PRACTICAL

ELECTRONICS

SEPTEMBER 1973

20p

QUADRAPHONIC

FOUR CHANNEL SOUND

PE RONDO

COMPLETE SQ SYSTEM FOR THE CONSTRUCTOR

Also: Phasing Unit • Photographic Thermometer & Exposure Meter

PRACTICAL
ELECTRONICS

VOLUME 9 No. 9 SEPTEMBER 1973

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

Our October issue will be published on Friday, September 14, 1973

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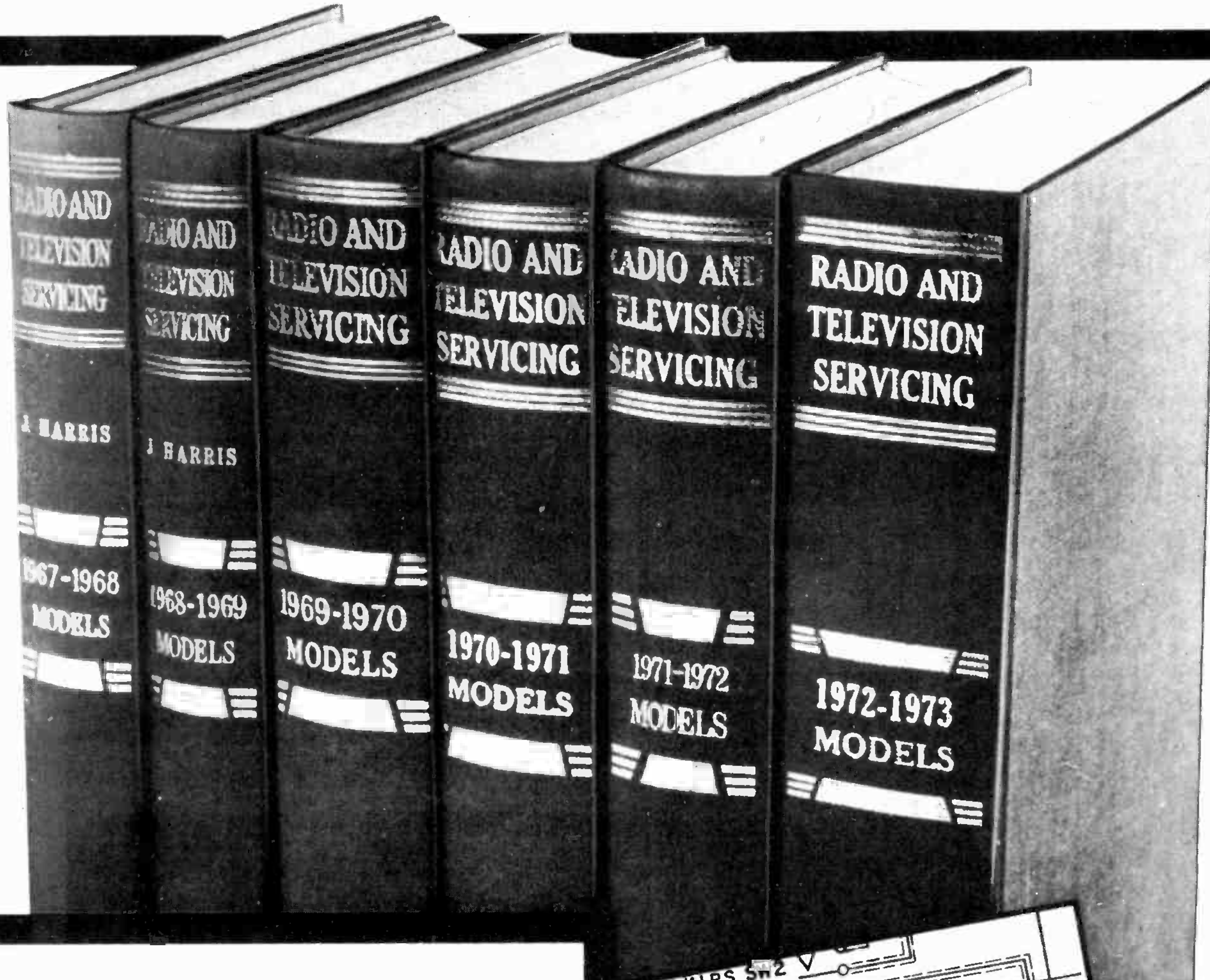
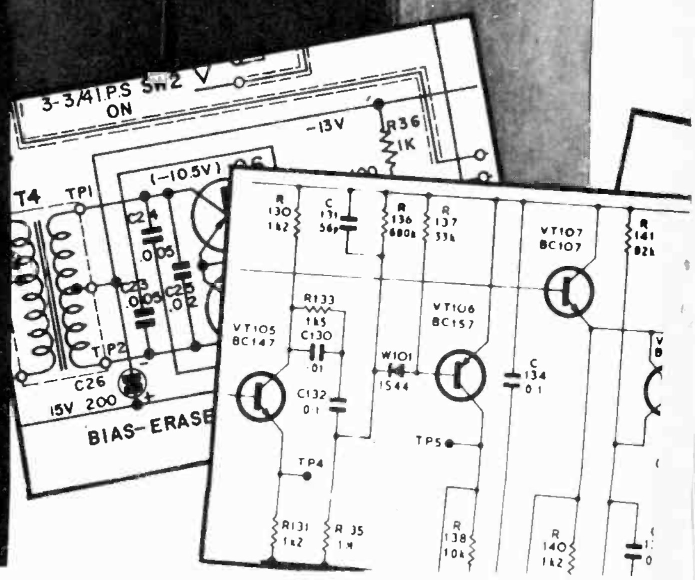
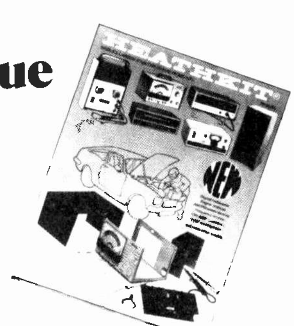
RADIO & TV SERVICING



Essential data for over 1500 popular models

With this vast 6-volume library at your fingertips you have all the necessary servicing data you need covering almost every popular model from 1967 to the very latest on the market today. And not only radio and TV but stereograms, record players and tape recorders too. Much of the earlier information on this equipment is quite unobtainable elsewhere and *Radio & TV Servicing* is now the only available source of technical data. The 1973 edition, now ready, brings the library right up-to-date with abstracts from manufacturers' service bulletins issued during the past year. *Radio & TV Servicing* is the only work of its kind – a money-spinner that no service engineer should be without.




HEATHKIT

Sinclair Project 60

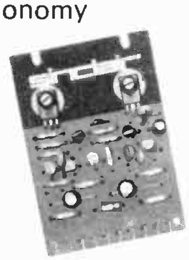
Now—the Z.50 Mk.2

with built-in automatic transient overload protection

When originally introduced, the Sinclair Z.50 proved how it was possible to design and produce a popularly priced modular power amplifier having characteristics to challenge the world's costliest amplifiers. Many thousands of Z.50's are now giving excellent service day in, day out. But we have also learned that constructors do not always use their Z.50's ideally. That is why we have introduced modifications whereby risk of damage through mis-use is greatly reduced and performance further enhanced. The Z.50 Mk.2 has improved thermal stability, more accurately regulated D.C limiting to ensure more symetrical output voltage swing and clipping and still less distortion at lower power. Z.50 Mk.2 is compatible with all other Project 60 modules, and may be incorporated to advantage in existing systems. Eleven silicon epitaxial planar transistors are now used, two more than in the original Z.50; circuitry has been re-designed, making this versatile high performance amplifier better than ever.

with free manual
£5.48

Z.30 the power amplifier for quality and economy

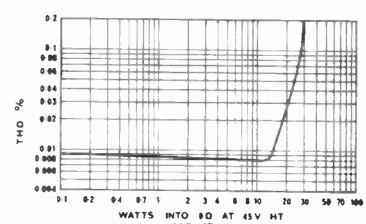


with free manual
£4.48

The Z.30 provides excellent facilities for the constructor requiring a high fidelity audio system of less power than that available from Z.50's. Using a power supply of 35 volts, Z.30 will deliver 15 watts RMS into 8 ohms, or 20 watts RMS into 3 ohms using 30 volts. Total harmonic distortion is a fantastically low 0.02% at 15 watts into 8 ohms with signal to noise ratio better than 70 dB unweighted. Input sensitivity 250mV into 100K ohms. Size 80 x 57 x 13 mm ($3\frac{1}{8}$ x $2\frac{1}{4}$ x $\frac{1}{2}$) Z.30, Z.50 and Z.50 MK.2 modules are compatible and interchangeable.

