. As is wise when checking the current consumption of any newly constructed equipment, initially switch the testmeter to a high current range. The testmeter can then be set to the requisite lower range after the initial reading has shown that it is safe to do so.

Calibration is carried out by making successive timing runs, and unfortunately there is no short-cut here. First set VR1 almost fully anticlockwise then check with the aid of a clock or a watch having a second hand, or with a digital watch having seconds indication, the time that elapses before the alarm sounds. VR1 is then readjusted several more times, as necessary, and the process repeated until a setting is found which gives a timing period of 2 minutes within a few seconds. The front panel is then marked with a '2' at the appropriate point.

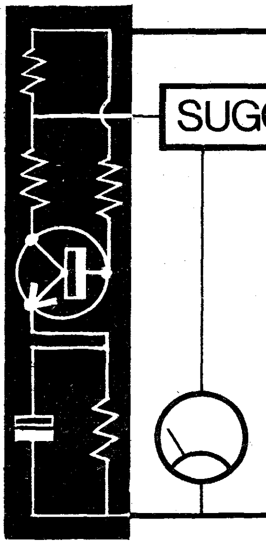
The procedure is then repeated to find the 3, 4, 5 and 6 minute settings. These later calibration runs do not take as long as might be expected because the scale is reasonably linear although due to imperfections in VR1, not perfectly so. The numbers and lettering on the author's unit were taken from 'Panel Signs' Set No. 4, available from the publishers of this journal. The legend 'ON' is affixed below S1, and the legend 'MIN.' below the knob of VR1.

If, after the unit has been completed, it is found that it does not give a time delay after being switched on, capacitor CX is added to the component board. Its position is shown in Fig. 4. ■

'AUDIO CONTROL CIRCUITS'

In the three articles under this heading which appeared in the July, August and September issues, the electronic attenuator i.c. employed is the Motorola MC3340P. As was explained in the first article, in the July issue, the MC3340P has superseded the MFC6040, which is electrically identical and has very similar pinning. Pinning diagrams for both versions were given.

Although superseded, stocks of the MFC6040 are still held by retailers, and readers who find difficulty in purchasing the MC3340P are advised to obtain the MFC6040 instead. This will fit directly into the 'Audio Control Circuits' Veroboard layouts, whilst the printed board design on page 46 of the August issue will need to be modified slightly to take the altered pin spacing.



SUGGESTED CIRCUIT

CONSTANT CURRENT TRANSISTOR GAIN METER

By G. A. French

Constant current sources have many uses in electronics and may be employed in current limiters, in waveform shaping networks, in reference voltage circuits and in numerous other applications. In the transistor gain meter to be described in this article, two constant current sources are employed in a circuit which indicates when a certain predetermined current is being passed, and they thereby replace a much more expensive meter which might otherwise be required.

CONSTANT CURRENT CURVE

A typical voltage and current characteristic curve for a constant current source has the general appearance shown in Fig. 1. When currents which are below the constant current level flow through the source the voltage across it remains at a low level whose actual value depends upon the particular design of the source. This voltage increases when the constant current level is approached, then changes to what is virtually a straight vertical line at the constant current itself. Currents greater than the constant current cannot be made to flow despite large increases in voltage across the source.

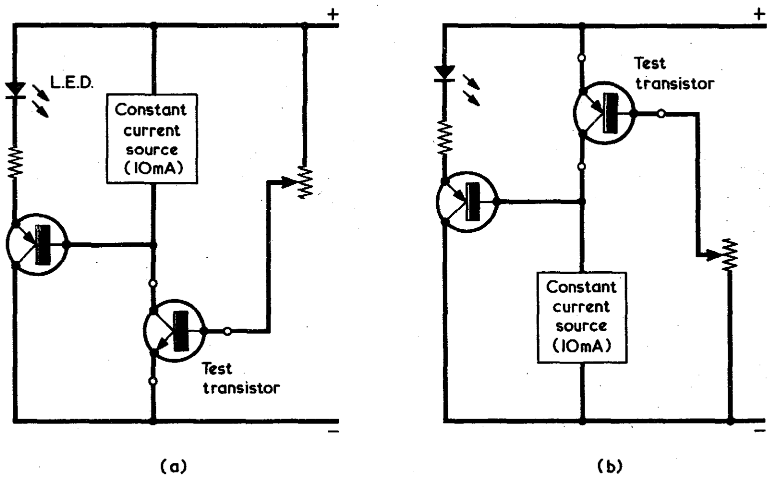


Fig. 2(a). Employing a constant current source to find the current gain of an n.p.n. transistor

(b). Here the current gain of a p.n.p. transitor is being measured

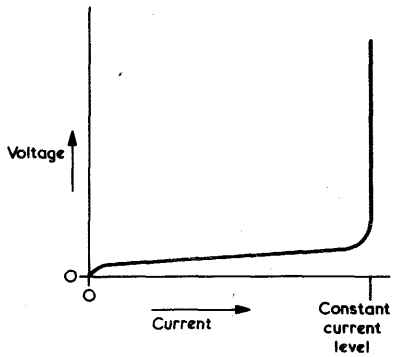


Fig. 1. Typical voltage-current curve for a constant current source

In Fig. 2(a) a constant current source is used in a circuit which measures the hFE of an n.p.n. transistor. The source has been pre-set to give a constant current of 10mA. Connected to its lower terminal is the base of an emitter follower which draws a negligibly low current in comparison. The emitter of the emitter follower feeds a light-emitting diode via a current limiting resistor.

There is a variable resistor between the base of the test transistor and the positive supply rail, and this is initially set to a high value. The collector current of the test transistor, which flows in the constant current source, is consequently well below the constant current value and the voltage across the source is low. A low value is therefore applied to the emitter follower and the l.e.d. does not light.

The variable resistor is next adjusted so that it inserts a continually reducing resistance into circuit. Because of this, the collector current of the transistor increases until it closely approaches the 10mA constant current value. The voltage across the constant current source now starts to increase, causing the l.e.d. to light up.

As the variable resistance is further reduced the test transistor collector current reaches the constant current value of 10mA, and the voltage across the constant current source rises to the supply voltage less that dropped in the test transistor, which is now fully turned on. The l.e.d. is illuminated at its full brightness and will remain in this state with further reductions in the variable resistance.

The range of variable resistance over which the l.e.d. is illuminated at less than maximum brightness is small, and the point at which it achieves full brightness can be readily resolved. Thus, the variable resistor is adjusted until it reaches the setting at which the l.e.d. just achieves maximum brilliance. The base current of the test transistor may then be calculated from the value of the variable resistance and the voltage of the supply, whereupon the hFE of the transistor at a collector current of 10mA can be determined. In practice, the variable resistor will have been previously calibrated directly in terms of transistor current gain.

Fig 2(b) shows a test set-up for determining the hFE of a p.n.p. transistor. This time a 10mA constant current source is interposed between the test transistor collector and the negative rail, and the variable resistor is also returned to this rail. The emitter follower and l.e.d. are the same as before, and once more couple to the collector of the test transistor.

Again the variable resistor is initially set to a high value, whereupon the collector current of the test transistor is lower than 10mA. In consequence, only a low voltage appears across the constant current source, causing a relatively high negative voltage to be applied to the base of the emitter follower. The l.e.d. lights up. The variable resistance is then reduced in value, causing the collector current of the test transistor to increase. As the collector current approaches 10mA the voltage across the constant current source rises, causing the l.e.d. illumination to decrease. When the collector current is equal to the 10mA constant current the voltage across the source becomes equal to that of the supply less the small voltage dropped in the test transistor, and the l.e.d. extinguishes. The range of variable resistance over which the l.e.d. brightness decreases is small, and of course the setting of the variable resistor which causes the l.e.d. to just extinguish is easily discernible.

Thus, in Fig. 2(b) the variable resistance is decreased to the point at which the l.e.d. just extinguishes. The current gain of the test transistor is then read from a scale previously fitted to the variable resistor.

FULL CIRCUIT

The full circuit of the transistor gain meter appears in Fig. 3. Here, R1, LED1 and TR1 provide the same function as in Figs. 2(a) and (b), and are connected to the collector test terminal. This test terminal also connects to the arm of switch S1(c). When this switch is set to the "NPN" position the collector terminal is taken to the positive rail via the constant current source given by TR2, VR2, D1 and D2. Turning S1(c) to the "PNP" position causes the collector terminal to be connected to the negative rail via the constant current source consisting of TR3, VR3, D3 and D4. The conditions of Figs. 2(a) and (b) are thus repeated in the practical circuit. VR2 and VR3 are small skeleton pre-set potentiometers, and are both set up for collector currents in TR2 and TR3 respectively of 10mA.

The variable base resistor of the previous circuits is now given by R2 and VR1 in series. R2 is a current limiting resistor and prevents the flow of excessive base current in the test transistor. VR1 is a standard carbon track potentiometer and is mounted on the front panel of the gain meter. S1(b) connects it to either the positive or the negative supply rail according to the polarity of the transistor being checked. S1(a) similarly connects the emitter test terminal to the positive or

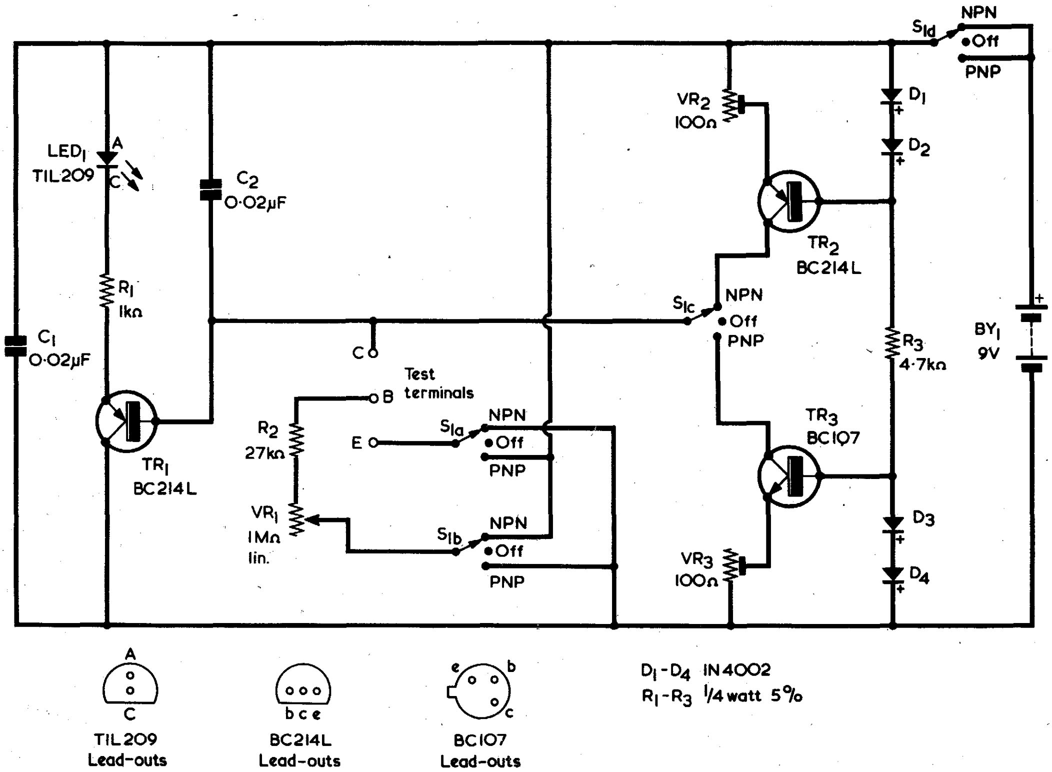


Fig. 3. Complete circuit of the constant current transistor gain meter

negative supply rail, as required.

S1 is a 4-pole 3-way rotary switch and the fourth section, S1(d) acts as an on-off switch. It is essential to have a central "Off" setting between the "NPN" and "PNP" positions as, with the usual type of make-before-break switch, the supply could otherwise be momentarily short-circuited each time the switch is operated.

Capacitors C1 and C2 are added to prevent possible instability in the circuit. This could prove troublesome when checking high gain r.f. transistors.

It should be noted that there is little risk of damaging a transistor if it is connected incorrectly to the test terminals. The highest current which can flow is limited to 10mA by the constant current sources.

Current consumption from the 9 volt battery is around 12mA when a p.n.p. transistor is being checked. With n.p.n. transistors it is around 1.5mA when the l.e.d. is extinguished, rising to 12mA when the l.e.d. lights up.

CALIBRATION

The complete circuit may be housed in any convenient plastic case with LED1, the switch and VR1 mounted on the front panel.

It is first necessary to set up VR2 and VR3. Before switching on, ensure that these two potentiometers insert maximum resistance into circuit. This is a most important point: if either VR2 or VR3 inserts too low a resistance damage may result to the meter used for setting up, the associated transistor and the potentiometer itself.

Set the switch to "NPN" and connect a current reading meter across the collector and emitter test terminals, with positive to the collector terminal. Initially select a high current range in case a wiring error causes an excessive current to flow, then switch to a lower range if the first reading indicates that it is safe to do so. Slowly reduce the resistance inserted by VR2 until the meter indicates 10mA.

Disconnect the meter and select "PNP". Reconnect the meter to the collector and emitter test terminals, with negative this time to the collector terminal. Again, initially select a high current range in case of wiring errors. Then slowly reduce the resistance inserted into circuit by VR3 until the meter once more reads 10mA.

The remaining task consists of calibrating VR1 in terms of test transistor current gain, and it is necessary here to make an arbitrary choice of the voltage which will be assumed to appear across this potentiometer and R2 when the test transistor is turned on. Nearly all the transistors to be checked will be silicon types, with a drop across the base-emitter junction of about 0.6 volt. Since the battery voltage will average at around 8.5 volts over most of its useful life, it would be reasonable to assume that the voltage across VR1 and R2 can be taken as being 8 volts. A transistor with an hFE of 100 will pass a base current of 0.1mA when its collector current is 10mA, and 0.1mA at 8 volts corresponds to 80kΩ. Thus, a resistance of 80kΩ in R2 plus VR1 corresponds to a gain of 100 times, and VR1 scale may be marked up accordingly. A gain of 200 will correspond to a resistance of 160kΩ, and so on up to a gain of 1,000 corresponding to 800kΩ. Below 80kΩ, a restance of 40kΩ corresponds to a gain of 50 times.

VR1 is, in consequence, calibrated by measuring the resistance of R2 plus VR1 and marking the gain figures directly on a scale fitted to the potentiometer. The gain meter is then employed for measuring transistor gain in the manner outlined when discussing Figs. 2(a) and (b), S1 being set as required to suit the test transistor polarity.

As is to be expected, the gain calibration obtained by assuming a voltage of 8 volts across R2 and VR1 will not be very accurate, although it should be more than adequate for most day-to-day applications. Incorporating a supply voltage stabilizing stage for the entire circuit is a little unattractive considering its low cost and basic simplicity. There is, however, another method of obtaining higher accuracy and this can be given, if desired, by adding the zener diode circuit shown in Fig. 4. The two zener diodes stabilize the voltages applied to R2 and VR1 and cause only a little extra current to be drawn from the battery.

The voltage now available for R2 and VR1 is 5.6 volts, whereupon it can be assumed that the voltage across these two components is 5 volts when checking a silicon transistor. A current gain of 100 times now corresponds to a resistance in R2 plus VR1 of 50kΩ, a gain of 200 times to 100kΩ, and so on up to 1,000 times and 500kΩ, and VR1 is calibrated accordingly. The values of R2 and VR1 are also changed to accommodate the lower voltage applied to them. ■

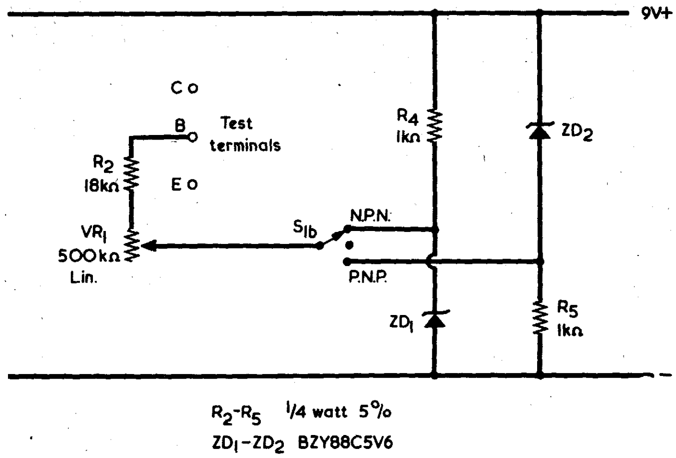


Fig. 4. A modification which allows a higher degree of accuracy in readings

SOME ELECTRONIC PUZZLES

In the first puzzle under this heading in the September 1976 issue it was stated that 'Jim takes a quarter of the remainder plus half a resistor'. This should have read 'three-quarters of the remainder plus half a resistor', and we much regret the added problem put to puzzlers.

GENERAL PURPOSE PRE-AMPLIFIER

By F. G. Rayer

A simple pre-amplifier which may be added to the "General Purpose I.C. Amplifier" described in our July 1976 issue.

Since building the "General Purpose I.C. Amplifier", which appeared in the July 1976 issue of this journal, the author has felt that additional gain may be of use for some applications. In consequence, the pre-amplifier described here was made up. This offers an input at low impedance and may be readily added to the main amplifier, from which it obtains its power.

