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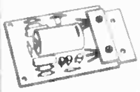
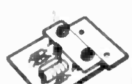


SS103
Compact I.C. amp. 3 watts R.M.S. Single channel (mono). On P.C.B. size 3½" x 2". Needs 10-20V supply. £1·75

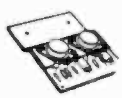
SS103-3
Stereo version of above. (Two I.Cs.) £3·25



NEW! SS105 Mk. 2
A compact all-purpose power amp. Size 3½" x 2". Useful 5W output (mono) into 3Ω using 12V. Two in bridge formation give 20W R.M.S. from 12V, for P.A. etc. £2·25

SS110 Mk. 2
Similar in size to SS105 but will give 10W output into 4Ω using 24V (mono). Two in stereo give first-class results, suitable for many domestic applications. £2·75

NOW—SS120
Size 3½" x 2" 20W R.M.S. into 4Ω using 34V. £3·00



SS140*
Beautifully designed. Will give up to 40W R.M.S. into 4Ω. Excellent S.N.R. and transient response. Fine for P.A., disco use, etc. Operates from 45V DC. Two in bridge formation will give 80W R.M.S. into 8Ω. £3·60

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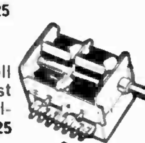
SS100
Active tone control unit to provide Bass and Treble cut and boost. Full instructions (stereo). £1·60

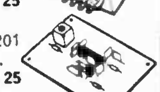
SS101
Pre-amp for stereo ceramic cartridges, radio and tape. £1·60

SS102
Pre-amp for low-output stereo magnetic cartridges, radio and tape. £2·25

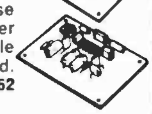
BUILD A STEREO F.M. TUNER



SS201
Front End assembly. Ganged tuning with well engineered slow-motion geared drive in robust housing. A.F.C. facility. Requires 6-16V. Excellent sensitivity. 88-108mHz. £6·25



SS202
I.F. Stage (with I.C.). Designed to use with SS201 uses I.C. Carefully checked before despatch. £5·25



SS203
Stereo Decoder. Designed essentially for use with SS201 and SS202, this excellent decoder can also make a stereo tuner of almost any single channel FM tuner. Supplied ready aligned. A.L.E.D. can easily be fitted. £5·62

Above 3 units together special price **£12·12**

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- **TP5** 20 Transistors, PNP Germanium, Red Spot A.F.
- **TP6** 20 Transistors, PNP Germanium, White spot RF.
- **TP7** 1 2N174 150w 80Vce Power Transistor, with mounting assembly.
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- **TP23** Twenty NPN Silicon uncoded T05. Similar to BFY50/2, 2N696, 2N1613, etc. Complementary to TP24.
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- **UT4** 100 Silicon diodes, min. glass, similar to IN914, IN916.
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40N2	NPN	40	40	30p
40P1	PNP	15	15	20p
40P2	PNP	40	40	30p

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90N2	NPN	40	40	35p
90P1	PNP	15	15	25p
90P2	PNP	40	40	35p

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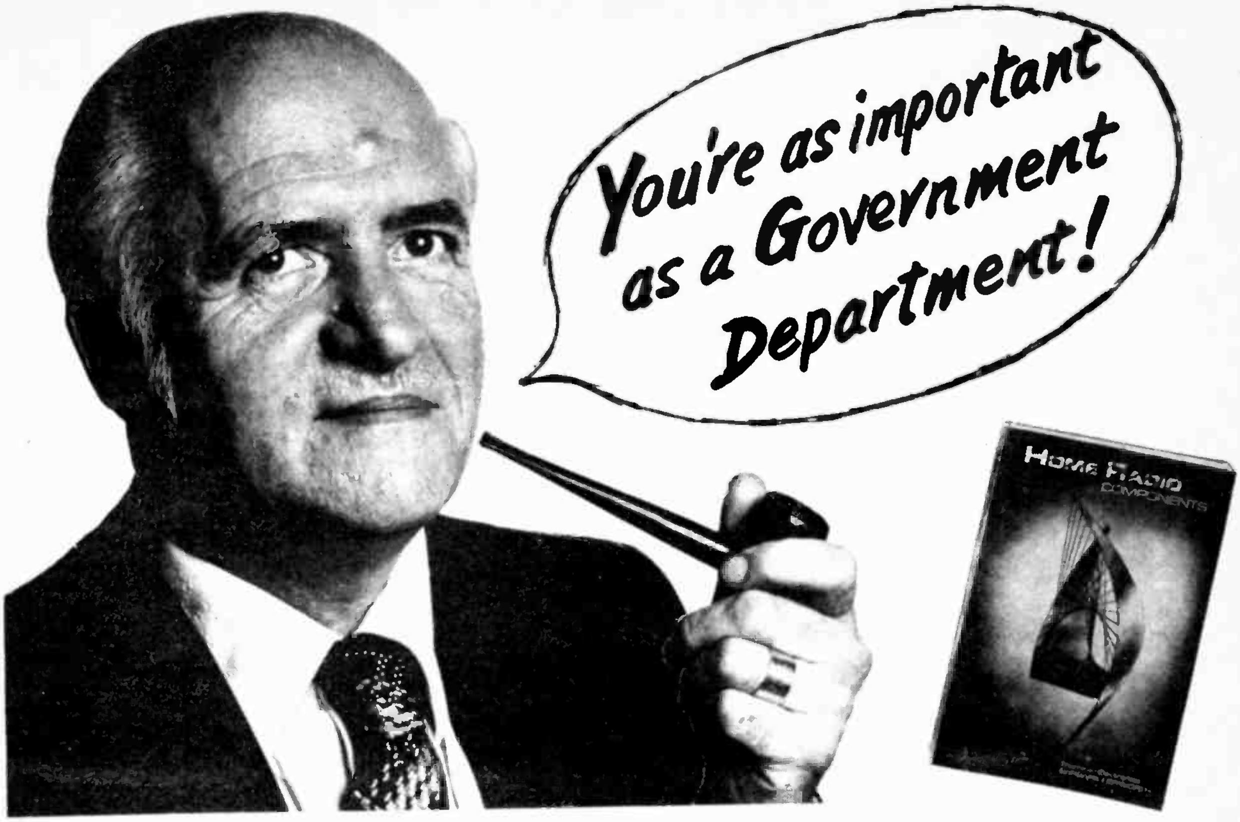

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AC127	0·19
AC128	0·19
AC132	0·15
AC134	0·15
AC137	0·15
AC141	0·19
AC141K	0·30
AC142	0·19
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AC151	0·16
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AC187K	0·28
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ACY27	0·19
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ACY29	0·36
ACY30	0·29
ACY31	0·29
ACY34	0·21
ACY35	0·21
ACY36	0·29
ACY40	0·18
ACY41	0·19
ACY44	0·36
AD130	0·39
AD140	0·49
AD142	0·49
AD143	0·39
AD149	0·51
AD161	0·36
AD162	0·36
AD161 & AD162(MP)	0·69
ADT140	0·51
AF114	0·25
AF115	0·25
AF116	0·25
AF117	0·25
AF118	0·36
AF124	0·21
AF125	0·21
AF126	0·29
AF127	0·29
AF139	0·31
AF178	0·51
AF179	0·51
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AF186	0·51
AF239	0·38
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BSY41	0·29
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BSY95A	0·13
BU105	£2·04
C111E	0·51
C400	0·31
C407	0·26
C424	0·26
C425	0·51
C426	0·36
C428	0·20
C441	0·31
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C450	0·22
MAT100	0·19
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MJE521	0·56
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MJE3440	0·51
MPF102	0·43
MPF104	0·38
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ORP12	*0·44
ORP60	*0·41

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P20	0·51
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P397	0·42
ST140	0·13
ST141	0·18
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TIP30	0·52
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UT46	*0·28
ZN414	£1·11
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2N696	0·13
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2N718	0·25
2N718A	0·51
2N726	0·29
2N727	0·29
2N743	0·20
2N744	0·20
2N914	0·15
2N4061	0·12
2N4062	0·12
2N4284	0·18
2N4285	0·18
2N4286	0·18
2N4287	0·18
2N4288	0·18
2N4289	0·18
2N4290	0·18
2N4291	0·18
2N4292	0·18
2N4293	0·18
2N5172	0·12
2N5194	0·56
2N5294	0·56
2N5296	0·56
2N5457	0·32
2N5458	0·32
2N5459	0·41
2N6122	0·69
2S301	0·51
2S302A	0·43
2S302	0·43
2S303	0·56
2S304	0·71
2S305	0·80
2S306	0·80
2S307	0·80
2S321	0·75

* 74 SERIES T.T.L. I.C's

BI-PAK STILL LOWEST IN PRICE. FULL SPECIFICATION GUARANTEED. AYL FAMOUS MANUFACTURERS.

Type	Quantities 1	25	100+
7400	0·14	0·13	0·12
7401	0·14	0·13	0·12
7402	0·14	0·13	0·12
7403	0·14	0·13	0·12
7404	0·14	0·13	0·12
7405	0·14	0·13	0·12
7406	0·36	0·31	0·29
7407	0·36	0·31	0·29
7408	0·23	0·22	0·21
7409	0·23	0·22	0·21
7410	0·14	0·13	0·12
7411	0·23	0·22	0·21
7412	0·26	0·25	0·24
7413	0·30	0·29	0·28
7416	0·28	0·27	0·26
7417	0·28	0·27	0·26
7420	0·14	0·13	0·12
7422	0·28	0·27	0·26
7423	0·37	0·36	0·35
7425	0·37	0·36	0·35
7426	0·37	0·35	0·33
7427	0·37	0·35	0·33
7428	0·42	0·39	0·37
7430	0·14	0·13	0·12
7432	0·37	0·35	0·33
7433	0·39	0·37	0·35
7437	0·32	0·30	0·28
7438	0·32	0·30	0·28
7440	0·14	0·13	0·12
7441	0·69	0·66	0·59
7442	0·69	0·66	0·59
7443	£1·11	£1·06	£1·02
7444	£1·11	£1·06	£1·02
7445	£1·48	£1·44	£1·39
7446	£1·11	£1·06	£1·02
7447	£1·02	0·99	0·97
7448	£1·02	0·99	0·97
7450	0·14	0·13	0·12
7451	0·14	0·13	0·12
7453	0·14	0·13	0·12
7454	0·14	0·13	0·12
7460	0·14	0·13	0·12
7470	0·30	0·27	0·25
7472	0·30	0·27	0·25
7473	0·38	0·36	0·32
7474	0·38	0·36	0·32
7475	0·56	0·54	0·52
7476	0·41	0·40	0·39
7480	0·56	0·54	0·51
7481	£1·02	0·97	0·93
7482	0·83	0·79	0·74
7483	£1·11	£1·06	0·97
7484	0·93	0·90	0·88
7485	£1·48	£1·44	£1·39
7486	0·32	0·31	0·30
7489	£3·70	£3·47	£3·24
7490	0·60	0·58	0·56
7491	£1·02	0·97	0·93
7492	0·69	0·66	0·59
7493	0·69	0·66	0·59
7494	0·79	0·76	0·69
7495	0·79	0·76	0·69
7496	0·89	0·86	0·80
74100	£1·39	£1·34	£1·30
74104	0·56	0·54	0·51
74105	0·56	0·54	0·51
74107	0·41	0·39	0·37
74110	0·56	0·51	0·46
74111	0·83	0·81	0·78
74118	0·93	0·88	0·83
74119	£1·39	£1·30	£1·20
74121	0·46	0·44	0·41
74122	0·65	0·63	0·60
74123	0·69	0·66	0·65
74141	0·79	0·76	0·73
74145	£1·20	£1·16	£1·11
74150	£1·39	£1·30	£1·20
74151	£1·02	0·97	0·93
74153	0·93	0·88	0·83
74154	£1·57	£1·48	£1·45
74155	£1·11	£1·06	£1·02
74156	£1·11	£1·06	£1·02
74157	0·93	0·88	0·83
74160	£1·30	£1·25	£1·20
74161	£1·30	£1·25	£1·20
74162	£1·30	£1·25	£1·20
74163	£1·30	£1·25	£1·20
74164	£1·67	£1·62	£1·55
74165	£1·67	£1·62	£1·55
74166	£1·48	£1·44	£1·39
74174	£1·48	£1·44	£1·39
74175	£1·02	0·97	0·93
74176	£1·16	£1·11	£1·06
74177	£1·16	£1·11	£1·06
74180	£1·16	£1·11	£1·06
74181	£3·66	£3·54	£3·47
74182	£1·16	£1·11	£1·06
74184	£1·67	£1·62	£1·55
74190	£1·81	£1·76	£1·71
74191	£1·81	£1·76	£1·71
74192	£1·81	£1·76	£1·71
74193	£1·81	£1·76	£1·71
74194	£1·20	£1·16	£1·11
74195	£1·02	0·97	0·93
74196	£1·11	£1·06	£1·02
74197	£1·11	£1·06	£1·02
74198	£2·55	£2·50	£2·45
74199	£2·31	£2·21	£2·11

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.

* D.T.L. 930 SERIES

Type	Quantities 1	25	100+
BP930	0·14	0·13	0·12
BP932	0·15	0·14	0·13
BP933	0·15	0·14	0·13
BP935	0·15	0·14	0·13
BP936	0·15	0·14	0·13
BP944	0·15	0·14	0·13
BP945	0·28	0·26	0·23
BP946	0·14	0·13	0·12
BP948	0·28	0·26	0·23
BP951	0·65	0·60	0·56
BP962	0·14	0·13	0·12
BP9093	0·42	0·40	0·38
BP9094	0·42	0·40	0·38
BP9097	0·42	0·40	0·38
BP9099	0·42	0·40	0·38

* TRIACS

	Case	100V	200V	400V
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

* D.I.L. SOCKETS

	1	25	100+
TSO14 14 pin type	0·31	0·28	0·25
TSO16 16 pin type	0·35	0·32	0·30
TSO24 24 pin type	0·69	0·64	0·62
BPS 8 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

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* LINEAR I.C's

Type	Quantities 1	25	100+
72702	0·46	0·44	0·42
72709	0·23	0·21	0·19
72709P	0·19	0·18	0·17
72710	0·32	0·31	0·28
72741	0·28	0·27	0·26
72741C	0·26	0·25	0·24
72741P	0·28	0·27	0·26
72747	0·79	0·74	0·61
72748P	0·35	0·33	0·31
SL201C	0·46	0·42	0·37
SL701C	0·46	0·42	0·37
SL702C	0·46	0·42	0·37
TAA263	0·74	0·65	0·56
TAA293	0·92	0·88	0·83
TAA350A	£1·71	£1·67	£1·57
uA703C	0·26	0·24	0·22
uA709C	0·19	0·18	0·17
uA711C	0·32	0·31	0·28
uA712C	0·32	0·31	0·28
uA723C	0·45	0·42	0·40
76003	£1·39	£1·34	£1·30
76023	£1·39	£1·34	£1·30
76660	0·88	0·86	0·83
LM380	0·93	0·90	0·88
NE555	0·45	0·42	0·40
NE556	0·88	0·86	0·83
TBA800	£1·39	£1·34	£1·30
ZN414	£1·11	—	—

SILICON RECTIFIERS

PIV	300mA (DO 7)	750mA (SO 16)	1 Amp Plastic		1·5 Amp (SO 16)	3Amp (SO 10)	10Amp (SO 10)	30Amp (TO 48)
50	0·05	0·06	1N4001	0·05	0·07	0·14	0·19*	0·56*
100	0·05	0·07	1N4002	0·06	0·09	0·16	0·21*	0·69*
200	0·06	0·09	1N4003	0·07	0·12	0·20	0·23*	0·93*
400	0·07	0·14	1N4004	0·09	0·14	0·28	0·35*	£1·25*
600	0·08	0·16	1N4005	0·09	0·16	0·33	0·42*	£1·76*
800	0·11	0·18	1N4006	0·10	0·18	0·35	0·51*	£1·94*
1000	0·13	0·23	1N4007	0·11	0·23	0·44	0·60*	£2·31*
1200	—	0·32			0·28	0·54	0·69*	£2·88*

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SUPER UNTESTED PAKS

Pak No.	Description	Price £p
U 1	120 Glass Sub-min. General purpose Germ. diodes	0·60
U 2	60 Mixed Germanium transistors AF/RF	0·60
U 3	75 Germanium gold bonded sub-min. like OA5, OA47	0·60
U 4	30 Germanium transistors like OC81, AC128	0·60
U 5	60 200mA sub-min. silicon diodes	0·60
U 6	30 Sil. Planar trans. NPN like BSY95A, 2N706	0·60
U 7	16 Sil. rect. TOP-HAT 750mA VLTG. RANGE up to 100	0·60
U 8	50 Sil. planar diodes DO-7 glass 250mA like OA200/202	0·60
U 9	20 Mixed voltages, 1 Watt Zener Diodes	0·60
U10	20 BAY50 charge storage diodes DO-7 glass	0·60
U11	20 PNP Sil. planar trans. TO-5 like 2N1132, 2N2904	0·60
U13	30 PNP-NPN Sil. transistors OC200 & 2S104	0·60
U14	150 Mixed silicon and germanium diodes	0·60
U15	20 NPN Sil. planar trans. TO-5 like 2N696, 2N697	0·60
U16	10 3Amp sil. rectifiers stud type up to 1000 PIV	0·60
U17	30 Germanium PNP AF transistors TO-5 like ACY 17-22	0·60
U18	8 6 Amp sil. rectifiers BYZ13 type up to 600 PIV	0·60
U19	20 Silicon NPN transistors like BC 108	0·60
U20	12 1 5 Amp sil. rectifiers top hat up to 1000 PIV	0·60
U21	30 AF. Germ. alloy transistors 2G300 series & OC71	0·60
U23	25 MADT's like MHz series PNP transistors	0·60
U24	20 Germ. 1 Amp rectifiers GJM series up to 300 PIV	0·60
U25	25 300 MHz NPN silicon transistors 2N708, BSY27	0·60
U26	30 Fast switching silicon diodes like IN914 Micro-Min	0·60
U29	10 1 Amp SCR's TO-5 can. up to 600 PIV CRS1/25-600	*£1·20
U32	25 Zener diodes 400 mW DO-7 case 3-33 volts mixed	0·60
U33	15 Plastic case 1 Amp sil. rectifiers IN4000 series	0·60
U34	30 silicon PNP alloy trans. TO-5 BCY26 28302/4	0·60
U35	25 Silicon planar transistors PNP TO-18 2N2906	0·60
U36	20 Silicon planar NPN transistors TO-5 BFY50/51/52	0·60
U37	30 Silicon alloy transistors SO-2 PNP OC200, S2322	0·60
U38	20 Fast switching silicon trans. NPN 400 MHz 2N3011	0·60
U39	30 RF. Ger. PNP transistors 2N1303/5 TO-5	0·60
U40	10 Dual transistors 6 lead TO-5 2N2060	0·60
U43	25 Silicon trans. plastic TO-18 A.F. BC113/114	0·60
U44	20 Silicon trans. plastic TO-5 BC115	0·60
U45	7 3A SCR. TO66 up to 600 PIV	*£1·20
U46	20 Unijunction transistors similar to TIS43	*0·60
U47	10 TO220AB plastic triacs 50V 6A	*£1·20
U48	9 NPN Sil. power transistors like 2N3055	£1·20
U49	12 NPN Sil. plastic power trans. 60W like 2n5294/5296	£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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* THYRISTORS

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	0·60	0 60	0 57	0·62	0 62	£1·63
400	—	—	0·30	0 39	0·55	0 57	0·52	0·71	0·77	£1·79
600	—	—	0 39	0·48	0·69	0·69	0 78	0 99	0·90	—
800	—	—	0 58	0 65	0 81	0 81	0·92	£1·22	£1·39	£4·07

DIODES

Type	Price	Type	Price	Type	Price	Type	Price
AA119	0·08	BY101	0 12	BYZ16	0·41	OA85	0·09
AA120	0 08	BY105	0·18	BYZ17	0 36	OA90	0·07
AA129	0 08	BY114	0 12	BYZ18	0 36	OA91	0·07
AAY30	0·09	BY124	0 12	BYZ19	0·28	OA95	0 07
AAZ13	0·10	BY126	0·15	CG62 (OA91Eq)	0·06	OA200	0·07
BA100	0 10	BY127	0 16	CG651 (OA70-OA79)	0 07	OA202	0·07
BA116	0·21	BY128	0 16	OA5 Short Leads	0·21	SD10	0·06
BA126	0·22	BY130	0 17	OA10	0·14	SD19	0·06
BA148	0·15	BY133	0 21	OA47	0·07	1N34	0·07
BA154	0·12	BY164	0 51	OA70	0·07	1N34A	0·07
BA155	0·15	BYX38/300	0 43	OA79	0·07	1N914	0·06
BA156	0·14	BYZ10	0 36	OA81	0·07	1N916	0·06
BA173	0·15	BYZ11	0 31			1N4148	0·06
BB104	0·15	BYZ12	0 31			18021	0·10
BY100	0·16	BYZ13	0·26			18951	0·07

QUALITY TESTED PAKS

Pak No.	Quality Tested Paks	Price
Q 1	20 Red spot transistors PNP	0 60
Q 2	16 White spot R.F. transistors PNP	0·60
Q 3	4 OC 77 type transistors	0·60
Q 4	6 Matched transistors OC44/45/81/81D	0·60
Q 5	4 OC 75 transistors	0·60
Q 6	5 OC 72 transistors	0·60
Q 7	4 AC 128 transistors PNP high gain	0·60
Q 8	4 AC 126 transistors PNP	0 60
Q 9	7 OC 81 type transistors	0·60
Q10	7 OC 71 type transistors	0 60
Q11	2 AC 127/128 Complementary pairs PNP/NPN	0·60
Q12	3 AF 116 type transistors	0·60
Q13	3 AF 117 type transistors	0·60
Q14	3 OC 171 H.F. type transistors	0·60
Q15	7 2N2926 Sil. Epoxy transistors mixed colours	0·60
Q17	5 NPN 2×ST.141 & 3×ST.140	0·60
Q18	4 MADT'S 2×MAT 100 & 2×MAT 120	0·60
Q19	3 MADT'S 2×MAT 101 & 1×MAT 121	0·60
Q20	4 OC 44 Germanium transistors A.F.	0·60
Q21	4 AC 127 NPN Germanium transistors	0·60
Q22	20 NKT transistors A.F. R.F. coded	0·60
Q23	10 OA 202 Silicon diodes sub-min	0 60
Q24	8 OA 91 diodes	0·60
Q25	15 IN 914 Silicon diodes 75PIV 75mA	0·60
Q26	8 OA95 Germanium diodes sub-min IN69	0 60
Q27	2 10A 600 PIV Silicon rectifiers 1S425B	*0 60
Q28	2 Silicon power rectifiers BYZ 13	0·60
Q29	4 Sil. transistors 2×2N696, 1×2N697, 1×2N698	0 60
Q30	7 Silicon switch transistors 2N706 NPN	0·60
Q31	6 Silicon switch transistors 2N708 NPN	0·60
Q32	3 PNP Sil. trans. 2×2N1131, 1×2N1132	0·60
Q33	3 Silicon NPN transistors 2N1711	0·60
Q34	7 Sil. NPN trans. 2N2369, 500MHz (code P397)	0·60
Q35	3 Silicon PNP TO-5 2×2N2904 & 1×2N2095	0·60
Q36	7 2N3646 TO-18 plastic 300 MHz NPN	0 60
Q37	3 2N3053 NPN Silicon transistors	0·60
Q38	5 PNP transistors 3×2N3703, 2×2N3072	0·60
Q39	5 NPN transistors 3×2N3704, 2×2N3705	0·60
Q40	5 NPN transistors 3×2N3707, 2×2N3708	0 60
Q41	3 Plastic NPN TO18 2N3904	0·60
Q43	5 BC 107 NPN transistors	0·60
Q44	5 NPN transistors 3×BC 108, 2×BC 109	0·60
Q45	3 BC 113 NPN TO-18 transistors	0·60
Q46	3 BC 115 NPN TO-5 transistors	0·60
Q47	4 NPN high gain transistors 2×BC 167, 2×BC 168	0·60
Q48	3 BCY 70 PNP transistors TO-18	0·60
Q49	3 NPN transistors 2×BFY 51, 1×BFY 52	0·60
Q50	7 BSY 28 NPN switch transistors TO-18	0·60
Q51	7 BSY 95A NPN transistors 300MHz	0·60
Q52	8 BY 100 type silicon rectifiers	£1·20
Q53	25 Sil. & Germ. trans. mixed all marked new	£1·60
Q54	6 TIL 209 Red LED	*£1·20

* UNTESTED T.T.L. PAKS

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

Pak No.	Contents	Price	Pak No.	Contents	Price
UIC00—	12×7400	0·60	UIC72—	8×7472	0·60
UIC01—	12×7401	0·60	UIC73—	8×7473	0·60
UIC02—	12×7402	0·60	UIC74—	8×7474	0·60
UIC03—	12×7403	0·60	UIC75—	8×7475	0·60
UIC04—	12×7404	0·60	UIC76—	8×7476	0·60
UIC05—	12×7405	0·60	UIC80—	5×7480	0·60
UIC06—	8×7406	0·60	UIC81—	5×7481	0 60
UIC07—	8×7407	0·60	UIC82—	5×7482	0·60
UIC10—	12×7410	0·60	UIC83—	5×7483	0·60
UIC13—	5×7413	0·60	UIC86—	5×7486	0·60
UIC20—	12×7420	0·60	UIC90—	5×7490	0·60
UIC30—	12×7430	0·60	UIC91—	5×7491	0·60
UIC40—	12×7440	0·60	UIC92—	5×7492	0·60
UIC41—	5×7441	0·60	UIC93—	5×7493	0 60
UIC42—	5×7442	0·60	UIC94—	5×7494	0 60
UIC43—	5×7443	0·60	UIC95—	5×7495	0·60
UIC44—	5×7444	0·60	UIC96—	5×7496	0 60
UIC45—	5×7445	0·60	UIC100—	5×74100	0·60
UIC46—	5×7446	0·60	UIC121—	5×74121	0·60
UIC47—	5×7447	0·60	UIC141—	5×74141	0·60
UIC48—	3×7448	0·60	UIC151—	5×74151	0 60
UIC50—	12×7450	0·60	UIC154—	5×74154	0·60
UIC51—	12×7451	0 60	UIC193—	5×74193	0 60
UIC53—	12×7453	0·60	UIC199—	5×74199	0 60
UIC54—	12×7454	0·60	UIC X1	25 Assorted 74's	£1·60
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UIC70—	8×7470	0·60			

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ULIC710	7 × 710	0·60
ULIC741	7 × 741	0·60
ULIC747	5 × 747	0·60
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1-24	25-99	100+
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3015F Minitron 7 Segment Indicator £1·11*
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FULL RANGE IN STOCK
VOLTAGE RANGE 2-33V

400 mw	1·5 w	10 w*
8p	17p	30p

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Individual prices of these are:
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4 track record playback heads £1·10 each.
Erase heads are also available separately—
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1 R.P.M. MOTOR+GEAR BOX

Made by the famous Chamberlain & Hookham Ltd. These could be made to drive clock or similar. Really robust reliable unit.
Price £1·50 + 30p Post & VAT

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2 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole 6 way—1 pole, 12 way. All at 38p + 15p post & VAT each

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Price £1·40 + 45p post & VAT.