Brilliant new technical specifications

Input impedance 100 KΩ
Input (for 30w into 8Ω) 400mV
Signal to noise ratio, referred to full o/p at 30v HT 80dB or better
Distortion 0.02% up to 20W at 8Ω. See curve
Frequency response 10Hz to more than 200 KHz ±1dB
Max. supply voltage 45v (4Ω to 8Ω speakers) (50v 15Ω speakers only)
Min. supply voltage 9v
Load impedance – minimum: 4Ω at 45v HT
Load impedance – maximum: safe on open circuit



Typical Project 60 applications

System	The Units to use	together with	Units cost
Simple battery record player	**Z.30**	Crystal P.U., 12V battery volume control, etc.	**£4.48**
Mains powered record player	**Z.30, PZ.5**	Crystal or ceramic P.U. volume control, etc.	**£9.45**
12W. RMS continuous sine wave stereo amp. for average needs	**2 x Z.30s, Stereo 60; PZ.5**	Crystal, ceramic or mag. P.U., F.M. Tuner, etc.	**£23.90**
25W. RMS continuous sine wave stereo amp. using low efficiency (high performance) speakers	**2 x Z.30s, Stereo 60; PZ.6**	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	**£26.90**
80W. (3 ohms) RMS continuous sine wave de luxe stereo amplifier. (60W. RMS into 8 ohms)	**2 x Z.50s, Stereo 60; PZ.8, mains transformer**	As above	**£34.88**
Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**

F.M. Stereo Tuner **(£25)** & A.F.U. **(£5.98)** may be added as required.

Guarantee

If, within 3 months of purchasing any product direct from Sinclair Radionics Ltd., you are dissatisfied with it, your money will be refunded at once. Many Sinclair appointed Stockists also offer this same guarantee in co-operation with Sinclair Radionics Ltd.

Each Project 60 module is tested before leaving our factory and is guaranteed to work perfectly. Should any defect arise in normal use, we will service it at once and without any charge to you, if it is returned within two years from the date of purchase. Outside this period of guarantee a small charge (typically £1.00) will be made. No charge is made for postage by surface mail. Air Mail is charged at cost.

sinclair

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BRAND NEW FULLY GUARANTEED DEVICES

Cut these 3 pages out and keep for reference

AC107	0·22	AD162	0·37	BC148	0·11	BD137	0·50	BF188	0·44
AC113	0·22	AD161 &		BC149	0·13	BD138	0·55	BF194	0·13
AC115	0·26	AD162(MP)		BC150	0·20	BD139	0·61	BF195	0·13
AC117K	0·22		0·61	BC151	0·22	BD140	0·66	BF196	0·16
AC122	0·13	ADT140	0·55	BC152	0·19	BD155	0·88	BF197	0·16
AC125	0·19	AF114	0·27	BC153	0·31	BD175	0·66	BF200	0·50
AC126	0·19	AF115	0·27	BC154	0·33	BD176	0·66	BF222	1·05
AC127	0·19	AF116	0·27	BC157	0·20	BD177	0·72	BF257	0·50
AC128	0·19	AF117	0·27	BC158	0·13	BD178	0·72	BF258	0·66
AC132	0·16	AF118	0·39	BC159	0·13	BD179	0·77	BF259	0·94
AC134	0·16	AF124	0·33	BC160	0·50	BD180	0·77	BF262	0·61
AC137	0·16	AF125	0·28	BC161	0·55	BD185	0·72	BF263	0·61
AC141	0·16	AF126	0·31	BC167	0·13	BD186	0·72	BF270	0·39
AC141K	0·19	AF127	0·31	BC168	0·13	BD187	0·77	BF271	0·33
AC142	0·16	AF139	0·33	BC169	0·13	BD188	0·77	BF272	0·88
AC142K	0·19	AF178	0·33	BC170	0·13	BD189	0·83	BF273	0·39
AC151	0·17	AF179	0·55	BC171	0·16	BD190	0·83	BF274	0·39
AC154	0·22	AF180	0·55	BC172	0·16	BD195	0·94	BFW10	0·66
AC155	0·22	AF181	0·50	BC173	0·16	BD196	0·94	BFX29	0·30
AC156	0·22	AF186	0·50	BC174	0·16	BD197	0·99	BFX84	0·24
AC157	0·27	AF239	0·41	BC175	0·24	BD198	0·99	BFX85	0·33
AC165	0·22	AL102	0·72	BC177	0·21	BD199	1·05	BFX86	0·24
AC166	0·22	AL103	0·72	BC178	0·21	BD200	1·05	BFX87	0·27
AC167	0·22	ASY26	0·28	BC179	0·21	BD205	0·88	BFX88	0·24
AC168	0·27	ASY27	0·33	BC180	0·27	BD206	0·88	BFY50	0·22
AC169	0·16	ASY28	0·28	BC181	0·27	BD207	1·05	BFY51	0·22
AC176	0·22	ASY29	0·28	BC182	0·11	BD208	1·05	BFY52	0·22
AC177	0·27	ASY50	0·28	BC182L	0·11	BDY20	1·10	BFY53	0·19
AC178	0·31	ASY51	0·28	BC183	0·11	BF115	0·27	BPX25	0·94
AC179	0·31	ASY52	0·28	BC183L	0·11	BF117	0·50	BSX19	0·17
AC180	0·19	ASY54	0·28	BC184	0·13	BF118	0·77	BSX20	0·17
AC180K	0·22	ASY55	0·28	BC184L	0·13	BF119	0·77	BSY25	0·17
AC181	0·19	ASY56	0·28	BC186	0·31	BF121	0·50	BSY26	0·17
AC181K	0·22	ASY57	0·28	BC187	0·31	BF123	0·55	BSY27	0·17
AC187	0·24	ASY58	0·28	BC207	0·12	BF125	0·50	BSY28	0·17
AC187K	0·22	ASZ21	0·44	BC208	0·12	BF127	0·55	BSY29	0·17
AC188	0·24	BC107	0·10	BC209	0·13	BF152	0·61	BSY38	0·20
AC188K	0·22	BC108	0·10	BC212L	0·12	BF153	0·50	BSY39	0·20
ACY17	0·28	BC109	0·11	BC213L	0·12	BF154	0·50	BSY40	0·31
ACY18	0·22	BC113	0·11	BC214L	0·16	BF155	0·77	BSY41	0·31
ACY19	0·22	BC114	0·17	BC225	0·28	BF156	0·53	BSY95	0·14
ACY20	0·22	BC115	0·17	BC226	0·39	BF157	0·61	BSY95A	0·14
ACY21	0·22	BC116	0·17	BCY30	0·27	BF158	0·61	Bu105	2·20
ACY22	0·18	BC117	0·17	BCY31	0·29	BF159	0·66	C111E	0·55
ACY27	0·20	BC118	0·11	BCY32	0·33	BF160	0·44	C400	0·33
ACY28	0·21	BC119	0·33	BCY33	0·24	BF162	0·44	C407	0·28
ACY29	0·39	BC120	0·88	BCY34	0·28	BF163	0·44	C424	0·22
ACY30	0·31	BC125	0·13	BCY70	0·16	BF164	0·44	C425	0·55
ACY31	0·31	BC126	0·20	BCY71	0·20	BF165	0·44	C426	0·39
ACY34	0·23	BC132	0·13	BCY72	0·16	BF167	0·24	C428	0·22
ACY35	0·23	BC134	0·20	BCZ10	0·22	BF173	0·24	C441	0·33
ACY36	0·31	BC135	0·13	BCZ11	0·28	BF176	0·39	C442	0·33
ACY40	0·19	BC136	0·17	BCZ12	0·28	BF177	0·39	C444	0·39
ACY41	0·20	BC137	0·17	BD121	0·66	BF178	0·33	C450	0·24
ACY44	0·39	BC139	0·44	BD123	0·72	BF179	0·33	MAT100	0·21
AD130	0·42	BC140	0·33	BD124	0·66	BF180	0·33	MAT101	0·22
AD140	0·53	BC141	0·33	BD131	0·55	BF181	0·33	MAT120	0·21
AD142	0·53	BC142	0·33	BD132	0·66	BF182	0·44	MAT121	0·22
AD143	0·42	BC143	0·33	BD133	0·72	BF183	0·44	MPF102	0·46
AD149	0·55	BC145	0·50	BD135	0·44	BF184	0·28	MPF104	0·41
AD161	0·37	BC147	0·11	BD136	0·44	BF185	0·33	MPF105	0·41