CIRCUIT DETAILS

The pre-amplifier circuit appears in Fig. 1. Jack sockets JK1 and JK2 are both 3.5mm. types with a contact which breaks when the plug is inserted. VR1 is the volume control already fitted in the main amplifier.

An input applied to JK1 is fed via C1 to the base of TR1. This has R3 as its collector load, whilst R1 and R2 provide base bias. C2 assists in giving stability by providing negative feedback at high frequencies. R4 and C4 are decoupling components, with R4 connecting to the positive supply point in the main amplifier. The amplified signal at TR1 collector is passed to JK2 by way of C3.

To use the pre-amplifier an input signal is applied by a jack plug in JK1. The amplified signal is then fed to VR1 and the main amplifier via the break contact of JK2. When the plug is removed from JK1 the break contact of this socket closes and the input is short-circuited. This ensures that TR1 contributes negligible noise when not in use. Inserting a plug into JK2 enables the main amplifier to function in the same manner as before, the break contact isolating the main amplifier input from C3 and TR1.

Should the input socket already fitted in the main amplifier have a break contact, this may be employed as it stands for JK2 of Fig. 1. If not, a new socket with a break contact must be substituted. The inset diagram in Fig. 1 shows standard tag layout for most 3.5mm. jack sockets having an open construction. If

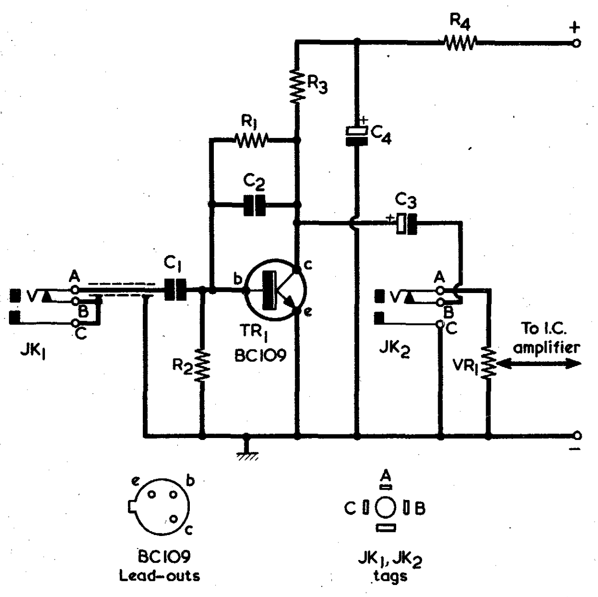


Fig. 1. The circuit of the pre-amplifier

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)
- R1 2.2MΩ
- R2 270kΩ
- R3 39kΩ
- R4 5.6kΩ
- VR1 Present in main amplifier

Capacitors
- C1 0.05μF disc ceramic
- C2 220pF ceramic or silvered mica
- C3 4.7μF electrolytic, 25V Wkg.
- C4 220μF electrolytic, 25V Wkg.

Transistor
- TR1 BC109

Sockets
- JK1 3.5mm. jack socket with break contact
- JK2 3.5mm. jack socket with break contact (see text)

Miscellaneous
- Veroboard panel, 0.1in. matrix, 28 holes x 14 strips Screened wire, etc.

any doubt exists, the tag locations may be determined by visual examination of the socket.

BOARD LAYOUT

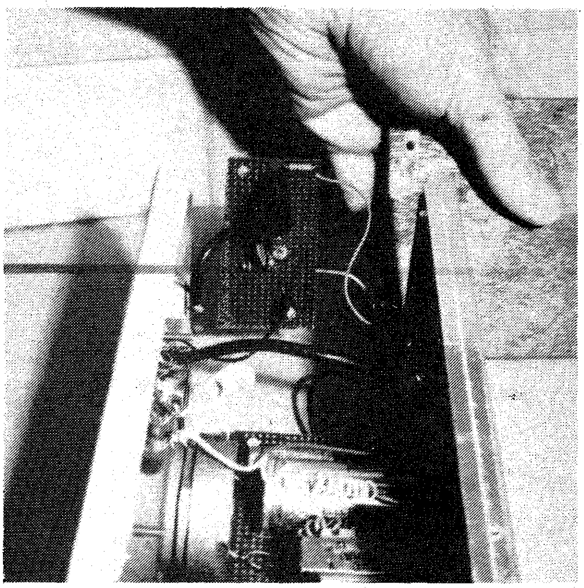
Apart from the sockets, the components are assembled on a Veroboard panel of 0.1in. matrix having 28 holes by 14 strips. The copper side of the panel is illustrated in Fig. 2, the components above the board being shown in broken line. Two mounting holes are shown and these should correspond with the holes in the left-hand flange of the front panel of the main amplifier. The holes may be drilled out 6BA clear. The copper strips are cut at the points indicated. A wire link, on the copper side of the board, joins 9 strips which are all at chassis potential. The components are next fitted and soldered in position.

Take up a few inches of screened wire and solder its braiding to the point marked "MC" in Fig. 2. Connect the centre wire of the screened lead to C1. The other end of the screened lead has its braiding connected to tags "B" and "C" of JK1, and its centre wire to tag "A" of JK1. JK1 is fitted to the amplifier front panel about an inch above the original input socket (which is now JK2).

A short wire runs from C3 to tag "B" of JK2. Run a red inslulated lead from R4 to connect to the positive lead-out of the 2,500μF reservoir capacitor in the main amplifier. Run a black insulated lead from any convenient point on the 9 strips at chassis potential to connect to the negative lead-out of the reservoir capacitor. (This connection supplements any chassis connection by way of the mounting washers and JK1.)

The Veroboard panel is fitted by screws passing through the board and the holes in the left-hand flange of the front panel, with spacing washers between the two. The panel projects backwards inside the amplifier case.

As a final point, the current drawn by the pre-amplifier is quite small and it can be used with the i.c. amplifier when this incorporates a mains transformer having a secondary rated at 100mA. ■



Fitting the pre-amplifier to the main amplifier case

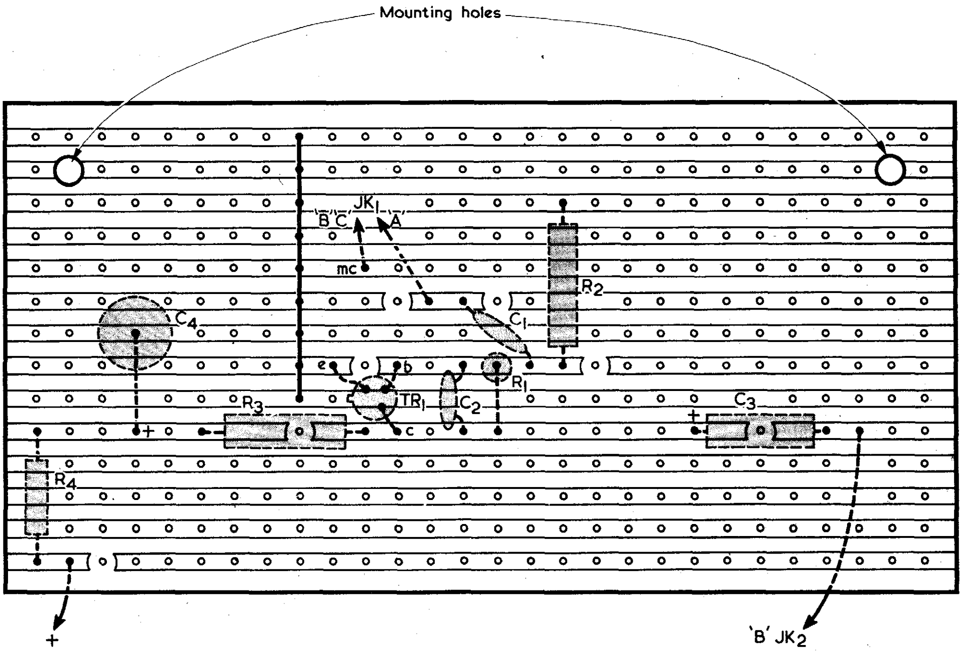
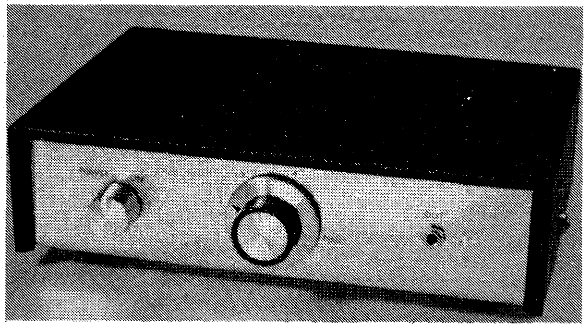


Fig. 2. The components are assembled on a Veroboard panel, the copper side of which is shown here

PHASE LOCKED I

Part 1



**Incorporating a recent COS/M
f.m. tuner has no more than two t
one has to be adjusted during se
mono reception, the tuner neverth
performance in areas of good
described here, as also are the f
remainder of the construction will
cluding**

Over the past few years there have been many changes in electronics, mainly due to the introduction of new integrated circuits and other modern semiconductor devices. This has not only broadened the range of projects available to the home constructor but has also introduced new design techniques for types of project that have been in existence for many years.

The f.m. tuner which forms the subject of the present article falls into this last category, and it employs a modern COS/MOS phase locked loop (p.l.l.) integrated circuit for demodulation. This, together with the low i.f. used and the absence of i.f. transformers or filters, makes the circuit a little unusual, to say the least.

Despite the novel stage line-up the unit makes an excellent tuner for use with a mono cassette recorder or record player amplifier, etc., and in most areas it will provide good reception of B.B.C. Radios 2, 3 and 4 using only a few feet of wire as an aerial. Any local stations that are operating in the area can be received in this manner. With three feet of wire as an aerial the prototype provides good reception of the three national transmissions as well as B.B.C. Radio Medway at a distance of some 25 miles from the Wrotham transmitter.

Although not primarily designed for use with a stereo decoder, the prototype produces an acceptable output when coupled to a decoder based on the popular Motorola MC1310P i.c. The noise level on stereo is not as low as with a conventional tuner and a fairly high input signal strength is required in order to obtain a good signal to noise ratio. The tuner can only be employed satisfactorily in this way in areas of good reception, or where a proper aerial is available. On mono the tuner has a very low noise level.

The unit is self-contained and is powered by an internal PP3 9 volt battery. A reasonable battery life is obtained, the current consumption being about 8mA. The tuner provides an output signal level of about 200mV, and this should preferably be fed to an amplifier input impedance of 50kΩ or more. Most amplifiers will have a suitable input. The frequency coverage of the tuner extends from about 88 to 102MHz.

It is possible to use the unit as a personal receiver by plugging a crystal earphone or crystal headphones into the output socket.

PHASE LOCKED LOOP

A phase locked loop is used for the demodulation process and reference to Fig. 1 will be of help to those who are unfamiliar with these devices. Looking at a p.l.l. in broad terms it is a fairly simple device consisting of two main parts: a voltage controlled oscillator (v.c.o.) and a phase comparator.

The v.c.o. feeds one input of the phase comparator and the input signal is fed to the other input. The output of the phase comparator is proportional to the difference in the phase and frequency of the two input signals. In practice only a very small phase

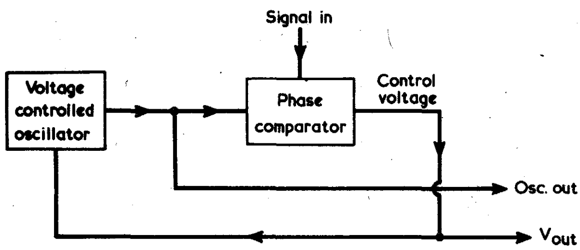


Fig. 1. The basic requirements for a phase locked loop. Two outputs are available, these being a signal from the voltage controlled oscillator and the control voltage from the phase comparator

,OOP F.M. TUNER

By R. A. Penfold

)S phase locked loop i.c., this uned circuits and of these only :ting up. Intended primarily for ›less gives an acceptable stereo ›ignal strength. The circuit is irst steps in construction. The be covered in next month's con- ırticle.

difference is required to produce a significant comparator output voltage, and this output voltage is used to control the operating frequency of the v.c.o. As a result the v.c.o. is caused to oscillate with the same frequency and phase as the input signal, and it remains locked to the input frequency even when the latter is continually changing.

In some applications such as stereo decoding it is the v.c.o. output signal that is of use, but it is the output voltage of the phase comparator that is used when a p.l.l. is employed as an f.m. demodulator.

If an input signal at about the centre frequency of the v.c.o. range is fed to the input of the p.l.l., the voltage at the phase comparator output will be at about the centre of its range also. If the input frequency is raised the output voltage of the phase comparator will change in order to raise the frequency of the v.c.o. and keep it in step with the input signal. If the input signal is reduced in frequency the phase comparator output voltage will change in the opposite direction in order to maintain the v.c.o. in phase.

The phase comparator output voltage of the p.l.l. thus rises and falls with changes of input frequency. Most practical circuits are arranged to have a linear relationship between frequency and phase comparator output voltage. This is of course just what is required for f.m. demodulation, and in fact p.l.l.'s make excellent f.m. demodulators.

Although the basic concept of a p.l.l. is a relatively simple one, practical circuits tend to be extremely complex, often employing more than a hundred components. For this reason p.l.l. systems almost inevitably utilise specialist i.c.'s. This tuner is no exception and it employs an RCA CD4046AE i.c. for demodulation.

This device is one of the COS/MOS range of i.c.'s, and has the advantages of relatively low cost and very modest power requirements. One disadvantage of this i.c. is that it is intended for low frequency applications, and has a typical maximum operating frequency, at a supply of 5 volts, of 500kHz. This is obviously inadequate for use with an ordinary 10.7MHz i.f., but the problem is overcome here by the use of a low frequency i.f. of the type used in pulse counting tuners. This point is discussed more fully later.

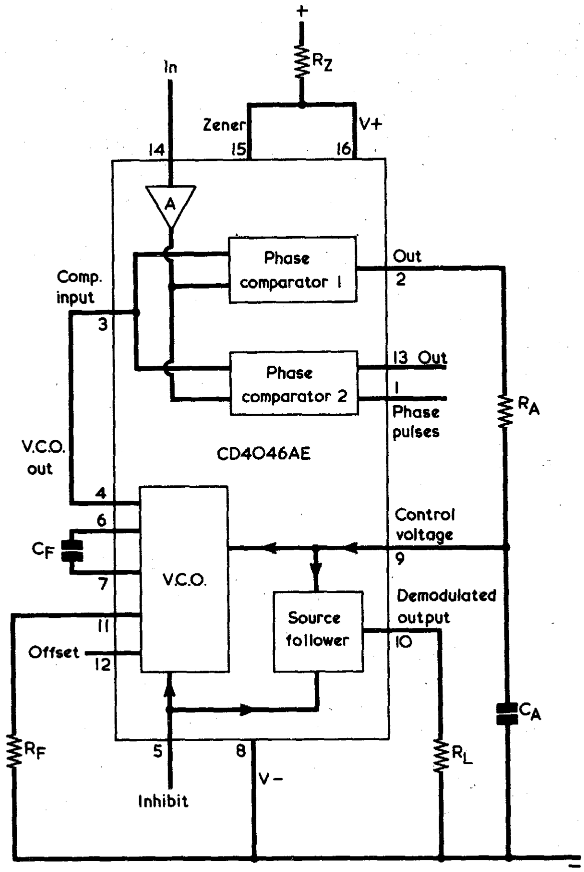
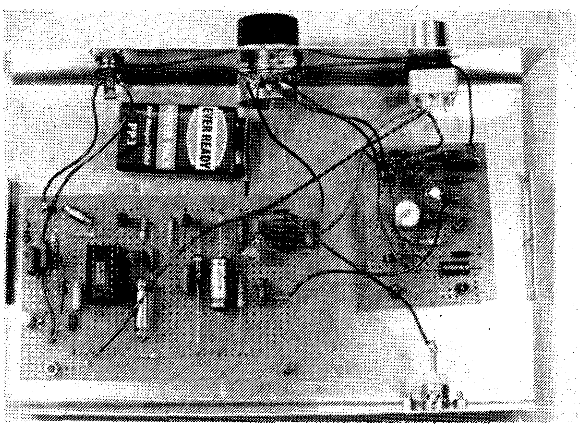


Fig. 2. Details of the RCA integrated circuit type CD4046AE, as employed in the tuner

Fig. 2 shows the various stages of the CD4046AE in block diagram form, together with details of the pin functions and the few discrete components required to complete a practical p.l.l. circuit incorporating the device. The CD4046AE is contained in a standard 16 pin d.i.l. package.

The frequency range of the circuit is determined by



Internal layout, showing the positions taken up by the two component boards

the values of CF and RF. The maximum to minimum lock-in frequency range is about 10 to 1. The values used in the tuner circuit give a frequency range of approximately 30 to 300kHz.

Two phase comparators are available in the device, and it is phase comparator 1 that is used here. This brings the v.c.o. to its centre frequency with no signal present at the input, whereas phase comparator 2 operates the v.c.o. at its minimum frequency under these conditions. The output of the phase comparator is fed to the v.c.o. via a simple low pass filter consisting of RA and CA. The signal here is at a fairly high impedance, and so a source follower buffer amplifier is used between the v.c.o. input and the output of the device at pin 10.

A high input impedance amplifier is available at the input of the i.c., and the input signal is applied to pin 14. It is preferable for the device to be operated from a stabilized supply, and a 5·2 volt zener diode is incorporated between pins 15 and 8 (the negative supply input) of the i.c. RZ is the usual zener feed resistor. The frequency offset (pin 12), inhibit (pin 5) and phase pulse output (pin 1) facilities of the device are not used in the present application.