SLIDE SWITCHES

Slide Switch. 2-pole changeover panel mounting by two 6B.A. screws. Size approx. 1in. × ⅜in rated 250V lamp. 15p + 7p post & VAT.

SubMiniatureSlide Switch. DPDT19mm (⅜in approx.) between fixing centres. 28p + 9p post & VAT each or 10 for £1·90. SP Change over spring return 250V 1 amp. 25p + 8p post & VAT.

6 DIGIT COUNTER

Resettable. 440 ohm coil up to 25 impulses per second. Ex-equipment but guaranteed perfect. £2·30 + 40p Post & VAT each.
4 digit counter as specified for telephone charge calculator 93p.

PRESSURE SWITCH

Containing a 15 amp change over switch operated by a diaphragm which in turn is operated by air pressure through a small metal tube. The operating pressure is adjustable but is set to operate in approx. 10in. of water. These are quite low pressure devices and can in fact be operated simply by blowing into the inlet tube. Original use was for washing machine to turn off water when tub has reached correct level but no doubt has many other applications £2·10 each + 25p post & VAT.

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for portable, car radio or transmitter. Chrome plated—six sections, extends from 7½ to 47in. 50p + 15p Post & VAT.
KNUCKLED MODEL FOR F.M. 80p + 17p Post & VAT.

LIGHT DIMMER KIT

For dimming up to 250w without heat sink or 750w with heat sink. This comprises quadrac variable control potentiometer, condenser, resistors, tag strip for mounting and data. Price £1·95 + 30p Post & VAT.

RELAY BARGAIN

Type 600 relay, 2 changeover one open and one closed contact. Twin 500 ohm coils make this suitable or closing off DC 6v, DC 12v, DC 24v or AC mains using resistor and rectifier. 40p each. Resistor and rectifier 20p extra..
and Post VAT 20p.

TERMS

CASH DISCOUNTS

25% on order over £500, 20% over £100, 15% £50, 10% £30.

SMALL ORDERS

Please add 30p if order under £5.

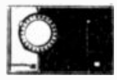
LARGE ORDERS

Deduct discounts as follows: £30-£50 deduce 10%; £60-£100 deduce 15%; £100-£499 deduce 20%; over £500 deduce 25%.

SWITCH TRIGGER MATS

So thin is undetectable under carpet but will switch on with slightest pressure. For burglar alarms, shop doors, etc.
24in × 18in £1·90. Post & VAT 30p.
18in × 9in £1·50. Post & VAT 25p

SMITHS CENTRAL HEATING CONTROLLER

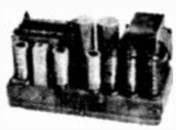


Push button gives 10 variations as follows:—(1) continuous hot water and continuous central heating (2) continuous hot water but central heating off at night (3) continuous hot water but central heating on only for 2 periods during the day (4) hot water and central heating both on but day time only (5) hot water all day but central heating only for 2 periods during the day (6) hot water and central heating on for 2 periods during the day time only—then for summer time use with central heating off (7) hot water continuous (8) hot water day time only (9) hot water twice daily (10) everything off. A handsome looking unit with 24 hour movement and the switches and other parts necessary to select the desired programme of heating. Supplied complete with wiring diagram. Originally sold, we believe, at over £15—we offer these, while stocks last, at £6·95 each, VAT & Postage 85p each.

WALL THERMOSTATS (SMITHS)

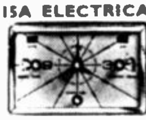
Wall mounting and in a handsome plastic case. (Cream and beige). Adjustable by slider (lockable) and may be set to control temperatures from around freezing through to 50°C. The slide panel is engraved and indicates (frost), (warm), (very warm), etc. The thermostat will control heaters, etc., up to 15 amp at normal mains voltage and is ideal for living room, bedroom and greenhouse, etc. Price £1·95. VAT & Postage 30p. Don't miss this.

AUDIO AMPLIFIER



Part of the famous Rediltune background music system, secondhand, but believed in good order. However, no guarantee; we are selling for spare value only. These are 6 valve amplifiers, the output valves are 2 × EL 84 in push/pull, complete with mains transformer, rectifier and ample smoothing equipment. The mains transformer alone, today would cost at least £4. Size is 9½" × 5½" × 4½". Price only £8·00 + postage and VAT £1·50.

15A ELECTRICAL PROGRAMMER



Learn in your sleep: Have radio playing and kettle boiling as you awake—switch on lights to ward off intruders—have a warm house to come home to. All these and many other things you can do if you invest in an electrical programmer. Clock by famous maker with 15 amp. on/off switch. Switch-on time can be set anywhere to stay on up to 6 hours. Independent 60 minute memory jogger. A beautiful unit. Price £2·95. VAT & Postage 60p, or with glass front, chrome bezel, £1·50 extra.

SHORTWAVE CRYSTAL SET

Although this uses no battery it gives really amazing results. You will receive an amazing assortment of stations over the 19, 25, 31, 39 metre bands—Kit contains chassis front panel and all the parts, £1·50—crystal earphone 55p, VAT & Postage 75p.

THIS MONTH'S SNIP

Smiths 24 hr. timer heart, really the "Autoset" without its plastic case. This is a 24 hr. twice on, twice off, clock switch which will repeat until re-programmed. Switches rated at 15 amps. Limited supplies—£3.95 VAT & post 55p. each.

12 VOLT 1½ AMP POWER PACK

This comprises double-wound 230/240V mains transformer with full wave rectifier and 2000 mfd smoothing. Price £3·75 plus VAT and Post £1.

Heavy Duty Mains Power Pack. Output voltage adjustable from 15-40V in steps—maximum load 250W—that is from 6 amp at 40V to 15 amp at 15V. This really is a high power heavy duty unit with dozens of workshop uses. Output voltage adjustment is very quick—simply interchange push on leads. Silicon rectifiers and smoothing by 3·000mF. Price £10·50 plus £25 VAT & post.

TANGENTIAL HEATER UNIT

This heater unit is most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. Comprises motor, impeller, 2kW element and 1kW element allowing switching 1, 2 and 3kW and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only needs control switch. £5·82 plus VAT & post £1. 2kW Model as above except 2kW £4·25 plus VAT & post 75p. Don't miss this. Control Switch 44p. P. & P. 40p.

INSTANT START FLUORESCENT LIGHTING BARGAINS

Starterless control gear, complete with tube ends and tube clips for window lighting, signs, fascias, etc. 4 ft. 40 w. £1·90; 5 ft. 65w. £2·00; 5 ft. 80w. £2·20: 6 ft. 80w. £2·45; and for pairs as follows:—twin 2 ft. 20w. £2·55; twin 3 ft. 30w. £2·65; twin 4 ft. 40w. £3·25; twin 5 ft. 65w. £3·25; twin 5 ft. 80w. £3·95; twin 8 ft. 125w. £5·75. These are about one half of maker's current prices and can't be repeated once stocks are cleared. Please add 30p per piece to cover postage or carriage and 8% VAT.

MAINS TRANSFORMERS

All standard 230-250 volt primaries.

		£ p
1v	1 amp (special)	1·75
2·4v	5 amp	·85
6·3v	2 amp	1·25
6·3v	3 amp	1·75
9v	1 amp	·95
9v	3·5 amp	2·50
12v	1½ amp	1·50
12v	1 amp	1·00
6·5v-0-6·5v	1 amp	1·50
18v	1 amp	1·50
24v	2 amp	2·25
24v	3 amp	2·50
12-0-12v	50mA	1·20
6-0-6v	50mA	1·20
8-0-8v	½ amp	1·50
18-0-18v	2 amps	2·50
25v	1½ amp	1·95
50v 2 amp & 6·3v	1 amp	4·50
60v 5 amp & 5v	1 amp	7·50
27v	8 amp	4·50
30v	37 amp	22·00
80v tapped 75v & 70v	4 amp	5·50
230v-60mA & 6·3v	1·5 amps	1·75
275-0-275v at 90mA & 6·4v	3 amps	2·25
EHT Transformer 5000v 23mA	(intermittent)	5·50
Charger Transformers		
6v and 12v	2 amps	1·50
6v and 12v	3 amps	2·25
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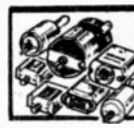
Add 30p per piece to cover postage and VAT 25%..

ONLY £1·50 FOR SEVEN ELECTRIC MOTORS



7 powerful batt. motors as used in racing cars & power models. Output & types vary for use in hundreds of different projects—Tools, toys, models, etc. All brand new reversible & for 1½-12v. batts. Wiring diag. inc. VAT & Post 40p. FREE plan for min. power station.

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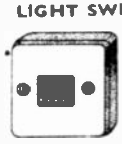
As used in discotheques and for stage effects, etc. Virtually no white light appears until the rays impinge on luminous paint or white shirts, etc. We offer 9", 6w tubes complete with starter, choke, lamp-holders and starter-holder. Price £2·75 + 30p post. Tubes only £2. Post & VAT 50p.

MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied.

Model 1153 500mW power output £1·10 + 40p post & VAT.
Model 1172 1W. power output £1·25 + 45p post & VAT.
Model EP9000 4 watt power output £2·40 + 50p post & VAT.
EP 9001 twin channel or stereo pre amp. £2·50 + 50p post & VAT.

LIGHT SWITCH



Automatically switches on lights at dusk and off at dawn. Can also be used where light and dark is a convienent way to stop and start an operation. Requires only a pair of wires to the normal switch. In bakelite box, normal switch-plate size. 1 amp model £3·75.
VAT and Postage 50p.

MAINS TRANSISTOR PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises: main transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only £1·50. VAT & Postage 60p.

SOUND TO LIGHT UNIT

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MAINS MOTOR

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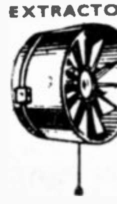
1" stackmotor £1·25 + VAT & postage 25p. 1½" stackmotor £1·50 + VAT & Postage 30p.

EXTRACTOR FAN



Cleans the air at the rate of 10,000 cubic ft. per hour. Suitable for kitchens, bathrooms, factories, changing rooms, etc., it's so quiet it can hardly be heard. Compact, 5½" casing with 5½" fan blades. Kit comprises motor, fan blades sheet steel casing, pull switch, mains connector and fixing brackets. £4·95 VAT & Postage £1·60.

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everyday electronics

PROJECTS. THEORY....

AN UNACCEPTABLE FACE

A certain sameness of appearance characterises much electronic equipment, externally as well as within. The variety of styles in components is somewhat limited, and at a glance, one electronic assembly might look like a dozen or more others, though all be entirely different circuit-wise. Externally, the same general tendency towards uniformity is experienced. The components that show their face to the outer world and are intended for observing or manipulating are likewise of restricted variety or style. So a broadly similar appearance is assumed by most electronic gadgets unless steps are deliberately taken to avoid this.

A square or rectangular box with a collection of toggle switches, rotary controls, indicator lamps, and maybe a loudspeaker or a meter, all mounted on one surface, and sockets or terminals for external connections on the opposite face of the housing—this is the well recognised conventional form of much electronic equipment. The resulting severely workaday look is perfectly satisfactory in many cases. Especially if the gadget is normally installed in semi-obscurity, or if it is an item of test gear or an instrument having strictly technical applications.

When electronics strays from these technical and generally masculine dominated environments and bids to enter those domestic areas reigned over by the more fastidious female, a quite different situation arises. To be acceptable in feminine eyes, electronic gadgets have to disguise their technical character. Often they will only win acceptance provided they look "what they ain't."

Many spouses will have suffered the unequivocal rejection of some prized gadget after it has been painstakingly built, because the lady of the house will not permit it in kitchen, lounge or wherever it was intended to take up residence.

Yet the female instinct is not really wrong in these matters. Electronic circuits don't have to be restrained by the straightjacket of the conventional metal box. With domestic devices, mechanical design and styling is every bit as important as circuit design; for functional no less than for aesthetic reasons. The designer of this month's Egg Timer puts this argument extremely well in the opening to his article. The strategy described and implemented in this particular design is faultless. The non-electronic look should assure safe entry of this Egg Timer into that peculiarly feminine domain, the kitchen.

Down-trodden husbands must not be satisfied with this one single victory, of course, but should plan to carry this war of infiltration to the farthest corners of the house. To create other Trojan Horses, all it needs is craftiness of the best kind—what in professional circles goes by the more dignified title of industrial design.

Fred Bennett.

Our December Issue will be published on Friday, November 21

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..EASY TO CONSTRUCT
..SIMPLY EXPLAINED

VOL. 4 NO. 11 NOVEMBER 1975

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

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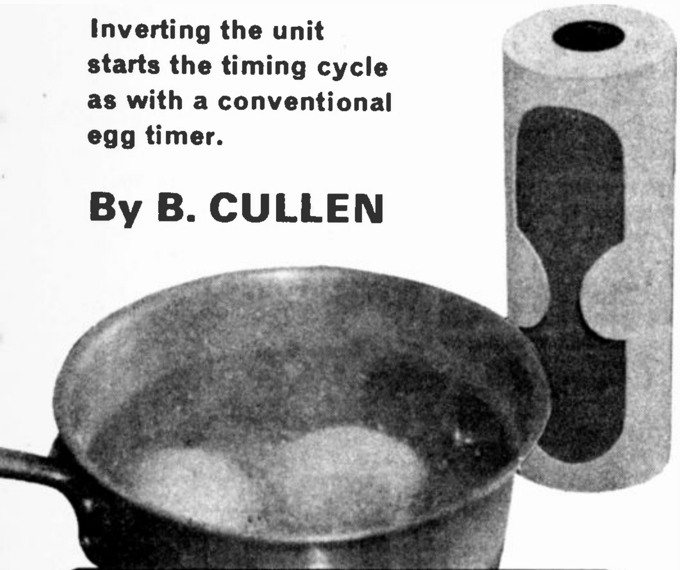
THERE have been several circuits published in recent years which have been intended as replacements for the traditional sand-in-glass egg-timer. As far as this writer is aware, all of these designs have performed faultlessly, demonstrating to all who like their eggs done to the nearest millisecond, the elegance of electronic solutions to traditional problems.

But wait! If these marvels of twentieth century technology are so good, why havent they taken the kitchens of the nation by storm? Why is it that throughout the land, the most indispensable item to go with a boiled egg (apart from bread soldiers of course!) is still an old-fashioned sand-in-glass timer? Where did we, of the amateur electronics fraternity go wrong?

EGG
BLEEP BLEEP BLEEP
TIMER

Inverting the unit starts the timing cycle as with a conventional egg timer.

By B. CULLEN



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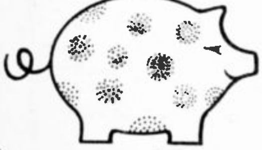


£5.80 excluding case

*Based on prices prevailing at time of going to press

The answer, I am afraid, lies in the hands of the fair-sex. When we budding boffins present our respective ladies with that beautiful, gleaming, aluminium box, complete with snazzy chromed toggle switch, and natty plastic knob, they thank us politely and then proceed to dispose of it where it will do least harm. Common ploys are, hiding it in the knives and forks drawer—accidentally dropping it into a well filled sink—even baking it for an hour or so at Regulo 5. Of course, they are very sorry, but by this time we are hard at work on our electronic lawn-sprinkler or something, and the matter is forgotten.

Believe me, fellow sufferers, they will go to *any lengths* to get those horrible tin boxes with those silly switches and ridiculous plastic knobs, out of their kitchen, to be swiftly replaced by the old sand-in-glass heirloom which they rescued from the dustbin when our backs were turned.

COUNTER MEASURES

It was in the context related above that this electronic Egg Timer was conceived as the ultimate weapon to convince the author's wife that electronics *really did* have a part to play in her life.

It was accepted from the outset that knobs dials and switches were *out*, and anyone who has wrestled with the controls of an electric cooker timer without a handbook might agree that there *is* a case to be made for simplicity in the kitchen!

It was also decided that the finished article should bear no resemblance to any electronic gadget, alive or dead, and furthermore, to completely allay suspicion, it should look as much as possible like the object it was intended to replace. A sort of electronic Trojan horse!

The result of this soul searching design exercise is a smooth, cylindrical object, about 180mm tall. No natty switches protrude through the case, no snazzy plastic knobs invite a twiddle, and the whole device is in washable plastic.

The ultimate triumph is realised in the instructions for use, since there is nothing new to learn. The timer uses the same method of operation as the sand-in-glass timer—turn it upside down and it begins to time your egg. When the preset timing period has expired, the alarm is sounded to tell you, it's as simple as that!

CIRCUIT DETAILS

The complete circuit diagram is shown in Fig. 1. and the design is based on two of the cheap and popular 555 timer integrated circuits, one

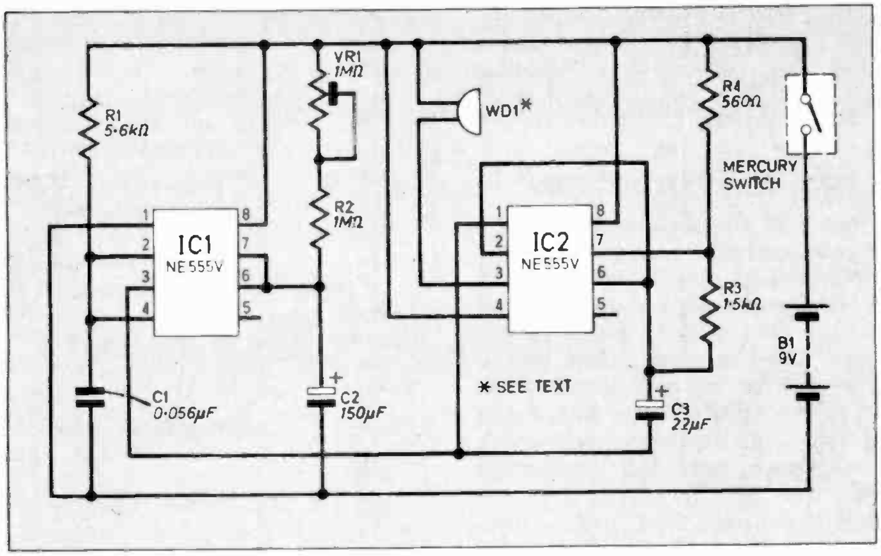


Fig. 1. The complete circuit diagram of the Egg Timer.

(IC1) being used to determine the timing period, and the other being used as an alarm tone oscillator and driver.

The secret behind the abolition of external controls is the mercury switch (S1), which is physically positioned so that when the unit is inverted, the current from the battery is turned on by the action of gravity on the mercury, and the timing period is initiated.

Integrated circuit IC1 is connected as a monostable multivibrator which is triggered when power is applied by the combination of R1 and C1 which are connected to the reset input (pin 4). The monostable period is determined by the values of VR1, R2, and capacitor C2, and in practice VR1 allows the timing period to be set between three and six minutes to suit personal preferences.

At the end of the monostable period, the output (pin 3) switches to its low voltage (ground) state, and it is a feature of the 555 that in the low state the output can sink 200 milliamps, a fact which makes it feasible to switch the supply current to the alarm tone generator directly.

WARBLE

The second i.c. (IC2) is connected as an astable, or free-running, multivibrator, which is used to modulate the alarm tone at about 15Hz to give a pleasing and compelling "warble". The warble frequency is determined by R3, R4, and C3.

The alarm sounder itself is rather unusual, being not simply a speaker but a "Bleeptone" unit which is a balanced armature oscillator/sounder which self oscillates to produce a piercing 2500Hz audio tone when a d.c. supply is connected to it.

It would be possible to drive the Bleeptone unit directly from IC1, but this would result in a continuous 2500Hz note which would probably drive the listener to distraction after a few seconds exposure! The combination of the 2500Hz note and the 15Hz modulation from IC2 results in a domestically acceptable sound which is nevertheless quite penetrating !

BATTERY

Power for the circuitry is obtained from a nine volt PP3 battery and since the drain during the timing period is only about 5 milliamps, and during the alarm period about 25 milliamps, battery life is extensive. The benefits of low consumption accrue from (a) the use of the

Components....

SEE **SHOP TALK**

Resistors
- R1 5·6kΩ
- R2 1MΩ
- R3 1·5kΩ
- R4 560Ω
- All ¼W carbon ±5%

Potentiometer
- VR1 1MΩ skeleton preset (lin.)

Capacitors
- C1 0·056μF plastic or ceramic
- C2 150μF 10V elect.
- C3 22μF 10V elect.

Integrated Circuits
- IC1 NE555V timer i.c. 8 pin d.i.l.
- IC2 NE555V timer i.c. 8 pin d.i.l.

Miscellaneous
- S1 s.p.s.t. mercury switch
- WD1 audible warning device (Bleeptone)
- B1 9 volt PP3 with battery clips to suit
- Veroboard: 0·1 inch matrix size 23 strips by 27 holes; sockets to suit IC1,2 (2 off); terminal pins; case (63mm diameter plastic drain pipe, 180mm long).

highly efficient alarm unit (b) the inherently low drain of the 555 timers, and (c) the power-switched operation of IC2 which means that no power is applied to this i.c. during the timing period.