OC19	0·39	2G371	0·18	2N2219	0·22	2N3054	0·51	2N4059	0·11
OC20	0·70	2G371B	0·13	2N2220	0·24	2N3055	0·55	2N4060	0·13
OC22	0·42	2G373	0·19	2N2221	0·22	2N3391	0·16	2N4061	0·13
OC23	0·46	2G374	0·19	2N2222	0·22	2N3391A	0·18	2N4062	0·13
OC24	0·62	2G377	0·33	2N2368	0·19	2N3392	0·16	2N4284	0·19
OC25	0·42	2G378	0·18	2N2369	0·16	2N3393	0·16	2N4285	0·19
OC26	0·28	2G381	0·18	2N2369A	0·16	2N3394	0·16	2N4286	0·19
OC28	0·55	2G382	0·18	2N2411	0·27	2N3395	0·19	2N4287	0·19
OC29	0·55	2G401	0·33	2N2412	0·27	2N3402	0·23	2N4288	0·19
OC35	0·46	2G414	0·33	2N2646	0·52	2N3403	0·23	2N4289	0·19
OC36	0·55	2G417	0·28	2N2711	0·23	2N3404	0·31	2N4290	0·19
OC41	0·22	2N388	0·39	2N2712	0·23	2N3405	0·46	2N4291	0·19
OC42	0·27	2N388A	0·61	2N2714	0·23	2N3414	0·17	2N4292	0·19
OC44	0·17	2N404	0·22	2N2904	0·19	2N3415	0·17	2N4293	0·19
OC45	0·14	2N404A	0·31	2N2904A	0·23	2N3416	0·31	2N5172	0·13
OC70	0·11	2N524	0·46	2N2905	0·23	2N3417	0·31	2N5457	0·35
OC71	0·11	2N527	0·54	2N2905A	0·23	2N3525	0·83	2N5458	0·35
OC72	0·16	2N598	0·46	2N2906	0·17	2N3646	0·10	2N5459	0·44
OC74	0·16	2N599	0·50	2N2906A	0·20	2N3702	0·11	2S301	0·55
OC75	0·17	2N696	0·14	2N2907	0·22	2N3703	0·11	2S302A	0·46
OC76	0·17	2N697	0·15	2N2907A	0·24	2N3704	0·12	2S302	0·46
OC77	0·28	2N698	0·27	2N2923	0·16	2N3705	0·11	2S303	0·61
OC81	0·17	2N699	0·39	2N2924	0·16	2N3706	0·10	2S034	0·77
OC81D	0·17	2N706	0·09	2N2925	0·16	2N3707	0·12	2S305	0·93
OC82	0·17	2N706A	0·10	2N2926 (G)		2N3708	0·08	2S306	0·93
OC82D	0·17	2N708	0·13		0·14	2N3709	0·10	2S307	0·93
OC83	0·22	2N711	0·33	2N2926 (Y)		2N3710	0·10	2S321	0·62
OC84	0·22	2N717	0·39		0·12	2N3711	0·10	2S322	0·46
OC139	0·22	2N718	0·27	2N2926 (O)		2N3819	0·31	2S322A	0·46
OC140	0·22	2N718A	0·55		0·11	2N3820	0·55	2S323	0·62
OC169	0·28	2N726	0·31	2N2926 (R)		2N3821	0·39	2S324	0·77
OC170	0·28	2N727	0·31		0·11	2N3823	0·31	2S325	0·77
OC171	0·28	2N743	0·22	2N2926 (B)		2N3903	0·31	2S326	0·77
OC200	0·28	2N744	0·22		0·11	2N3904	0·33	2S327	0·77
OC201	0·31	2N914	0·16	2N3010	0·77	2N3905	0·31	2S701	0·46
OC202	0·31	2N918	0·33	2N3011	0·16	2N3906	0·30	40361	0·44
OC203	0·28	2N929	0·23	2N3053	0·19	2N4058	0·13	40362	0·50
OC204	0·28	2N930	0·23						
OC205	0·39	2N1131	0·22						
OC309	0·44	2N1132	0·24						
OCP71	0·48	2N1302	0·16						
ORP12	0·48	2N1303	0·16						
ORP60	0·44	2N1304	0·19						
ORP61	0·44	2N1305	0·19						
P346A	0·22	2N1306	0·23						
P397	0·46	2N1307	0·23						
ST140	0·14	2N1308	0·26						
ST141	0·19	2N1309	0·26						
TIS43	0·33	2N1613	0·22						
UT46	0·30	2N1711	0·22						
2G301	0·21	2N1889	0·35						
2G302	0·21	2N1890	0·50						
2G303	0·21	2N1893	0·41						
2G304	0·27	2N2147	0·79						
2G306	0·44	2N2148	0·63						
2G308	0·39	2N2160	0·66						
2G309	0·39	2N2192	0·39						
2G339	0·22	2N2193	0·39						
2G339A	0·18	2N2194	0·39						
2G344	0·20	2N2217	0·24						
2G345	0·18	2N2218	0·22						

DIODES AND RECTIFIERS

AA119	0·09	BY133	0·23	OA10	0·39
AA120	0·09	BY164	0·55	OA47	0·08
AA129	0·09	BYX38/30		OA70	0·08
AAY30	0·10		0·46	OA79	0·08
AAZ13	0·11	BYZ10	0·39	OA81	0·08
BA100	0·11	BYZ11	0·33	OA85	0·10
BA116	0·23	BYZ12	0·33	OA90	0·07
BA126	0·24	BYZ13	0·28	OA91	0·07
BA148	0·16	BYZ16	0·44	OA95	0·08
BA154	0·13	BYZ17	0·39	OA200	0·07
BA155	0·16	BYZ18	0·39	OA202	0·08
BA156	0·15	BYZ19	0·31	SD10	0·06
BY100	0·17	CG62		SD19	0·06
BY101	0·13	(OA91 Eq.)		1N34	0·08
BY105	0·19		0·06	1N34A	0·08
BY114	0·13	CG651—		1N914	0·07
BY126	0·16	(OA70–OA79)		1N916	0·07
BY127	0·17		0·07	1N414B	0·07
BY128	0·17	OA5	0·39	1S021	0·11
BY130	0·18	OA58L	0·23	1S951	0·07

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Pak No.	Qty.	Description	Price
C 1	250	Resistors mixed values approx. (count by weight)	0·55
C 2	200	Capacitors mixed values approx. (count by weight)	0·55
C 3	50	Precision Resistors 1% mixed values	0·55
C 4	75	⅛th W Resistors mixed preferred values	0·55
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C 6	2	Tuning Gangs, MW/LW VHF	0·55
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C 8	10	Reed Switches	0·55
C 9	3	Micro Switches	0·55
C10	15	Assorted Pots & Pre-Sets	0·55
C11	5	Jack Sockets 3 × 3·5m 2 × Standard Switch Types	0·55
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C13	20	Electrolytics Trans. types	0·55
C14	1	Pack assorted Hardware—Nuts/Bolts, Gromets, etc.	0·55
C15	4	Mains Slide Switches, full POINT	0·55
C16	20	Assorted Tag Strips & Panels	0·55
C17	10	Assorted Control Knobs	0·55
C18	4	Rotary Wave Change Switches	0·55
C19	3	Relays 6—24V Operating	0·55
C20	4	Sheets Copper Laminate approx. 10in × 7in	0·55

Please add 10p post and packing on all component packs, plus a further 10p on pack Nos. C1, C2, C19 and C20.

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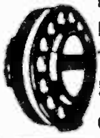

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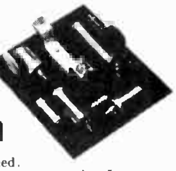
THE NEW S.G.S. EA 1000 AUDIO AMP MODULE *Guarantee



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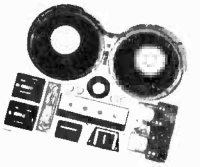
Module Tested and Guaranteed. Qty. 1—9 £2·89; 10—25 £2·51 Price each. Larger quantities quoted on request. Full hook-up diagrams and complete technical data supplied free with each module or available separately at 10p each.

SYSTEM 12 STEREO

Each Kit contains two Amplifier Modules, 3 watts RMS, two loudspeakers, 15 ohms, the pre-amplifier, transformer, power supply module, front panel and other accessories, as well as an illustrated stage-by-stage instruction booklet designed for the beginner.
Further details available on request.