LOW FREQUENCY I.F.

As mentioned earlier, the tuner employs a low frequency intermediate frequency of the type used in pulse counting tuners. In a pulse counting tuner the local oscillator operates close to signal frequency, and is adjusted to only about 100kHz on either side of the signal frequency. This gives an i.f. of only about 100kHz, and a low frequency such as this can be handled by simple amplifiers using resistive loads and no i.f. filters. The i.f. output is fed to a limiter and then to a pulse counting circuit. The limiter is required to clip the i.f. signal and so remove any noise spikes on the signal before it is fed to the demodulator. The pulse counting demodulator is simply a circuit that has an output voltage which is proportional to the number of pulses being supplied at its input, and the complete tuner is shown in Fig. 3(a).

The present tuner uses the very similar arrangement illustrated in Fig. 3(b), which also shows the semiconductor devices employed in each stage. In this case the low i.f. is at about 150kHz. The two types of circuit differ after the i.f. output, with the limiter and pulse counting stages of Fig. 3(a) being replaced by the p.l.l. stage. The limiter is not required as any noise spikes on the input will not affect the operation of the p.l.l. unless they cause the input signal to be reduced to less than the threshold voltage needed for maintaining frequency lock. Thus, the p.l.l. has, in effect, its own built-in limiting action.

TUNER CIRCUIT

The complete circuit of the phase locked loop tuner f.m. tuner is shown in Fig. 4. TR1 is a dual gate MOSFET and is used as the mixer. L1 and C2 form the signal input tuned circuit, and this is a broadband circuit that covers the whole of the f.m. band. The aerial is connected to a tap in L1. A secondary function of L1 is to provide the bias for gate 1 of TR1 by coupling it to chassis at d.c. R2 is the source bias resistor for TR1 and C3 is its bypass capacitor. R1 is the drain load, and it is across this resistor that the i.f. signal is developed.

A common base Colpitts circuit is used in the local oscillator stage, which incorporates TR4. R17 and R18 are the base bias resistors, and C15 is the base bypass capacitor. C14 provides positive feedback between the collector and emitter of TR4. L2 is the os-

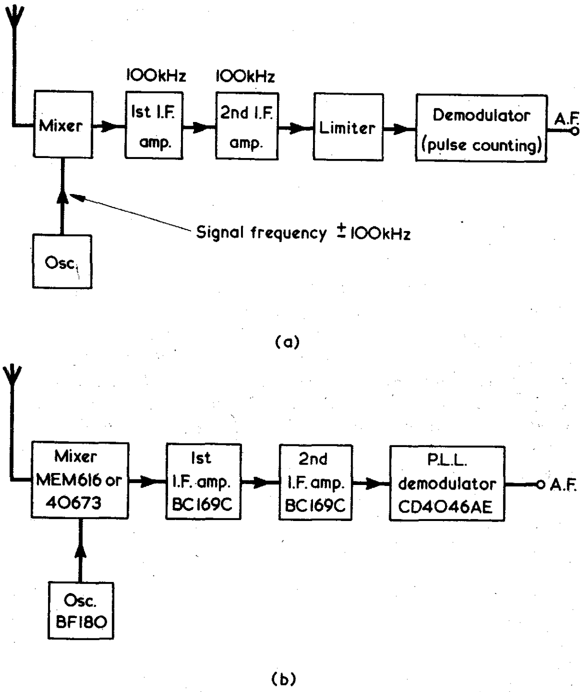


Fig. 3(a) Basic line-up of a typical f.m. tuner with pulse counting demodulation
(b). The line-up of the phase locked loop f.m. tuner described in this article, showing also the active semiconductor devices used in each stage

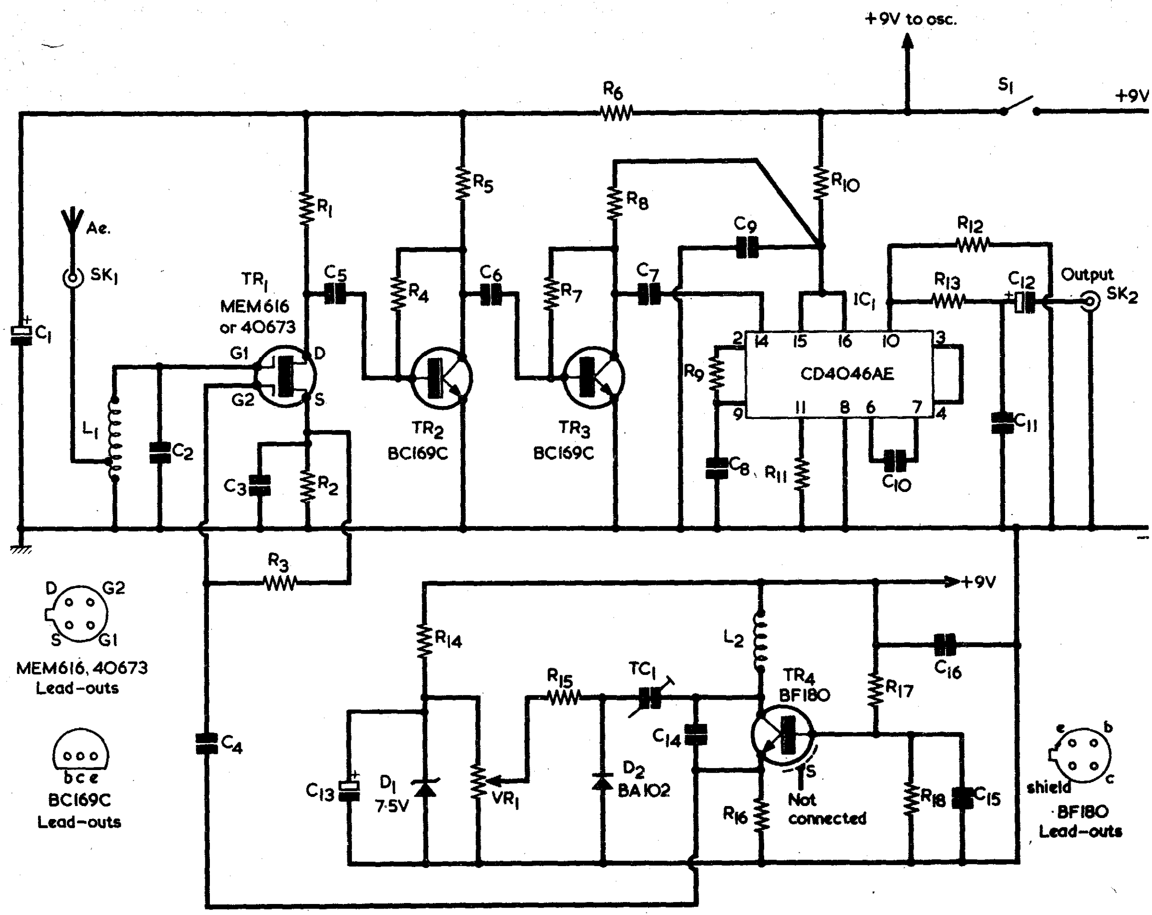


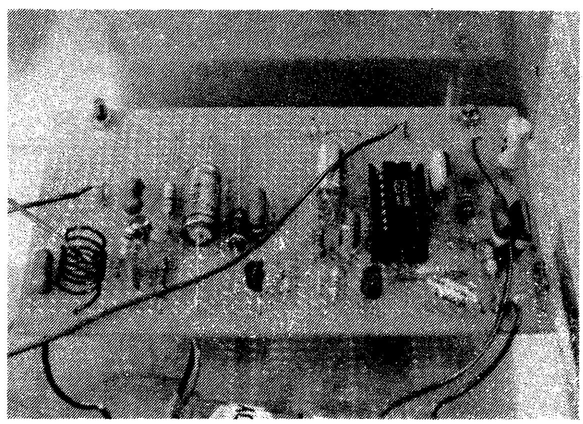
Fig. 4. Full circuit diagram of the phase locked loop f.m. tuner

cillator coil, and this and L1 are the only inductors employed in the complete circuit.

Varicap oscillator tuning is used, and the varicap diode, D2, is coupled to the oscillator circuit via TC1. A variable reverse bias for D2 is fed from VR1 slider to D2 via R15. Altering the bias voltage across D2 alters its capacitance, and VR1 thus acts as the tuning control. It is important that the voltage across VR1 be stabilized, as otherwise changes in supply voltage due to battery ageing would seriously affect the tuning. R14, C13 and D1 form a conventional zener diode shunt stabilizer and apply a voltage of about 7.5 volts across VR1.

Note that TR4 is a 4-lead device having the shield connection that is common to many r.f. transistors. In this particular circuit the shield lead-out is not connected.

The two i.f. amplifiers use high gain BC169C transistors in the common emitter configuration, and these are much the same as conventional common emitter a.f. stages. The only real difference is that lower value interstage coupling capacitors (C5 and C6) are used here, because the amplifiers do not need to handle frequencies as low as those in the a.f. spectrum.



A close view of the main component board on which is mounted the phase locked loop integrated circuit

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)
R1 470Ω
R2 220Ω
R3 100kΩ
R4 2.2MΩ
R5 4.7kΩ
R6 390Ω
R7 1.2MΩ
R8 2.2kΩ
R9 12kΩ
R10 1kΩ
R11 3.9kΩ
R12 10kΩ
R13 3.3kΩ
R14 4.7kΩ
R15 330kΩ
R16 1.2kΩ
R17 15kΩ
R18 15kΩ
VR1 100kΩ potentiometer, linear

Capacitors
C1 100μF electrolytic, 10 V. Wkg.
C2 8.2pF ceramic
C3 0.005μF disc ceramic
C4 1.8pF ceramic or silvered mica
C5 0.01μF type C280 (Mullard)
C6 0.0047μF polystyrene
C7 0.047μF type C280 (Mullard)
C8 470pF polystyrene
C9 0.1μF type C280 (Mullard)
C10 470pF polystyrene
C11 0.015μF type C280 (Mullard)
C12 10μF electrolytic, 10 V. Wkg.
C13 10μF electrolytic, 10 V. Wkg.
C14 5.6pF ceramic
C15 0.022μF disc ceramic
C16 0.005μF disc ceramic
TC1 10-30pF trimmer

Inductors
L1, L2 (see text)

Semiconductors
IC1 CD4046AE
TR1 MEM616 or 40673
TR2 BC169C
TR3 BC169C
TR4 BF180
D1 7.5V zener diode type BZY88C7V5
D2 BA102

Switch
S1 s.p.s.t., rotary

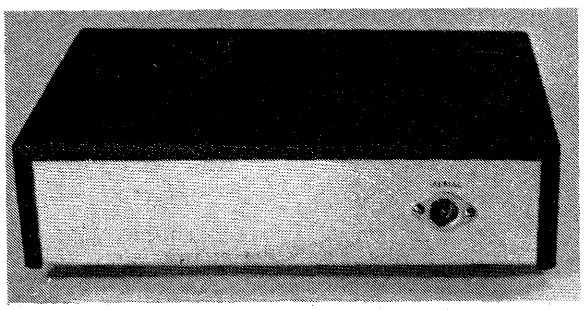
Sockets
SK1 coaxial socket, flush mounting
SK2 3.5mm. jack socket (see text)

Miscellaneous
Instrument case type BV1 (Bi-Pak)
Plain perforated s.r.b.p. board, 0.1in. matrix, 43 x 25 holes
Ditto, 23 x 17 holes
Large control knob
Small control knob
16 s.w.g. enamelled copper wire (for L1 and L2)
PP3 battery
Battery connector
16-way i.c. holder
4 rubber feet
Nuts, bolts, wire, etc.

It is possible to ascertain the functions of most of the discrete components associated with the i.c. by referring back to Fig. 2. There are three additional components. These are the de-emphasis network, R13 and C11, and the output d.c. blocking capacitor, C12.

Pre-emphasis, which is basically a degree of treble boost, is applied to the audio signal at the transmitter. It is the purpose of the de-emphasis network to reduce the treble response of the tuner in order to compensate for the pre-emphasis, and so give a flat overall frequency response. The reason for using this technique is that it gives a very worthwhile improvement in the signal to noise ratio of the complete system.

If the output of the tuner is to feed a stereo decoder the de-emphasis network must be removed, and the output taken directly from pin 10 of the i.c. via C12. Note that the low pass filter given by R9 and C8 does not provide de-emphasis. The values used here are



The only part mounted on the rear panel is the coaxial aerial socket

chosen to enable the v.c.o. to faithfully follow the carrier signal of the received transmission. Increasing the value of C8 by a significant amount would not reduce the treble content of the audio output of the demodulator but would instead prevent the v.c.o. from keeping in step with the input carrier, and this would prevent the demodulator from working at all. It is this which enables the tuner to feed a stereo decoder satisfactorily, whereas a pulse counting type of tuner is unable to do so.

C1, R6, C9 and C16 are supply decoupling components. S1 is the on-off switch.

Turning to practical details, TC1 in the oscillator circuit can be any miniature trimmer having a minimum capacitance of 10pF or less and a maximum capacitance of about 30pF. A ceramic type is to be preferred. The integrated circuit type CD4046AE is available from several retailers. Socket SK2 should be a 3.5mm. jack socket of open construction, i.e. not an insulated type. This is because it provides a chassis connection by way of its mounting bush and nut.

CASE

The tuner is housed in a ready-made case type BV1, which can be obtained from Bi-Pak. The front, base and rear consist of a single piece of aluminium, and the outer casing is plastic covered steel. The case dimensions are 203 by 133 by 51mm. (8 by 5¼ by 2in).

The drilling and general layout inside the case is illustrated in Fig. 5. This is all quite straightforward, and the mounting holes for the two component boards are marked up and drilled after the corresponding holes have been made in the boards. In order to simplify the diagram, Fig. 5 shows the aluminium part of the case as though it were laid out flat. If desired, four holes can be drilled near the corners of the base for rubber feet.

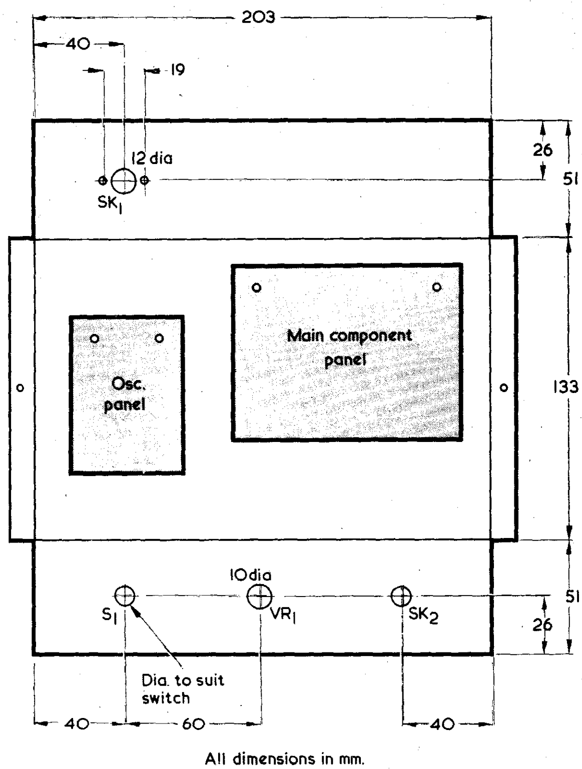


Fig. 5. Drilling details for the chassis. The front and rear panels are shown flat for ease of presentation

MAIN CIRCUIT BOARD

Most of the components are assembled on a plain perforated board of 0.1in. matrix having 43 by 25 holes. Assembly details are given in Fig. 6.

The board is first cut out from a larger panel with the aid of a small hacksaw. This type of board is a little brittle and care has to be taken to avoid cracking it as it is being cut. Then drill out the two 6BA clear mounting holes.

Next, mount the components in the positions indicated in fig. 6, bending the lead-out wires flat against the underside of the board. The lead-out wires are then soldered together to conform to the underside view of the board. Where necessary, lead-outs can be extended by means of 22 s.w.g. tinned copper wire. This wire may also be used for the long negative supply wire running along one edge of the board. In several places wires run close to each other, whereupon it is necesssary to cover at least one of the wires with sleeving.

The integrated circuit is not wired directly to the board. Instead, a 16-way d.i.l. integrated circuit holder is mounted on the board in the position indicated for the i.c. in Fig. 6. The i.c. is fitted into this holder much later, and it should not as yet have the protective conductive foam or metal foil removed from its pins.

Coil L1 is home-wound with a short piece of 16 s.w.g. enamelled copper wire, and it is self-supporting. It is initially wound on a round object having a diameter of $\frac{5}{16}$in., such as the shank of a $\frac{5}{16}$in. twist drill. It has precisely 5 turns and is 0.6in. long. The enamel insulation is scraped off 1¼ turns from what will be the earthy end of the coil when it is mounted, and this area is tinned with solder. This provides the tap and will be connected to the aerial socket later. The end lead-outs of the coil project downwards and are also tinned after the enamel has been scraped off. The coil is then mounted on the board and soldered into circuit, reasonable care being taken not to distort the winding. (The photographs of the receiver interior tend to give an impression that the coil has 6 turns; 5 turns is the correct number).

Veropins are inserted in the board at the points where leads from external components, such as SK2, will later be connected. If the board is of Vero manufacture these should be Veropins intended for boards of 0.1in. matrix. Should the board be of alternative manufacture it will be found that 0.15in. Veropins give a better fit. The pins should be of the full-pin type which projects on both sides of the board. Make sure that the connections to the pins under the board are physically sound so that they will not come adrift when the soldering iron is applied to the tops of the pins.