CIRCUIT BOARD CONSTRUCTION

The main circuitry of the unit, including the mercury switch, was mounted on a piece of 0·1 inch matrix Veroboard of size 22 strips by 27 holes. In the prototype the i.c.'s were mounted in sockets, and this is a course which brings several advantages, offset to some extent by the increase in parts cost. It is not essential that sockets be used in the construction, but if the small extra cost can be justified it is well worth it for the convenience and the protection afforded the i.c.'s.

The type of mercury switch used in the prototype enabled it to be fitted to the small component board although any two-contact mercury switch can be used, but a different type may require relocation of the components on the board, so it would be wise to obtain the switch before commencing construction. The switch used came with a metal supporting bracket which should be discarded along with the two copper braid leads which come attached to the switch pins.

WARNING

A word of warning on mercury is in order at this point, since this heavy metal is **extremely toxic**. On no account attempt to manufacture your own switch using mercury, and if a commercial switch should fracture, make sure that none of the mercury is left lying about where it could be swallowed by children or pets.

ASSEMBLY

After the Veroboard has been cut to size and the required spot-face cuts made, the mercury switch can be anchored to the board with two wire loops soldered on the underside. The i.c.'s/sockets, resistors and capacitors can be mounted next, followed by the wire connecting links. The last item to be installed should be the skeleton preset VR1, since it sits above R2 and C2. Two leads of this component will have to be extended with tinned copper wire before installation, to ensure that they reach the board, see Fig. 2.

The flying leads which connect to the board were anchored to terminal pins in the prototype to make the terminations neat and easy to locate. These pins may be omitted if desired.

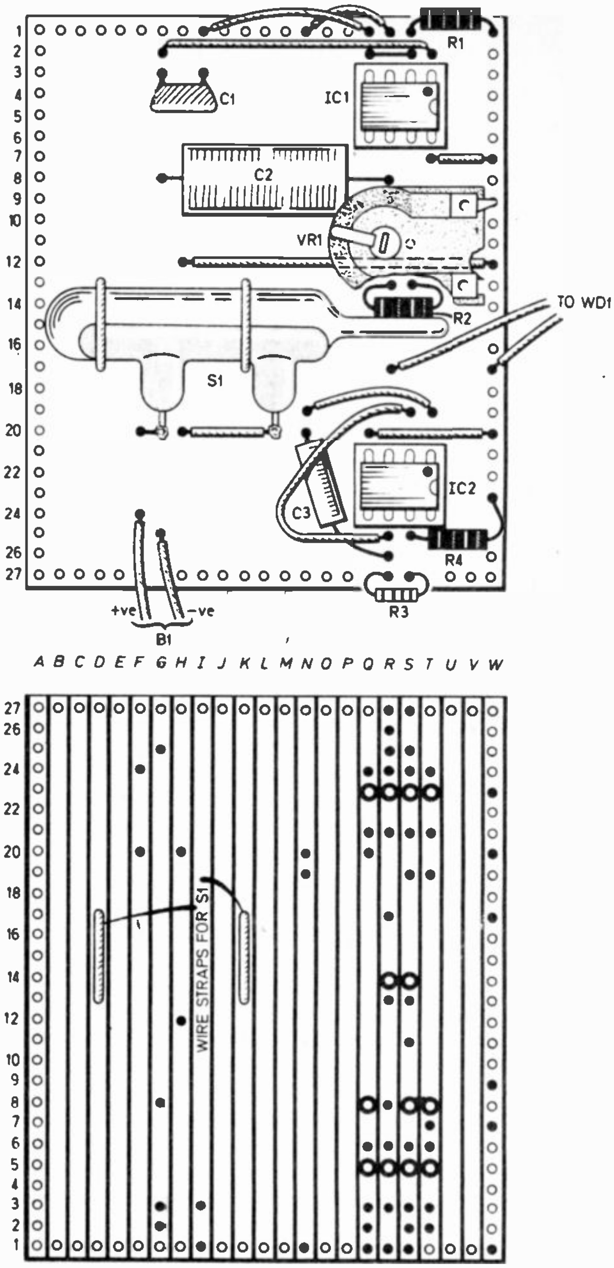
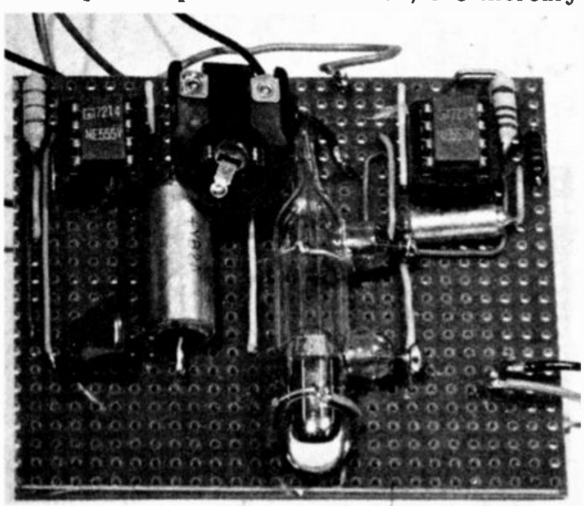


Fig. 2. The layout of the components on the Veroboard and wiring details.



Photograph of prototype component board.

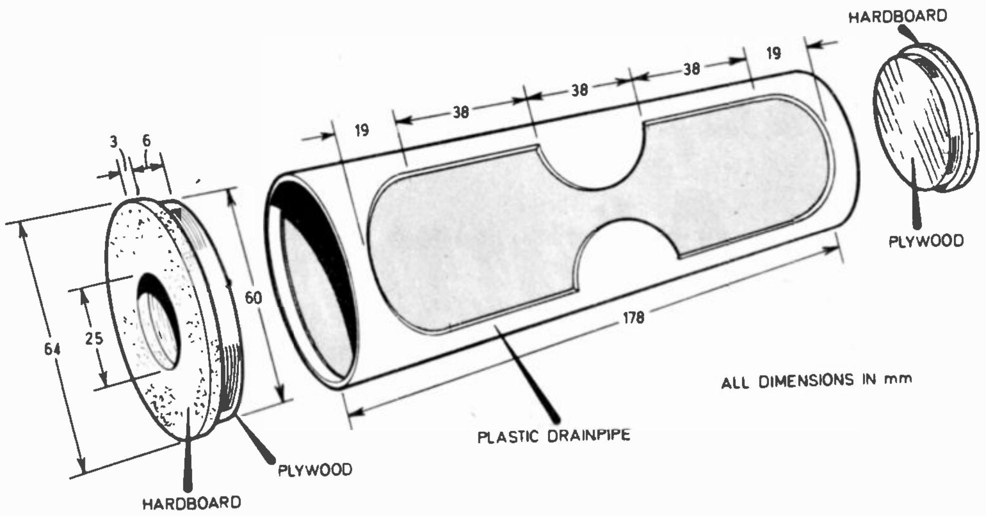


Fig. 3. Shows the construction details of the case made from 60mm diameter plastic drainpipe.

CASE CONSTRUCTION

The case is constructed from a piece of plastic drainpipe, 180mm long, obtained from a builders merchant, with two cut-outs made in the sides for purely decorative reasons, see photograph.

The ends of the pipe are stoppered with two "plugs", one of which mounts the Bleeptone and is permanently cemented in place, the other of similar dimensions being removeable to facilitate battery replacement.

The cut-outs in the cylinder are intended to be reminiscent of the traditional sand-in-glass shape, and these can be made by applying full size tracings of the shape to the pipe, and then cutting round the outline with a pad-saw, finishing off with a file.

The end plugs are made from hardboard and plywood discs stuck together with contact adhesive, the Bleeptone unit being fixed to the plug which has a hole in it, also with contact adhesive. It is important to ensure that the vents in the Bleeptone body remain unobstructed to allow maximum sound output.

The completed case can be painted or covered with self adhesive plastic sheet such as Fablon or Contact, and the cut-outs can be backed with stiff card also covered with plastic sheet, but in a contrasting (preferably plain) colour.

The circuit board is intended to be a push fit inside the tube, so no special mounting is necessary. The board must, however, be mounted the correct way up, that is, the switch contacts should be "made" by the mercury when the Bleeptone end of the case is uppermost.

OPERATION

The time delay can be set to suit personal preference using VR1, about 3 to 4 minutes being the norm for average eggs. It is possible to produce widely different time delays for special applications by altering the value of C2 or even VR1 or R2. A modification of this type was temporarily installed in the prototype to make it a 45 second timer for a fund raising game at a local fete.

RESULTS

This manifest example of electronic chauvinist piggery has been a resounding success in the kitchen, accurate and easy to use, even the battery refuses to go flat. The millennium has apparently arrived. ▣

PLEASE TAKE NOTE

In the *Courtesy Light* article E.E. Oct. '75, captions Fig. 4 and Fig. 5 should be transposed.

In the *Tremolo* article, E.E. Oct. '75, Fig. 2 shows capacitor C6 positioned the wrong way round. The unit should still function with C6 as shown.

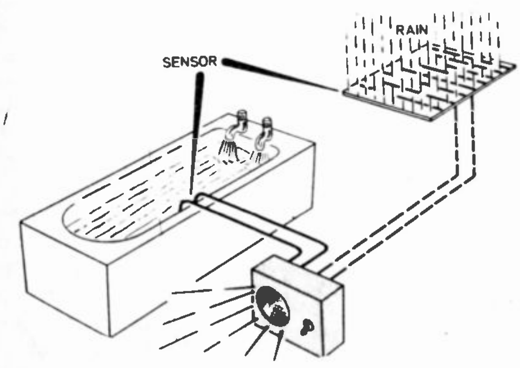
RAIN/WATER LEVEL Alarm

An audible tone is produced when water bridges the sensor. **BY ROBERT GOFFIN**

THIS ultra simple device has primarily been designed for use as a rain alarm, although it can be used in any application where it is necessary for an alarm to sound when water touches a sensor. As an example, the sensor could be positioned so that when the water running into a bath reaches a predetermined level, it makes contact with the sensor and the alarm is sounded, the device thus acting as a water level alarm.

The unit is battery operated and is therefore quite safe in this type of application. As no appreciable battery current is drawn until the alarm is activated, the battery should have a life of many months with normal use.

SIMPLY



When the sensor contacts are bridged by water, base bias current is supplied to TR1 of the oscillator causing it to oscillate and produce and audible tone.

THE CIRCUIT

The theoretical circuit diagram of the alarm is shown in Fig. 1. This consists of an unbiased audio oscillator, which will not run until a bias current is supplied through the detected water which bridges the contacts of the sensor.

Looking at the circuit in more detail, TR1 and TR2 are both grounded emitter amplifiers, and with no water at the sensor, TR1 can receive no

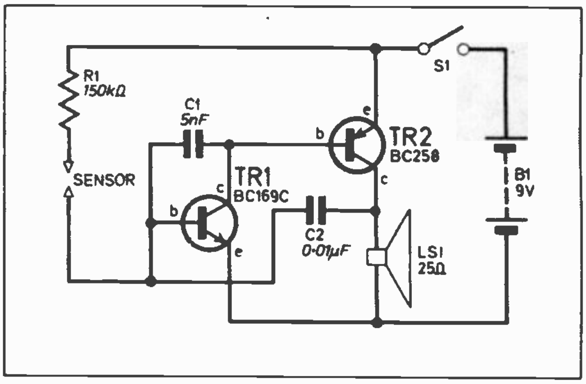


Fig. 1. The circuit diagram of the Rain/Water Alarm.

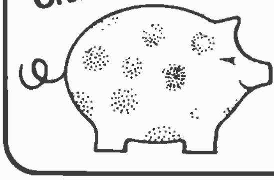
base bias, and is therefore cut off; TR2 will therefore not receive any significant base bias via the emitter-collector junction of TR1, and is also cut off. The only currents that will flow from the battery are minute leakage currents.

When water bridges one of the sets of contacts, the resistance of the water, although being rather high, contains enough impurities to permit a sufficiently large current to flow via the sensor and R1 into the base of TR1, to turn TR1 slightly on.

This will cause a larger, but still fairly modest current to be passed by TR2, as this is now receiving a base current from TR1. This causes the voltage at the junction of C2 and LS1 to swing more positive, this voltage pulse being fed via C2 to the base of TR1. This causes TR1 to conduct more heavily, which causes TR2 to conduct more heavily, which in turn causes the

FOR GUIDANCE ONLY

ESTIMATED COST* OF COMPONENTS
excluding V.A.T.



£1.50
excluding case

*Based on prices prevailing at time of going to press

2.2 KIRCHOFF'S LAW OF VOLTAGES

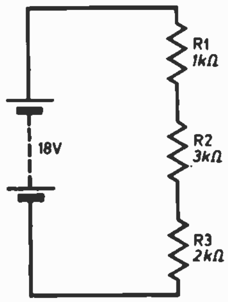


Fig. 2.2a. A simple circuit devised to illustrate Kirchoff's law.

Let us perform Ohm's law operations on the circuit diagram of Fig. 2.2a. The total resistance in series with the battery is (1 + 3 + 2) kilohms=6 kilohms.

The current flowing round the circuit is, from Ohm's law ($I=V/R$) given by $I=\frac{18\text{ volts}}{6000\text{ ohms}}=3\text{mA}$

The voltage across $R1$, is by Ohm's law $I \times R1$=3mA × 1 kilohm=3 volts. Therefore V_{R1} equals 3 volts.

Similarly, voltage across $R2$ is $I \times R2$=3mA × 3 kilohms. Therefore V_{R2}=9 volts.

Finally, voltage across $R3$ is $I \times R3$=3mA × 2 kilohms. Therefore V_{R3}=6 volts.

(Notice the method of writing voltages with "subscripts" to indicate which particular voltage).

The separate voltages across each resistor are called **voltage drops.** We say for instance, that *R2* is "dropping" 9 volts, *R1* is "dropping" 3 volts etc. Looking carefully at the voltage drops again, we may notice that the sum of the voltage drops happens to equal 18 volts which is the supply voltage of the battery. This is not peculiar to this example, it is a perfectly general result which will always apply. In fact it is called **Khirchoff's law** which reads roughly as follows:

The sum of the voltage drops always equals the supply voltage

Remember this because it is very useful.

2.3 RELATIVE POTENTIALS AND POLARITIES

To explain a few more electronic terms, we make use of the previous circuit but this time showing the voltage drops, see Fig. 2.3a.

Note also that we have marked the polarity of the battery with the signs, + (positive) and − (negative).

When speaking of voltage, we imply *two points*, because a voltage drop can only exist between one point in a circuit and another. Another term, almost synonomous with voltage is **potential.** Thus we can say *R2* drops 9 volts or equally well say there is a **potential difference** of 9 volts across *R2.* The polarity of the various voltages are also important. For example, the most negative point in the circuit is *A*, the most positive is point *D*. It is important to understand that polarity is a relative term.

Examples

Point *B* is positive with respect to *A*, but is negative with respect to *C*.

Point *C* is 15 volts positive with respect to *A*, but is 3 volts negative with respect to *D*.

In many electronic circuits, one particular point or wire is considered the "reference" and all other potentials are stated with respect to this reference wire, sometimes called the **common line** and is usually, but not necessarily, one particular terminal of the battery. Thus if *A* in Fig. 2.3a is designated the reference or common line, *B* is "at 6 volts" *C* is "at 15 volts" etc.

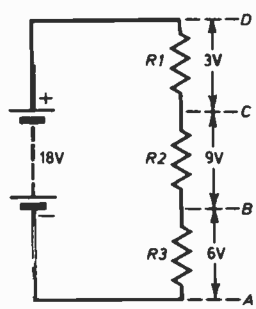


Fig. 2.3a. Shows that two points are involved when we speak of voltage.

2.4 KIRCHOFF'S CURRENT LAW

Consider the circuit diagram of Fig. 2.4a. It can be seen that there are three different currents flowing in various parts of the circuit:

(a) I_B, the battery current.
(b) I_1, the current through the 6 ohm resistor.
(c) I_2, the current through the 3 ohm resistor.

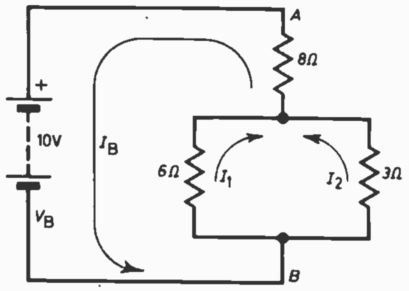


Fig. 2.4a. A simple circuit devised to illustrate Kirchoff's current law (electron flow indicated).

First find the total resistance across *AB* which is,

$$\left[8 + \frac{(3 \times 6)}{(3 + 6)}\right] \text{ohms} = 10 \text{ ohms.}$$

The battery current is therefore given by,

$$I_B = \frac{10 \text{ volts}}{10 \text{ ohms}} = 1 \text{ amp (from Ohm's law).}$$

The volts drop across the 8 ohm resistor is therefore, 1 amp × 8 ohms = 8 volts. By Khirchoff's law of voltages, this leaves 2 volts across the parallel branch, i.e. voltage across the 6 ohm and the 3 ohm resistors must be 2 volts.

Therefore the current I_1 = 2 volts/6 ohm = 1/3 amp, and I_2 ohm = 2 volts/3 ohm = 2/3 amp. Notice that the sum of the branch currents equals battery current. This is not a coincidence, but an example of **Kirchoffs law of currents.**

The sum of the currents flowing away from any junction equals the current entering

Example

If 8 amps flow into a junction of two parallel resistors, and one of them carries 5 amps, then the other must carry 3 amps. Pretty obvious really.

The two Khirchoff laws we know, highlight a couple more useful tips.

(a) Components in series always carry the same current, but can have different voltages across them.
(b) Components in parallel always have the same voltage across them but can have different currents flowing through them.

2.5 CONVENTIONAL CURRENT

Some annoying conventions are embedded in the language of electronics for which we must blame the early pioneers. The direction of current flow is a particular example i.e. if you draw an arrow representing current, which way should it point? As previously mentioned electrons flow from negative to positive through the battery.

Unfortunately the electron theory of current flow was not known to the ancients and they thought or rather assumed, that charge was transported by positive particles. Thus arrows representing current were drawn the otherway round, from positive to negative externally, and negative to positive through the battery. When electrons arrived, the mistake was too firmly entrenched to change the habit and so current arrows in most text books continue to point in the original direction which is now known as **conventional current.** If electron current arrows are used it is necessary to state this clearly, see Fig. 2.5a and b.

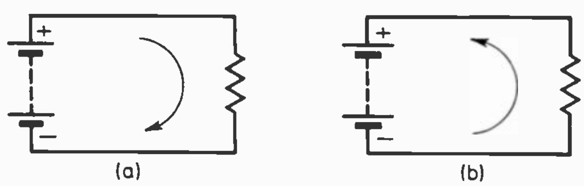


Fig. 2.5a. Shows direction of conventional current flow and (b) electron current flow.

2.6 ELECTRO-MOTIVE FORCE (e.m.f.)

Although e.m.f. and voltage drops are both measured in volts, there is, according to the boffins, a subtle difference. The prime source of energy in a circuit (in our case the battery) is said to deliver an e.m.f. because it is changing chemical energy into electrical energy. Similarly, a microphone delivers an e.m.f. because it is changing sound energy into electrical energy. A voltage drop or potential difference across a resistor, for instance, causes electrical energy to change to some other form such as heat.

2.7 MEASURING VOLTAGE

How do we measure such quantities as current voltage and resistance? The meter you have purchased is called a microammeter and measures current; one hundred microamps worth will push the needle fully over to the right—called "full scale deflection" (f.s.d.).

If you were to dismantle it, *which you must not attempt,* you would find a coil of fine wire on a cylindrical "former" which carries the pointer. The former is on a delicate pivot and held to one side by a tiny spring. Surrounding the former is a permanent magnet.

When the current to be measured is passed through the coil it acts as a small magnet which is attracted by the permanent magnet. The needle thus moves across the scale against the spring tension, the amount it moves being directly proportional to the current flowing through the meter coil.

Strangely, although our meter measures current, we shall never use it to directly measure current. During construction of the Circuit Deck, we used some resistors to turn it into a voltmeter. The calculation of these resistor values will now be an excellent exercise to practise Ohm's law.

Suppose we wish to convert our 100 microamp current meter into a voltmeter to read 0 to 25 volts. This can be done by inserting a resistor in one of the leads so that the meter and resistor are in series see Fig. 2.7a.

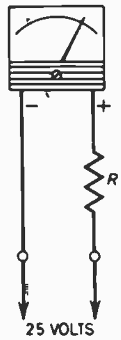


Fig. 2.7a. Converting an ammeter to a voltmeter using a series resistor.

We know that for full scale deflection, the current flowing must be 100 microamps, so the resistor value must be calculated to allow this amount of current to flow when the test prods are placed across a 25 volt supply. By Ohm's law:

$$R = \frac{V}{I} \quad \frac{25 \text{ volts}}{100 \text{ microamps}} = 250 \text{ kilohms}$$

The scale of the meter will no longer be literally correct and you must mentally convert it to 25 volts full scale, 12·5 volts half scale, etc.

TEACH-IN '76 EXPERIMENTS AND EXERCISES

EXPERIMENT 2

To verify Khirchoff's law of voltages.

PROCEDURE

1. Assemble the components as shown in (Fig.2A.1)
2. Using the meter on the 10V range, measure the voltage across each of the three resistors and then across the battery. The sum of the resistor voltages should equal the battery voltage (Khirchoffs law of voltages) When measuring voltages try and make sure the meter leads are not reversed or the meter will try to read backwards. This will not necessarily damage the meter but it should be avoided. The black meter lead (negative) should always be nearer the bottom of the resistor chain than the red.
3. Repeat the tests using the 4·5V battery and the meter on the 5V range.
4. Repeat again using the 4·5V battery, the meter on the 5V range and any three resistors (don't use less than 1 kilohm or greater than 25 kilohm).

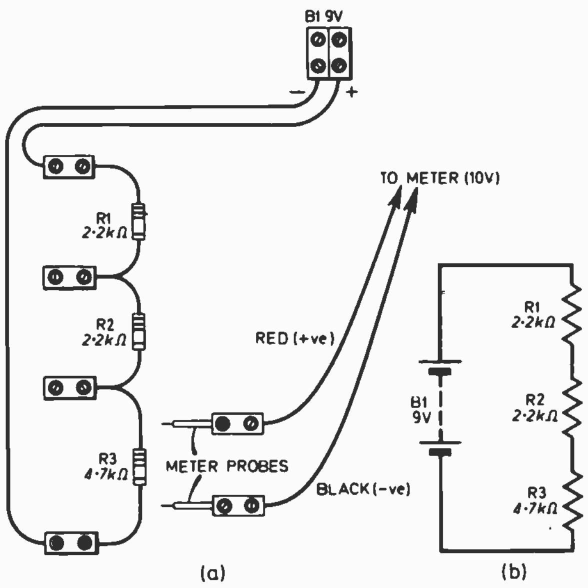


Fig. 2A.1. The layout and connecting details of the components on the Circuit Deck. Also shown is theoretical circuit diagram.

EXERCISES

2.1, A 12 ohm and a 6 ohm resistor are in parallel. What is the total resistance?

2.2 What value resistor in parallel with a 3 kilohm resistor will make the total resistance 2 kilohm?

2.3 What is the approximate resistance if a 1 kilohm resistor is in parallel with a 1 megohm resistor? What is the approximate resistance if these two resistors are in series?

2.4 A 2 kilohm resistor and a 16 kilohm resistor are in series across a 9 volt battery. What is the voltage across the 16 kilohm resistor?

2.5 If the internal resistance of a 100 microamp meter is 1 kilohm, what external resistance is required for it to be able to read 0 to 0·2 volt?

Answers

2.1 4 ohms. 2.2 6 kilohms. 2.3 1 kilohm; 1 megohm. 2.4 8 volts. 2.5 1 kilohm.

NOTE: In Fig. 1B.2 caption last month "parallel" should be changed to "series opposing".

Last month in the Teach-In 76 Component list on page 525 the requirement for two 10kΩ ¼W 5% resistors has been duplicated. Also, 147kΩ should read 47kΩ.

On page 529 referring to the microamp, 10^{-9} should read 10^{-6}.

A GUIDE TO SOLDERING . . .