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1A TO5	0·26	0·28	0·34	0·48	0·59	0·70
3A TO66	0·28	0·37	0·41	0·52	0·63	0·77
5A TO66	0·34	0·52	0·54	0·62	0·75	0·88
5A TO64	0·34	0·52	0·54	0·62	0·75	0·88
7A TO48	0·52	0·55	0·63	0·74	0·85	0·99
10A TO48	0·56	0·64	0·67	0·83	1·07	1·32
16A TO48	0·59	0·70	0·83	1·03	1·38	1·65
30A TO48	1·27	1·54	1·76	1·93	—	4·40

SIL. RECTS. TESTED

PIV	300mA DO7	750mA SO16	1A Plastic	1·5A SO16	3A SO10	10A SO10	30A SO32A
50	0·04	0·06	0·06	0·08	0·16	0·23	0·66
100	0·04	0·07	0·06	0·15	0·18	0·26	0·83
200	0·06	0·10	0·07	0·16	0·22	0·27	1·10
400	0·07	0·15	0·08	0·22	0·30	0·41	1·38
600	0·08	0·18	0·11	0·26	0·38	0·50	2·05
800	0·11	0·19	0·12	0·28	0·41	0·61	2·20
1000	0·12	0·30	0·16	0·33	0·51	0·70	2·75
1200	—	0·37		0·42	0·63	0·83	—

TRIACS

VBOM	2A TO-5	6A TO-66	10A TO-48
	£p	£p	£p
100V	33	55	83
200V	55	66	99
400V	77	83	1·21

DIACS

FOR USE WITH TRIACS BR100 (D32) 41p each

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One 50p Pak of your own choice free with orders valued £4 or over.

BRAND NEW TEXAS GERM. TRANSISTORS

Coded and Guaranteed

Pak No.			EQVT
T1	8	2G3713	OC71
T2	8	D1374	OC75
T3	8	D1216	OC81D
T4	8	2G381T	OC81
T5	8	2G382T	OC82
T6	8	2G344B	OC44
T7	8	2G345B	OC45
T8	8	2G378	OC78
T9	8	2G399A	2N1302
T10	8	2G417	AF117

All 55p each pak

2N2060 NPN SIL. DUAL TRANS. CODE D1699 TEXAS. Our price **28p** each.

120 VCB NIXIE DRIVER TRANSISTOR. Sim. BSX21 & C407, 2N1893 FULLY TESTED AND CODED ND 120. 1-24 **19p** each. TO-5 N.P.N. 25 up **17p** each.

Sil. trans. suitable for P.E. Organ. Metal TO-18 Eqvt. ZTX300 **6p** each. Any Quantity.

ZENER DIODES

400mW (DO-7 Case), range 2-33V, **15p** each. 1·5W (Top-Hat), range 2-33V, **20p** each. 10W (SO-10 Stud), range 2-33V, **33p** each.

10 amp POTTED BRIDGE RECTIFIER

on heat sink. 100PIV. 99p each

NEW LINE

Plastic Encapsulated 2 Amp. BRIDGE RECTS.

50V RMS	35p each
100V RMS	41p each
400V RMS	51p each

Size 15mm × 6mm.

UNIJUNCTION TRANSISTORS

Direct replacement for TIS43 and BEN3000 also electrically equivalent to 2N2646 Qty.: 1-24 **30p** each, 25-99 **28p** each, 100+ **22p** each.

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ORP12 **48p**
ORP60, ORP61 **44p** each

GENERAL PURPOSE NPN SILICON SWITCHING TRANS. TO-18 SIM. TO 2N706/8. BSY-27/28/95A. All usable devices no open or short circuits. ALSO AVAILABLE in PNP Sim. to 2N2906, BCY70. When ordering please state preference NPN or PNP.

		£p
20	For	0·55
50	For	1·10
100	For	1·92
500	For	8·25
1000	For	14·30

SIL. G.P. DIODES £p

300mW	30	0·55
40PIV(Min.)	100	1·65
Sub-Min.	500	5·50
Full Tested	1,000	9·90

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U 3	75	Germanium Gold Bonded Sub-Min. like OA5, OA47	0·55
U 4	40	Germanium Transistors like OC81, AC128	0·55
U 5	60	200mA Sub-Min. Silicon Diodes	0·55
U 6	30	Sil. Planar Trans. NPN like BSY95A, 2N706	0·55
U 7	16	Sil. Rectifiers TOP-HAT 750mA VLTG. RANGE up to 1000	0·55
U 8	50	Sil. Planar Diodes DO-7 Glass 250mA like OA200/202	0·55
U 9	20	Mixed Voltages, 1 Watt Zener Diodes	0·55
U10	20	BAY50 charge storage Diodes DO-7 Glass	0·55
U11	25	PNP Sil. Planar Trans. TO-5 like 2N1132, 2N2904	0·55
U12	12	Silicon Rectifiers Epoxy 500mA up to 800 PIV	0·55
U13	30	PNP-NPN Sil. Transistors OC200 & 2S 104	0·55
U14	150	Mixed Silicon and Germanium Diodes	0·55
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U16	10	3 Amp Silicon Rectifiers Stud Type up to 1000PIV	0·55
U17	30	Germanium PNP AF Transistors TO-5 like ACY 17-22	0·55
U18	8	6 Amp Silicon Rectifiers BYZ13 Type up to 600 PIV	0·55
U19	25	Silicon NPN Transistors like BC108	0·55
U20	12	1·5 Amp Silicon Rectifiers Top Hat up to 1000 PIV	0·55
U21	30	AF. Germanium Alloy Transistors 2G300 Series & OC71	0·55
U23	30	MADT's like MHz Series PNP Transistors	0·55
U24	20	Germanium 1 Amp Rectifiers GJM Series up to 300 PIV	0·55
U25	25	300MHz NPN Silicon Transistors 2N708, BSY27	0·55
U26	30	Fast Switching Silicon Diodes like IN914 Micro-Min.	0·55
U27	12	NPN Germanium AF Transistors TO-1 like AC127	0·50
U29	10	1 Amp SCR's TO-5 can, up to 600 PIV CRS1/25-600	1·15
U30	15	Plastic Silicon Planar Trans. NPN 2N2926	0·55
U31	20	Silicon Planar Plastic NPN Trans. Low Noise Amp 2N3707	0·55
U32	25	Zener Diodes 400mW DO-7 case 3-18 volts mixed	0·55
U33	15	Plastic Case 1 Amp Silicon Rectifiers IN4000 Series	0·55
U34	30	Silicon PNP Alloy Trans. TO-5 BCY26 2S302/4	0·55
U35	25	Silicon Planar Transistors PNP TO-18 2N2906	0·55
U36	25	Silicon Planar NPN Transistors TO-5 BFY50/51/52	0·55
U37	30	Silicon Alloy Transistors SO-2 PNP OC200, 2S322	0·55
U38	20	Fast Switching Silicon Trans. NPN 400MHz 2N3011	0·55
U39	30	RF. Germ. PNP Transistors 2N1303/5 TO-5	0·55
U40	10	Dual Transistors 6 lead TO-5 2N2060	0·55
U41	25	RF Germanium Transistors TO-5, OC45, NKT72	0·55
U42	10	VHF Germanium PNP Transistors TO-1 NKT667, AF117	0·55
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U44	20	Sil. Trans. Plastic TO-5 BC115/NPN	0·55
U45	7	3A SCR. TO66 up to 600PIV	1·10