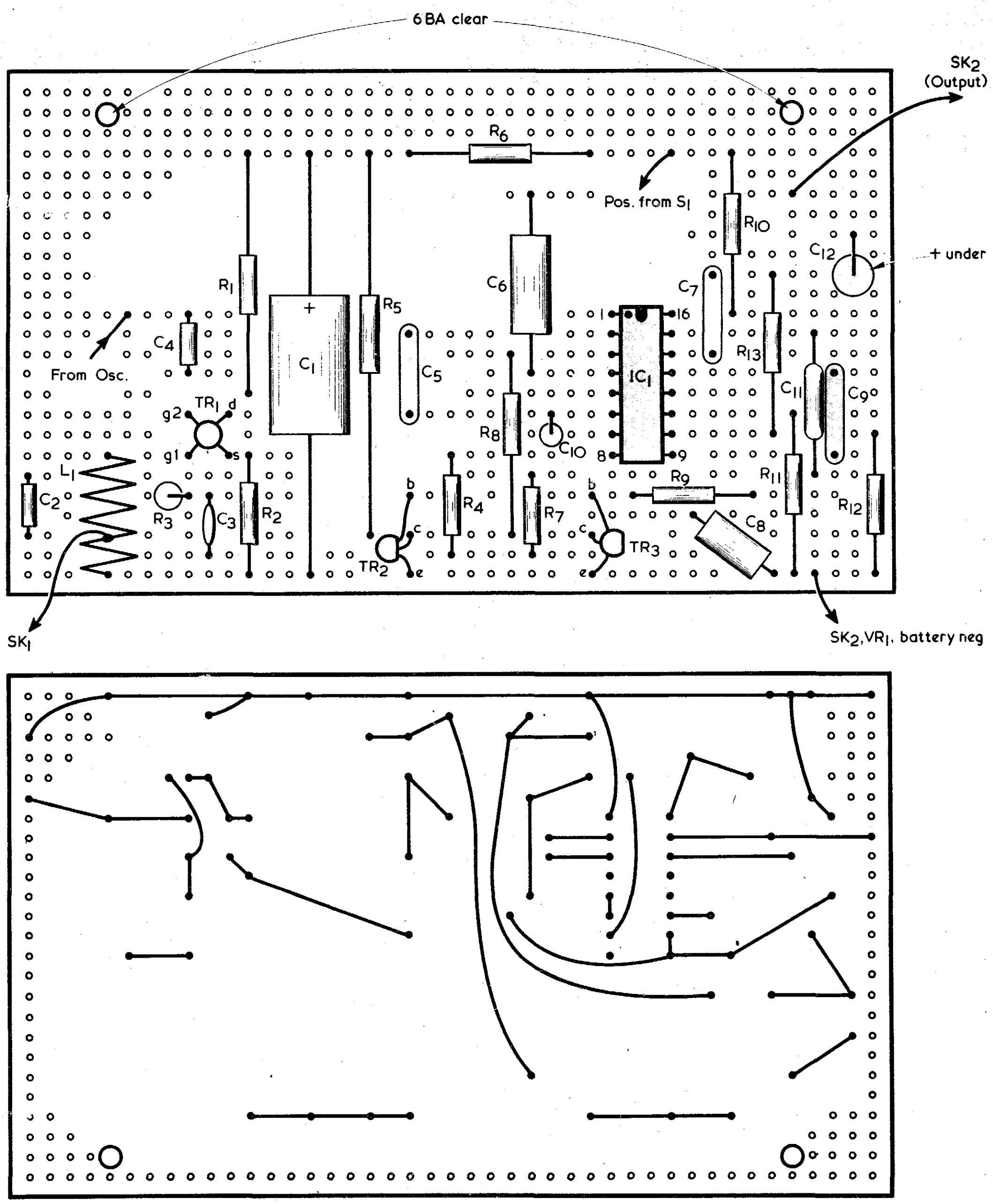


Fig. 6. Part layout and underside wiring on the main component board

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NEXT MONTH

Next month's concluding article will describe the mounting of the main component panel board in the case, then carry on to the assembly of the oscillator board and the final setting up of the tuner.

(To be concluded)

Precedence Detector

by D. Snaith

A simple circuit incorporating an R-S flip-flop.

The use of an R-S flip-flop in a precedence detector is not new, and a design for such a detector was described by R. J. Caborn in the May 1973 issue of this journal. Light-emitting diodes were not readily available to home constructors at that time and the 1973 design incorporated filament bulbs with transistor drivers. Due to the relatively high current consumption which resulted, the precedence detector employed a mains power supply.

It is worth returning to the R-S flip-flop now that l.e.d.'s are so easily obtainable. The illuminating current for an l.e.d. can be supplied direct from the output of a t.t.l. integrated circuit, and much simpler battery-powered circuits can be devised.

The function of a precedence detector of the type to be described is to indicate which of two circuits has been opened first. It lends itself particularly well to games where two contenders are required to press a button in response to a stimulus, and to quiz contests based on the familiar formula encountered in BBC sound radio programmes. More serious applications include the study of ganged switch or relay performance and the like.

R-S FLIP-FLOP

The basic R-S flip-flop is illustrated in Fig. 1, where two 2-input NAND gates are cross-connected in the manner shown. There are two inputs, R (for Reset) and S (for Set), and two outputs, Q and not-Q. The latter is represented by the letter Q with a bar above it. It will be remembered that the output of a NAND gate falls to 0 (a low positive voltage) only when *all* its inputs are at 1 (a high positive voltage).

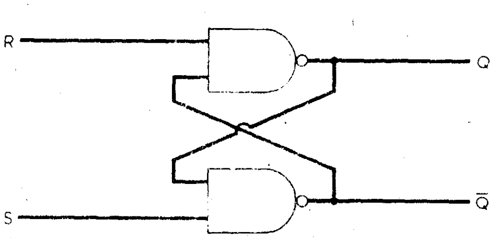


Fig. 1. Basic circuit of the R-S flip-flop.

R	S	Q	$\bar{Q}$
0	0	1	1
1	0	0	1
0	1	1	0
1	1	as previous state	

Fig. 2. Truth table for the flip-flop.

Let us next assume that both the R and S inputs in Fig. 1 are at 0. The two NAND gate outputs, at Q and not-Q, are then at 1. In consequence the upper NAND gate has a 1 input from the lower NAND gate output, and the lower NAND gate has a 1 input from the upper NAND gate output.

We next take the R input from 0 and raise it to 1. Since the upper NAND gate now has two 1 inputs, its output, Q, falls to 0. This output is applied to the lower NAND gate with the result that, if we next raise the S input to 1, the lower NAND gate is inhibited by the 0 passed to it by the upper NAND gate, and the outputs do not change.

If we initially raise the S input instead of the R input to 1 the output of the lower NAND gate, at not-Q, falls to 0. The upper NAND gate is inhibited this time, and the outputs do not change if the R input is subsequently raised to 1.

The operation of the flip-flop is illustrated by the truth table of Fig. 2. In the first line of this table both R and S are at 0, causing Q and not-Q to be at 1. (This combination of inputs is not, incidentally, normally used in serious digital work where it is desirable that Q and not-Q have opposite values.) If R is taken to 1, as in the second line, Q falls to 0. Should we next take S to 1, thereby giving us the fourth line in the table, there is no change in Q and not-Q; Q remains at 0 and not-Q at 1.

In the third line of the table R is at 0 and S has been taken to 1. This time it is not-Q which falls to 0. The outputs then remain unaltered if R is next taken up to 1, as in the fourth line of the table.

The value of the R-S flip-flop as a precedence detector is that it functions virtually instantaneously. If R is taken to 1 only fractionally before S, this fact is indicated by Q falling to 0 and remaining at that level. Similarly, not-Q stays at 0 if it is S which is first taken to 1.

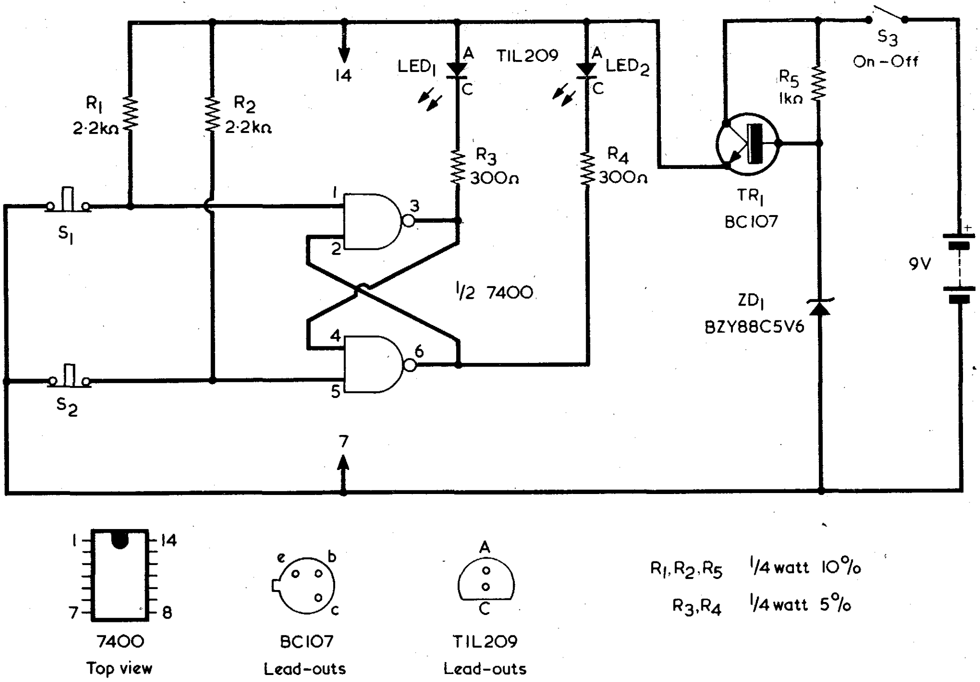


Fig. 3. The circuit of the precedence detector. One of the two l.e.d.'s lights up to indicate the push-button which has been pressed first.

CIRCUIT DIAGRAM

The circuit of the precedence detector incorporating the R-S flip-flop appears in Fig. 3. The flip-flop itself is given by two of the four NAND gates in a 7400 integrated circuit. The supply is provided by a 9 volt battery coupled to the voltage stabilizing circuit given by TR1, R5 and ZD1. A stabilized voltage of nominally 5 volts is given at the emitter of TR1, and this supplies the 7400 and the circuitry around it. The stabilizing provided is adequate for falling battery voltage to a lower limit of around 6.5 volts.

The output of a 7400 NAND gate can sink (i.e. draw from the positive rail) currents up to 16mA when it is at the 0 level. As a result it can be used to feed an l.e.d. direct via a suitable current limiting resistor. When the output at pin 3 (Q in Fig. 1) is at 0, LED1 lights up. If the output at pin 6 (not-Q) is at 0, LED2 becomes alight. R3 and R4 limit the current in each l.e.d. to about 12mA.

The inputs at pin 1 (R) and pin 5 (S) are held at 0 level by the normally closed push-buttons S1 and S2, which connect them to the negative rail. If S1 is pressed, this connection is broken and pin 3 is taken to 1 by way of R1. The output at pin 3 falls to 0, LED1 lights up and it stays alight even if S2 is pressed immediately afterwards. Similarly, LED2 lights up and stays alight if S2 is pressed first. The circuit reverts to its initial state, with no l.e.d. illuminated, when the two push-buttons are released.

R1 and R2 can be omitted if the wiring to the two push-buttons is short. This is because the internal circuitry of the NAND gate takes an input effectively up to the 1 level if it is open-circuit and is not actively held down to 0. It is possible, however, that quite long wiring may be used to connect the push-buttons to the remainder of the circuit, whereupon it is preferable to retain R1 and R2 so that the push-button wiring is at a low impedance when the push-buttons are pressed.

No connections are made to the unused gates of the 7400, and only the i.c. pins which appear in Fig. 3 are wired into circuit. A negative supply connection is made to pin 7, and the 5 volt positive supply is connected to pin 14. The current drawn from the 9 volt supply is approximately 18mA when both S1 and S2 are closed, this rising to some 26 to 28mA when one or both of the push-buttons is pressed.

4.5 VOLT SUPPLY

Logic integrated circuits from the 74 series are specified as requiring a supply potential which lies between the limits of 4.75 and 5.25 volts. Obviously, it would be undesirable to apply a supply voltage higher than the recommended maximum but the i.c., in a simple circuit of the type employed here, cannot be damaged if the supply voltage is slightly below 4.75 volts.

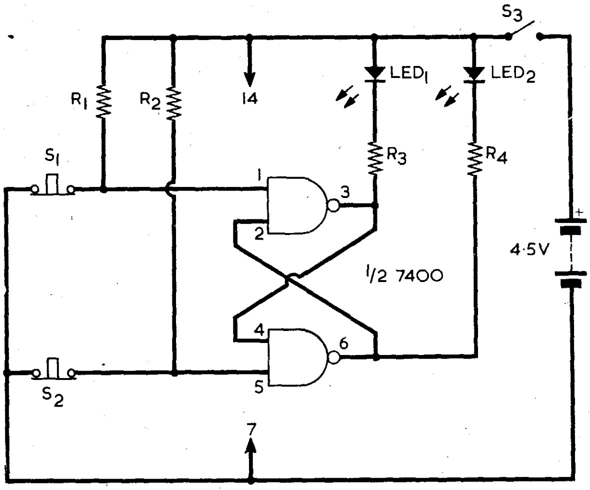


Fig. 4. Simplified experimental version of the precedence detector.

A simplified version of the precedence detector appears in Fig. 4, in which diagram the voltage stabilizing components are omitted and the circuit is simply powered direct by a 4.5 volt battery. The operation of this circuit cannot be guaranteed, because the i.c. is being used outside manufacturer's specifications, but in practice it will be found that the majority of 7400's will work in the circuit with supply voltages down to about 4 volts. Fig. 4 is presented, therefore, as an experimental circuit which has the advantage of extreme simplicity. The current consumption from the 4.5 volt battery is about 5mA lower than the current drawn from the 9 volt battery in Fig. 3. The circuit has the slight disadvantage that it ceases to function when the battery voltage has fallen by a smaller fraction of its nominal value than occurs in Fig. 3. ■

The PORT & STARBOARD STEREO AMPLIFIER

Part 2
by
Sir Douglas Hall, K.C.M.G.

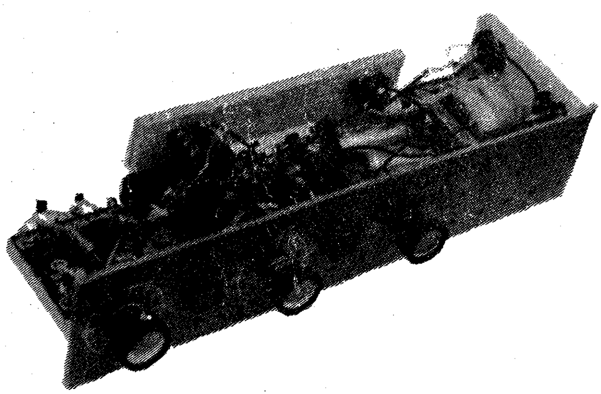
This concluding article gives details of the connections to the gram deck, then carries on to describe the construction of a case for the amplifier.

In the article which was published in last month's issue details were given of the circuit functioning of this amplifier. Construction was also described, together with the simple setting up procedures required. We now carry on to the connections between the amplifier and the gram deck with which it is used.

GRAM DECK CONNECTIONS

The pick-up connections are connected via screened stereo cable to the 3-way jack plug at the amplifier, earthing the screening at both ends. The 3-way mains lead from the amplifier is also taken to the gram deck. If the turntable motor is automatically switched off at the end of a record or at the end of a changer cycle, it may be possible to wire the amplifier mains input to the gram deck switch so that the amplifier turns off at the same time as does the motor. Detailed instructions cannot be given here owing to wiring variations between different decks, and the process should only be attempted by the experienced constructor who fully appreciates what is involved. Alternatively, a mains on-off switch may be installed at the gram deck position or an "in-line" switch inserted in the lead from the mains to the gram deck.