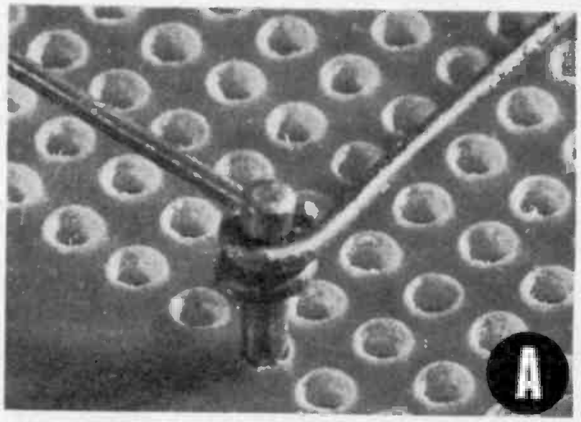
THE only way to learn to solder correctly is to practice. You would be surprised at the number of people who have high qualifications in electronics but who are unable to make a good soldered joint. It is no good plunging straight into your first project without practicing a few joints first—if you do you will probably be very disappointed with the results.

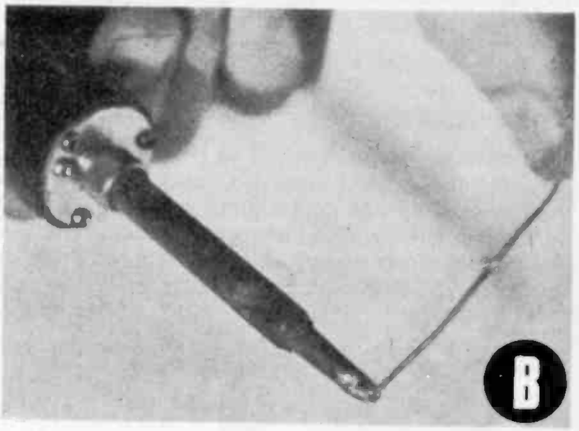
Soldering is easy, once learnt, but don't think that because it is easy that you will be able to do it first time, you are fooling yourself if you do.

We hope the pictures and text of this article will help you learn to solder and give you a good idea of what the finished joint should look like. The tools for the job are an electrically heated iron of between 15 and 30 watts with a 3mm (1/8 inch) to 6mm (1/4 inch) diameter bit. A good pair of small pointed nose pliers and small side cutters are also required and a wire stripper is useful although, with care, sidecutters, a penknife, or even the teeth can be used instead.

The solder must be a flux cored type—*no acid flux should ever be used* with electronic wiring.

Before soldering *the parts must be clean* and there should be a good mechanical joint. This is not always possible but you must remember that solder itself is not very strong and only really provides a good electrical joint. In the instance shown the wires from two components have been wrapped around a solder pin ready for soldering. Make sure the joint is neat at this stage, with no big gaps between the wire and the pin (**A**).





With the iron hot "tin" the bit by melting a small amount of solder onto it (**B**)—if necessary wipe off excess solder and clean the bit with a cloth or on a damp sponge as provided with some iron stands.

This small amount of solder on the bit helps to make good thermal contact with the joint. No other solder should be added to the bit in order to make the joint, if this is done the flux will quickly be burnt off by the iron and a poor or "dry" joint will result.

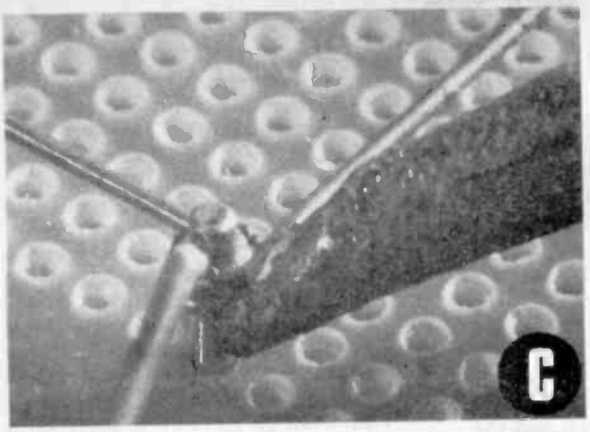
Finally the soldered joint can be made (**C**). Place the bit against the joint and melt the solder onto the joint until the solder has flowed evenly over the whole area and only add enough solder to allow this—do not finish up with a large blob of solder and try not to allow the solder to run down the pin or wires.

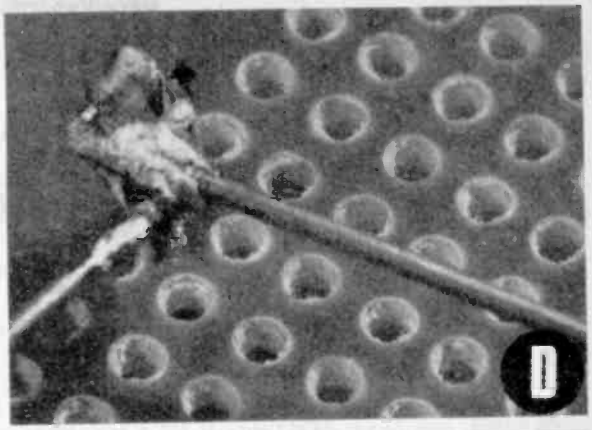
One bad (**D**) and one good (**E**) joint. Joint D is very bad, a neat mechanical joint was not achieved, making the finished joint ragged and weak. The soldered joint is "dry"—the solder has crystalised, is weak and probably has a high resistance. This could have been caused by carrying the solder to the joint on the iron, keeping the iron on the joint too long, thus burning off the flux, or by moving the wires before the solder has cooled.

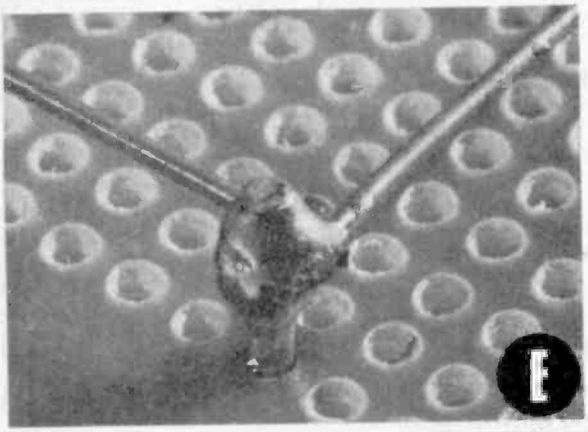
Joint E is a good one—the solder is shiny and has flowed evenly over the whole joint but has not run down the pin or along the wires.

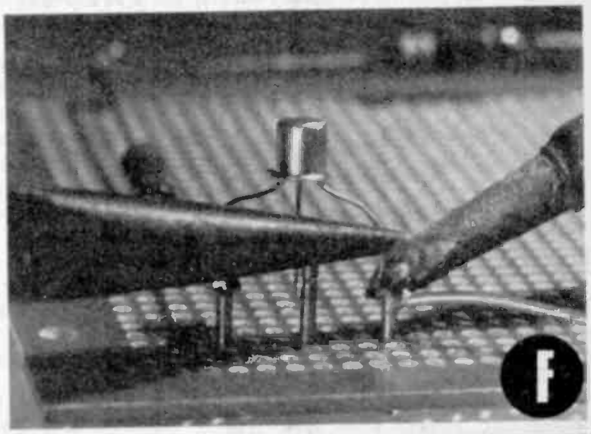
Using a heat shunt to protect a transistor whilst soldering (**F**). A pair of pliers are used to grip the lead being soldered to prevent the heat from reaching the transistor, particularly necessary with germanium types. Note how the solder is being melted onto the joint with the iron held behind the joint.

To avoid the need for three hands when using a heat shunt the solder can be stood up and the job can be moved with the pliers on the lead to be soldered. Alternatively an elastic band can be wrapped around handles of the pliers to keep them gripping the joint.









TEACH-IN 76 *Matters Arising*

KITS/SYLLABUS

I have recently purchased the October issue of EVERYDAY ELECTRONICS and read the article called *Teach-In 76*.

On making enquiries, I have found that the kit of components will cost in the region of £15 to £16. As this is a reasonably large amount of money, could you give me some details about the course.

I have a small knowledge of electronics but refreshers are always handy, so could you tell me some of the things you will be covering in the study course, and the type of things we will be able to make with these components at the end.

Also how many months will the course run?

S. P. Middleditch,
Hertford.

Kits for Teach-In 76 are offered by a number of advertisers. Prices vary, but seem to start at just over £14.

All the components listed on page 525 are commonly used items, and will provide a valuable stock for the beginner. As already stressed, these components should not suffer damage during their use in the Teach-In experiments and at the end of this 12 month course, the components will be useful in constructional projects.

The most expensive individual item is the meter, however this will find a permanent home in the special multimeter design which will be fully described at the conclusion of Teach-In 76. This is a piece of test equipment no constructor can do without.

For those with any serious intent in d.i.y. electronics, this kit of components will prove to be a sound investment. Nothing need be discarded.

Teach-In 76 is planned to run for 12 months. The course will cover the most common types of electronic components, including capacitors, inductors, various diodes, various transistors and their functions and parameters, and will go on to describe waveforms, various circuit configurations, interstage coupling, electromagnetism, a.c. theory, operator j, transformers, filters, rectification, various oscillators and other basic circuit configurations such as the Schmitt trigger. This is in addition to the subject matter of the first two parts.

SCHOOL ACTIVITIES

We have heard from the Electronics Club at Langdon School, London, that they will be actively following the Teach-In 76 series.

The club meets at the school after school hours once a week, and study and experiment with basic electronics. They will be reporting to us from time to time and commenting on the series. We invite other schools and clubs using this series, to write to us.

CIRCUIT DECK

We understand that the undermentioned can supply the Circuit Deck woodwork as used in Teach-In 76. It is available as a ready to assemble kit for £1·75 or ready assembled and varnished for £2·80. Both prices include post and packing.

B. H. Malme, "Newhaven", Mill Lane, East Runton, Cromer, Norfolk, NR27 9PH.

Your Career in ELECTRONICS

By Peter Verwig

BRITAIN'S TECHNICAL ARMY

A career in electronics is an exciting prospect! Month by month our contributor Peter Verwig explains what working in electronics is all about, how to prepare yourself for a rewarding career, and the job opportunities available in the world's fastest growing industry.

MY POSTBAG and numerous direct conversations with young people suggest that there is quite a large body of readers who dread the nine-to-five routine of business or, if school leavers, dread even the thought of it. These are the people who long for a bit of adventure in life, would like to move about a bit, like sport and the open air and yet would still like to use their knowledge of and interest in electronics to good purpose.

The armed services are tailor-made for them. This was true 30 years ago. It is even truer today. I shall be writing about career development in the Royal Navy and Royal Air Force in future issues of EVERYDAY ELECTRONICS next year. This month I shall concentrate on the British Army.

The first thing to understand about the modern army is that it is much slimmer in size than it used to be. There are fewer men and women in it and those who are in it are fully professional people being paid professional rates for providing a professional service. There are no low-paid conscripts as are found in many armies throughout the world.

Britain's defence commitments have eased in recent years in a number of overseas territories and this is one factor which allows us to have a smaller army. But the main reason is economic. If troops are to be well paid then manpower becomes the most expensive item in a defence budget. So down comes the numbers. But at the same time it is still necessary to have an effective defence force and preferably one not less effective than before.

The answer is found in more and better tools for the job. Greater mobility, improved communications, battlefield sensors, more effective fire-power. In short, more and better equipment. The balance is restored by creating, through machines and other mechanical and electronic aids, a much higher level of efficiency per man.

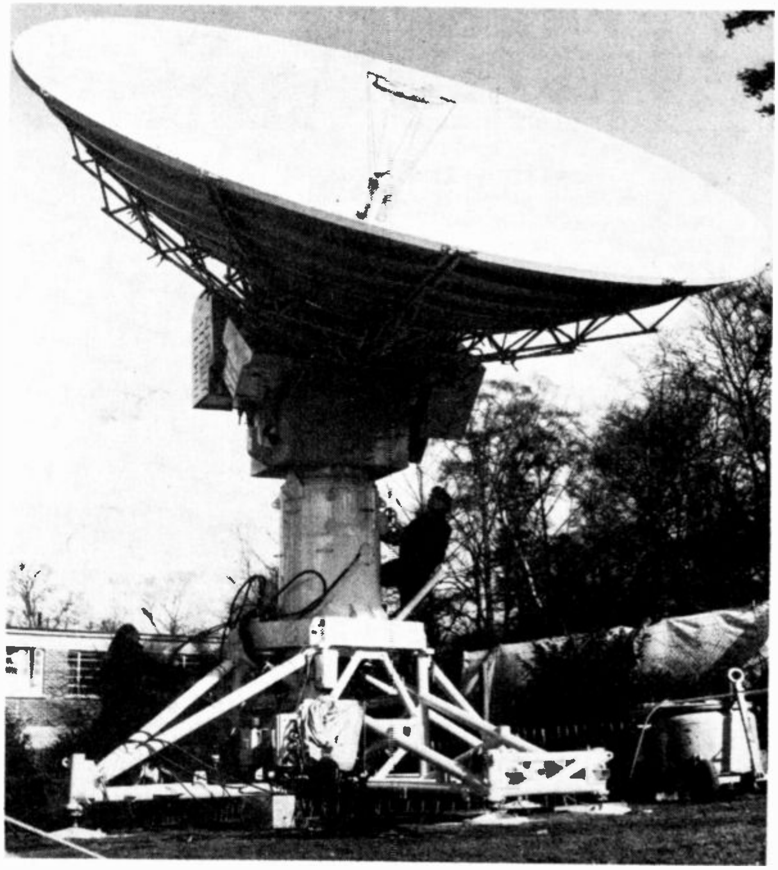
The two corps employing the greatest number of electronics technicians are the Royal Corps of Signals and the Royal Electrical and Mechanical Engineers. The Royal Signals is concerned entirely with military communications and operates and maintains the complete network down to unit level.

Overseas, the Royal Signals also looks after a larger proportion of Royal Air Force communications and even has detachments at sea with the Royal Navy. Royal Signals men are also based at headquarters of allied defence treaty organisations. The Royal Signals has an operational side as well as its own in-built technical support.

The Royal Electrical and Mechanical Engineers (REME) has no direct operational role and is entirely a servicing corps responsible for inspection, modification and overhaul of all the weapons and equipment used by the army. In the field of electronics REME activities are widespread and involve not only communications equipment but also radar, electronic control equipment of many types, and avionics.

One benefit of a career in the

A complete air-transportable earth terminal built by Marconi Space and Defence Systems.



services is that not only can you receive all your technical training absolutely free and in ideal surroundings but it is also a standard which automatically attracts professional recognition. The Council of Engineering Institutions recognises army courses as meeting the academic requirements for official registration as Technician Engineer or Technician and a pass out on the appropriate courses can be equivalent to having sat and passed the Full Technological Certificate or HNC, or ONC or City and Guilds. In some cases you sit for these certificates.

If you take a commission you may, with suitable qualifications, obtain full membership of the IEE or IERE and, of course, if you are or become a graduate you will qualify for admission to membership in either commissioned or non-commissioned ranks.

ENTRY

Young men from 16-17½ years of age can take up an army apprenticeship. You stand a better chance of being accepted if you have some GCE 'O' levels or good CSE passes but you can apply without them. You will have to pass a series of tests at the Army Careers Information Office and at an Army Youth Selection Centre. And, of course, you have to be up to a good medical standard and be a British subject or a citizen of the Republic of Ireland.

A recent survey showed that 700 officers, including several of the rank of Lieutenant-Colonel and above, and over 1,000 Warrant Officers at present serving in the army started their careers as apprentices. So an apprenticeship clearly gives a good start.

If you join the Royal Signals you will go to the Apprentice College at Harrogate for military, academic and trade training. The first term is spent in getting used to the army and the emphasis is on military training and education and the basic principles of your chosen trade. The whole of the first year is really a foundation course and the second year is then devoted more intensively to technical subjects and practical work on military equipment.

As a Junior Entrant you will get paid according to your age starting at £18·27 a week and rising at 17½ and over to £32·76 but from this is deducted a total of £5·74 for accommodation and food.

Two afternoons a week are devoted to organised sport or games. There is local adventure training on the Yorkshire moors and during the course you may expect to participate in at least two five-day adventure training exercises and possibly a course at the Army Outward Bound School at Towyn in Wales. You will get ten weeks leave a year, generally three weeks at Christmas and Easter and four weeks in the summer.

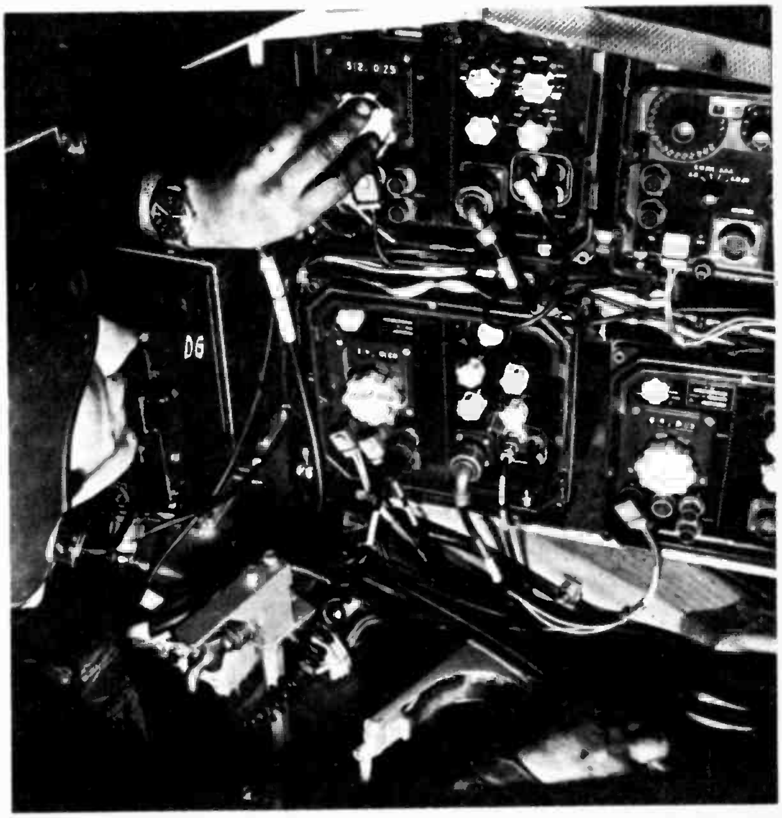
The general conditions outlined above also apply to REME apprentices except that they are based at the Apprentice College at Aberfield, near Reading. If you specialise in avionics (aviation electronics) you will complete your practical training at the Aircraft Engineering Training Wing of the Army Air Corps at Middle Wallop on Salisbury Plain.

If you are young and don't want to sign on as an apprentice you can join as a Young Soldier Entry and still get trained as a tradesman. In the Royal Signals you can, for example, join as a Junior Signalman between the ages of 16 and 17 and when you enter adult service you will clearly have career advantages among your own age group compared with colleagues who have joined later. And don't forget that if you are found to be outstanding in qualities such as personality and leadership in addition to your technical and academic proficiency, you may be selected for a commission.

The ordinary adult entry into the army starts at the age of 17 and any one can join up to the age of 25. But for the sort of people that the Royal Signals and REME require the age limit is extended upwards to 29 or 30. There are various schemes which your local Army Careers Officer will explain to you. One special scheme for the mature entrant who is already qualified technically is the Artificer Entry Scheme. In this you attend an interview board and if accepted you join with the rank of Sergeant and are given 15 months' training after which promotion is automatic to Staff Sergeant.

Mature qualified people can

Three Clansman v.h.f. vehicle sets and an h.f. set installed in a Chieftain tank.



also apply for a Special Regular Commission which is for a period of 16 years or a Short Service Commission of eight years of which only three are served and the balance are non-active reserve.

PROSPECTS

As an army technician you will be one of the elite, not in the same sense as a combat soldier but certainly in terms of early promotion and special pay for your skills. After a year of adult service you will have started up the promotional ladder in non-commissioned rank and after five years you should be well established in a supervisory capacity as a Staff Sergeant or Warrant Officer. Not untypical is the man of 25 years of age who is a Sergeant with an income of over £2,400 a year plus all the fringe benefits.

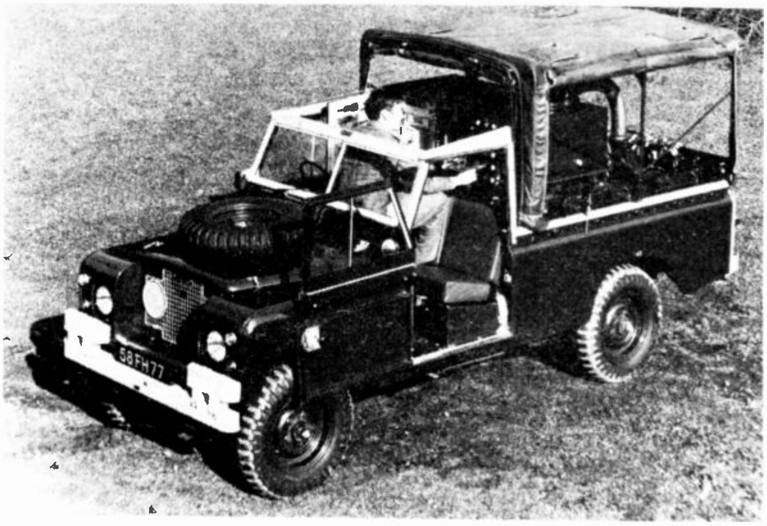
The present top pay for a Warrant Officer Class 1 on a nine-year or more scale of pay is £4,474 per year.

Unless there are special compassionate grounds you will have to go where you are sent and this means that you will probably spend at least some of your service life in Germany, Malta, Cyprus or Hong Kong. Many army units and their equipments are air-transportable for quick deployment. A REME technician may well find himself attached to a crack parachute or commando formation and travel with them.

YOUR JOB

The army is constantly introducing new equipment and you will be re-trained progressively to cope with this. Basically your job is to keep technical equipment in tip-top form and today's equipment is really technical. In communications, for example, the army is being re-equipped with the Clansman integrated radio system reckoned to be the finest in the world. As a REME technician you may well become a specialist on the world-breaking Rapier anti-aircraft missile system or on Cymbeline mortar-locating radar or working on electronics equipment in army aviation.

The scope is practically endless. But if you don't think you can measure up to the job of looking after modern developments such as infra-red "see-in-the-dark" technology, or laser beam target marking and guidance systems, don't bother. You may be better off in a bank or insurance office.



The Rapier missile forward repair and test vehicle now in service with the Army.

LAST WORD

One last word. Think hard before you act and find out all you can before taking a step you may regret. The best way of doing this is to contact your nearest Army Careers Information Office and you can find the address under *Army* in both the white and yellow pages of the telephone directory. But if all systems are go and you and the army like each other then it can be a full, exciting, profitable and, above all, a professional life ahead.

Comment on Careers

I do not agree with everything Mr. Peter Verwig says about the professional institutions (*Your Career in Electronics*, June 1975).

It seems to me that the professional institutions are largely mutual admiration societies intent on their own prestige and position in a crumbling civilisation. Mr. Verwig states that membership helps self development but I do not think that conforming to a certain pattern of employment for a large part of one's life can be said to do this, rather the reverse.

For those who wish to climb to the top of the heap, membership of an institution is no doubt essential. But for those who wish to make our own way in engineering, being a non-member need not hold any regrets.

Dennis Daniel, New Zealand
(Ex-Grad. IEE)

Our contributor Peter Verwig comments:

Mr. Daniel's views are not exclusive to engineers in the Antipodes. Many of his colleagues in Europe and the United States hold similar views on the role of the professional institutions and, indeed, the IEE, of which he is an ex-member, is itself passing through a period of re-appraisal of its own status and responsibilities and its relationship with the Council of Engineering Institions.

It remains a fact, however, that membership of a professional institution is an asset in career development in the electronics industry as currently constituted, and I would be failing in my duty to readers of EVERYDAY ELECTRONICS *if I failed to emphasise this point. But, equally, I have also made clear in recent articles that non-membership is not an absolute impediment "for those who wish to climb to the top of the heap".*

Mr. Daniel should consider rejoining the IEE with a view to exercising his reforming zeal from the inside. This surely would be more effective than being a lone and possibly increasingly embittered critic on the sidelines.

For your ENTERTAINMENT

By ADRIAN HOPE

Over the years I have been a sucker for gadgets, but have at last got the habit under control. Now I only buy, to keep, anything that really serves a purpose. Of course, there is a lot of fun to be had from gadgets that serve no useful purpose, but as money gets tighter so it makes more sense to think twice or three times before buying something just for the sake of it. So let's look at the interesting pros and cons of a couple of currently available gadgets.