Code Nos. 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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Q 2	16	White spot R.F. transistors *pnp*	0·55
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Q 4	6	Matched transistors OC44/45/81/81D	0·55
Q 5	4	OC75 transistors	0·55
Q 6	5	OC72 transistors	0·55
Q 7	4	AC128 transistors *pnp* high gain	0·55
Q 8	4	AC126 transistors *pnp*	0·55
Q 9	7	OC81 type transistors	0·55
Q10	7	OC71 type transistors	0·55
Q11	2	AC127/128 Complementary pairs *pnp/npn*	0·55
Q12	3	AF116 type transistors	0·55
Q13	3	AF117 type transistors	0·55
Q14	3	OC171 H.F. type transistors	0·55
Q15	7	2N2926 Sil. Epoxy transistors mixed colours	0·55
Q16	2	GET880 low noise Germanium transistors	0·55
Q17	5	*npn* 2 × ST.141 & 3 × ST.140	0·55
Q18	4	MADT'S 2 × MAT 100 & 2 × MAT 120	0·55
Q19	3	MADT'S 2 × MAT 101 & 1 × MAT 121	0·55
Q20	4	OC44 Germanium transistors A.F.	0·55
Q21	4	AC127 *npn* Germanium transistors	0·55
Q22	20	NKT transistors A.F. R.F. coded	0·55
Q23	10	OA202 Silicon diodes sub-min.	0·55
Q24	8	OA81 diodes	0·55
Q25	15	IN914 Silicon diodes 75PIV 75mA	0·55
Q26	8	OA95 Germanium diodes sub-min IN69	0·55
Q27	2	10A 600 PIV Silicon rectifiers IS425R	0·55
Q28	2	Silicon power rectifiers BYZ13	0·55
Q29	4	Silicon transistors 2 × 2N696, 1 × 2N697, 1 × 2N698	0·55
Q30	7	Silicon switch transistors 2N706 *npn*	0·55
Q31	6	Silicon switch transistors 2N708, *npn*	0·55
Q32	3	*pnp* Silicon transistors 2 × 2N1131, 1 × 2N1132	0·55
Q33	3	Silicon *npn* transistors 2N1711	0·55
Q34	7	Silicon *npn* transistors 2N2369, 500MHz (code P397)	0·55
Q35	3	Silicon *pnp* TO-5. 2 × 2N2904 & 1 × 2N2905	0·55
Q36	7	2N3646 TO-18 plastic 300MHz *npn*	0·55
Q37	3	2N3053 *npn* Silicon transistors	0·55
Q38	7	*pnp* transistors 4 × 2N3703, 3 × 2N3702	0·55

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INTEGRATED CIRCUIT PAKS

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

Pak No. Contents	Price	Pak No. Contents	Price	Pak No. Contents	Price
UIC00 = 12 × 7400	0·55	UIC46 = 5 × 7446	0·55	UIC86 = 5 × 7486	0·55
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UIC02 = 12 × 7402	0·55	UIC48 = 5 × 7448	0·55	UIC91 = 5 × 7491	0·55
UIC03 = 12 × 7403	0·55	UIC50 = 12 × 7450	0·55	UIC92 = 5 × 7492	0·55
UIC04 = 12 × 7404	0·55	UIC51 = 12 × 7451	0·55	UIC93 = 5 × 7493	0·55
UIC05 = 12 × 7405	0·55	UIC53 = 12 × 7453	0·55	UIC94 = 5 × 7494	0·55
UIC06 = 8 × 7406	0·55	UIC54 = 12 × 7454	0·55	UIC95 = 5 × 7495	0·55
UIC07 = 8 × 7407	0·55	UIC60 = 12 × 7460	0·55	UIC96 = 5 × 7496	0·55
UIC10 = 12 × 7410	0·55	UIC70 = 8 × 7470	0·55	UIC100 = 5 × 74100	0·55
UIC13 = 8 × 7413	0·55	UIC72 = 8 × 7472	0·55	UIC121 = 5 × 74121	0·55
UIC20 = 12 × 7420	0·55	UIC73 = 8 × 7473	0·55	UIC141 = 5 × 74141	0·55
UIC30 = 12 × 7430	0·55	UIC74 = 8 × 7474	0·55	UIC151 = 5 × 74151	0·55
UIC40 = 12 × 7440	0·55	UIC75 = 8 × 7475	0·55	UIC154 = 5 × 74154	0·55
UIC41 = 5 × 7441	0·55	UIC76 = 8 × 7476	0·55	UIC193 = 5 × 74193	0·55
UIC42 = 5 × 7442	0·55	UIC80 = 5 × 7480	0·55	UIC199 = 5 × 74199	0·55
UIC43 = 5 × 7443	0·55	UIC81 = 5 × 7481	0·55		
UIC44 = 5 × 7444	0·55	UIC82 = 5 × 7482	0·55	UICXI = 25 Assorted 74's	1·65
UIC45 = 5 × 7445	0·55	UIC83 = 5 × 7483	0·55		

Paks cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

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Coded GP100. BRAND NEW TO-3 CASE. POSS. REPLACE: OC25-28-29-30-35-36. NKT 401-403-404-405-406-430-451-452-453. T13027-3028, 2N250A, 2N456A-457A-458A, 2N511 A & B. 2G220-222, ETC. VCBO 80V VCEO 50V IC 10A PT. 30 WATTS Hfe 30-170.

PRICE	1-24	25-99	100 up
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SILICON High Voltage 250V NPN TO-3 case. G.P. Switching & Amplifier Applications. Brand new Coded R 2400 VCBO 250/VCEO 100/IC 6A/30 Watts. HFE type 20/fT 5MHZ.
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SN7401	0·17	0·16	0·13	SN7489	6·05	5·78	5·50
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SN7403	0·17	0·16	0·13	SN7491	1·10	1·05	0·99
SN7404	0·17	0·16	0·13	SN7492	0·74	0·71	0·64
SN7405	0·17	0·16	0·13	SN7493	0·74	0·71	0·64
SN7406	0·39	0·34	0·31	SN7494	0·85	0·82	0·75
SN7407	0·39	0·34	0·31	SN7495	0·35	0·82	0·75
SN7408	0·20	0·14	0·18	SN7496	0·86	0·93	0·86
SN7409	0·20	0·19	0·18	SN74100	1·82	1·76	1·71
SN7410	0·17	0·16	0·13	SN74104	1·07	1·04	0·97
SN7411	0·28	0·24	0·26	SN74105	1·07	1·04	0·97
SN7412	0·39	0·34	0·31	SN74107	0·44	0·42	0·40
SN7413	0·32	0·29	0·27	SN74110	0·51	0·59	0·55
SN7416	0·48	0·44	0·42	SN74111	1·38	1·27	1·21
SN7417	0·48	0·44	0·42	SN74118	1·10	1·05	0·99
SN7420	0·17	0·16	0·13	SN74119	1·40	1·38	1·21
SN7422	0·55	0·53	0·50	SN74121	0·44	0·41	0·38
SN7423	0·55	0·53	0·50	SN74122	1·54	1·43	1·21
SN7425	0·55	0·53	0·50	SN74123	3·08	2·97	2·86
SN7426	0·50	0·46	0·44	SN74141	0·74	0·71	0·64
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SN7437	0·71	0·68	0·66	SN74155	1·54	1·43	1·32
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SN7442	0·74	0·71	0·64	SN74161	1·98	1·87	1·76
SN7443	1·43	1·88	1·32	SN74162	4·40	4·13	3·85
SN7444	1·43	1·38	1·32	SN74163	4·40	4·13	3·85
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SN7446	1·07	1·04	0·97	SN74165	2·48	2·42	2·37
SN7447	1·10	1·07	1·05	SN74166	3·85	3·58	3·30
SN7448	1·10	1·07	1·05	SN74174	2·53	2·42	2·31
SN7450	0·17	0·16	0·13	SN74175	1·76	1·65	1·54
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SN7453	0·17	0·16	0·13	SN74177	2·75	2·64	2·53
SN7454	0·17	0·16	0·13	SN74180	2·20	1·76	1·54
SN7460	0·17	0·16	0·13	SN74181	6·05	5·50	5·23
SN7470	0·32	0·29	0·27	SN74182	2·20	1·98	1·76
SN7472	0·32	0·29	0·27	SN74184	3·85	3·58	3·30
SN7473	0·41	0·39	0·35	SN74190	2·15	2·09	2·04
SN7474	0·41	0·39	0·35	SN74191	2·09	2·04	1·98
SN7475	0·50	0·48	0·46	SN74192	2·15	2·09	2·04
SN7476	0·44	0·43	0·43	SN74193	2·20	1·98	1·93
SN7480	0·74	0·71	0·64	SN74194	2·97	2·86	2·75
SN7481	1·32	1·27	1·21	SN74195	2·20	2·09	1·98
SN7482	0·96	0·95	0·94	SN74196	1·98	1·87	1·76
SN7483	1·21	1·16	1·05	SN74197	1·98	1·87	1·76
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BP702C—SL702C	0·70	0·55	0·50
BP702—72702	0·59	0·50	0·44
BP709—72709	0·40	0·39	0·33
BP709P—μA709C	0·40	0·38	0·33
BP710—72710	0·40	0·46	0·44
BP711—μA711	0·40	0·48	0·44
BP741—72741	0·55	0·50	0·45
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BP946	0·13	0·12	0·11
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BP9093	0·44	0·42	0·39
BP9094	0·44	0·42	0·39
BP9097	0·44	0·42	0·39
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MODEL	CD66	GR116	3015F Minitron
Anode Voltage (Vdc)	170min	175min	5
Cathode Current (mA)	2·3	14	8
Numerical Height (mm)	16	13	9
Tube Height (mm)	47	32	22
Tube Diameter (mm)	19	13	12 wide
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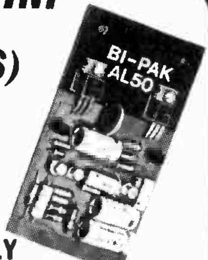

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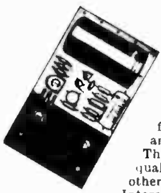
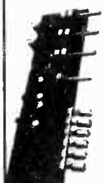


AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 68mm × 105mm × 30mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including:—Disco Systems, Public Address, Intercom Units, etc. Handbook available, 10p **PRICE £3·25**

TRANSFORMER BMT80 £2·15 p. & p. 28p

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.
Three switched stereo Inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.