There are, in consequence, three leads running from the deck. One 3-way lead carries the mains supply to the deck. A further 3-way lead takes the



Nearly all the components are assembled on a baseboard behind the front panel

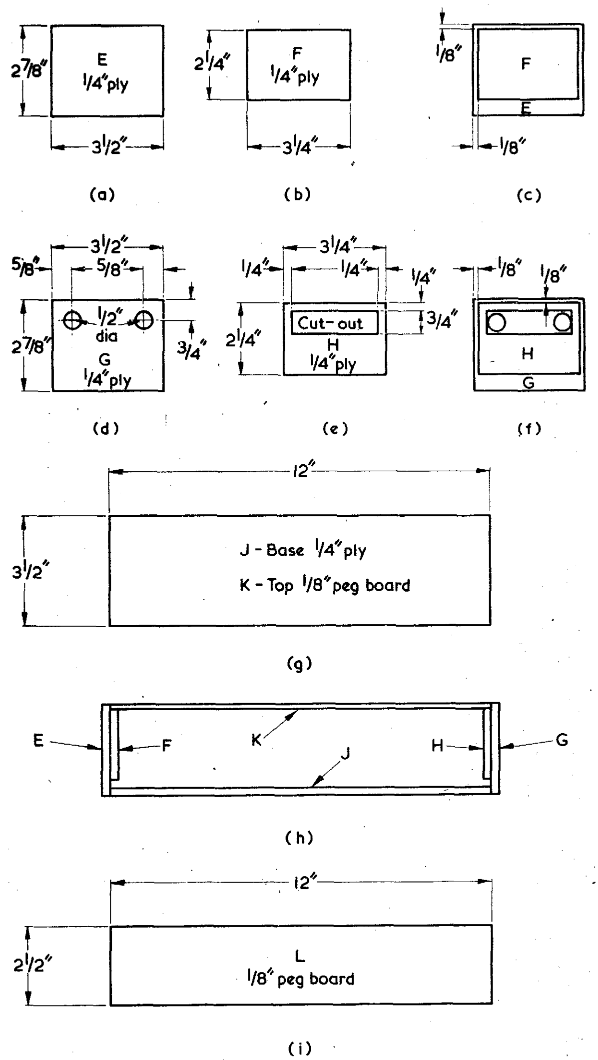
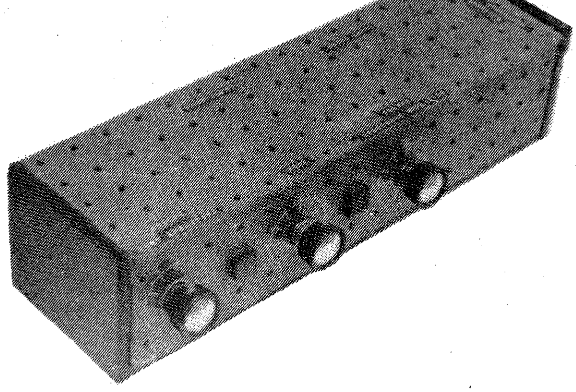


Fig. 4. The various parts which make up the amplifier case. The two sides are illustrated in (a) to (f), whilst (g) gives the dimensions of the base and the top. These are assembled as in (h). The back of the case is shown in (i)



A further look at the amplifier in its completed state

mains supply from the deck to the amplifier. Finally, a screened lead connects the pick-up to the amplifier input. Ensure that all mains connections are positioned so that there is no risk of accidental shock and that the mains earth connects reliably to the metalwork of the gram deck and the earth line of the amplifier.

THE CASE

A suitable case can be made up in the manner shown in Fig. 4. All the dimensions given here are intended as a guide only, as they assume that the peg board employed is exactly $\frac{1}{8}$in. thick, that the plywood is exactly $\frac{1}{4}$in. thick and that the amplifier sections have been made precisely to the dimensions given last month. In practice, case section dimensions should be checked against the amplifier itself, as constructed, and those shown in Fig. 4 slightly modified as required.

Sections E and F are made of $\frac{1}{4}$in. plywood and are screwed together as in Fig. 4(c). Similarly, sections G and H are made of $\frac{1}{4}$in. plywood and are screwed together as shown in Fig. 4(f). Note that there is a rectangular cut-out in section H which gives access to the two holes in section G.

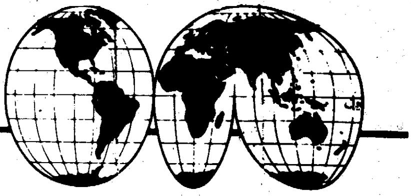
Section J provides the base of the case and is cut out from $\frac{1}{4}$in. plywood. Section K, the top of the case, has identical measurements but consists of $\frac{1}{8}$in. peg board.

All the sections so far described are assembled together by means of small wood screws as illustrated in Fig. 4(h), where the front of the case is towards the reader. The amplifier may now be slipped in so that its front panel, with the controls, is also towards the reader. Two small wood screws may be passed through section K into the rear panel of the receiver, on which are mounted the jack socket and mains connector. These will retain the chassis inside the case and will also provide the rigidity required in the rear panel when the mains socket and jack plug are inserted or removed.

Section L, the back of the case, consists of peg board, It fits into the $\frac{1}{8}$in. recesses at the rear of the EF and GH assemblies, and is secured by screws passing into the edges of sections F and H. Two holes of suitable size are required in section L to allow access to the jack socket and the mains connector. These holes are not shown in Fig. 4(i) and are marked out from the amplifier itself.

(Concluded)

SHORT WAVE NEWS
FOR DX LISTENERS



By Frank A. Baldwin

Times = GMT *Frequencies* = kHz

Whilst this article mainly deals with DX stations on the LF Tropical Bands, it being intended for Dx listeners, interesting transmissions on the higher frequency bands are often mentioned. Some of these stations are listed here.

● **SOUTH KOREA**
Seoul on **11860** at 1126, chimes interval signal repeated until identification by OM and YL at 1130, then a news summary, all in English.

● **CLANDESTINE**
Bizim Radyo (Our Radio) on **9586** measured at 1105, OM with harangue in Turkish. This is a pro-communist transmission scheduled from 1050 to 1115. Jammed by a continuous hetrodyne.

● **CHINA**
Radio Peking on **6645** at 1817, YL in Standard Chinese, songs and orchestral music, directed to Europe, North Africa and West Asia from 1730 to 1830.

Radio Peking on **6560** at 1822, Chinese music and OM in Farsi to Iran and Afghanistan, scheduled from 1800 to 1830, also in parallel on **7480.**

Radio Peking on **7800** at 2005, OM in Hungarian to Hungary, scheduled 2000 to 2100, also in parallel on **9965.**

Radio Peking on **9064** at 1424, YL in Chinese in 1st Domestic Programme, schedule from 2000 to 1735.

Radio Peking on **11290** at 1429, drama production complete with gongs and music in 1st Domestic Programme, schedule 2000 to 1735 and in parallel on **11330.**

● **N. KOREA**
Radio Pyongyang on **6398** measured at 2030, YL in Korean to South Korea, schedule 2000 to 2130.

● **SAUDI ARABIA**
Riyadh on **15245** at 1845, chants from the Quran (Koran) in a broadcast from the "Holy Quran Station" to North and Central Africa, schedule 1700 to 2000.

CURRENT SCHEDULES
The schedules published here are correct at the time of writing but some are subject to change at short notice whilst others are subject to seasonal variations.

● **AFGHANISTAN**
"Radio Afghanistan", Kabul, operates an External Service in English to Europe fromn 1130 to 1200 on **15195.** A programme in English is presented from 1400 to 1430 on **4775** to South Asia, this channel then continuing with the Pushtu/Baluchi transmission to Pakhtunistan until 1530, this latter transmission being part of the Domestic First Programme. Programmes in Pushtu/Dari continue on **4775,** as part of the Domestic Service, until 1740.

The Second Programme in the Domestic Service is from 1330 to 1430 on **3390.**

● **YEMEN ARAB REPUBLIC**
"Radio San'a", San'a, has a Domestic Service which operates from 0300 to 1000, 1100 to 2015 on **4853, 7235** and **9780,** then continuing on the latter two channels until 2200 sign-off.

● **BRAZIL**
"Radio Nacional", Brasilia, presents an External Service in which the English transmission to Europe is featured from 2100 to 2200 on **11780.** From 2200 to 2230 there is a relay of the Domestic Service La Voz do Brazil.

● **FINLAND**
"Yleisradio", Helsinki, in the External Service, radiates programmes in English to Europe, Middle East and West Africa from 1900 to 1930 on **11755** and **15110** and from 2100 to 2130 to Europe and North Africa on **9550** and on **11755.**

● **CHINA**
Foochow may be heard in the External Service when radiating to Quemoy and Matsu in Standard Chinese. For listeners here in the U.K. probably the best chances of logging this one would be from 0001 to 0030 and from 1500 to 1530 on **4975** and on **5040.**

AROUND THE DIAL
At this time of the year, LF band listeners here in the U.K. are tuning over the 60 and 90 metre tropical bands for those elusive signals from the Far East and in particular from Indonesia. During November, the short route signal path from Indonesia to the U.K. is mostly in darkness from around 1530 until 1600 (at which time most stations sign-off) only a few hundred miles being subject to the activities of the Sun. The Indonesians sign-on again from around 2200 to 2300 our time (GMT) and the following half hour is another favourite time to log these transmissions.

For Latin American enthusiasts on the LF bands, the whole South American Continent is in darkness from around 2400 (more correctly 0000 GMT) with signals reaching us via the short path, this remaining in darkness until 0730. Many Latin American stations however close around the 0230-0400 period but a few continue until 0600 or even operate on a 24-hour basis.

90 METRE BAND
On this band some Latin Americans have been

logged despite the commercial interference.

● **ECUADOR**

Radio Iris, Esmeraldas, on a measured **3381** at 0156, OM with announcements in Spanish then typical local-style music and songs. The schedule is from 1100 to 0500 and the power is 10kW. Esmeraldas is a port on the north-west coast of Ecuador, exports being bananas, timber, tobacco, cacao and rubber.

● **BRAZIL**

Radio Riberao Preto on **3205** at 0330, OM with station identification then YL with songs in Portuguese. Schedule is from 0800 to 0400 and the power is 5kW. Riberao Preto is a city situated amid rich agricultural surroundings in the south-east of Brazil north of Sao Paulo. Main crops are cotton, sugar and — you've guessed it — coffee!

Radio Gazeta de Alagaos, Maceio, on a measured **3327** at 0335, OM with a love song in Portuguese, guitar music — all good love sick stuff! Schedule is from 0755 to 2200, 2330 to 0400 and the power is 2.5kW. Maceio is a seaport situated south of Recife (formerly Pernambuco) and is the capital of Alagaos State, local produce being cotton, sugar, tobacco and soap, also being noted for its distilleries — and that is the proof of their spirit!

● **NIGER**

Niamey on **3260** at 1947, OM's having a discussion in a local dialect in the Home Service 1 programme. Schedule is from 0530 to 0630, 1700 to 2200 on weekdays, the latter transmission period being from 1500 to 2300 on Saturdays and from 1700 to 2130 on Sundays, the power being 4kW. Niamey is one of the termini (the other is Zinder) of the trans-Sahara motor routes.

● **NIGERIA**

Ibadan on **3204** at 1940, OM with a talk in local dialect, drums, chants, YL's in chorus. Schedule is from 0430 to 0730 and from 1420 to 2305, the power is 10kW. Ibadan is the capital of the Western Province of Nigeria and is situated 60 miles north of Lagos. Products of this university town include silk, tobacco and cotton.

Kaduna on a measured **3396** at 1839, local music, drums, YL's with choral songs African-style. Schedule is from 0430 to 0705 and from 1630 to 2305, the power being 10kW. Kaduna is a town in Northern Nigeria and is the capital of the Northern Provinces, being an important railway junction with main lines to Lagos and Port Harcourt.

● **BURUNDI**

Bjumbura on **3300** at 1836, OM and YL alternate in vernacular in a Home Service 1 programme. Schedule is from 0330 to 0600 (Sundays 2100) and from 1500 to 2100, the power is 25kW. Bjumbura is the capital of Burundi.

60 METRE BAND

● **BOLIVIA**

Radio Norte, Montero, on a measured **4938** at 0448, YL with song in Spanish, guitar music then a long talk about El Toro (The Bull) until 0502 fade-out. Obviously on an extended schedule, the normal transmission time (2nd period) is from 2100 to 0400 and the power is 1.5kW. Montero is a small town in the Department of that name and is situated north of Santa Cruz.

Radio Fides, La Paz, on **4845** at 0034, light orchestral music with announcements in Spanish. Schedule is from 1030 to 1930 and from 2200 to 0300 Mondays to Fridays and from 1030 to 0300 Saturdays and Sundays, the power is 5kW. La Paz is in the Department of that name and is the seat of government (Sucre is the legal capital). La Paz is an important commercial centre and products include copper, alpaca wool, cinchona (evergreen tree bark from which quinine is made) and textiles. The Department of La Paz is traversed by the Andes range of mountains.

Radio Abaroa, Riberalta, on a measured **4738** at 0205, OM with announcements and a talk in Spanish until 0218 when covered by QRM. Schedule is from 1000 to 0430 but sign-off can vary from 0400 to 0445 and sometimes identifies as La Voz de Riberalta; the power is 0.5kW. Only rarely can this one be heard here in the U.K., the low power and, more effectively the QRM, usually succeed in foiling us. Riberalta is in the far north of the country situated on the River Beni above rapids which limit any navigation to the upper course. A collecting centre for wild rubber, it is an important town in the Colonia Territory.

● **COLOMBIA**

Ondas del Meta, Villavicencio, on **4885** at 0440, OM with identification, Latin American style dance music. Schedule of this one is from 1000 to 0500 and the power is 1kW. Villavicencio is the capital of Meta Province of Colombia and the main occupation is that of cattle raising, laying astride the main road from the capital Bogota to the Venezuelan frontier.

Radio Guatapuri, Valledupar, on **4915** at 0045, OM with identification complete with echo-effect, songs in Spanish with flute accompaniment. Schedule is from 0930 to 0600 but has been reported closing on occasions at 0500; the power is 10kW. The echo-effect on station identifications is beloved by some Latin American stations but most certainly not by Dxers. It tends to distort announcements when heard over the distances involved here, the echo often merging with the actual spoken words which, in any case, are often pronounced in a sing-song fashion. LA disc-jockeys have another anti-Dxer weapon, but see under Ecuador. Valledupar is situated in the Magdalena Province in the north of Colombia, inland from Barranquilla and Cartagena.

● **ECUADOR**

Radio Difusora del Ecuador, Guayaquil, on **4765** at 0200, OM with identification in Spanish, commercials (all with echo-effect) local-style pops. Schedule is from 1030 to 0400 and the power is 10kW. Guayaquil is the chief port of Ecuador and is on the Guayas River some 30 miles above the Bay of Guayaquil. the city was virtually destroyed by fire in 1896 and again in 1899. Guayaquil in addition to its cathedral has a university and is a centre of industry; foundries, machinery, brewing and sawmills being some of the local activity. Perhaps they draw their beer from the wood! The anti-Dxer weapon mentioned above? Oh yes, the disc-jockeys take much pride in their ability to trill their R's for inordinate periods, so much so that our friends from north of the Cheviot Hills are completely outclassed in this verbal skill — if that is what it is!

REGENERATIVE SHORT WAVE SUPERHET

Part 2
By
F. G. Rayer

In this concluding article details are given of the i.f. and a.f. amplifier boards, together with the assembly and alignment of the receiver as a whole. Also covered is operation for the reception of a.m., c.w. and s.s.b. signals.

In last month's article the circuit of this receiver was discussed, and details were given of the mixer coilpack assembly. We carry on with constructional information, dealing next with the i.f. amplifier board.

I.F. AMPLIFIER BOARD

The i.f. amplifier is assembled on a perforated board of 0.15in. matrix having 16 by 7 holes, as in Fig. 5. Two 6BA clear mounting holes have to be drilled out at the points shown. The 6BA screws in these holes have solder tags under their nuts to provide a chassis connection, a further nut being fitted to each screw to provide spacing from the chassis. A central hole is necessary at each i.f. transformer to allow access to the lower core. Small holes are also drilled as necessary to take the i.f. transformer tags and mounting lugs. Trimmer TC5 will fit the board holes.

R12 may be wired in at this stage with no connection made to the lead-out remote from the board. Flying leads are fitted for later connection to VR2, R1 and C10. The connection from pin 8 of L4 is added later. All the wiring on the board should be short and direct, with good spacing between base and collector leads.

The i.f. transformers are supplied pre-aligned and their cores should not be touched. They will be given their final slight adjustments when the receiver has been completed.

AUDIO BOARD

Fig. 6 illustrates the a.f. amplifier board. This is also assembled on perforated board of 0.15in. matrix, the board having 14 by 13 holes. As with the i.f. amplifier board there are two 6BA clear mounting holes, and the 6BA bolts have solder tags under their nuts for chassis connection, together with spacing nuts. Two flying leads are required for the positive 9 volt connections, and single flying leads for the connections to the output jack and to VR3.

A 3.5mm. phone jack socket is employed to provide the output connection in the author's receiver. If this is of open construction it automatically takes up its chassis connection by way of its mounting bush, but if it is of insulated construction a chassis connection must be made to the contact nearer the front. The chassis connection can be taken from any convenient point near the socket. A disadvantage given by the use of a phone jack is that the socket contacts can be momentarily short-circuited as the plug is inserted or removed, and this could damage the integrated circuit if a high output signal level is in existence at the time.