Dimmers

Every other shop now seems to sell a thyristor control for dimming lights or controlling motor speed. More and more householders are replacing their wall-mounted on/off light switches with plaster-depth dimmer controls. These have the obvious advantage of enabling you to set the house lighting at whatever level you choose.

As well as saving on electricity, they save on lamp life by avoiding the heavy surge that a filament bulb receives when it is switched on from cold. But what nobody ever tells you about dimmer switches is that they play havoc with radio reception on the medium and long wavebands.

Most of the adverts talk grandly about the dimmer for sale being "interference suppressed"; but it just isn't possible to completely suppress the interference created by a dimmer switch with components small enough to squeeze into a plaster-depth mount. The dimmer works by the thyristor chopping up the mains a.c. waveform and each time it chops it creates a spiky r.f. pulse. The train of these pulses produces a harsh, motorboating sound on a radio receiving the medium and long waves.

The interference is strongest when the switch is in its halfway position, because it is in this position that the thyristor is taking the biggest bite out of the wave form.

Some buildings now contain so many dimmer switches that it is virtually impossible to use a radio on anything but v.h.f./f.m.

Wireless Intercoms

Likewise, I wonder how many people have bought mains-powered wireless intercoms on the strength of newspaper adverts promising "crystal clear communication"—and then been bitterly disappointed. Wireless intercoms (costing up to £30 a pair) differ from conventional, and much cheaper, battery powered intercoms with wired connections, in two important respects.

Firstly, the mains intercom is plugged direct into a domestic power point and receives its low voltage operating power via a step-down transformer and rectifier; secondly the audio signals which it produces are fed back into the mains via blocking capacitors. In this way, audio signals above a few hundred hertz can circulate through the local mains for up to several hundred metres and may be recovered by any matching intercom which is similarly plugged into the mains.

On the face of things, a pair of mains wireless intercoms is a very valuable gadget. Used in conjunction with a simple pair of domestic telephones (one main and one extension; quarterly rental £9·85), two intercoms can provide virtually the same facilities as the Post Office Plan 107 system (one main phone with switching to an extension; quarterly rental £14·25), which enables one phone to call up or route calls to or from the other.

Also, mains intercoms would seem at first sight to make an ideal baby alarm or invalid watching system, because they provide complete flexibility of use, enabling either station to change its location simply by plugging into the mains and without the need to relay any wires. Indeed some adverts seek to sell intercoms for just this type of use.

What the adverts don't tell prospective customers, however, is that wireless intercoms are highly susceptible to mains-borne interference. This is because the blocking capacitors let through any interference pulses for amplification along with the audio signals. Without doubt the worst source of interference for wireless intercoms is our old friend, the thyristor controlled dimmer.

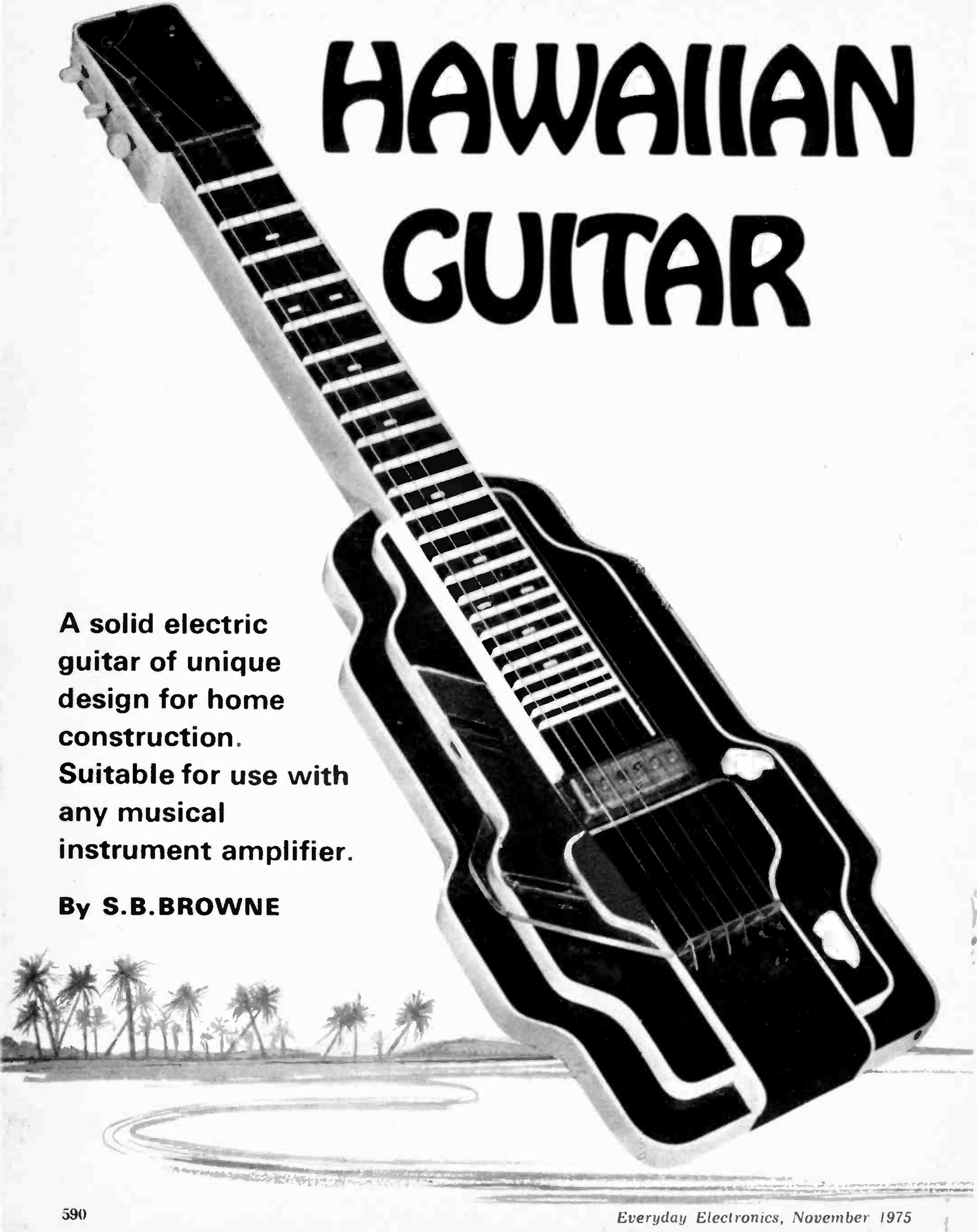
It is a pretty safe bet that if you try to use a wireless intercom you will, for at least some of the time find it reproducing far more spiky thyristor noise than useful signal. This makes it very dangerous for use as a baby or invalid alarm, because the interference noise will either irritate the user into turning down the volume or drown out any weak, distressed sounds.

Warning

One manufacturer, Eagle International, of Wembley, are well aware of the interference problems—in fact it was they who initially drew them to my attention when I asked to buy a pair. Eagle print a warning in their catalogue, that "wireless intercoms are not recommended for use as baby alarms" and are now putting stickers on all boxes.

When a customer returns a wireless intercom to Eagle as "faulty" and the problem turns out to be mains-borne interference, the firm replaces it with a wired type. The sooner all advertisements for wireless intercoms carry a similar clear warning to the public on their limitations, the better it will be for everyone, because as more dimmer switches are sold so the problem of thyristor interference will get worse rather than better.

HAWAIIAN GUITAR



A solid electric guitar of unique design for home construction. Suitable for use with any musical instrument amplifier.

By S.B.BROWNE

THE Hawaiian guitar, or to give it its full title, the Hawaiian Steel Guitar, as it was named by the natives of Hawaii, has in recent years become a widely known and popular musical instrument. It was only about 40 years ago that it was first heard outside Hawaii.

The instrument originated from the introduction of the Spanish guitar to the island by American sailors. The Spanish guitar was "converted" by raising the height of the strings above the fretboard by inserting a taller nut, and the strings were tuned differently.

The Hawaiian guitar is not held like the conventional guitar, but laid flat on the lap of the player. When played, the strings do not at any time come in contact with the frets, the latter being used only for reference. The notes are produced by plucking the strings with the right hand (normally equipped with three finger-picks) whilst the left hand slides a "steel" (hence the name) along the strings producing the well known glissando and vibrato effects typical of the "Hawaiian sound".

Almost any six-stringed guitar can be made into an Hawaiian sounding guitar by the method outlined above providing the bridge and neck are strong enough to withstand the extra strain imposed by the higher tuning (details later).

UNIQUE STYLING

This article describes the construction of a solid electric Hawaiian guitar of unique design. The body shape is in no way critical and can be modified to suit individual tastes and requirements.

As can be seen from the photographs, the whole instrument has been covered in Perspex to give a long lasting and durable finish. However, the details given here do not include the Perspex finish as this was thought to be outside the scope of many constructors. It is suggested that if a similar colour scheme is required, two colours of paint can be used, or one colour for the majority colour, and some of the many plastic glue or iron-on edging now available, be used around the perimeter of the bodywork.

NOTE

A few modifications have been made to the prototype which is shown in the photographs: (i) the original pick-up, shown mounted on section C has been omitted due to its complexity and inadequate performance (ii) the brass covered pick-up shown in photograph has been redesigned to use more readily available and cheaper magnets (iii) to simplify construction, the jack socket has been moved to the rear edge of the guitar (iv) the tone control has been moved nearer to the volume control.

SUPERSTRUCTURE

The body shape is shown half-scale in Fig. 1 and has been drawn on a grid to enable the body shape to be accurately transferred onto the wood from which the body is to be cut. The body is in fact a superstructure being made up from sections A, B and C; the neck and body are in one piece, the complete neck being made from section B on A; the head section E (in two parts) is separate and lap fixed to the neck, see Figs. 1, 2 and 6.

Begin construction with section A; first of all rule a grid of twice the matrix size (full scale) shown in Fig. 1 on the wood that the body is to be made from, and then draw in the centre line to extend at least 292mm from the intersection of the body and neck contours.

The grid lines on Fig. 1 should now be ruled in (i.e. joined up across the body shape) using a coloured ball-point pen.

Now with reference to the *complete* grid of Fig. 1, draw the body shape A, on the wood and rule in the neck (measure along the centre line) and then cut out the body complete with neck.

A fret saw will be found very useful for cutting out the curved sections and a spokeshave helpful for planing the curves to the final shape and obtaining a smooth finish.

Repeat the above procedure for section B, noting that the tail end of section B extends to the tail end of section A under section C. This can be seen clearly in Fig. 2. Also note that the body is cut out complete with neck. Drill the two holes for the control potentiometers.

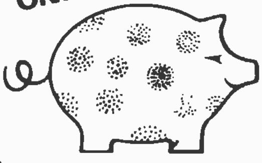
Use the grid to obtain the shape of section C, mark the centres for the six string holes (do not drill these until later) and rule in the slot to accommodate the bridge. Make the bridge cutout (right through the section) and then cut out section C.

Now place section B on A in the correct position and pin together (do not hammer the nails in fully). Two nails will be enough—use one where section C will be fitted and one along the neck.

Drill suitably sized holes along the centre line to suit 30mm long (approx.) No. 8 countersunk screws and then screw B to A. Six screws spaced equidistantly along the centre line will suffice. Each hole should be countersunk so that the screw heads are flush with or below the surface of B. Draw round the perimeter of B to produce this shape on A; remove the nails and screws and separate the two sections.

FOR GUIDANCE ONLY

ESTIMATED COST* OF COMPONENTS
excluding V.A.T.



£12.00 all parts listed

*Based on prices prevailing at time of going to press

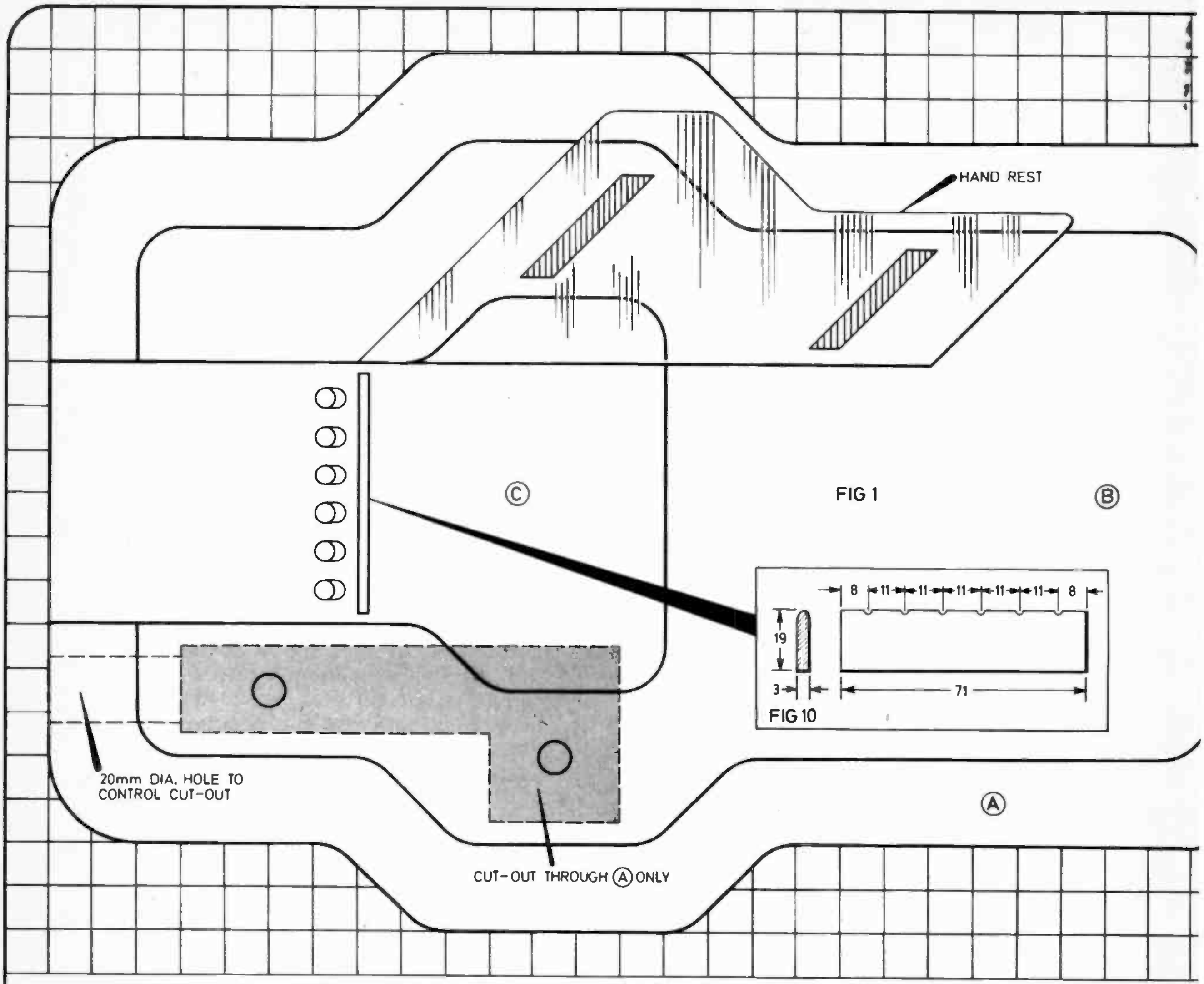


FIG 1

FIG 10

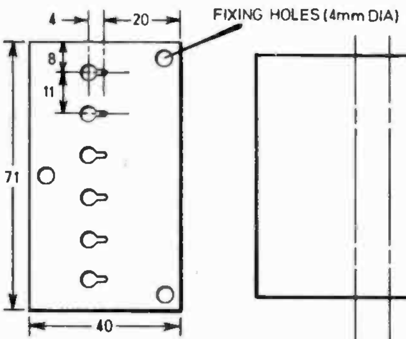


FIG 5

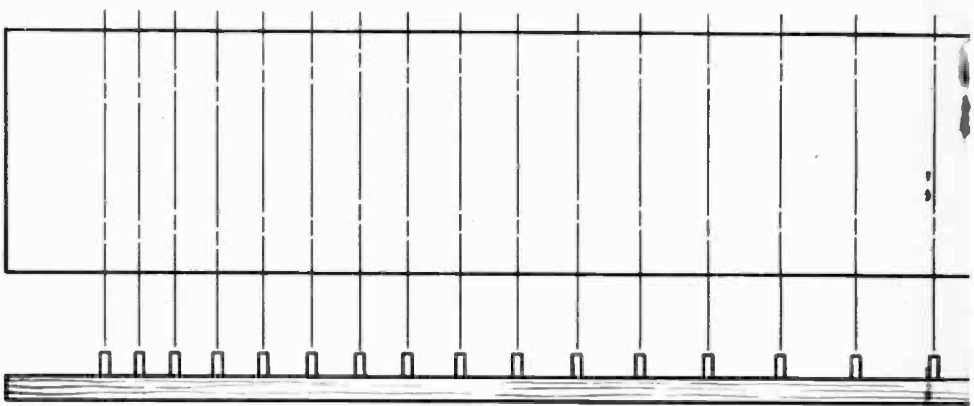
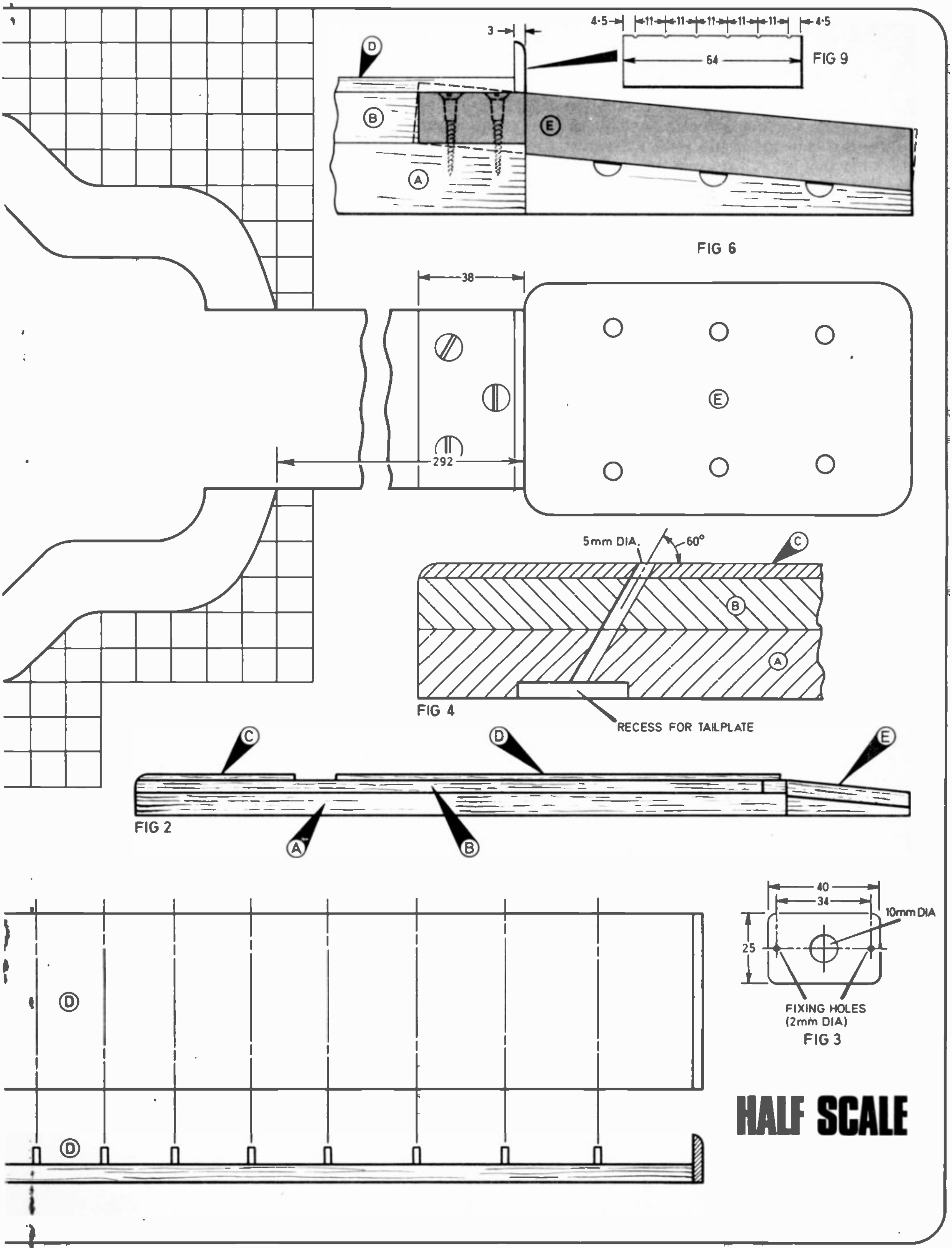


FIG 7



4·5
11
11
11
11
11
11
4·5
3
64
FIG 9
D
B
E
A
FIG 6
38
292
E
5mm DIA.
60°
C
B
A
FIG 4
RECESS FOR TAILPLATE
C
D
E
FIG 2
A
B
40
34
10mm DIA
25
FIXING HOLES
(2mm DIA)
FIG 3
D
D
HALF SCALE

CUT-OUTS

There is a cut-out to be made in A to accommodate the controls. With reference to Fig. 1, mark this cut-out on the top face of section A, ensuring that it comes within the perimeter of B and then remove using a fret saw. This cut-out is covered on the underside with a strip of plywood or hardboard. A lip must be made around the cut-out so that the cover comes flush with the underside when screwed in place.

With reference to Fig. 1, drill and/or chisel a hole in the rear edge of section A through to the control cut-out, to suit the jack socket used. The latter is held in position by means of a polished aluminium plate (see Fig. 3 for details) which is fixed in place on the rear edge of section A with two small screws; it can be sunk in to be flush with the rear edge if so desired by the constructor.

Glue and screw section B to A, and then glue and nail (use small oval nails) C to B. A suitable adhesive is Evo-Stik Resin W. The nails should be "punched" in so they can later be filled with Polyfilla to become invisible. Round off the tail section of C as shown in Fig. 2.

The six string holes through the body superstructure should be made next. These must be drilled parallel to the centre line, but at an angle of 60 degrees to the plane of the body, see Fig. 4. The holes resulting on the underside of A should now be used to site the tailplate which needs to be recessed sufficiently so that when the strings are inserted, the string retaining rings are situated away from the underside face of A. Details of the tailplate are given in Fig. 5 and should be made from steel plate.

Components....

Potentiometers
VR1, 2 100kΩ carbon lin. (2 off)
Capacitor
C1 0.47μF plastic or ceramic
Transformer
T1 M218 (Zeta Windings)
Socket
SK1 Standard jack socket
Miscellaneous
Magnets (6 off)—see text; 28 s.w.g. enamelled copper wire; screened lead; *Mahogany or similar*: 725 x 255 x 25mm (A); 690 x 205 x 15mm (B); 180 x 120 x 5mm (C); 505 x 65 x 5mm (D); 180 x 85 x 5mm (E upper). *Brass* 140 x 19 x 3mm (nut and bridge), 142 x 54 x 1mm plate (pick-up cover); *Steel* 71 x 40 x 1·5mm (tailplate); *Aluminium* 40 x 25 x 1mm (jack socket fixing plate); *Perspex* 210 x 75 x 5mm (hand rest); *Beading* (5 x 2mm) 2·7 metres (frets); *Hardboard* for control section cover; *Plywood* for lower head section; *Softwood* 100 x 40 x 3mm pick-up base; canvas for guitar underside; glue, small oval nails, screws; strings (6 off); machine heads (6 off); picks and steel.

SEE SHOP TALK

HEAD

The head (section E) is made in two sections, the upper part being lap fixed to the neck, and the lower section acting as a cover for the machine heads and completing the profile of the underside. This is screwed to the upper section.

Begin with the upper section and cut to size and shape as detailed in Fig. 6.

The head is made from a piece of mahogany size 180 x 85 x 22mm; the regions to be removed to obtain the slope are shown dotted in Fig. 7. This is screwed and glued to section A neck and butts against B neck.

The hole positions shown for the machine heads were correct for the type used in the prototype. It will be wise to obtain the machine heads before drilling the holes as they may have to be moved nearer to the head edge.

Details of the lower section of the head are given in Fig. 8.