SPECIFICATION

Frequency Response	20Hz — 20kHz ± 1dB
Harmonic Distortion	better than 0·1%
Inputs: 1. Tape Head	1·25mV into 50K Ω
2. Radio, Tuner	35mV into 50K Ω
3. Magnetic P.U.	1·5mV into 50K Ω

All input voltages are for an output of 250mV. Tape and P.U. inputs equalised to RIAA curve within ± 1dB from 20Hz to 20kHz.

Bass Control	± 15dB at 20Hz
Treble Control	± 15dB at 20kHz
Filters: Rumble (High Pass)	100Hz
Scratch (Low Pass)	8kHz
Signal/Noise Ratio	better than — 65dB
Input overload	+26dB
Supply	+35 volts at 20mA
Dimensions	292mm × 82mm × 35m

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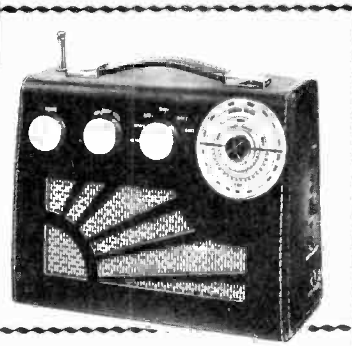
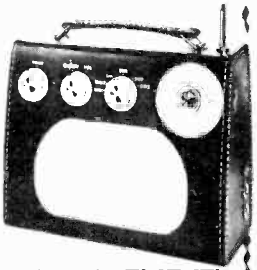
TOTAL BUILDING COSTS **£9·35** P.P. & INS. 52p (OVERSEAS P. & P. £1·05)



ROAMER EIGHT Mk. I

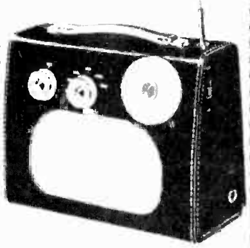
NOW WITH VARIABLE TONE CONTROL



7 TUNABLE WAVEBANDS: MW1. MW2. LW. SW1. SW2. SW3 AND TRAWLER BAND. Built-in ferrite rod aerial for MW and LW. Retractable chrome plated telescopic aerial for short waves. Push-pull output using 600mW transistors. Car aerial and tape record sockets. Selectivity switch. 8 transistors plus 3 diodes. Fine tone moving coil speaker. Air spaced ganged tuning condenser. Volume/on/off, tuning, wave change and tone controls. Attractive case in rich chestnut shade with gold blocking. Size 9in × 7in × 4in approx. Easy to follow instructions and diagrams. Parts price list and plans 25p (FREE with parts).

TOTAL BUILDING COSTS **£7·68** P. P. & INS. 47p (OVERSEAS P. & P. £1·05)

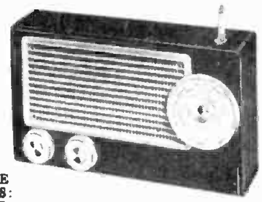
ROAMER SEVEN Mk. IV



7 TUNABLE WAVEBANDS: MW1. MW2. LW. SW1. SW2. SW3 AND TRAWLER BAND. Extra medium waveband provides easier tuning of Radio Luxembourg, etc. Built-in ferrite rod aerial for MW and LW. Retractable 4 section 24in chrome plated telescopic aerial for SW. Socket for car aerial. Powerful push-pull output. 7 transistors and 2 diodes, including micro-alloy R.F. transistors. Fine tone moving coil speaker. Air spaced ganged tuning condenser. Volume/on/off, tuning and wave change controls. Attractive case with carrying handle. Size 9in × 7in × 4in approx. Easy to follow instructions and diagrams. Parts price list and plans 25p (FREE with parts).

TOTAL BUILDING COSTS **£6·58** P. P. & INS. 47p (OVERSEAS P. & P. £1·05)

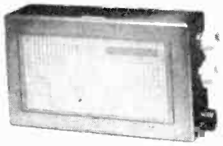
ROAMER SIX



6 TUNABLE WAVEBANDS: MW. LW. SW1. SW2. TRAWLER BAND PLUS AN EXTRA MW BAND FOR EASIER TUNING OF LUXEMBOURG, ETC. Sensitive ferrite rod aerial and telescopic aerial for short waves. 3in speaker. 8 stages—6 transistors and 2 diodes including micro-alloy R.F. transistors, etc. Attractive black case with red grille, dial and black knobs with polished metal inserts. Size 9in × 5½in × 2½in approx. Plans and parts price list **25p** (FREE with parts).

TOTAL BUILDING COSTS **£4·38** P. P. & INS. 31p (OVERSEAS P. & P. £1·05)

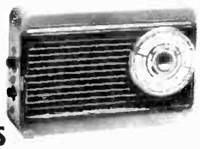
POCKET FIVE



3 TUNABLE WAVEBANDS: MW. LW. TRAWLER BAND WITH EXTENDED MW BAND FOR EASIER TUNING OF LUXEMBOURG, ETC. 7 stages—5 transistors and 2 diodes, supersensitive ferrite rod aerial, fine tone moving coil speaker. Attractive black and gold case. Size 5½in × 1¼in × 3½in. Plans and parts price list 15p (FREE with parts).

TOTAL BUILDING COSTS **£2·50** P. P. & INS. 24p (OVERSEAS P. & P. 65p)

TRANSONA FIVE



5 TRANSISTORS AND 2 DIODES

3 TUNABLE WAVE BANDS: MW. LW AND TRAWLER BAND. 7 stage—5 transistors and 2 diodes, ferrite rod aerial, tuning condenser, volume control, fine tone moving coil speaker. Attractive case with red speaker grille. Size 6½in × 4½in × 1½in. Plans and parts price list 15p (FREE with parts).

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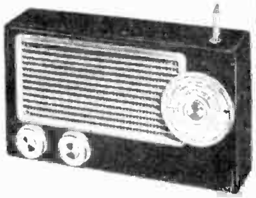

8 TRANSISTORS AND 3 DIODES

6 TUNABLE WAVEBANDS: MW. LW. SW1. SW2. SW3 AND TRAWLER BAND. Sensitive ferrite rod aerial for MW and LW. Telescopic aerial for short waves. 3in speaker. 8 improved type transistors plus 3 diodes. Attractive case in black with red grille, dial and black knobs with polished metal inserts. Size 9in × 5½in × 2½in approx. Push-pull output. Battery economiser switch for extended battery life. Ample power to drive a larger speaker. Parts price list and plans **25p** (FREE with parts).

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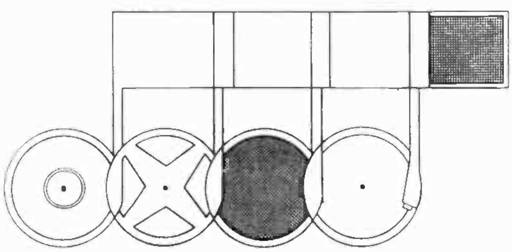

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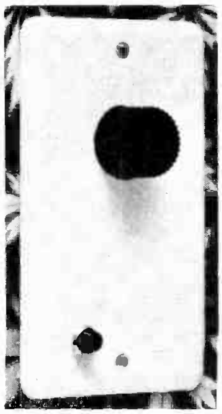

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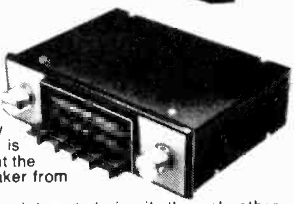