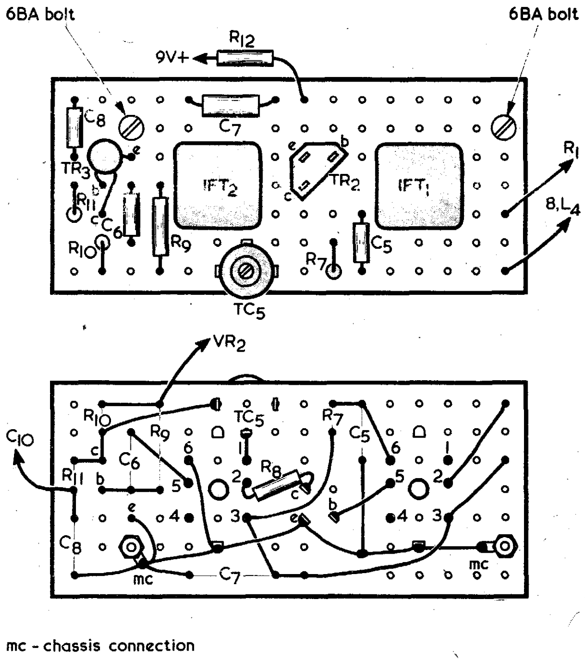


Fig. 5. Wiring and component layout on the i.f. amplifier board

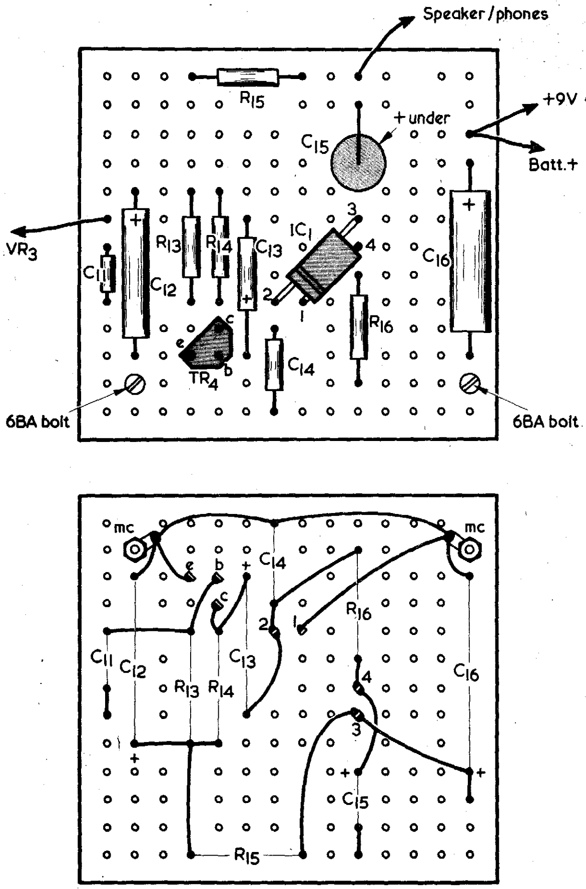


Fig. 6. The a.f. amplifier board is wired up in the manner shown here

In consequence, it is necessary to turn the receiver volume to minimum when fitting or removing the plug. Constructors who would prefer to avoid this procedure can fit two insulated sockets for connection to the speaker or headphones instead.

PANEL AND CHASSIS

The front panel of the receiver measures 10 by 6in. and the chassis, on which are mounted the i.f. and a.f. amplifier boards measures 6 by 4 by $\frac{1}{4}$in. It can consist of a 6 by 4in. "Universal Chassis" flanged side, available from Home Radio. It is fitted to the front panel such that its surface is 1in. above the lower edge of the panel and its right hand edge is $\frac{1}{2}$in. in from the right hand edge of the panel. It is secured by a 6BA bolt and the output jack socket, or output sockets. A solder tag is fitted under the 6BA nut. The chassis needs four 6BA clear holes for the two boards, two holes under the i.f. transformer centres for access to the lower transformer cores, and a hole for the lead from the a.f. board which travels to VR3. The positioning of these holes can be assessed from Fig. 7.

On the front panel are mounted the various controls, these taking up the positions shown in the diagram and in the photographs. VC1(a)(b) is mounted by means of the three tapped 4BA holes in its front plate, being spaced back as indicated. It is important to ensure that the mounting bolt ends do not project beyond the inside of the capacitor front plate, as the vanes could then be damaged. Countersunk 4BA bolts are employed. The coilpack is secured to the front panel by means of the switch bush nut.

The wiring shown in Fig. 7 may then be carried out. The connection from the coilpack to pin 2 of IFT1 will need to be completed before the i.f. board can be mounted. All the flying leads from the boards and coilpack are shortened as necessary when they are finally connected.

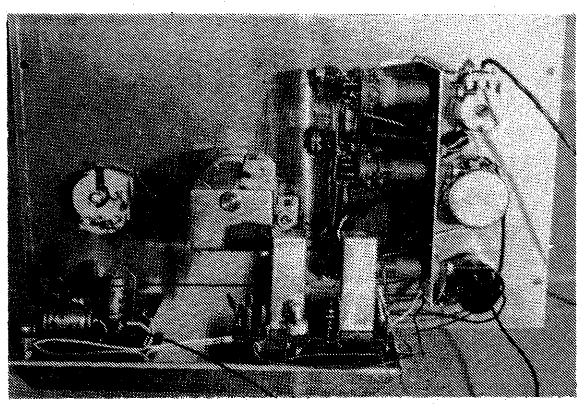
The three potentiometers are wired in the following manner. VR1 takes its chassis connection from the adjacent chassis tag on the coilpack. The lead from pin 8 of L1 passes under the coilpack up to the other track tag of VR1. The slider tag of VR1 connects later to the aerial socket, which will be at the rear of the case.

VR2 is below VR1, and its slider tag takes the lead from R9 and R10 on the i.f. amplifier board. C9 and the two track tags are connected as shown, the positive 9 volt connection being taken from R12.

In turn, VR3 is below VR2, and it takes its "MC" chassis connection from the solder tag under the 6BA nut securing the chassis to the front panel. The lead from C8 and R11 on the i.f. amplifier board runs along the chassis top surface to C10, which is mounted as shown. The lead from C11 on the a.f. amplifier board passes through the adjacent hole in the chassis and runs under the chassis to the slider of VR3.

MIXER ALIGNMENT

Mixer alignment consists mainly of the setting up of the coil cores and trimmers in the aerial circuit. Initially, TC4 is set to about half maximum capitance. If it is found that TC1, TC2 or TC3 require an adjustment to a value lower than their minimum capacitance, the value of TC4 can be increased a little to bring the received signal frequency within the range of the aerial trimmer. Similarly, TC4 value can be decreased a little if an aerial trimmer



The uncluttered layout is readily apparent in this rear view

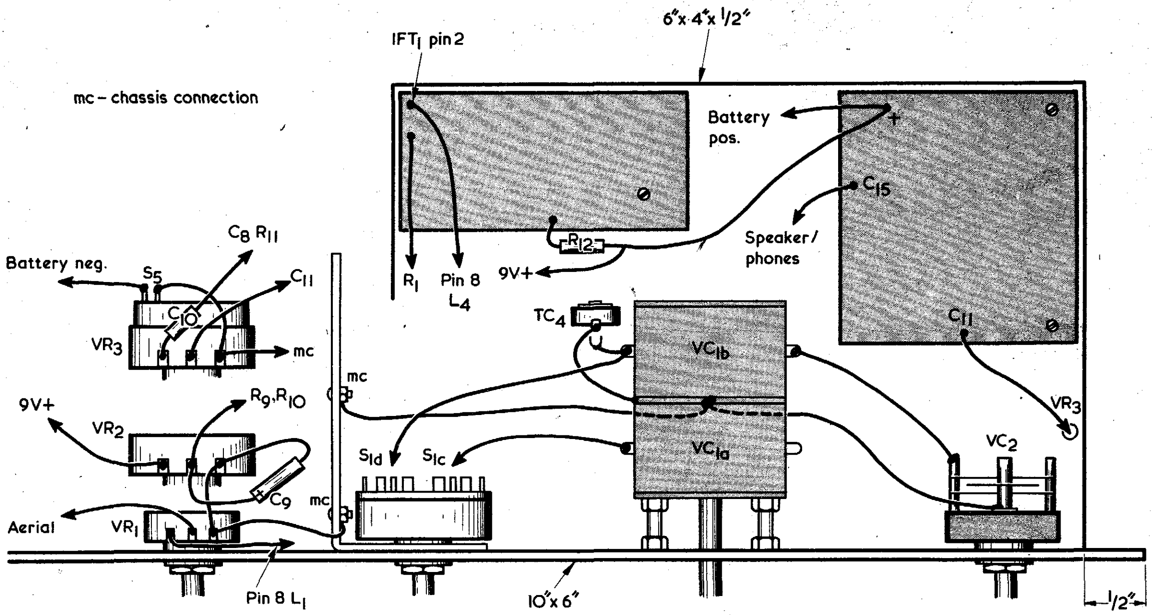


Fig. 7. Final wiring steps as the various sections and the panel controls are connected together

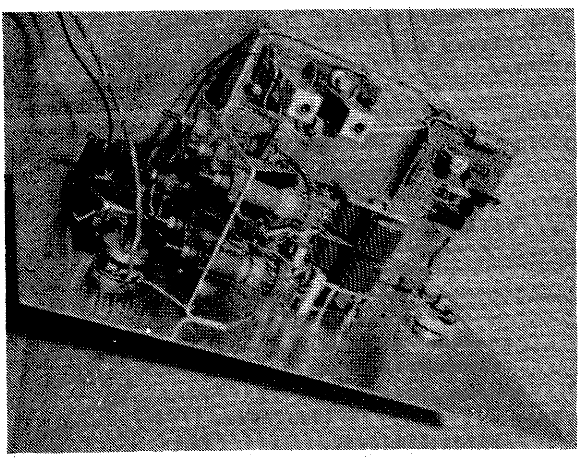
requires a value greater than its maximum capacitance.

Each band is treated individually, and it is probably easiest to commence with the lowest frequency band. VC2 is set to half its maximum capacitance. Tune in a signal with VC1(a)(b) nearly at maximum capacitance (say at about 1.9MHz) and adjust the core of L3 for greatest volume. Then tune in a signal with VC1(a)(b) close to minimum capacitance (say 4MHz) and adjust TC3 for strongest signal. Check both adjustments several times until no improvement can be obtained.

The second range can then be aligned in the same way, adjusting the core of L2 for a signal near the low frequency end of the band and adjusting TC2 for a signal near the high frequency end of the band. After this the highest frequency band can be aligned by adjusting the core of L1 and TC1 in a similar manner.

When the alignment is complete, the oscillator cores can be maintained in position by passing 6BA nuts over the threaded brass stems and locking these gently against the plastic former material.

If it is necessary to modify band coverage for any range, this is carried out by adjusting the core of L4, L5 or L6, as applicable. The corresponding aerial coil core and trimmer must then be readjusted.



Here, we are looking down at the top of the chassis

I.F. ALIGNMENT

It should be possible to pass at least strong signals through the i.f. amplifier with the i.f. transformers in their pre-aligned state, as received. If this does not occur the receiver should be checked for a fault in the wiring; the i.f. transformer cores are best left untouched until the receiver is in a working state. Initially, TC5 should be set to minimum capacitance, and VR2 to a central setting or to a slightly lower setting if this is necessary to prevent the detector from oscillating. A weak steady a.m. signal is carefully tuned in and the i.f. cores adjusted for maximum volume. A correct trimming tool, such as the Denco type TT5, should be employed as the cores may otherwise be damaged.

Next set VR2 about two-thirds advanced and, with the same or a similar a.m. signal, increase the capacitance of TC5 until a whistle is heard. Adjusting VC2 should vary the pitch of the whistle, and backing off VR2 should leave the detector circuit in a sensitive but non-oscillating condition.

If it is found that oscillation occurs at all settings of TC5, the value of R8 may be increased a little to increase the i.f. amplifier stability.

RECEIVER OPERATION

When receiving a.m. signals with headphones VR3 need not be advanced very far. It is used to control volume both for speaker and for headphones. If a strong signal causes overloading and distortion its strength is reduced by VR1.

VR3 is turned well up for c.w. signals and signal strength is kept down by means of VR1. VR2 is advanced just beyond the oscillation point, thus producing a heterodyne. The pitch of the heterodyne is adjusted by VC2.

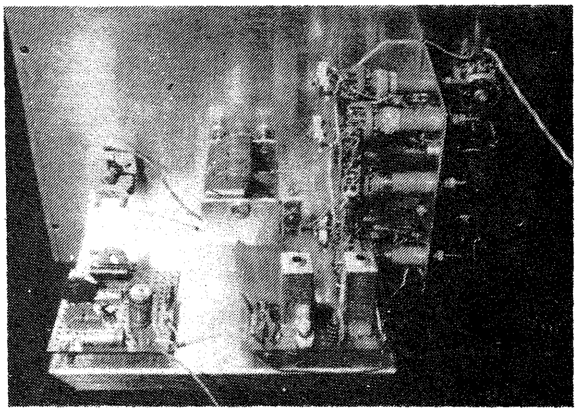
Adjustments for s.s.b. are similar to those for c.w., but here it is even more desirable to keep signal strength down by means of VR1. A more critical adjustment of VR2 and VC2 will also be needed. Once a little operating experience has been obtained no particular difficulties should arise.

It must be reiterated that satisfactory s.s.b. and c.w. reception cannot be obtained if strong signals are not considerably reduced in level by VR1. Also, if VR2 is turned back too far during a.m. reception the detector stage will overload and introduce distortion. It should be found that the detector transistor can be smoothly taken up to the oscillation point, with selectivity and sensitivity increasing rapidly just before this point is reached.

CASE

The receiver can be accommodated in a case made up from the parts for a Home Radio "Universal Chassis" measuring 10 by 6 by 4in. The front panel is, in effect, the top plate of this chassis and another 10 by 6in. plate forms the rear. The parts for such a case are given in the Components List published last month. The "hardware kit" in the Components List consists of the screws and nuts required for its assembly.

Alternatively, a 10 by 6 by 6in. cabinet with steel front panel may be obtained. A range of cases is available from H. L. Smith & Co. Ltd., 287 Edgware Road, London W2. Very small knobs are not recommended for any of the controls, and a quite large knob is convenient for VC2 and also for VC1(a)(b). A cursor can be fitted to the latter with a scale affixed to the panel behind it. A suitable scale is provided in "Panel Signs" Set No. 5, available from the publishers of this journal.



Another rear view, taken from a slight angle

Sockets for aerial and earth are fitted at the back of the case. The earth socket connects to the chassis at any convenient point, whilst the aerial socket connects to the flying lead from VR1 shown in Fig. 7.

An earth connection is not essential, although it can be expected to improve results. Many signals can be received with an indoor aerial. However, an outdoor aerial, positioned high and clear of adjacent objects, will naturally give increased range and more volume with distant signals.

The receiver can be operated from any 9 volt battery, with a fairly large type offering most economical running. A PP9 battery is satisfactory and can be accommodated in the case. Current consumption is about 8 to 10mA with no signal input or at low volume settings. The current rises with increased volume, giving current peaks of about 20 to 30mA when the receiver is providing a full loudspeaker output.

(Concluded)

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 the cover price stated on the issue, 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.

RECENT PUBLICATIONS

SYNTONY AND SPARK — THE ORIGINS OF RADIO. By Hugh G. J. Aitken. 365 pages, 225 x 150mm. (9 x 6in.) Published by John Wiley & Sons, Ltd. Price £10.95.

Try and imagine a time in which there is no such thing as an electronic amplifying device, a thermionic diode or even a crystal detector of the early cat's whisker type. Would meaningful radio communication be possible under such conditions? Not only was it possible but it was eminently practicable, and in the early years of the twentieth century the energetic inventiveness of Marconi, his predecessors and his contemporaries resulted, amongst other things, in the setting up of two-way transatlantic communication between Nova Scotia and Clifden in the U.K. The r.f. energy at the transmitter was produced by a spark coupled by broadly tuned circuits to an enormous aerial, whilst an equally enormous aerial at the receiver coupled to a coherer detector. In its simplest form a coherer consisted of a glass tube containing metal particles which cohered and passed a current when an r.f. signal was applied across two electrodes at the tube ends. The particles tended to remain in the cohered state and the tube had to be "tapped back" mechanically to prepare them for reception of the next r.f. signal.

It was with elementary tools of this nature that the radio pioneers created their achievements. The spark transmitters were flatly tuned, as were the receivers, so that great bands of the radio frequency spectrum were occupied by single communication channels. Also, the frequencies were low since it was found empirically that these best suited the large aerial arrays employed.

The fascinating early days of radio unfold before the reader in "Syntony and Spark". "Syntony", which derives from the Greek *syn*, meaning "together", and *tone*, was the euphonious term applied in those times to tuning or resonance, and the author employs it to enlarge on the overall concept of harmony and congruence. The book commences its narrative section with the experiments of Hertz, deals next with Lodge, then carries on to the immense contributions to radio which are due to Marconi. Not only does the reader learn about the technical equipment which was used but he is also presented with a tale of commercial entrepreneurship, of patent disputes and of financial exploitation. The book brings to life the achievements of the first men in radio as well as their individual characters. In addition, the author paints a very broad canvas and illustrates the interlocking aspects of pure science, technology and practical application in an advancing society.

"Syntony and Spark" should be enjoyed by anybody who is interested in early radio communication and its background. It should be enjoyed, indeed, by anyone who likes to settle down and read an absorbing true success story.

A GUIDE TO AMATEUR RADIO, Sixteenth Edition. By Pat Hawker, G3VA. 124 pages, 245 x 190mm. ($9\frac{3}{4}$ x $7\frac{1}{2}$in). Published by Newnes-Butterworths. Price £3.95.

This is the sixteenth edition of a book which has now become a classic amongst British radio amateurs. Its purpose is to assist the beginner to learn more about amateur radio and to help him in obtaining his transmitting licence. Also included are technical information and operating data of interest to radio amateurs and listeners.

The book introduces the reader to the world of amateur radio and the process of embarking on the hobby. Subsequent chapters deal with communication receivers, amateur transmitters, transmitting licence examinations, the operation of an amateur station, workshop practice and amateur radio equipment. Following these are a chapter explaining the role of the Radio Society of Great Britain, and further chapters covering international amateur organisations, the learning of the morse code, and international call-signs.

Entirely new material has been added in this edition to the last three chapters, and the book is a virtual must for anyone who is contemplating amateur radio as a hobby.