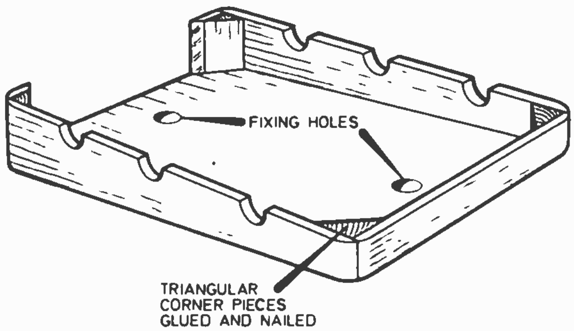


Fig. 8. Details of the head lower section.

FRETBOARD

The next stage is to cut the fretboard base to size and mark on the positions of the frets according to Fig. 7 (shown half scale). Now glue the fretboard base in position along the neck such that the distance from the bridge to the twelfth fret mark is the same as the latter is from the nut.

Prepare the frets by cutting 24 pieces 64mm long from a length of beading of cross section approximately 5mm × 2mm and then glue these to the fretboard base at the marked positions. An impact adhesive (such as Evo-Stik) was found suitable.

FITMENTS

In the prototype, the nut and bridge were made from 3mm thick brass to the dimensions shown in Figs. 9 and 10. Other suitable materials are: steel, copper or Perspex. When made, glue the nut in position at the top end of the fretboard; there is no need to glue the bridge in place.

On the prototype it was found very useful to have a rest on which the player can "rest" his right hand whilst playing. This is situated on the player side of the strings as can be seen in the photograph.

A suitable material, as used in the prototype, is 5mm thick Perspex mounted on two pillars of the same material glued with Perspex cement to the underside of the rest. When later glueing the rest to the guitar body, Evo-Stik or similar adhesive will be needed since Perspex cement will not stick to wood (or paint). The support area in contact with the body should be roughened using coarse emery paper before glueing.

The shape and size of the rest is not critical and can be changed to suit individual requirements. The prototype rest is shown half size in Fig. 1.

PICK-UP

A home-made low impedance type pick-up was used for the prototype, the magnetic pole pieces being situated immediately below each string. The magnets used were obtained from a type BM6 magnetic door catch. There are two magnets in each catch, so three catches will be needed.

An exploded view of the pick-up assembly is shown in Fig. 11. Balsa wood was found ideal for the magnet and coil former as this is fairly strong and easy to cut using a hobby knife. Begin by cutting the balsa wood to size and making the slots to take the six magnets. Glue the two extreme magnets in position and then glue this assembly to the lower cardboard winding guide and allow to set. One by one glue the remaining four magnets in place followed by the upper cardboard winding guide. Allow to set firm and then wind on 100 turns of 28 s.w.g. enamelled copper wire; a dab of paint, glue or nail varnish here and there will prevent the coil from unravelling.

Prepare the pick-up base and fix in position on the guitar body. A hole should now be drilled in the pick-up base at an angle so that it reaches the control section and must be large enough to feed through screened cable.

Hammer in two veneer pins next to the hole and solder on a length of screened cable and pass through to the control section. Glue the coil/magnet assembly to the pick-up base and solder the coil leads to the veneer pins as shown.

The pick-up cover in the prototype was made from 1mm thick brass plate. This should now be cut, drilled and bent to shape shown in Fig. 11 and the internal edges of the open joints soldered to form a rigid cover; the top corners of the cover will be sharp—round off slightly so they are not a hazard to the player. Screw the cover in position using brass screws to match the cover material.

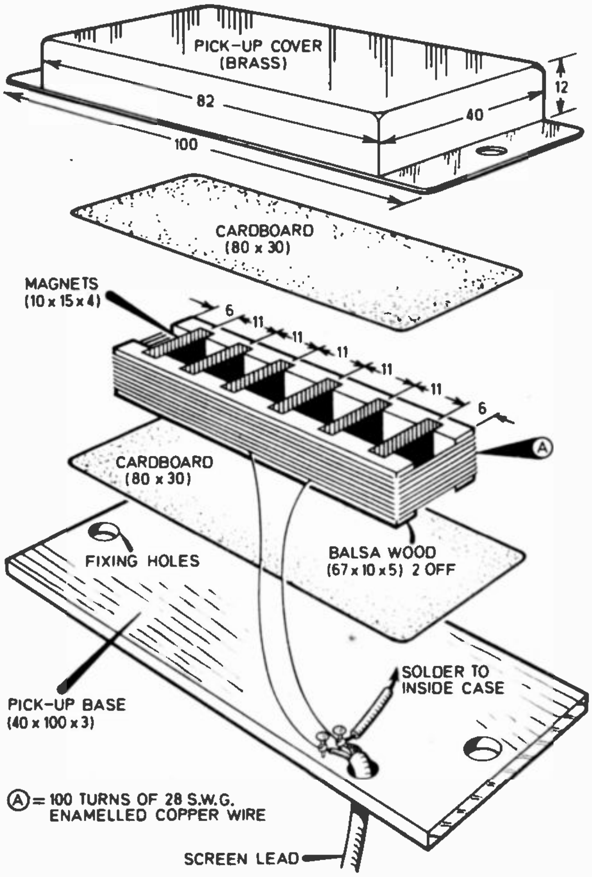


Fig. 11. An exploded view of the pick-up giving full constructional details.

CIRCUIT

The circuit diagram of the electronics within the control section is shown in Fig. 12. The signal induced in the pick-up coil is passed to T1 where it is stepped up (voltage) and appears across the volume control VR1. The wiper of VR1 is taken to the output socket SK1 where it is available for inputting to an amplifier.

Potentiometer VR2, wired as a variable resistor, and capacitor C1 are in parallel with the output. The resistance (or more correctly, reactance) of C1 varies with frequency, being low for high frequencies and relatively high for lower frequencies. Thus with VR2 turned for minimum resistance, the effect of C1 is to shunt the higher frequencies to earth (treble cut), thereby producing a bassy tone. With VR2 set for maximum

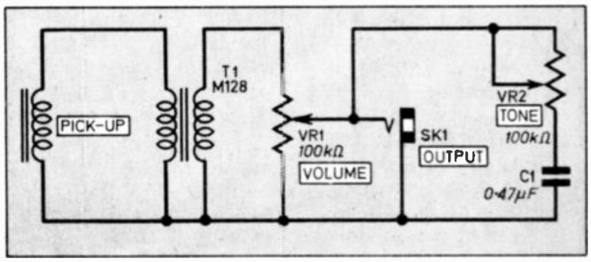


Fig. 12. The circuit diagram of the components in the control section.

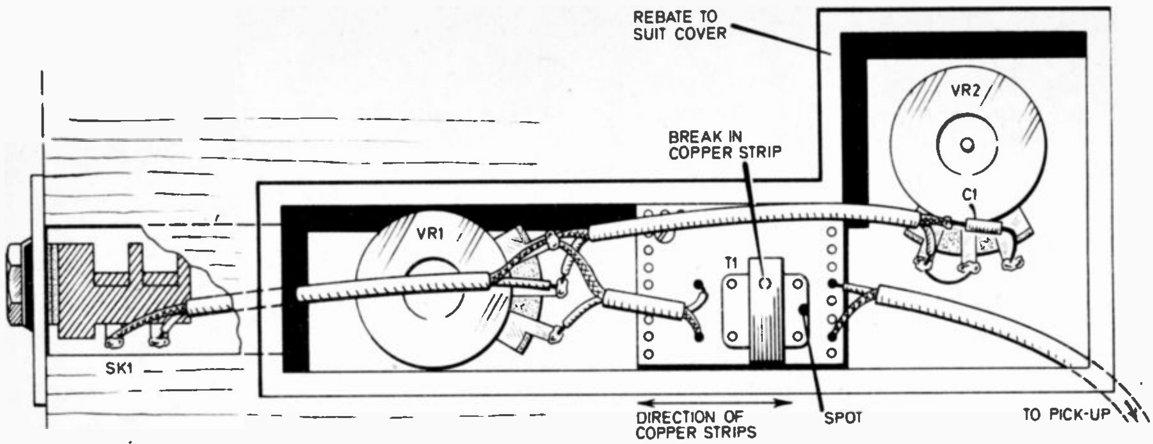


Fig. 13. The layout of the components in the control section and complete wiring up details. Note the spot on T1 indicating input.

resistance, the effect of C1 is eliminated. Intermediate settings of VR2 give varying degrees of treble cut.

WIRING UP

The layout of the components in the control recess and wiring up details are shown in Fig. 13. For convenience the transformer is mounted on a small piece of 0·1 inch matrix Veroboard and screwed to the underside of section B. Two small Z-shaped brackets need to be made to hold the potentiometers in place; these brackets are fixed to the underside of section B.

When the wiring up is complete, secure the control recess panel in place, place the bridge in its slot and attach the machine heads and strings.

Photograph showing method of holding and playing the guitar.

TUNING

The strings should be connected to the guitar so that they are in descending order of thickness away from the player.

Labelling the strings 1st, 2nd, 3rd, 4th, 5th and 6th from the thinnest to the thickest, they should be tuned with the aid of Hawaiian pitch pipes or a piano.

There are many different types of tuning, the most popular being E7th and High Bass tuning. These are shown below.

	6th	5th	4th	3rd	2nd	1st
E7th	E	B	D	G♯	B	E
High Bass	A	C♯	E	A	C♯	E

It is advised that those unaccustomed to the Hawaiian guitar obtain a book on "How To Play The Hawaiian Guitar" to obtain the maximum enjoyment from the instrument. These should be available from stockists of sheet music.

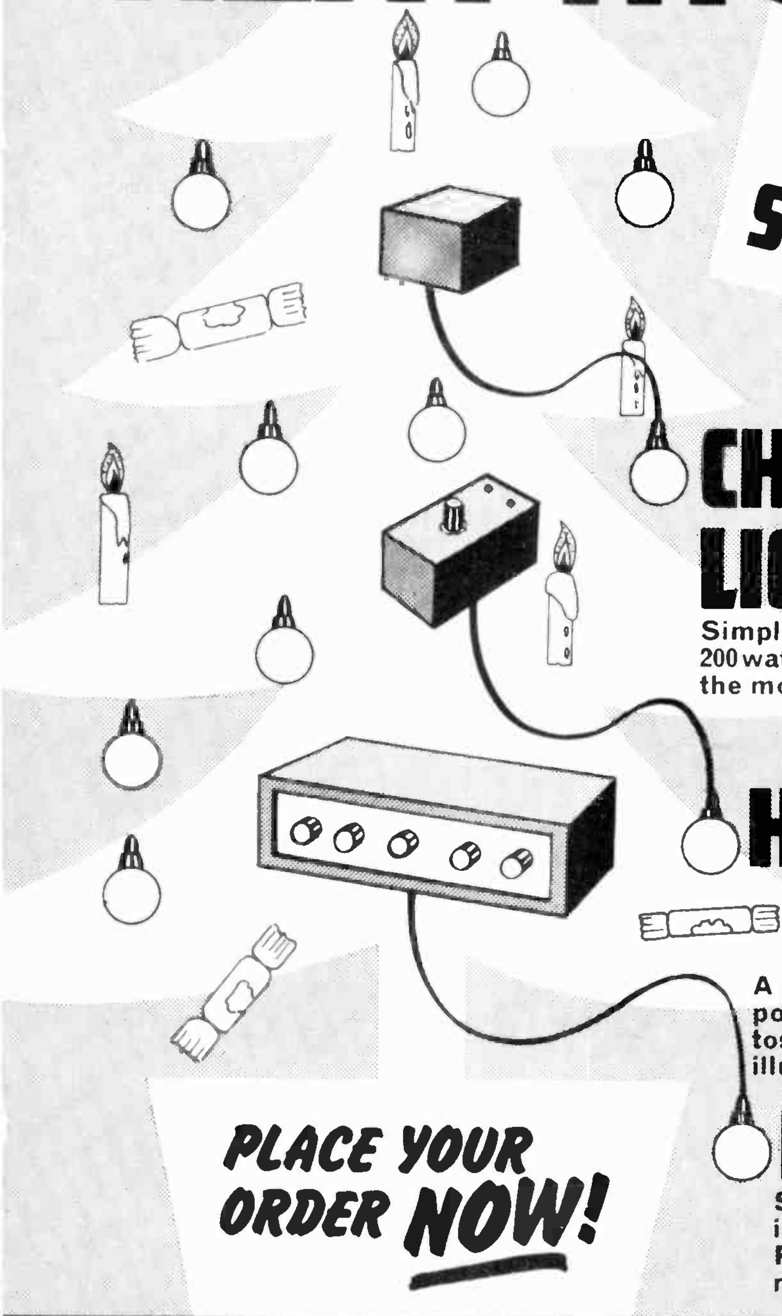
Briefly, for the right-handed player, the guitar is laid on the lap with the fingerboard to the player's left. A thumb pick and two finger picks are fitted to the right hand and these are used to pluck the strings while the left-hand carries the "steel" which is slid along the strings, see photograph. Many different types of steel are known, the two most common types being the "flat" and "roller" steel. The steel and picks should be available from most musical instrument accessory stockists.

FINISH

When you are satisfied that the instrument performs alright, all the fitments should be removed and the guitar well rubbed down with sandpaper and any unwanted holes/indents filled in with Polyfilla or similar filler. The finish—Perspex, paint or whatever will be a personal choice so no details are given.

Finally, the underside surface of the guitar should be covered with a slip resistant material such as baize or canvas. ◼

NEXT MONTH



SPECIAL OFFER! SOLDERING KIT

CHRISTMAS LIGHTS FLASHER

Simple mains powered flasher for lamps up to 200 watts. The flash rate is adjustable to provide the most pleasurable effect.

HEAD & TAILS GAME

A novelty device showing how it is possible to electronically simulate the tossing of a coin. The article also illustrates the operation of the bistable.

AMPLIFIER

Stereo amplifier design using integrated circuits for simplicity. Providing 4 watts r.m.s. per channel output.

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DECEMBER ISSUE ON SALE FRIDAY, NOVEMBER 21

New products and component buying for constructional projects

SHOP TALK

By Mike Kenward

As mentioned last month the Henry's catalogue is now available and we have received our copy. Perhaps its a sign of the times that Henrys' now operate a £2 minimum order charge for mail order, plus minimum 30p post and packing (rising to £1 for parcels and £5 for special items). This is the first "completely new" catalogue from Henrys for three years although most of the items are listed and displayed in much the same way as in previous editions. However what is new is the free price supplement which will be published quarterly available on request—another sign of the times.

The catalogue has about 200 pages with plenty of photographs and line drawings and must be good value at 50p plus 15p post and packing. It contains a 50p voucher that can be used against orders of £5 or more as instructed.

Remaining on the prices theme we note that Home Radio have had to increase the cost of their catalogue due to the increase in production costs—it is now 85p plus 33p post and packing.

Hawaiian Guitar

Not many electronic components are employed in the *Hawaiian Guitar* and those that are should all be readily available. However some of the parts are rather unusual as far as this magazine is concerned.

The magnets used in the pick-up come from door catches and should be available from most hardware stores, the type is quoted in the article. Perspex for the hand rest should also be available from hardware stores if not, a sign manufacturer may be able to help.

There may be problems with buying the wood in some areas, if you have difficulty try a large timber yard or a boat builder if there is one.

The machine heads and strings should be available from shops selling guitars as should some instruction on playing the *Hawaiian Guitar*.

The M218 transformer is available from Zeta Windings, 26 All Saints Road, London W11. The cost including post, packing and VAT is £2·50. Incidentally Zeta make this transformer especially to suit the constructed pick-up and hence no alternative is available.

Egg Timer

Some of the components used in the *Egg Timer* require buying notes; the Bleeptone output device is available from A. P. Besson Ltd., Saint Joseph's Close, Hove, BN3 7EZ. Please send a request for this component by post only, making mention of this magazine and enclosing a cheque or postal order for £2·35. This price includes post. packing and VAT.

The particular type of mercruy switch is available from J. Bull (Electrical) Ltd., for £1·85 including post and packing and V.A.T.

The case for the timer is formed from a piece of drain pipe, it may be necessary to buy a metre length of this unless an off cut can be obtained from a local builder or plumber.

Rain/Water Level Alarm

None of the components employed in the *Rain/Water Level Alarm* should prove difficult to obtain. If your local supplier does not have them some of the big firms will be able to supply mail order. The case used can be virtually any type of a suitable size and there are plenty of commercial aluminium or plastic ones available. Alternatively one could easily be home constructed.

Radio Control Receiver

The first part of a simple short range radio control link the *Radio Control Receiver* should not present the reader with any component buying problems. In fact the only component which may not be readily available is the R.S. reed relay. Doram are the suppliers for this relay and it will cost you £1·33 including post, packing and V.A.T. Incidentally 50p of that is for post, packing and V.A.T. so you can see how much postal charges and tax are now affecting your hobby.

The transmitter to suit this receiver will be published in a few months and a field strength monitor will follow that. The monitor can be used with any transmitter for setting up etc.

Teach-In 76

A brief note for any readers who may have missed the first part of *Teach-In 76* (we are unable to supply any back issues or copies of articles but a local library may keep them). A complete kit of parts for the Circuit Deck and for all the experiments to be described in *Teach-In 76* is available from a number of advertisers, we suggest you go through the advertisements in this issue for prices etc.

Some further points concerning *Teach-In 76* are made under the heading *Teach-In 76 Matters Arising* on page 585.

"Tom hasn't got time to cut the grass—he's busy making a radio control system for the lawnmower."

PHYSICS is FUN

By DERRICK DAINES

COPPER PLATING

Copper plating is a process that everyone finds interesting. It also has the advantage of being useful and reasonably inexpensive. Copper sulphate is sold by most chemists in the form of large blue crystals. Dissolve a few grams in 250ml of warm water and set up the electrolysis arrangement as before, see Fig. 1.

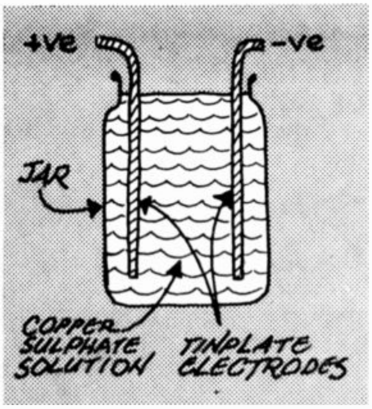


Fig. 1. Electrolysis arrangement for plating.

Almost anything will do for the electrodes—nickel, tinplate, even carbon rods. As a demonstration, carbon rods out of spent batteries are best as the deposits easily show up against the black carbon.

Connect a power source of 2 to 12 volts dc. After a short time the cathode will be covered by a deposit of pure red copper. If you change the polarity of the supply, the carbon that was plated will become black again, whilst the other will receive a deposit of copper. This is the simple principle of copper-plating. In order to plate any metal object, it is simply immersed in the solution and used as the cathode.

Readers with a variable-voltage power supply will notice that as the current is increased, the grains of copper deposited will become larger and will stick to the surface less well. It follows therefore that for the best results, patience and a small current are required.

As a first experiment in this work, it is a good idea to copy a small brooch or ornament such as a cross to be worn round the neck. Press the cross into a blob of plasticine and press another blob over the top. Carefully separate the two halves and remove the cross. Press a matchstick into the meeting faces so that the copper sulphate solution will freely flow into the mould, at several points, see Fig 2.

Now prepare a tiny coil of copper wire as a cathode and fit this into the mold, with one end of the wire sticking out of one of the access holes. Gently place the two halves of the mould together, pinching the extreme edges to make them stick. You are now ready to go.

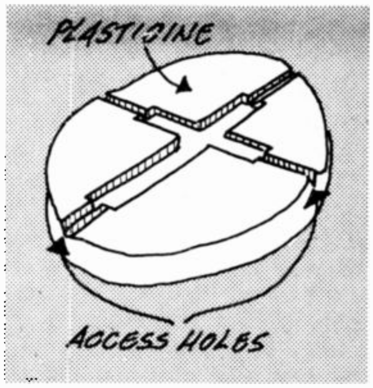


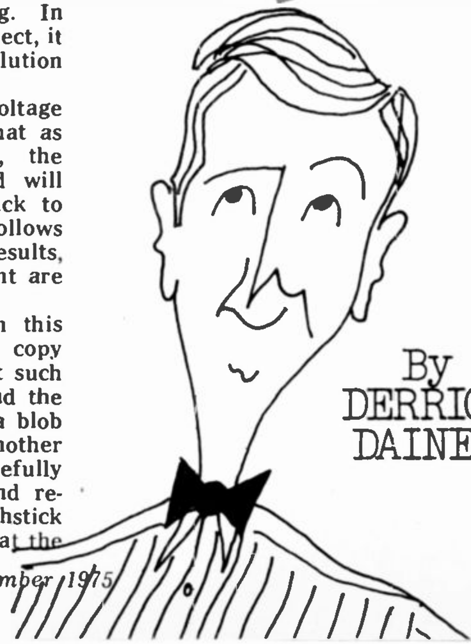
Fig. 2. The mould for making a small cross.

Connect an insulated wire to the end of the coil and lower the whole thing into the copper sulphate solution. Make sure that your coil inside the mould is connected to the negative terminal and switch on. Keep the current very low and go away and find something else to do.

Gradually, the inside of the mould will fill up with pure copper, initially building round the coil. The growing cross will continue to act as a cathode and will eventually continue its growth through and then even outside of the access holes. When this happens, one may be sure that the inside of the mould is full and the current may be switched off. Remove the copy from the mould and file off the surplus before drilling a hole for the chain.

The method has countless applications. In industry it is widely used for plating objects with copper, nickel, chromium, gold platinum and zinc (galvanising). It is worth noting however that some metals do not adhere easily. Chromium does not readily stick to steel, for example. In such cases a primer coating (usually copper or zinc) has to be applied first.

The electrolytic method is also used for the extraction of metals from their compounds.

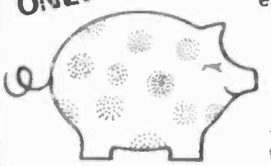


RADIO CONTROL RECEIVER

By R.A.PENFOLD

FOR GUIDANCE ONLY

ESTIMATED COST* OF COMPONENTS
excluding V.A.T.



£4.50

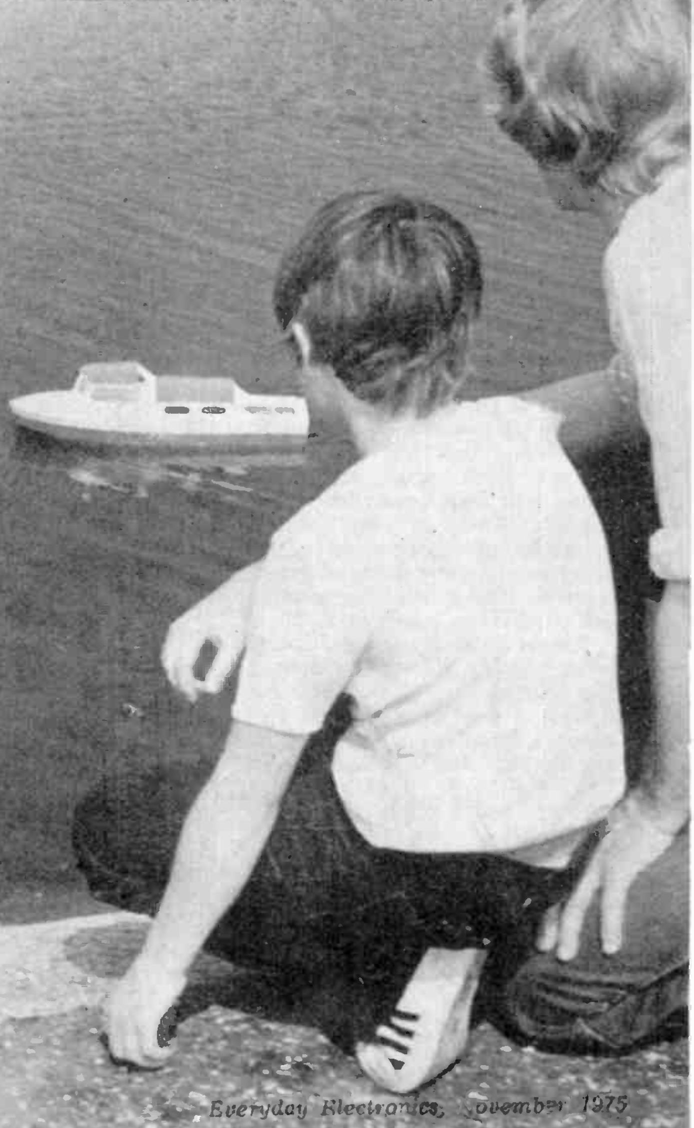
*Based on prices prevailing at time of going to press

A simple design providing single channel control.