The Tourist PB is suitable for 12 volt working on both negative and positive earth vehicles it covers the full medium and long wave bands. It is permeability tuned and sturdily constructed. Output is a full 2·5 watts into an 8 ohms speaker. But the Tourist PB will operate into any loudspeaker from 8 to 15 ohms.
Apart from the output stage, which is an integrated circuit, the only other electronic components that need soldering are some capacitors, resistors, etc. The kit includes a pre-built RF tuner unit, and fully modulised IF stages which are pre-aligned before despatch. As well as electronic components this kit also contains 2 diamond-spun aluminium knobs, elegant matching front panel, dial, washers, screws and wire.
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* Circuit diagram and comprehensive instructions 55p free with parts.
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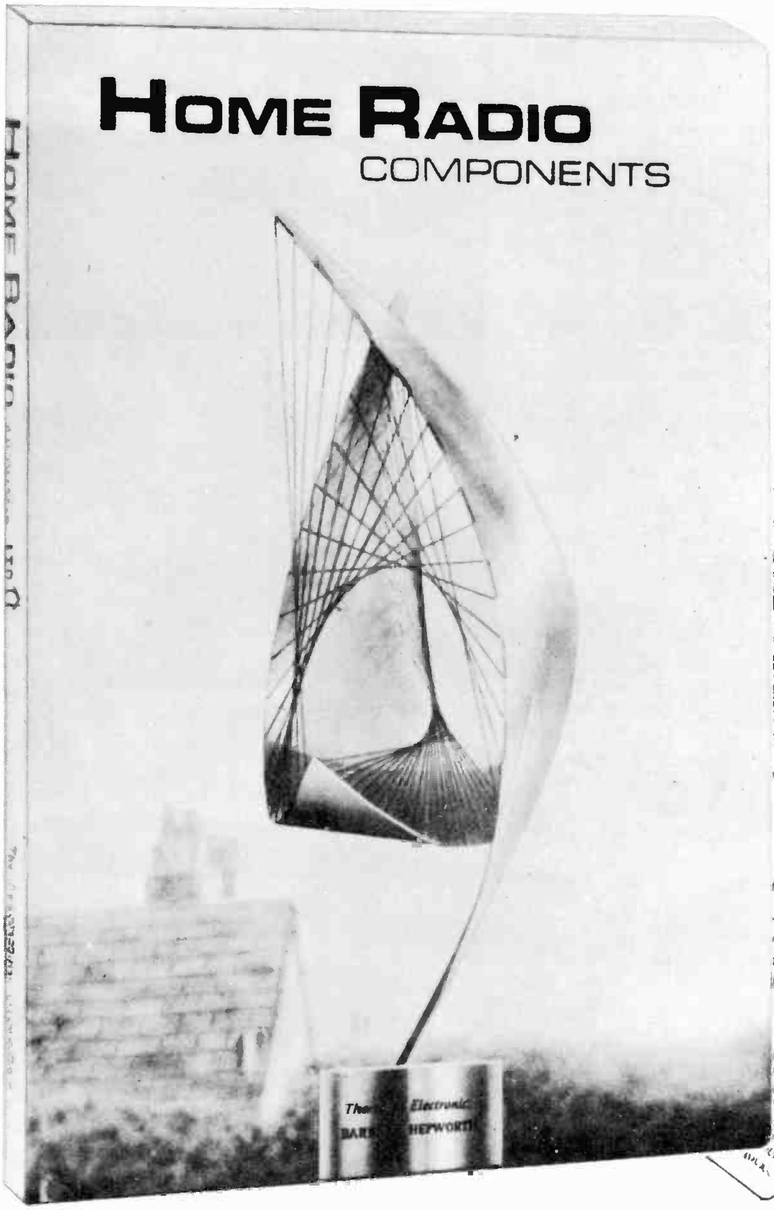

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A NEW DIMENSION IN SOUND

FOUR years ago we commented upon the visionary views of the eminent musician Leopold Stokowski who had just then proposed the idea that stereo was by no means the ultimate in sound reproduction, but that a four channel system offered greater possibilities for extending musical pleasure by bringing the listener right into the midst of the performers.

Whilst applauding this somewhat revolutionary notion, we ventured to express our fears concerning the formidable nature of the task being set before the engineer. Timidity is out of place in electronics, and we should have known better!

In rather less than four years the technical problem of recording four channels upon disc in such a manner that their subsequent recovery would be possible using a normal stereo stylus has been solved. An account of the various rival systems and the current trend is given in the opening article of our new series featuring the P.E. Rondo—the first complete quadraphonic system to be offered to the constructor.

Now that the technical problems have (to all intents and purposes) been solved and both hardware and software are available, quadraphonic surround sound has become a reality and can be experienced in any home.

But what, exactly, does quadraphonic sound mean in the final analysis—in the strictly musical sense? If the ordinary listener is a little confused by what he has already sampled during demonstrations, this is not at all surprising. It is still early days for a new art. The recording companies show no single-minded approach to quadraphonics. In the US, CBS (originators of the strongly favoured SQ system) are experimenting with unconventional circular arrangements for orchestras when recording classical works in their studios, so providing the listener with the illusion of being right in the centre, on the conductor's rostrum. At home, EMI, in contrast, opts for the traditional concert platform set-up and uses the two rear channels in a rather subsidiary role, to add "concert hall ambience" to stereo.

In the case of popular music, recording engineers and producers seem permitted greater latitude to exploit the possibilities of four-channel recording. Less inhibited by nature, the pop musicians can be counted upon to make more dramatic use of the directional properties of quad, and new sound patterns will be devised, with the likelihood of the listener being assailed first from one corner then from another.

Following the establishment of stereo, the engineers accepted the next challenge and with the aid of the latest electronic technology have made the musician's dream possible. Now it is the creative artist's turn to experiment. Such a radical development in sound reproduction for the home sets a challenge for the composer and performer, in both the classical and pop areas. The impact of quadraphonics upon the world of music will be interesting to follow. It should produce some exciting and surprising sounds, though the initial period of experimentation may be a little wearing upon the listener's ears—and neck muscles.

F.E.B

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PE RONDO QUADRAPHONIC SOUND SYSTEM

BY R.A.COLE *

Audio systems are fast expanding into complex and very expensive set-ups offering all manner of facilities. In the PE RONDO system, *PRACTICAL ELECTRONICS* offers the home constructor a modular equipment housed in one case which may incorporate a selection of functions so as to form anything from a simple stereo amplifier system through to a complex AM/FM receiver/quadraphonic/stereo control and amplification system.

THE SAYING, "history repeats itself" must surely be proven when applied to recorded sound. At each stage of its development the eternal pessimists have sagely remarked that "it will never catch on."

When the first long playing records were introduced over two decades ago many record shops refused even to contemplate stocking them. The multiplicity of recording characteristics backed by various manufacturers of records caused even the hardiest of audio enthusiasts to think twice. The Jeremiahs considered that the LP was too fragile and the technical difficulties in reproduction too great.

But within a few years the LP was established and one standard recording characteristic was adopted.

STEREO

The introduction of the stereo LP caused just as much soul searching. Apart from plain disbelief that one groove could contain two signals, long and learned dissertations on recording techniques proliferated. There were even two contending methods of groove cutting, one "hill and dale" and the other "45-45" Blumlein method.

Fortunately this problem was soon decided in favour of the 45-45 method which is standard today. One of the earliest demonstration records had a commentator who spoke the historic words, "ping . . . pong", one word from each speaker, and immortalised "ping-pong" stereo.

Despite these problems the purist seems to live alongside the more gimmicky listener and all seem to be happy with their respective lots notwithstanding an occasional rumbling from the old ghosts of the past quarter century.

* Quadrasonics Ltd.

COST £80 approx. TO BUILD

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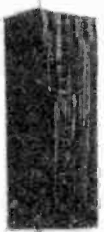
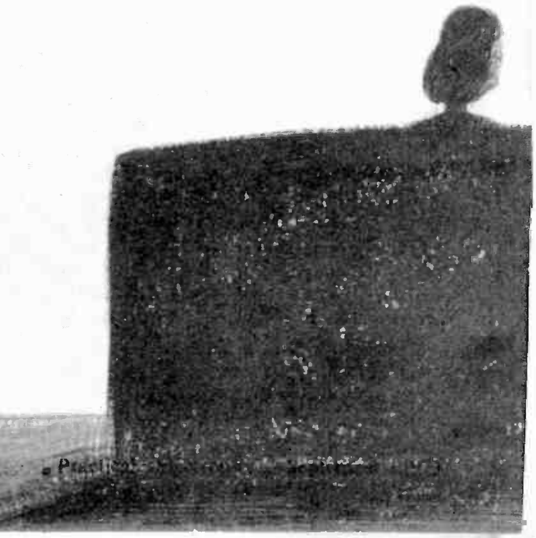




QUADRAPHONICS

Four channel sound has been with us now for several years and our enthusiast is just as confused as his predecessors by the old ghosts and Jeremiahs who seem to have reappeared for a "new season of sport."