QUESTIONS AND ANSWERS ON RADIO AND TELEVISION, Fourth Edition. By H. W. Hellyer and I. R. Sinclair. 126 pages, 165 x 110mm. ($6\frac{1}{2}$ x $4\frac{1}{4}$in.) Published by The Butterworth Group. Price £1.25.

This little book can slip handily into a pocket and it provides information in a question and answer form. A typical question, appearing in the first chapter, is "What is inductance?" The answer takes up some twelve lines of the text, and is followed by the next question and answer. This approach has the advantage that continual reading on a topic is not necessary, as occurs with a conventional text book. The book can, if desired, be dipped into at any convenient time.

The chapters deal with basic electricity, sound and radio waves, transistors, basic circuits, the functioning of a radio receiver, television principles and the functioning of a television receiver. These are followed by an appendix giving common abbreviations and a helpful and comprehensive index.

In your work-shop

This month Smithy the Serviceman, aided as always by his able assistant, Dick, takes an introductory look at the basic functioning of CMOS logic. In the process he is able to demonstrate what can happen if an unused CMOS gate input is left floating.

"This," remarked Dick bitterly, "is it."

A snort of irritation arose from Smithy's bench. The Serviceman leaned forward as he checked a voltage reading in the television set in front of him.

"Yes," complained Dick to Smithy's back, "this is it."

Smithy's hand, holding a test prod, faltered.

"Isn't it?" completed Dick.

Irritably, Smithy replaced the test prod on his bench then turned to face his assistant.

"For heaven's sake," he fumed. "What on earth is up with you now? During the last quarter of an hour you've done nothing but moan and say 'this is it' all the time. Can't you get on with some work or something?"

"This is it," retorted Dick. "Or at least it's partly it. I haven't got any work to do."

Smithy glanced over to the "For Repair" rack, which was completely devoid of equipment requiring attention.

"Humph," he grunted. "You must have been busy while I've been stuck with the TV set I've got here."

"All the sets I did happened to have easy snags on them." replied Dick. "So I'm now half-way through the afternoon with nothing more to do."

"I see," said Smithy, partly mollified by his assistant's diligence. "You said that having nothing to do was only part of what's troubling you. What's the other part?"

"You," stated Dick, "and your broken promises!"

Smithy drew himself up to his full height.

"I would have you know, sir," he remarked haughtily, "that you are talking to a man of honour."

"I wouldn't know about that," responded Dick. "What I do know is that you promised me several months ago that we'd be having a session on CMOS logic devices, and it still hasn't come off yet."

CMOS LOGIC

Smithy looked at the injured expression on his assistant's face and suddenly grinned.

"You don't half take things seriously," he chuckled. "Oh, all right then. You give me a hand in finishing off this TV and we'll then have a stab at the CMOS business."

Eagerly, Dick walked over to Smithy's bench. Smithy had been on the point of locating the fault when Dick had interrupted him, and he finally ran it down to earth (or should that be ground?) shortly after Dick joined him. The Serviceman watched contentedly as Dick replaced an open-circuit electrolytic capacitor, and then he finally pronounced the television receiver to be fully serviceable. Whilst Dick carried the receiver to the "Repaired" rack, Smithy pulled his note-pad towards him and took a ball point pen out of his jacket pocket.

"Well now," he remarked as his assistant returned, "bring your stool over, and we'll get started. We'll begin at the beginning with the name CMOS itself. This is another version of COSMOS, which stands for 'complementary symmetry metal oxide silicon'. And that expression refers to the use, inside COSMOS integrated circuits, of n-channel insulated gate f.e.t.'s and p-channel insulated gate f.e.t.'s."

"Fair enough," said Dick, as he settled himself comfortably on his stool. "I seem to remember you saying that there are linear CMOS devices as well as digital CMOS devices."

"That's right," confirmed Smithy. "However, we'll confine ourselves to the digital devices this afternoon. There are CMOS flip-flops, inverters, NAND gates, NOR gates and many of the other logic devices that appear in the t.t.l. range, and they have three outstanding advantages. First, they can work at any supply voltage from 3 to up to a maximum of 15 volts. Second, they draw fantastically tiny currents in the quiescent state, when they are not actually switching over from one output state to the other. And third, they are much more immune to noise voltages on the supply rails than are t.t.l. devices."

"From what I hear," put in Dick, "they have to be handled very carefully."

"They need to be treated with reasonable care," Smithy corrected him. "They've got protective diodes inside them to prevent the internal f.e.t. gate insulation being damaged by static electric charges but, even so, a few precautions need to be observed. We'll get on to these precautions later. What we'll do first is take a quick look at the n-channel and p-channel insulated gate f.e.t.'s that are used in CMOS devices."

Smithy drew his note-pad towards him and sketched out the outline of a field-effect transistor. (Fig. 1.)

"Now here," he went on, laying down his pen, "is an n-channel insulated gate f.e.t. This is pretty well the same as the discrete n-channel MOSFET's most people have become used to and which are employed as r.f. amplifiers and things like that in radio receivers. There is the drain, which goes to supply positive, and the source, which goes to supply negative. I've put a resistor in series with the drain to represent a load. There is a p-type substrate, or supporting layer, and a thin n-type channel between the drain and the source. The drain and source are also n-type material. Mounted at the channel and insulated from it by a very thin layer of silicon oxide, which is a relative of glass, is the metallic gate."

"I know how this f.e.t. works," interrupted Dick. "When the gate is

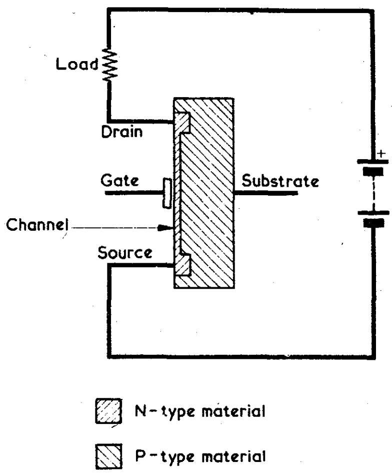


Fig. 1. Cross-sectional view of an insulated gate n-channel f.e.t. The drain connects to the positive supply, and current in the channel is controlled by the potential on the gate with respect to the source

negative it repels electrons in the channel, with the result that current cannot flow from the drain to the source. If it is positive it attracts electrons and permits the flow of current through the channel."

"You've got the general idea," confirmed Smithy. "Now, the situation wouldn't be altered if we were to connect the substrate to the source, because no current can flow from any part of the n-type material to the substrate since they constitute a reverse biased n.p. junction."

"What about at the source itself?"

"For current to flow there," said Smithy, "the source would have to be 0.6 volt negative of the substrate, just as occurs in a normal silicon diode."

"Oh yes, of course."

"Now," went on Smithy, "because the gate is insulated from the channel the f.e.t. has an exceptionally high input resistance, in the region of thousands of megohms or more. At the same time, because the gate insulation is exceptionally thin, it can be broken down by quite a low gate voltages of around 30 volts or even less. This fact, combined with the very high input resistance, means that the insulation can be broken down by a static voltage with virtually negligible current behind it, and this is the reason why CMOS devices have to be treated rather carefully."

P-CHANNEL F.E.T.

"Let's," said Dick restlessly, "get on to the p-channel f.e.t."

"Hang on a minute, I haven't quite finished with the n-channel one yet. I'll draw its circuit symbol next."

Smithy scribbled out the symbol. (Fig. 2(a).)

"In this symbol," he went on, "the gate part is obvious, and the drain and source parts are separated by a line which represents the substrate. As you can see, I've joined the substrate to the source. Since this is a p-type substrate there is an arrow pointing inwards at the substrate. You get the same inward-pointing arrow on the emitter of a p.n.p. transistor. The gate controls the current between the drain and the source in the manner you've just mentioned, but I think I should polish up your description a bit. In the insulated gate n-channel f.e.t.'s used in CMOS devices the drain-to-source current is completely cut off when the gate is at the same potential as the source. If the gate is then taken sufficiently positive, current starts to flow in the channel, increasing as the gate goes further positive."

"Fair enough. Now how about the p-channel f.e.t.?"

"For goodness sake," snorted Smithy. "Don't be so darned impatient."

"This is it," complained Dick. "Here am I dead keen to find out about these things, and you're holding me back all the time."

"We'll darned well get on to the p-

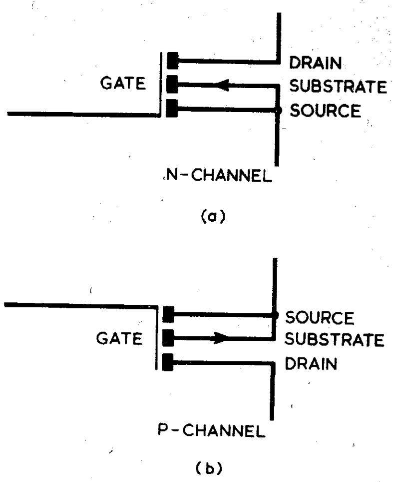


Fig. 2(a). The symbol for an n-channel f.e.t. with substrate connected to source (b). The symbol for a p-channel f.e.t. can be identified by the fact that the substrate arrow points outwards

channel f.e.t. when I'm good and ready."

"Huh! This is it!"

"For the love of Mike," roared Smithy. "Stop saying 'this is it'. I've never known anyone like you for running current phrases to death. Last year it was 'no way', now it's 'this is it'."

"Well, this is it," said Dick. "I've got to express . . ."

Dick's voice trailed off into silence as the furious Serviceman glowered belligerently at him.

"There are times, so help me," growled Smithy eventually, "when you'd get up the nose of Job himself. Dash it all, I've forgotten now what I was talking about."

"You said," stated a chastened Dick, "that you would get on to the p-channel f.e.t. when you were good and ready."

"So I did. Well, as it happens I *am* ready after all, as I've finished with the n-channel f.e.t. for the time being. Let me collect my thoughts. Ah, yes."

Smithy pondered for a few moments, then made a further drawing on his pad. (Fig. 2(b).)

"This," he said, his irritation slowly evaporating as he once more lost himself in his subject, "is the symbol for the p-channel f.e.t. It's precisely opposite in make-up to the n-channel f.e.t. The channel, the source and the drain are all p-type and the substrate is n-type. Because of this the substrate arrow points outwards, like the emitter arrow of an n.p.n. transistor. The substrate connects to the source as before, and this goes to the positive supply point. If the drain is taken to a negative supply point via a load, then a current path is available from the source through the channel, through the drain and then through the load. As with the n-channel f.e.t., this current path is cut off when the gate has the same potential as the source. If the gate of the p-channel f.e.t. is taken negative a current will start to flow through the channel, and it will increase as the gate goes further negative."

"How high," asked Dick, "can the current go?"

"That depends on the supply voltage," replied Smithy. "With low current CMOS devices the p-channel f.e.t. current can go up to about 20mA with a 15 volt supply, and the n-channel f.e.t. current can go up to around 10mA with the same level of supply. However, you take care to avoid the flow of currents of this magnitude and they usually appear if the output of a CMOS gate is accidentally short-circuited. In practice, the lower current types of CMOS device can withstand output short-circuits, and these will not cause their maximum wattage ratings to be exceeded. But it is still unwise to subject them to this treatment."

"What is the maximum dissipation?"

"It's 200mW per integrated circuit," replied Smithy. "But we're getting ahead of ourselves here. Let's have a look at a CMOS inverter next."

CMOS INVERTER

Smithy opened a drawer in his bench, took out a data book and commenced to turn its pages.

"Ah, here we are," he said, laying down the book on his bench. "This is the gen for a CD4000 i.c. Amongst other items the CD4000 includes an inverter, and we'll concentrate on that next."

Smithy pointed at the inverter section of the i.c. in the data book diagram. (Fig. 3.)

"This seems fairly simple," commented Dick. "I see that the negative supply goes to pin 7 and the positive supply goes to pin 14."

"That's right," confirmed Smithy. "It's the same supply pinning as you have with many t.t.l. gates when these are in a 14-pin d.i.l. package. The positive supply is referred to as VDD and the negative supply as VSS. VSS

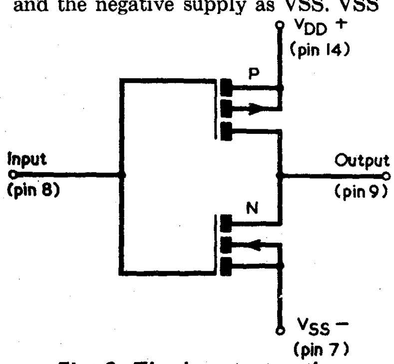


Fig. 3. The inverter section of the CD4000 i.c.

is normally at earth potential and the use of these letters conforms with the use of VCC as the positive supply for ordinary transistors."

"Hang on a minute," said Dick, frowning. "There's something wrong here."

Smithy waited expectantly.

"There *is* something wrong," repeated Dick. "It isn't the drain of the p-channel f.e.t. that goes to VDD in that diagram, it's the source!"

"Very good," remarked Smithy approvingly. "There is a bit of an anomaly here, but it's really of an academic nature. You get the same sort of irregularity in integrated circuits which have p.n.p. transistors in them. The p.n.p. transistor emitters are supplied by the positive rail even though it's called VCC. Still, I'm glad you noticed that little point."

"Eyes like an 'awk, I've got," pronounced Dick cheerfully.

"In my old army days," commented Smithy drily, "we had a prefix for the word 'hawk'. Well now, let's start to have a bit of action. Let's say that the input of this inverter is connected to the output of another CMOS device and that that output is fully positive, at 1. With CMOS logic the output voltage of a device when it is at 1 is very close to the VDD supply voltage and, under normal loading conditions, will be less than 0.01 volt below it. What happens in the inverter when the input is fully positive, at 1?"

Dick stroked his chin reflectively.

"Well," he said, "the gate of the p-channel f.e.t. will be at the same potential as its source and so the p-channel f.e.t. will be cut off. On the other hand, the gate of the n-channel f.e.t. will be highly positive of the n-channel source, and so the n-channel f.e.t. will be turned on. As a result, the output will be fully negative, at 0."

"Good", said Smithy encouragingly, "and what happens when the input is fully negative, at 0? I should add, incidentally, that fully negative with a CMOS device normally means an output voltage that is less than 0.01 volt above the VSS rail."

"With the input at 0 the opposite will happen", said Dick quickly. "The p-channel f.e.t. will turn on and the n-channel f.e.t. will turn off, giving an output that is fully positive, at 1."

"Exactly", confirmed Smithy. "In other words the circuit has acted as an inverter. Now we come to a little of the magic that exists in CMOS. If the output of one CMOS device is connected to the inputs of other CMOS devices, all the output has to drive are gates which are virtually fully insulated from the channels on which they are mounted. The fan-out for CMOS to CMOS devices is 50, which means that one CMOS device can drive up to 50 other CMOS devices. Almost the only gate input current which flows in CMOS is probably that due to gate input capacitance, which is typically 5pF."

"Blimey," said Dick, impressed.

"How much current would that inverter we've been looking at draw from the supply rails?"

"In the quiescent state", replied Smithy, "when its output is either at 1 or 0, the current will typically be less than 0.001μA."

"But", protested Dick, "that's fantastically low."

"I know it is", grinned Smithy. "However, the inverter will momentarily draw a much higher current when its output is changing from one state to the other. When the output voltage is about mid-way between the 1 and 0 states during a changeover, both the f.e.t.'s are partly conductive and the current drawn from the supply rails will rise to a level in the order of milliamps. Well, that's enough about inverters, so let's have a look at a more interesting device."

NAND GATE

Smithy turned the pages of the data book.

"Here's a good example", he said. "I've turned now to the CD4011 quad NAND gate. This has got four NAND gates in it. See?"

Smithy pointed to the CD4011 outline and the circuit of one of its NAND gates.

"That looks quite a bit more complicated", said Dick, as he peered closely at the diagram. "I suppose the output of each gate is 0 only when both the inputs are 1."

"That's correct", confirmed Smithy. "As a matter of fact I've been doing a little mail-order shopping recently, and I got one of these CD4011 i.c.'s in for interest's sake. I'll show it to you later. To explain how this NAND gate works, I'll just add numbers to the f.e.t.'s in the circuit."

Smithy numbered the f.e.t.'s in the data book circuit from 1 to 4. (Fig. 4.)

"Let's say", he continued, "that both the NAND gate inputs are negative, at 0. This will cause FET4 to be off. FET3 will also be off although there is, in any case, no source current available for it via FET4. Both FET1 and FET2 are turned on, and so the output is fully positive, at 1."

"What happens", asked Dick, "if you take, say, input B up to 1?"

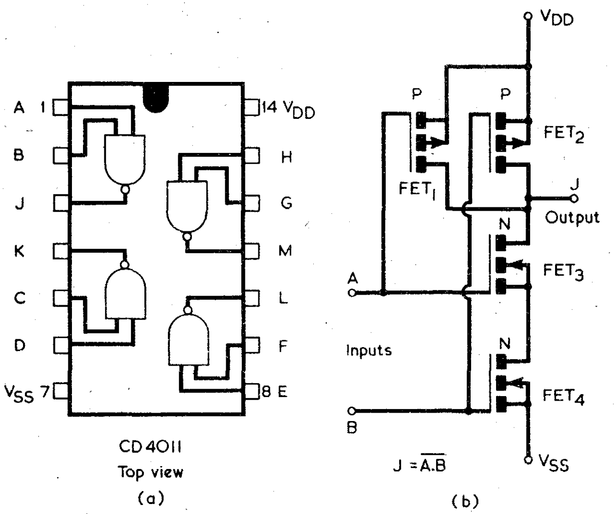
"If we do that", said Smithy, "we have input A at 0 and input B at 1. FET4 is now biased to be fully on, but it cannot turn on in practice because there is no drain current available for it from the fully turned off FET3. With input B at 1, FET2 is turned off. At the same time, input A is at 0 and FET1 is turned fully on. So FET1 maintains the output at 1."