ALTHOUGH a few years ago there were many published designs for simple single channel radio control gear, few designs ever appear these days. One reason for this is the advent of the multi-channel proportional r.c. system which allows very precise control of models, and has to a large extent ousted single channel control. This is perhaps a shame, as the complexity of proportional systems has resulted in the majority of r.c. links being commercially built, and there is relatively little scope for the amateur constructor here, especially for the inexperienced constructor. Proportional systems are also very expensive.

This article describes a simple single channel r.c. receiver, and subsequent articles will describe a matching transmitter, and a useful field strength monitor. These provide a low cost r.c. link which is suitable for use with a model boat or a land model, and produces a maximum range of up to about 100 metres.

This equipment does only give a fairly basic link between the controller and the model, with a press button on the transmitter, which when depressed, causes a pair of relay contacts at the receiver to close. However, by employing a suitable actuating mechanism, this system can be used to provide quite sophisticated control.



RECEIVER OPERATION

The receiver has a three transistor circuit, and uses a super-regenerative detector. The unit responds to an audio tone which modulates the carrier wave of the transmitter when the push button is pressed. This is preferable to the system where the receiver responds to the transmitter's unmodulated carrier, as a super-regen. receiver has a rather wide bandwidth, and is less likely to receive interference from any nearby r.c. transmitter with the system adopted here.

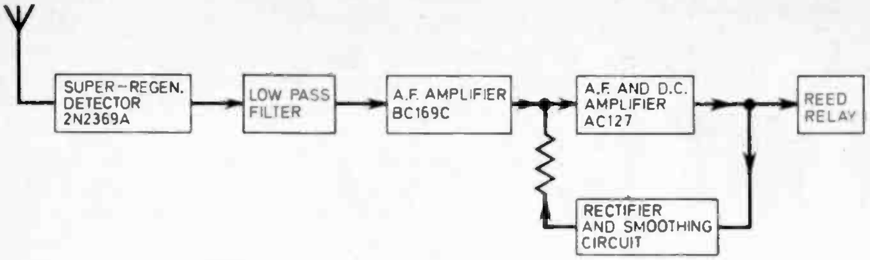


Fig. 1. Block diagram of the various stages of the Radio Control Receiver.

The various stages of the receiver are shown in block diagram form in Fig 1. As will be seen from this, the aerial couples straight to the detector, and the output from the detector is taken to a low pass filter.

A super-regen. detector is a rather unusual circuit in which an r.f. oscillator is continually going in and out of oscillation at a high audio or an ultra-sonic frequency. Since the receiver is designed to respond to an audio tone on the carrier from the transmitter, the low pass filter is necessary to prevent the ordinary output from the detector from causing the relay contacts to be continuously closed. It will pass the relatively low frequency of the modulating tone, but will block the high frequency output of the detector.

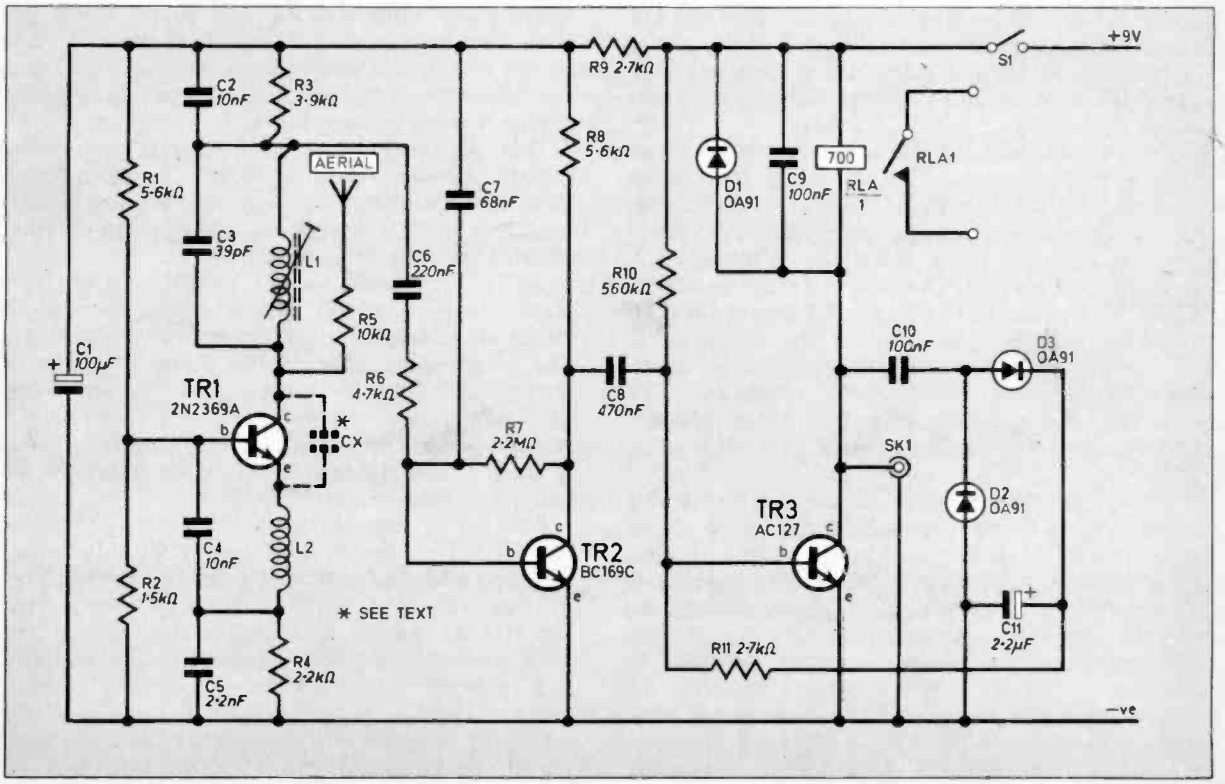
The output of the filter is fed to a high gain audio amplifier. This feeds a reflex amplifier where the signal is first amplified at a.f., and then after rectification and smoothing it amplifies the resultant d.c. signal. This stage thus amplifies the signal twice, and enables a very high gain circuit to be accomplished with only three transistors. The output of the final stage is used to operate a reed relay.

CIRCUIT

A Colpitts oscillator having suitably modified circuit values forms the basis of the detector. This is built around TR1 of Fig. 2, the circuit diagram of the entire receiver being shown in Fig. 2. Feedback for the oscillator is provided by a low value capacitor (CX) connected between the collector and emitter of TR1. In practise this is made by the constructor from two short lengths of insulated wire, which are twisted together.

It is necessary to use only a fairly loose coupling between the aerial and the detector, as

Fig. 2. The circuit diagram of the Radio Control Receiver.



Components....

SEE SHOP TALK

Resistors

R1	5·6kΩ	R7	2·2MΩ
R2	1·5kΩ	R8	5·6kΩ
R3	3·9kΩ	R9	2·7kΩ
R4	2·2kΩ	R10	560kΩ
R5	10kΩ	R11	2·7kΩ
R6	4·7kΩ	All ¼W ±5% carbon	

Capacitors

C1	100µF elect. 10V	C7	68nF
C2	10nF	C8	0·47µF
C3	39pF polystyrene	C9	100nF
C4	10nF	C10	100nF
C5	2·2nF polystyrene	C11	2·2µF elect. 16V
C6	0·22µF		

Mullard C280 except where stated

Semiconductors

TR1	2N 2369A silicon *npn*
TR2	BC 169C silicon *npn*
TR3	AC127 germanium *npn*
D1, 2, 3	OA91 (3 off)

Miscellaneous

RLA1 6-9V 700Ω reed relay (Doram 348-970)
S1 s.p.s.t. slide or toggle switch
SK1 3·5mm jack socket
L1 7mm dia. screw fixing coil former with tuning slug, 24 s.w.g. enamelled copper wire
L2 7mm dia. plain former, 32 s.w.g. d.c.c. or enamelled copper wire
0·1 inch matrix plain perforated board 34 x 18 holes. 9V battery and connectors, crystal earpiece, connecting wire,

otherwise aerial loading effects can prevent the detector from operating. In this circuit the aerial is coupled to the detector via a resistor, this being R5. Coil L1 and C3 form the tuned circuit of the detector.

Resister R6 and C7 form the low pass filter, with a certain amount of filtering also being provided by C2 and C9; TR2 is a conventional high gain common emitter amplifier. Transistor TR3 has the reed relay coil as its collector load, and is biased by R10. The output from the collector of TR2 is fed to the base of TR3 via C8. The amplified signals appearing at the collector of TR3 are fed via C10 to a voltage doubling rectifier circuit using D2 and D3. Capacitor C11 smoothes the resulting signal to a positive d.c. bias which is fed to the base of TR3 by way of R11.

When the carrier wave of the transmitter is unmodulated there is no significant audio signal present at TR3 collector, and so only a minute bias voltage is produced. When the carrier is modulated, a bias which is large enough to largely increase the base bias of TR3 is produced. This causes the collector current of TR3 to increase to a point where the relay is activated.

Removing the modulation on the carrier will, of course, remove the additional base bias and the relay contacts will open again. Diode D1 protects TR3 against the high reverse voltage produced across the relay coil when the supply voltage is removed. Components R9 and C1 provide supply decoupling, and S1 is the on off switch.

Power is obtainable from a 9 volt battery, and the current consumption is about 9mA with the relay contacts closed, and 3·5mA when they are open. A crystal earphone can be plugged into SK1, and this helps with the setting up of the receiver, as described later.

WIRING

With the exceptions of the battery, on/off switch, and SK1, all the components are wired up on a plain 0·1inch matrix s.r.b.p. panel. This has 34 x 18 holes, and can conveniently be a piece cut from a 146mm x 50mm board, using a small hacksaw. The component layout and underside wiring of the panel are shown in Fig. 3. The few other connections required to complete the receiver are also shown in this diagram.

Before mounting any of the components, drill the two 6BA mounting holes using a No. 31 twist drill. Also drill the mounting holes for L1. This is wound on a 7mm former, most of which require 8BA mounting bolts (No. 42 drill).

Then mount the former and the other components in the positions indicated in Fig. 3. Mount a solder tag on one of the securing bolts of the former of L1.

The board is then turned over and the component leadouts are bent over at right angles against the underside of the board. They are then wired up as shown in the diagram. In any places where the leadouts are too short to reach one another, use 20 s.w.g. (approx.) tinned copper wire extension leads.

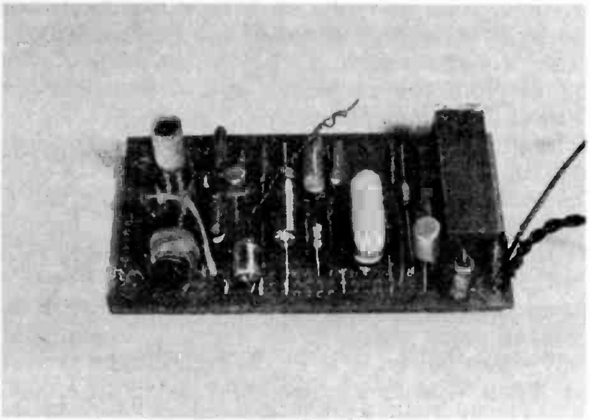
Two 50mm lengths of 24 s.w.g. enamelled copper wire are used to form CX. After these have been soldered in, they are twisted tightly together over a length of about 1 to 2 cms., where they emerge from the panel.

Coil L2 is wound on a 1·5cm length of 7mm plastic former, which will probably have to be cut from a longer length using a small hacksaw. The winding consists of 100 turns of 32 s.w.g. enamelled or double cotton covered d.c.c. wire. This is scramble wound, and some adhesive is smeared over the completed winding to prevent it from springing apart. It is then glued to the panel and soldered into circuit.

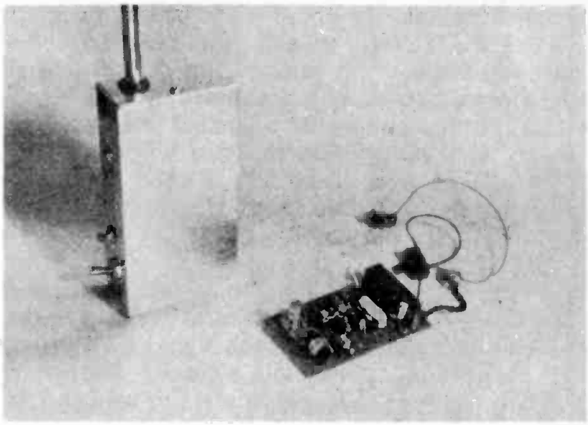
Coil L1 is wound using 24 s.w.g. enamelled copper wire. Take a short length of this (about 250mm) and solder one end into position. Keeping the wire taut, wind 10 turns of wire around the former, neatly in a single layer. Then prepare and connect the second end of the wire. Try to keep the wire tight so that the winding remains rigid.

Finally, connect S1, the battery, and the short aerial lead connecting to the solder tag on L1.

The receiver circuit panel.



The receiver together with the transmitter to be described in a future issue.



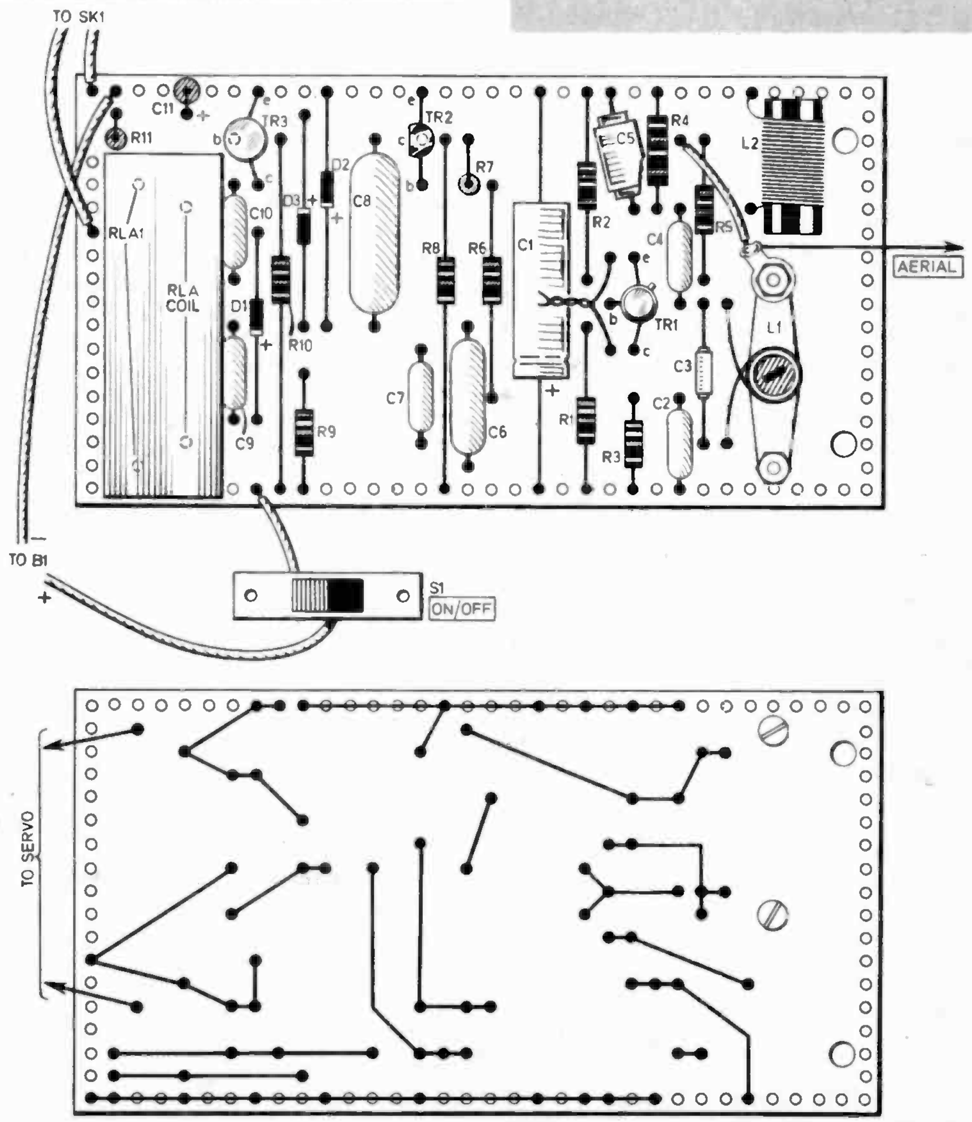


Fig. 3. Layout and wiring of the Radio Control Receiver. Readers are advised to follow this exactly.

ADJUSTMENT

Connect a 9 volt battery to the clips (PP3 or PP6) and connect a short length of wire to the aerial terminal, say about 30 to 60mm. Connect a crystal earphone to SK1 and switch on the receiver. Adjust the tuning slug of L1 so that it is screwed a little way down into the coil.

A slight hissing should be heard from the earphone, and by twisting the two wires forming CX together over a greater length, it should be possible to obtain a much louder hissing sound from the earphone.

An operating r.c. transmitter is placed near the receiver, and using the plastic trimming tool, the core of L1 is adjusted to search for the transmitter's signal. When the signal is received, the background noise will virtually disappear, and any tone used to modulate the transmitter will be heard from the earphone. If the setting of the core of L1 is greatly altered from its original one, the two wires forming CX will probably need some slight readjustment. Other factors, such as the length of the aerial, may also have some effect on the required adjustment of these leads.

In order to obtain maximum sensitivity from the receiver it is important that the set is tuned accurately. When the receiver is finally installed in the model it is a good idea to use a spot of glue on the core of L1 to ensure that vibration does not alter its setting. It is also important that CX is adjusted properly. The two wires should be twisted together sufficiently to produce a loud hiss from a crystal earpiece connected to SK1, but care must be taken not to twist them together over too great a length. This would result in a rise in the pitch of the noise from the earphone, and a very marked loss of detection efficiency.

A length of wire or a telescopic antenna can be used as the aerial. This should be as long as practicable. It is essential to have the aerial in a vertical or nearly vertical position.

Do not mount the receiver with the underside wiring touching a material which is an electrical conductor, or even a partial conductor, such as wet or damp wood. If the receiver is mounted anywhere where it is in danger of getting wet or damp, it should be enclosed in a plastic case.

RELAY

The specified reed relay is quite inexpensive, but only has s.p.s.t. contacts with maximum ratings of 200mA, 600V, and 5W. This is adequate for some actuators, but many constructors will require additional contacts with a greater power handling capability.

If a 6 volt relay having a 700 ohm coil and suitable contacts can be obtained, this can be connected in place of the specified relay. Alternatively, the reed relay can be used to control a high speed slave relay having the required contacts.

READERS' LETTERS

Colour Bind

Your reader P. H. Alley (Readers Letters September '75) says the colour code follows no logic. I would suggest that a short experiment with a box of child's paints will show that there is some logic in it.

Start by looking at the first three colours, black, brown and red. Try mixing the two outside colours (black and red) and what do you get brown! Now mix red and yellow and you get orange. So the pattern starts to emerge. The colours representing the odd numbers are the result of the mixing of the even number colours on either side of them together i.e. black and red gives brown, red and yellow make orange, yellow and blue make green. But then unfortunately the pattern falls down somewhat! Blue and grey do not quite make violet, but if you hold tongue in cheek violet and white do make a colour that resembles grey, at least the grey that most manufacturers seem to use for marking a sort of pale violet that sometimes makes it difficult to distinguish seven from eight.

Thank you for your excellent magazine, I especially like the articles on construction and finishing techniques. As I work in electronics I know the way a manufacturer produces equipment but it is a different kettle of fish trying to produce a "finished" job at home.

B. H. Eden,
Berks.

My favourite mnemonic for the colour code is:

Better Buy Resistor Or Your Grid Bias May Go West

which will impress the code firmly in your mind.

Derek Ground,
Teaching Support Services Officer,
London Graduate School
of Business Studies

Presumably the "M" of may is for mauve instead of violet—ed.

Ref. resistor colour code Aide-Memoir' (E.E. Sept) may I offer my version.

Black	**Black**
Beetles	**Brown**
Running	**Red**
On	**Orange**
Your	**Yellow**
Garden	**Green**
Bring	**Blue**
Very	**Violet**
Good	**Grey**
Weather	**White**

R. F. Lapidge,
Berks.

The FIELD EFFECT TRANSISTOR

PART 2

By J. B. DANCE

In this, the second and final part, we discuss applications and testing.

APPLICATIONS

Field effect transistors are active devices (like transistors and valves) and can be used in amplifier and oscillator circuits, etc. Economical epoxy encapsulated f.e.t.s have become available in recent years, their prices being comparable with that of transistors. Nevertheless, the typical f.e.t. is still more expensive than the average transistor—presumably because transistors are sold in far greater numbers than f.e.t.s.

In general, f.e.t.s are used in circuits together with transistors. Junction f.e.t.s may be employed as the first stage of a circuit where a low noise device of fairly high input impedance is required (such as in capacitor microphone preamplifiers and in nuclear preamplifiers, etc.). The high input impedance of f.e.t.s also enables them to be used in the first stage of oscilloscope amplifiers.

Generally, a m.o.s.f.e.t. has an inferior noise performance to a junction f.e.t., except at very high frequencies. Both types of device can be used as radio frequency amplifiers.

Tetrode junction f.e.t.s have been used as intermediate frequency amplifiers, the signal being applied to one of the gates and the automatic gain control voltage to the other gate.

The m.o.s.f.e.t. is particularly useful in digital switching circuitry. It is usually incorporated into integrated circuits for this application.

Junction f.e.t.s operated at a low drain voltage may be used as voltage controlled variable resistors. If the applied drain voltage is less than about $V_p/3$, the drain current is approximately proportional to the drain voltage. Such variable resistance devices may be used in circuits for the automatic balancing of Wheatstone bridge type circuits, etc.

Many electrometer instruments (such as pH meters) now use m.o.s.f.e.t.s in their input stages in place of the electrometer valves used in the past. The input current must be very low.

BASIC CIRCUITS

The f.e.t. is normally used in either the common source or the common drain circuit see Fig. 13.

The common source circuit is comparable with the common emitter transistor circuit. It provides the largest voltage gain.

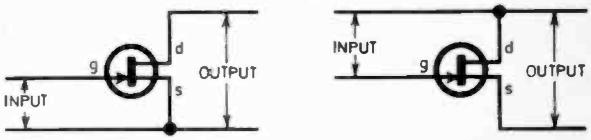


Fig. 13. The basic common source and common drain circuits.

The common drain (or source follower circuit) is like the common collector transistor circuit. It does not provide voltage amplification, but is the circuit with the highest input impedance and the greatest stability.

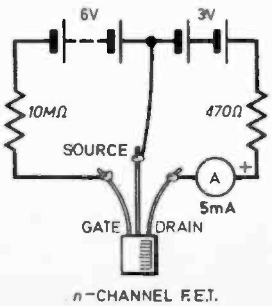
TESTING

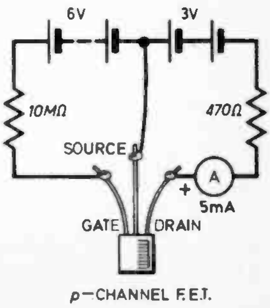
The circuit of Fig. 14 may be used for the testing of *n*-channel junction f.e.t.s and that of Fig. 15 for *p*-channel junction f.e.t.s. The polarity of the gate is opposite to that of the drain relative to the source and therefore a battery with a number of tappings is desirable for use in these circuits. A 9 volt grid bias battery is ideal.

The gate is initially connected to the source (instead of to the 10 megohm resistor shown in the circuits). It will be found that the meter needle indicates a current of about 3 milliamps, varying somewhat with the channel resistance of the f.e.t. The 470 ohm series resistor limits the current flowing to about 6 milliamps even if the source is shorted directly to the drain.

When the gate is connected to the 10 megohm resistor, the diode formed between the gate and

Fig. 14 (left). Circuit for testing an *n* channel junction f.e.t.
Fig. 15 (right). Circuit for testing a *p* channel junction f.e.t.





the channel is reverse biased. The greater the reverse bias, the narrower the channel width and the smaller the current which flows in the drain circuit. Connection of the gate to the 10 megohm resistor in the circuits shown will cause the drain current to fall to zero when most types of f.e.t. are being tested.

The upper end of the 10 megohm resistor in the circuit of Fig. 14 may be returned to a negative voltage of less than 6 volts and the drain current should increase as this negative bias is reduced. It will increase further if the resistor is returned to a small positive potential relative to the source. Opposite polarities may be used with *p*-channel devices.

It is interesting to note that the value of the resistor in the gate circuit can be increased to over 1,000 megohms without the value of the drain current being greatly affected by the value of this resistor. One may use one's own body as the connection between the gate electrode and the battery tappings.

The same type of circuit may be used for the testing of a depletion m.o.s.f.e.t. However, care should be taken to ensure that the gate is connected to the source during the setting up of the circuit and during the time any alterations are being made in order to avoid the possibility of breakdown of the gate insulating layer.

The upper end of the 10 megohm resistor in these circuits may be connected to points on the battery which are first positive and then negative with respect to the source, since these devices can operate with gate potentials of both polarities.

An enhancement m.o.s.f.e.t. can also be tested with the same basic circuits. Little current should flow when the gate is connected to the source. The upper end of the 10 megohm resistor should be connected to the drain (instead of being connected as in the Figs. 14 and 15). When the lower end of this resistor is connected to the gate, a drain current should flow.

TESTING UNKNOWN DEVICES

When an unknown device with unknown connections is to be tested, one may first ascertain whether any two leads can be found which pass a current in either direction. If so, these are the source and the drain connections.

These conduction tests may be performed by connecting pairs of leads in turn between the source and drain connections in the circuit of either Fig. 14 or Fig. 15.

If the third lead, the gate, conducts in one direction only to either of the other two leads, the device is a junction f.e.t. If this conduction takes place when the gate is positive, the device is an *n*-channel device. The gate of a *p*-channel device conducts when it is negative with respect to either of the other electrodes.

It is not easy to determine which electrode is the source and which is the drain, since these leads are to some extent interchangeable.

If the gate lead does not conduct in either direction to either of the other leads, the device is a m.o.s.f.e.t.

The channel of an enhancement m.o.s.f.e.t. will conduct only when a suitable gate potential is applied. Nevertheless, it is possible to ascertain the device type by simple experiments.

If the unknown device has four leads, one of them will probably be connected to the case. The leads of such a device should therefore first be tested in turn to find if one of them is connected to the metal case of the device, since one can then use the other three leads for the tests outlined above. Alternatively, the device may be a tetrode junction f.e.t. ■

READERS' LETTERS

More Colour

I would like to point out to P. H. Alley (Readers' Letters September 1975) that the resistor colour code is mainly based on the spectrum. That is to say red, orange, yellow, green, blue, violet; indigo is not used because it is too close to violet in colour and would cause confusion. The black, brown, grey and white, are used to give four extra different colours required for the numerical values of 0 to 9.

A further point which may be of interest is that a tolerance of ±2 per cent is noted by a red ring instead of gold and silver. I would like to conclude my letter by saying how much I enjoy reading your magazine and especially *Your Career in Electronics* by Peter Verwig.

W. G. Mather,
Nottinghamshire.

Photo crop

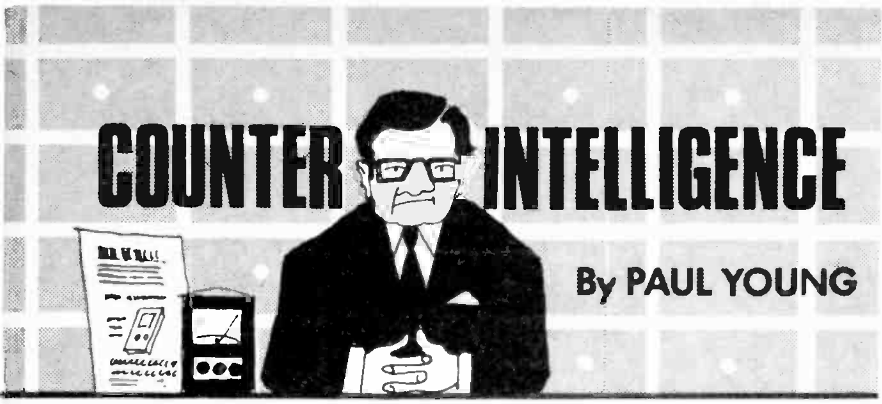
To put it mildly, British Police are useless! The present food prices are tempting thieves who can remove crops of potatoes, apples etc. (They are getting away with it too, so far).

Can an electronic device, which will trigger a camera taking a picture of apples being stolen, be inserted in E.E. (The same circuit would be flexible enough for the potato crop also.)

Just a thought for O.A.P.'s who are being hit by these vandals. Police cars are too comfortable methinks!

R. Wibberly,
Nottingham.

P.S. All this—and greenfly!



COUNTER INTELLIGENCE

By PAUL YOUNG

ONE of the most important qualities you need for electronics is patience, not, that this makes electronics unique, far from it. Several years ago, for my sins, I used to teach people to fly, and as they approached the point, when they were ready to make their first solo flight the weather had to be one hundred per cent perfect.

I remember a friend of mine who came to the aerodrome week after week and each time I would have to say to him "It's no good this week Alec, the wind is too strong". After about six weeks of this, he arrived one day and I said to him, "It's no good this week Alec, there's no wind". The expression on his face should have been preserved for posterity. However Alec possessed that one vital quality, patience, and he became an excellent pilot.

I might almost be inclined to say "Show me a man with no patience and I'll show you a man without a hobby!" You will now be saying, "How does all this concern me". Well in the first place although you are bound to have occasional failures, those will serve to highlight your successes, but as your mentor on supplies, I am thinking more of the frustration caused by delay that will from time to time occur, in the delivery of that vital part. Let me explain how it happens.

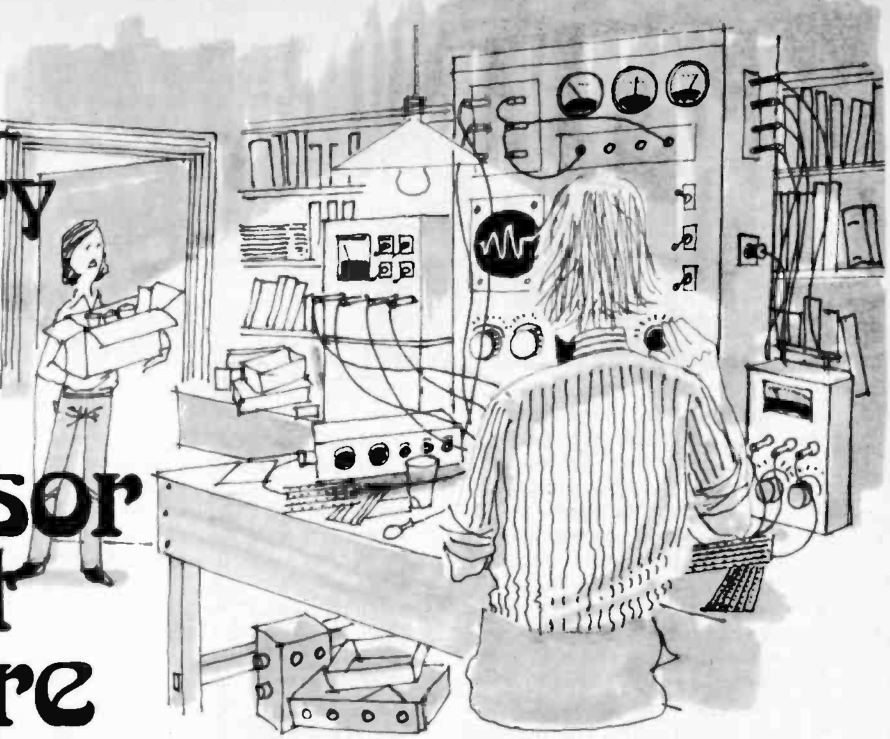
The magazine boffins first produce the designs and they are always most painstaking to see that all the parts they specify are freely available. Sometimes they even send out advance lists, so we can make sure we are carrying adequate stocks. Now comes the first stumbling block. I and my fellow dealers, scan the lists and check our supplies, but what we cannot forecast is how popular any particular circuit will be.

We try to use our judgement based on past experiences, and order accordingly, but in these days of cash shortage, we cannot be too rash in our buying. The second obstacle is this, the circuit may specify a component of which we sell thirty or forty a year, and suddenly it catches on.

This item might be made by only one manufacturer, and his usual demand might be for three or four hundred a year, suddenly this swells to over five hundred a week. Consequently his delivery time which was probably ten to fourteen days lengthens out to four weeks, then six, then ten.

I think you will appreciate that the poor old dealer is fairly helpless to do much to alleviate the situation, so whatever you do, do not blast him but try to order well in advance of your requirements.

The Extraordinary Experiments of Professor Ernest Eversure



by Anthony John Bassett

Professor Ernest Eversure, or the Prof. as his friends call him, has been experimenting in electronics for more years than anyone can remember and we thought that you might like to hear of, and perhaps repeat, some of his extraordinary experiments. Anthony J. Bassett recounts some of these experiments every month so why not follow the Prof's work and learn along with young Bob, his friend.

Bob was fascinated by the extraordinary experiments which The Prof. carried out in his amazing laboratory, and although he knew quite a lot about some of the Prof's experiments, he always realised that there was a tremendous lot that he did not know. Indeed some of the experiments, with strange odours, banks of flashing lights and moving meters, extraordinary sounds and vibrations, and computers, robots and apparatus of outrageous appearance, whet Bob's appetite and curiousity enormously. He was burning to know more about the experiments which the Prof. carried out when Bob was not in the lab., as the Prof. was always so helpful whenever he knew that Bob was around, he spent a lot of time explaining things.

What Bob now wanted was to see more of the Prof's own experiments in action, and he set out to spy secretly, and find out more of what went on! He crept silently into the Laboratory—and immediately became aware that something unusual was indeed going on!

The Prof. was communicating with his experimental robot, and Bob noticed that the robot was coupled to a huge computer by way of a two-way laser communication beam, and also connected to a rather special-looking transmitter, amplifier and loudspeaker. Could it be that the Prof. was programming the Robot for speech? Bob wondered; but he was soon to find that the Prof. had transcended that idea!

As the Prof. communicated with the Robot in his usual code of clicks and whistles, the Robot's replies came in quite a different manner. In between the clicks and whistles, Bob became aware of beautiful harmonious sounds. At least he thought they were sounds—he was not quite sure whether they didn't simply appear in his head! This reminded him of another electronic device which actually enables deaf persons to "hear" without direct application of sound waves.

From what Bob could remember, the ingenious apparatus operates by means of a high-frequency electrical signal coupled electrostatically to the person who receives it.

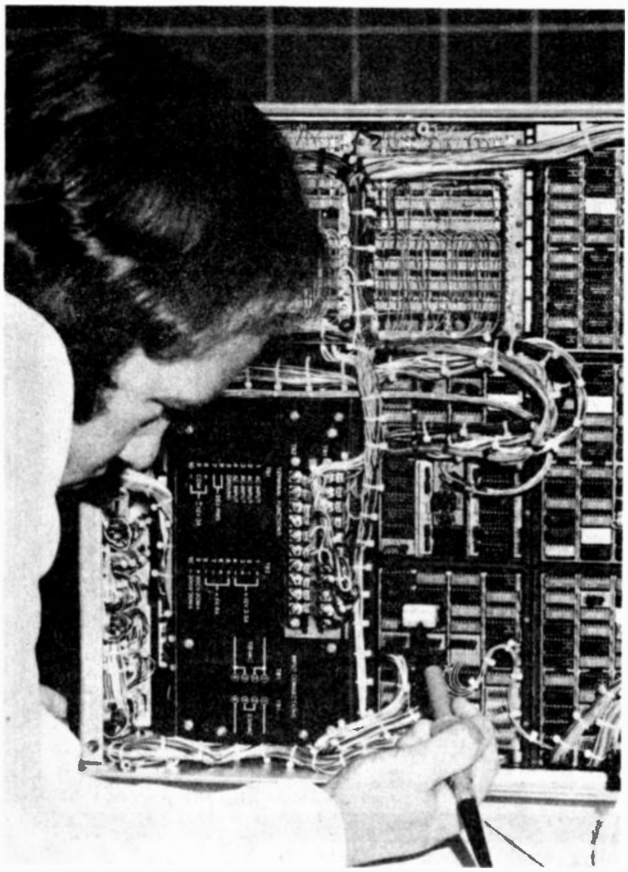
The audio frequencies are taken to the recipient by means of this oscillation which may have a frequency of 100kHz or more. Somehow the recipient is able to sort this out as "sound".

Although this does not appear to be closely related to bone conduction which involves audio frequency sound wave vibrations rather than a 100kHz modulated electrical signal, there is another phenomenon to which it seems likely to be related known as "electrophonic hearing".

This was first observed by one of the great pioneers of early electrical research, Volta, and the "sensation" of sound has been produced by passing currents of less than 30mA through the head from batteries of various voltages between 1 and 5 volts to obtain frequencies between 200Hz and 17kHz.

"Could this have been the first human voltage-controlled oscillator?" Bob speculated!

Whilst these thoughts were going through his mind a reel of printed paper had been gradually issuing forth from the computer. It appeared to carry the Robot's message in written form. Bob crept towards the computer in order to read the message without being observed by the Prof.! Here is what he read:



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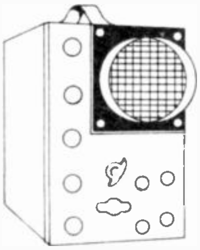

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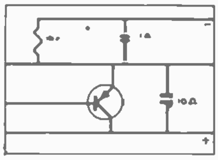

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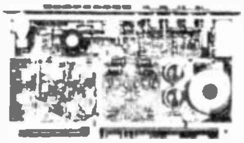

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Upon reading this, Bob realised that the game was up! The Prof. and his Robot had been aware of his approach right from the start, and with all their electronic gadgets to assist, they were much better able to spy on him, than he to spy on them! The old adage; "If you can't beat 'em, join 'em" seemed suddenly very appropriate.

"Prof., why is the printout from this computer so full of i's"? he asked.

"I am using the Robot in an experiment on a form of communication which I hope will overcome some of the limitations of speech. At this stage I have succeeded in translating the vowel sounds into a form of higher vibration which the computer can only represent as "i". There is still some difficulty with consonants.

"This is how it sounds at the present stage of development:" (As the Prof. continued, Bob heard once more strange harmonies like those which he had heard from the Robot).

"Whin I hivi mistirid thi cinsinints thiri will bi ni miri niid fir wirds!" came the printout from the computer.

"But now," the Prof. continued, I can see that you're very interested in some of my experiments, and in order to comprehend them better, you must build up some more on your basic learning."

TEST GEAR

Bob knew that the Prof. was right, and prepared himself for some more experiments on testing and selection of components.

"We have already done some experiments on in-circuit testing of components, and in the experiments on souping-up a superhet we saw how adjustments can be made to compensate for component variations discovered by 'in-circuit' tests. But in-circuit tests, and those tests made on separate forms of apparatus, are complementary to each other. This is because the 'out-of-circuit' tests usually aim to simulate some of the requirements and conditions which the component might meet when it is used in the circuit for which it is intended."

"What does that mean, Prof.?" Bob wanted to know.

"One of the most usual requirements of, let us say, a transistor, is that it shall amplify. So one of the most common types of test-apparatus for transistors is a gain tester which will measure the gain of devices under a variety of conditions.

By measuring the gain of a transistor at low current, we may assess its suitability for use in a pre-amplifier, as the low-current test simulates conditions in most types of pre-amplifier.

By measuring the gain of a power-transistor at high-current, we may assess its suitability for use in a power-output or high-current switching stage."

"Prof.," broke in Bob, "Electronic components appear to have a tremendous number of different properties. With transistors, for instance, I can see from the specifications sheets and books that as well as gain, there are noise figures, voltage figures, maximum current, frequency response, switching times and hosts of others. How can a learner like me do anything really worthwhile in electronics without spending ages studying all these things?"

Trust the Prof. to have a ready answer to this agonised question!

"Some people study all these theoretical questions without doing much practical work, whilst others seem to fumble around with components without any theoretical knowledge. It seems best to me to strike a middle path by doing as much practical work as your theoretical knowledge, together with the advice of persons of wider knowledge and experience, will allow.

"It is very easy to test the d.c. current gain of a transistor, or to build a gain tester for yourself as there are dozens of published designs. But if you wish to know the maximum current-rating, or the maximum power rating of a transistor, then it is best to take the maker's advice on this, as it is not easy for you to test these ratings without risk of damaging the component under test!"

"However, it is quite easy to test the breakdown voltage of transistors, and some diodes and thyristors, for yourself, and see how they compare with the maker's specification. These tests are very interesting, and I think it would be well worthwhile for you to consider building your own tester." Details next month.

JACK PLUG & FAMILY...

DOWN TO EARTH

By GEORGE HYLTON

CLICKS AND CRACKLES

Mr. Roy Cheers of Warrington writes: *"Both my cassette recorder and stereo amplifier contain power supplies which have large capacitors for voltage smoothing. Yet when an appliance is switched off elsewhere in the house, a loud crackle is heard from the loudspeakers. Why doesn't the smoothing capacitor prevent the crackle, and what would prevent it?"*

First, let me congratulate Mr. Cheers on a very clear description of the situation. In particular, he notes that the crackles occur when an appliance is switched *off*.

Most appliances contain motors, which, electrically speaking, are inductances. When an inductive load is switched off, there is a great chance of producing the kind of high-voltage impulse which can give rise to a crackle if it gets into audio equipment. This, after all, is how an ignition coil works: the high-voltage impulse which produces the spark when the current from the car battery is switched *off*.

SMOOTHING

The problem is, how does the impulse get into the audio gear? With all that smoothing, an impulse coming in through the mains transformer and rectifiers must be very heavily attenuated before it reaches the d.c. supply line of the audio equipment, and it will be attenuated still further before it gets to the low-signal-level parts of the circuit, where it is most serious. Still, it might just break through. It depends how big it is to begin with.

If the initial impulse is 1000 volts, and it is attenuated a millionfold there's still a millivolt left, and a millivolt at the input of a tape recorder is a sizeable signal.

INDIRECT ROUTES

Very often, however, switch-off impulses get into the equipment by rather more indirect routes. One is by magnetic induction.

The surge of current caused by a switch-off impulse (I'm going to call them "spikes" from now on) produces the inevitable magnetic field. This induces a voltage into any conductor, the closer the stronger. In particular, it's liable to induce a voltage into the *screening* of an input lead to a bit of audio equipment. You might well think that this won't matter. Screening is for keeping unwanted voltages *out*.

Unfortunately, it does matter, unless the screening happens to be round a pair of audio conductors which are balanced to earth. Domestic audio gear seldom incorporates this expensive refinement. A voltage in the screening of an unbalanced input connection (such as the usual coaxial lead) does get into the equipment.

EARTH CONNECTION

That's one indirect route. But there are others, of which the most important are concerned with the way in which a bit of gear, or the mains, is *earthed*. Or, more probably, the way in which it *isn't earthed* when it ought to be! It can happen when the audio gear isn't earthed as is often the case when battery equipment such as cassette recorders is worked off the mains with the help of an eliminator. In most cases there's only a two-lead mains cable, live and neutral but no earth.

It can also happen when the chassis of the audio gear is duly connected to the mains earth but something has gone wrong with the actual earth connection—a dry joint, say, or an incompetent bit of mains wiring. I'm inclined to suspect a faulty mains earth in the present case, so I'll explain what happens in some detail.

The mains earth isn't really earthed. Only the live and neutral are really connected. What happens when a spike runs through the mains wiring on the live and neutral sides only? There has to be some mechanism whereby the spike gets to the sensitive part of the audio gear without going through the smoothing circuits.

Now, both sides of the mains have a capacitance to earth. This capacitance charges up. There are innumerable paths to earth through which it can charge, and some of them go through the audio equipment. In particular, some go through the input circuitry of the audio equipment, and as we've noted already, a very small voltage here produces a big noise in the loudspeaker.

R.F. INTERFERENCE

Yet another way in which the crackles and clicks caused by switching off appliances can get into audio gear is as radio frequency interference. As everyone knows, radio sets also pick up crackles and clicks. This is because any voltage which changes very suddenly, especially if it causes arcing at switch contacts, as switching off an appliance does, contains radio frequency energy. (In the old days, the first practical transmitters, spark transmitters, depended on this fact). A *strong* r.f. impulse, picked up by the input leads of the audio gear, may get rectified by the transistors in the equipment to produce an audio impulse.

To sum up, the crackles could be caused by several things, but the most likely cause is some kind of earthing fault. This, then, is the first thing to check—with all due caution since it's the mains we are examining.

If the trouble is caused by induction, there's not a lot to be done about it other than fitting r.f. suppressors to the appliances, which can be an expensive business.

Finally, it's worth bearing in mind that useful information about how the crackles are getting into a bit of audio gear can often be gleaned from the volume control. If the crackles are just as bad with volume at minimum as they are when it's at maximum, then it's a fair bet that the unwanted voltages are somehow bypassing the input circuitry on their way into the equipment.

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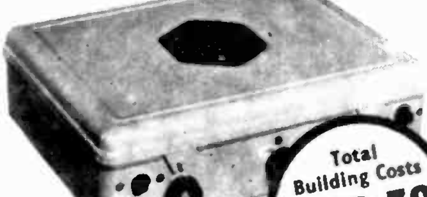

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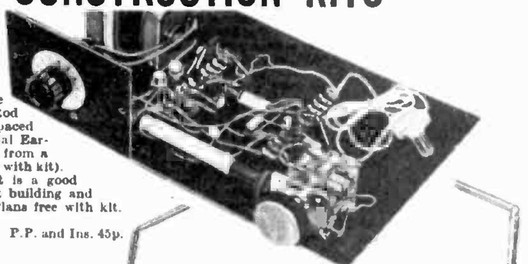

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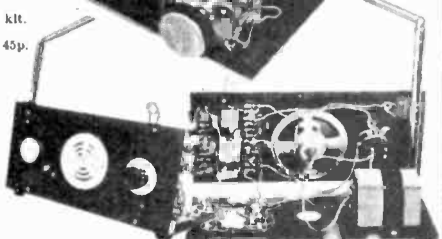

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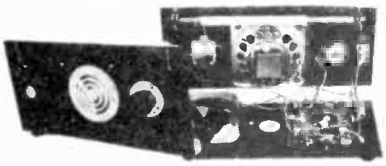

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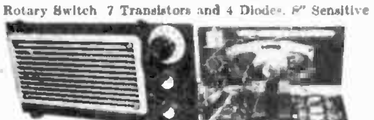

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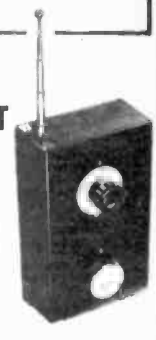

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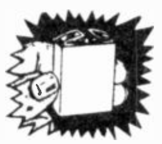

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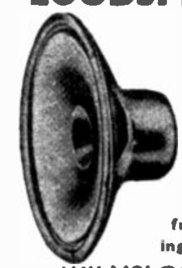

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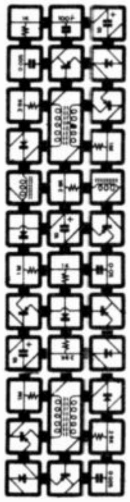

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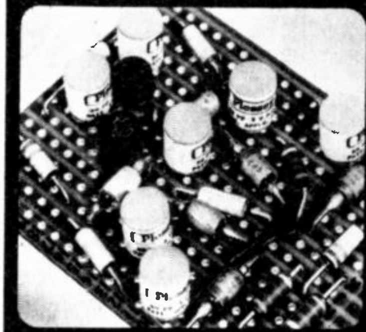

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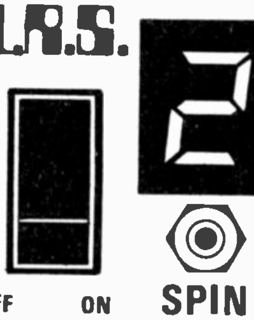

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