"Right", said Dick briskly. "I'll have a go now, with input A at 1 and input B at 0. This time it's FET3 which is biased to turn on, but it can't do anything about it because there's no source current available for it from FET4. With input A at 1, FET1 is turned off. But FET2 is turned on by the 0 at input B, and so the output still stays at 1."

"You've got the idea," commended Smithy. "To finish off, all we have to do is to see what happens when both inputs are at 1. FET1 and FET2 are both turned off. FET4 is now conductive and passes current to the source of FET3, which also turns on. So the two f.e.t.'s in series take the output down to 0. Easy, isn't it?"

"It's a piece of cake," agreed Dick. "Turning to another point, what about the precautions that are taken to prevent the breakdown of f.e.t. gate insulation?"

"As I said," stated Smithy, picking up his pen and drawing a furthur circuit on his pad. "Protective diodes for each gate are incorporated in the i.c. This is the diode circuit most commonly used."



A	B	J
0	0	1
1	0	1
0	1	1
1	1	0

(c)

Fig. 4(a). The pin allocations of the CD4011 (b). Circuit of one of the CD4011 NAND gates (c). Truth table for the NAND gate

Dick looked at the circuit Smithy had drawn. (Fig. 5.)

"I suppose", he remarked, frowning, "that those diodes prevent the input voltage from going outside the supply voltage limits."

"That's exactly what they do do," stated Smithy. "The input voltage to a CMOS device should never go positive of VDD or negative of VSS; but if it does, the appropriate protective diode or diodes conducts and protects the f.e.t. gate insulation. At first sight, one would imagine that these diodes would give complete protection against high voltages reaching the f.e.t. gates but the manufacturers don't seem to think so. They advise that CMOS gates be protected against static voltages by having their pins shorted together by metal foil or conducting material until they are wired to the circuit in which they are to be used, and that all soldering must be carried out with a soldering iron whose bit is reliably earthed."

"Stap me", said Dick, "that's being a little ultra-cautious, isn't it?"

"Not really," stated Smithy. "Presumably, it is possible for a transient static voltage to get past the protective diodes if it comes from a source having sufficient capacitance to earth. Getting away from static voltages, another point is that the protective diodes are rated for a maximum forward current of about 10mA only, so that an input signal from a low impedance source can burn one out if it causes it to pass too much forward current. Again, the diodes will be immediately burnt out if you apply a power supply with reversed polarity."

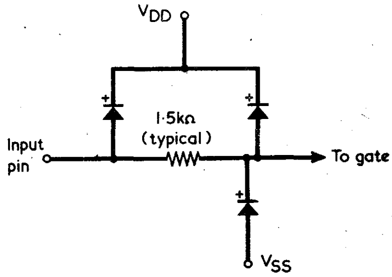


Fig. 5. The diode protection circuit provided at each f.e.t. gate

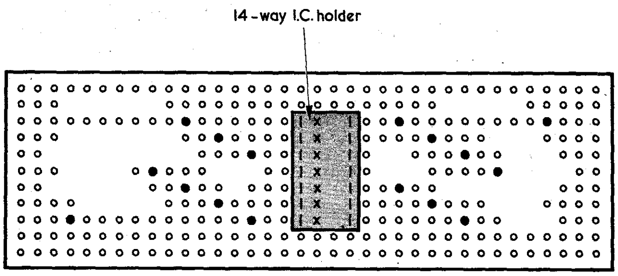
A LITTLE EXPERIMENT

Smithy opened the drawer in his bench once more and produced a small paper packet and a piece of Veroboard with an i.c. holder and a number of Veropins mounted on it.

"I mentioned just now", he remarked, "that I've got one of these CD4011 i.c.'s on hand, so we'll next use it in a little experiment."

"What", asked Dick, "is that Veroboard gubbins?"

"It's my digital i.c. test-bed," said Smithy with a grin. "It consists of a 14-way d.i.l. holder on a piece of Veroboard with Veropins stuck in it at strategic intervals. You can wire up



O·1" Veroboard 36 holes x 11 strips
● -Veropins
x - cuts in strips

Fig. 6. Smithy's 'test-bed' for experimental digital i.c. circuits. The Veropins connect to each socket of the i.c. holder, with an extra Veropin for pins 7 and 14, and are spaced out sufficiently to make hook-up wiring a simple matter

test circuits on it in a matter of minutes, after which you simply plug in the i.c. you're playing around with." (Fig. 6.)

"That's a knobby idea," remarked Dick. "Are you going to make up a test circuit now?"

"I am", replied Smithy, busy once more with his pen. "And, if you'll hang on a few minutes, I'll let you have a look at it."

Smithy completed his circuit and showed it to his assistant. (Fig. 7.)

"Another rule with CMOS gates," Smithy continued, "is that all inputs not in use must be tied to either the VDD or the VSS line. This little set-up will show us why."

"Would you", asked Dick, "like me to wire it up for you?"

"If you would, please."

Dick drew Smithy's Veroboard assembly towards him and quickly wired the Veropins together as indicated in the Serviceman's circuit. He next prepared two flexible leads terminated in crocodile clips for connection to the 9 volt battery. Smithy handed him the 10kΩ potentiometer required by the circuit and he wired this to the board with flexible leads also. Smithy then went to Dick's bench and returned with his assistant's battered testmeter. When Dick had finished the wiring Smithy connected the three meters into the circuit, these consisting of testmeters switched to the appropriate voltage or current ranges.

"We're using up pretty well all the meters we've got in the Workshop for this little job," he announced cheerfully. "Will you adjust that pot so that its spindle is at the negative end of its track?"

"Sure thing, Smithy."

Smithy picked up the paper packet, and took out of it a 14-pin d.i.l. integrated circuit. He removed the metal foil which had been passed over its pins, then carefully inserted it into the i.c. holder on the Veroboard. He connected the crocodile clips to a PP9 battery. The needle of the voltmeter connected to pin 4 of the i.c. at once rose to indicate 9 volts. The voltmeter connected to the potentiometer slider gave a zero reading whilst the current-reading meter inserted in the VSS

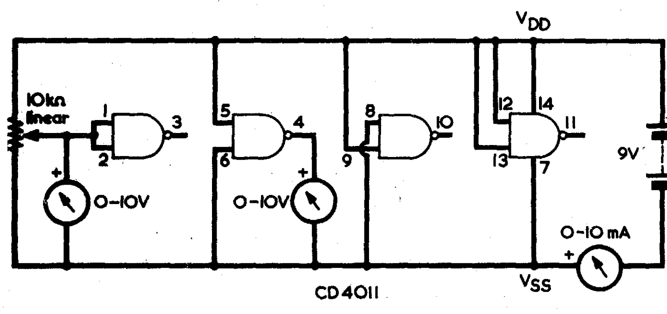


Fig. 7. The circuit which Dick wired up to check CD4011 performance

supply indicated a current of slightly less than 1mA.

"Hey", said Dick, "I thought you said that these CMOS gates passed very low currents."

"They do," confirmed Smithy. "That meter is merely indicating the standing current drawn by the 10kΩ pot. The i.c. itself will be drawing a tiny fraction of a microamp. Now, the voltmeter connected to pin 4 is reading 9 volts because pin 5 is connected to VDD and pin 6 is connected to VSS. So the output of the NAND gate concerned is positive, at 1. We should get a similar reading at pin 10."

Smithy disconnected the positive lead of the meter from pin 4 and applied it to pin 10, to be rewarded by another reading of 9 volts. When he next connected it to pin 11 there was a zero voltage reading. He finally connected it to pin 3, whereupon he got a further 9 volt reading.

"There was a zero reading at pin 11,," he announced, "because both of the inputs of that gate were at 1. I get a 9 volt reading at pin 3 since pins 1 and 2 are connected together and, with the pot slider at the negative end of its track, are at 0. This last gate is, in fact, working as an inverter. Let's try the effect of turning that pot spindle."

Slowly, Smithy rotated the spindle, whereupon the needle of the voltmeter connected to the potentiometer slider commenced to rise. After a small amount of rotation the reading in the current meter also started to rise whilst that of the voltmeter connected to pin 3 started to fall. The current indication rose to a peak reading above 2mA at about mid-travel of the potentiometer, after which it started to fall gain. The voltage at pin 3 also fell further. Eventually, the voltage at pin 3 became zero and the current-reading meter indicated potentiometer current only.

"We'll draw up a graph from these meter readings," announced Smithy. "You look after the current readings and I'll keep an eye on the voltage readings."

"All right, Smithy," said Dick excitedly. "Blimey, this is real laboratory work!"

They slowly took the potentiometer spindle through its travel again, making a note of the meter readings at each increment of voltage at the gate input. Smithy then produced a sheet of graph paper and carefully plotted two curves showing gate output voltage and current against gate input voltage from the potentiometer. (Fig. 8.)

"There you are," he pronounced proudly when he had completed this task. "This graph shows what happens when you change the input of a NAND gate wired as an inverter from fully negative to fully positive. When the input voltage approaches the centre voltage both n-channel and p-channel f.e.t.'s commence to conduct and the current drawn by the device increases by a very large amount. You would get a similar large increase in current if one gate input was at 1 and the other was changed from 0 to 1, or from 1 to 0."

"Is that why unused CMOS gate inputs should always be taken to VDD or VSS?"

"It is," replied Smithy. "If an input is floating it could take up a voltage midway between VDD and VSS, whereupon the appropriate gate would pass a relatively large current like the one we've seen just now. And, Dick, that's the end of this session on CMOS logic. The only final point I want to make is that CMOS devices having the prefix 'CD' are those in the RCA range. There is a tendency to give this prefix to equivalent devices made by other manufacturers."

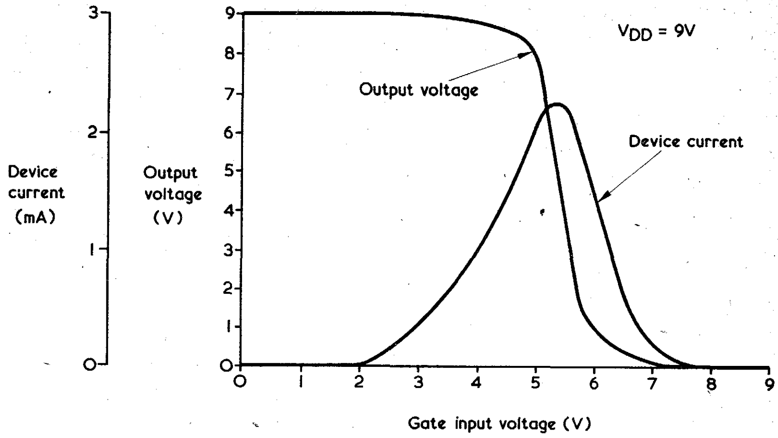


Fig. 8. Curves showing the total current drawn by the CD4011 and output voltage at pin 3 against input gate voltages at pins 1 and 2. The current curve has been corrected by subtracting the current drawn by the 10kΩ potentiometer

ROUNDING OFF

Dick gazed incredulously at the Serviceman.

"And is this really the end of the session?"

"It is."

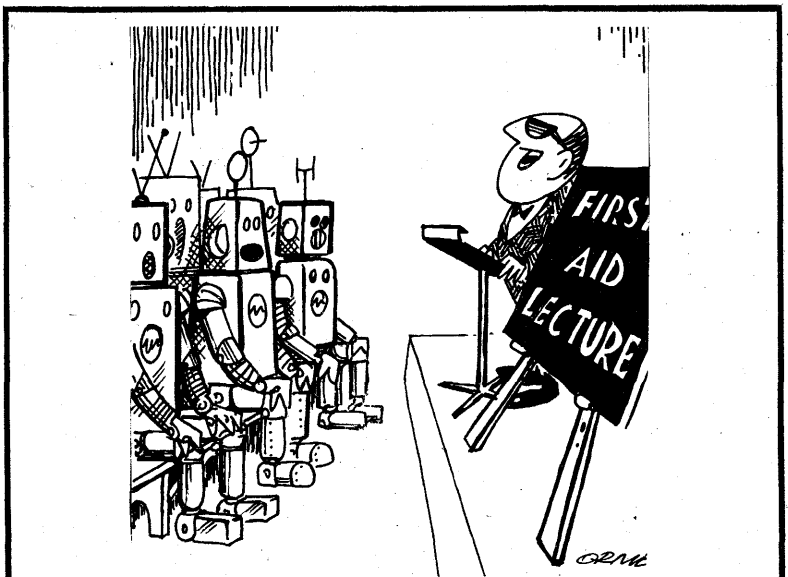
"Just like that?"

"Yep."

"Well," stated Dick. "This is it. It really is."

But Smithy was deaf to further pleas for information from his assistant. And who can blame him when the pair might otherwise have found themselves encroaching on the territory of others or even wandering through the advertising pages.

This is it. ■



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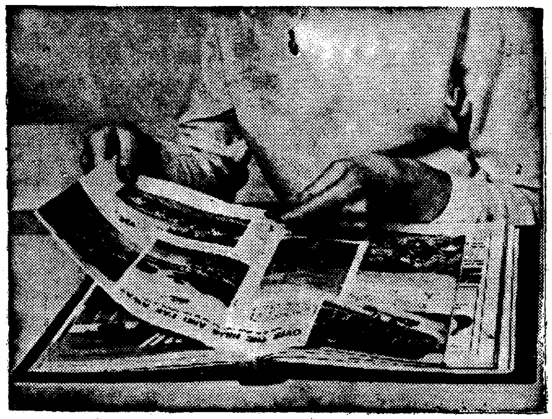

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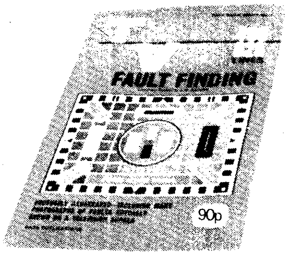

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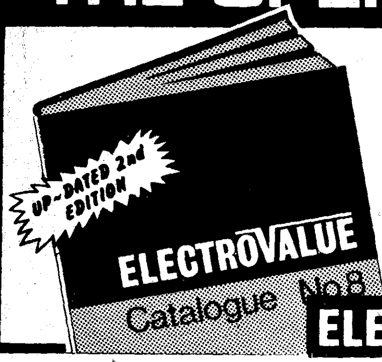

This catalogue — Electrovalue Catalogue No. 8 (Issue 2, updated) offers items from advanced opto electronic components to humble (but essential) washers. Many things listed are elsewhere very difficult to obtain. The company's computer is programmed to expedite delivery and maintain customer satisfaction. Attractive discounts are allowed on many purchases. Access and Barclaycard orders are accepted. +**FREE POSTAGE** on all C.W.O. mail orders over £2.00 list value (excluding V.A.T.) in U.K. If under, add 15p handling charge.

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FOR THE BEGINNER

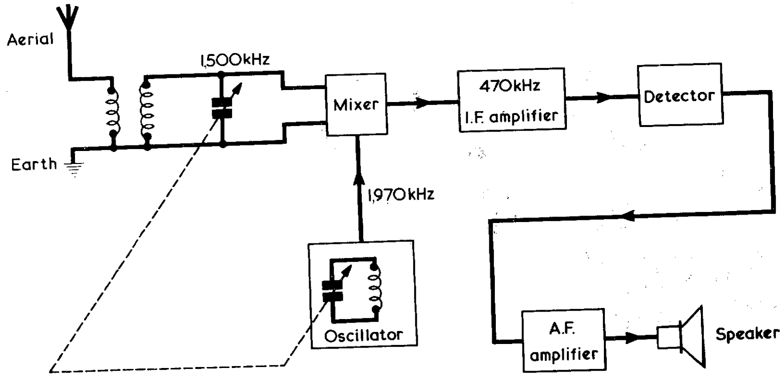
SUPERHET A.M. RECEIVERS

If two signals of different frequency are applied to a non-linear device, such as a transistor biased to produce distortion, four signals appear at the device output. Two of these have the frequencies of the original signals, one has a frequency equal to their sum and the fourth has a frequency equal to their difference. The superhet receiver employs the last of the four output frequencies.

In the diagram a radio signal at 1,500kHZ is applied via a tuned circuit to the distorting device, described as a "mixer", as also is the output of an oscillator running at 1,970kHZ. The resulting 470kHZ difference frequency is fed to a 470kHZ intermediate frequency amplifier, and thence to the receiver detector. The output of the detector is finally applied to an a.f. amplifier and the speaker. If it is desired to receive a signal at 1,800kHZ the aerial tuned circuit is changed to this frequency and the oscillator frequency changed to 2,270kHZ. Again, a 470kHZ difference signal is available for the i.f. amplifier.

The great advantage of the superhet is that the i.f. amplifier always functions at one frequency (or band of frequencies). In consequence it can have fixed tuned circuits capable of offering a high level of selectivity and can also provide a high level of gain. For continuous tuning, the aerial and oscillator tuned circuits have to be ganged such that oscillator frequency is always higher than aerial signal frequency by the intermediate frequency.

In practice, the oscillator and mixer are normally combined in a single transistor "mixer-oscillator" stage.



Last month's Electronics Data should have been entitled T.R.F. Receivers, as given in the Contents.

We apologise for any inconvenience caused to readers.