The writer will attempt to remove as much of the confusion as he can and will clear the decks by stating that four channel sound is here to stay and that *any* of the techniques currently available enhances the enjoyment of recorded music.

Many elegant terms have been adopted in recent months to describe multichannel reproduction. The writer will use the inelegant but generally accepted nomenclature. However, when a term is confusing, definition of that term will be attempted.

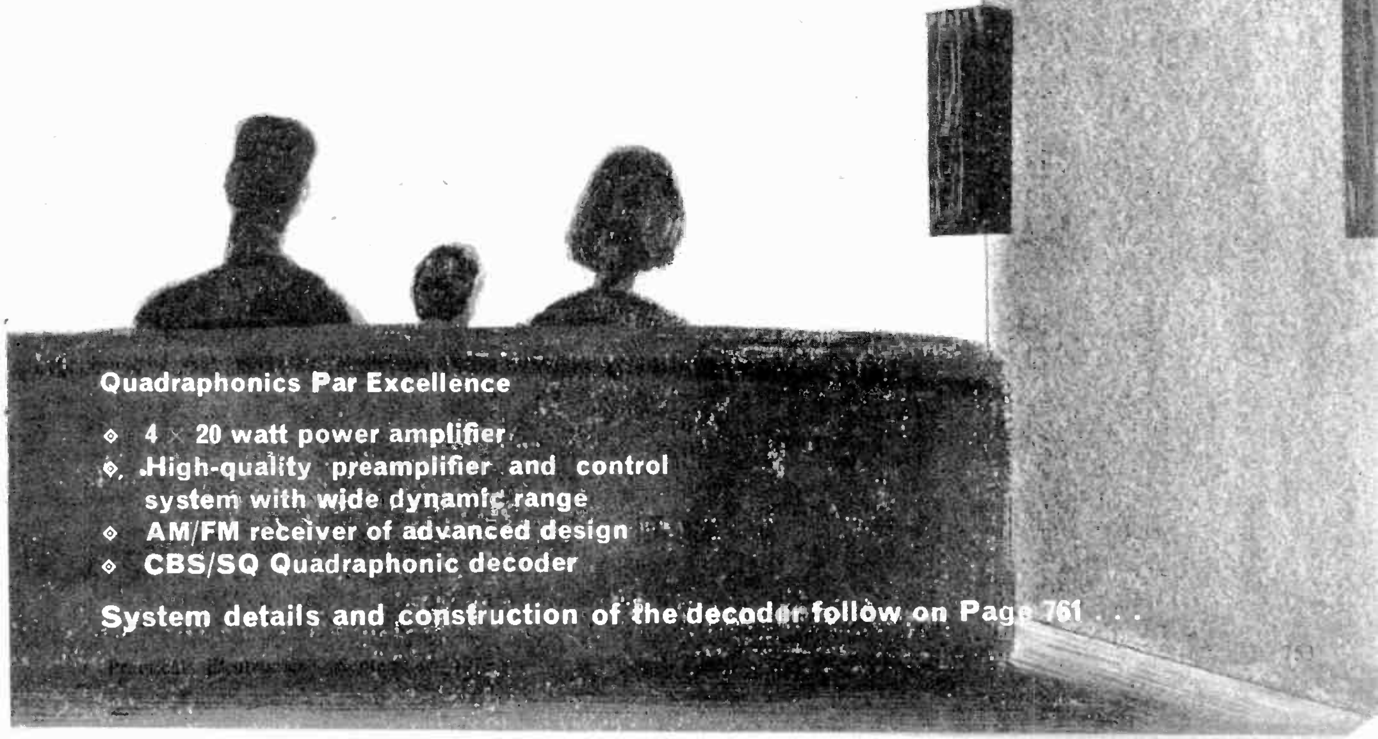
Equally, whilst there are numerous multichannel reproduction techniques that *could* have replaced the present direction of development, the writer will confine himself to the present direction dealing, in detail, with the viable techniques to which the major producers of software and hardware are committed. Brief mention will be made of future trends and, as existing techniques are liable to updating, a final article in the series will include reference to the state of the art at that date.

NOMENCLATURE

Four channel reproduction is generally called QUADRAPHONY (Quadraphonic) conveniently analogous with STEREOPHONY (Stereophonic).

AMBIENCE ENHANCING. A term applied to circuits which attempt to recover ambient information from a normal stereo disc. A noteworthy system is that promoted by Dynaco. Another is shown in Fig. 1.1 by B. B. Bauer (1961).

DISCRETE SYSTEM. One which has four independent channels which can achieve distinct and unconnected sound placement in each channel. Quadraphonic tapes can be called discrete. "Discrete" when applied to disc reproduction is a misnomer which is perpetuated in the description of the JVC CD4 system.



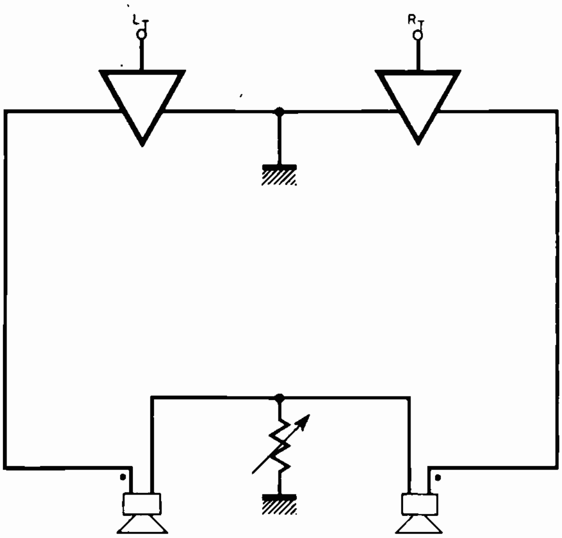


Fig. 1.1. Ambience enhancing in an attempt to recover ambient information from a normal stereo disc. This is the Bauer system developed in 1961

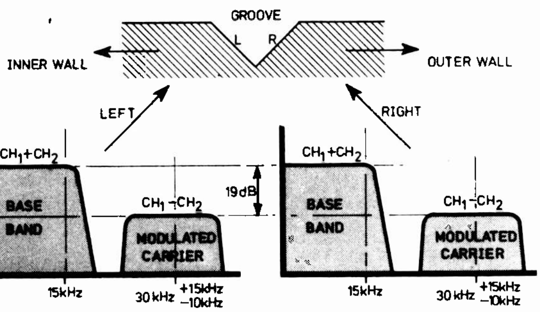


Fig. 1.2. Modulation direction and band separation on a CD4 disc

MATRIX. A term which, in Quadraphony, refers to the electronic mixing of four channels of sound into two composite channels for recording onto a disc followed by electronic re-creation of the original four channels of information. It is sometimes referred to as 4-2-4-matrixing. SQ, QS, RM and E-V are various matrixes.

CARRIER SYSTEM. For example, the JVC CD4 quadraphonic system, utilises two ultrasonic carriers and a matrix to achieve a recording on disc that can be demodulated upon playback to give four channels of information related to the original four recorded.

There are but three systems at present viable to which the major producers of hardware (equipment) and software (recordings—disc or tape) are committed and these can be broadly grouped into two. These are the JVC CD4 system, a carrier system, and the CBS SQ and Sansui QS systems, which are matrix systems.

THE CD4 SYSTEM

The CD4 system was developed by the Japan Victor Company (Nivico) and RCA, and first demonstrated publicly in September 1970. CD4 is a contraction of Compatible Discrete Four Channel. Work on similar lines was carried out by CBS before they opted for the SQ matrix.

The CD4 system combines matrixes with carriers by converting the four channels into sum and difference signals. Channel 1 + channel 2 (CH1 + CH2) is recorded on the left hand side of a 45-45 groove and CH3 + CH4 is recorded on the right hand side. The difference signals CH1−CH2 and CH3−CH4 modulate ultrasonic carriers and the resultants are superimposed upon the sum signals for recording.

The sum signals are called Base Bands and the difference signals are called Modulated Carriers (Fig. 1.2). The base bands are recorded to the RIAA characteristic and are the same as conventional stereo recording.

Due to a number of technical reasons the modulated carriers are frequency modulated below 800Hz and above 6kHz and phase modulated in between. (Recording is as shown in Fig. 1.3.)

Upon replay the two channel composite signals are demodulated and passed through a decoding matrix which "unscrambles" the sum and difference signals to give the four separated channels (Fig. 1.4).

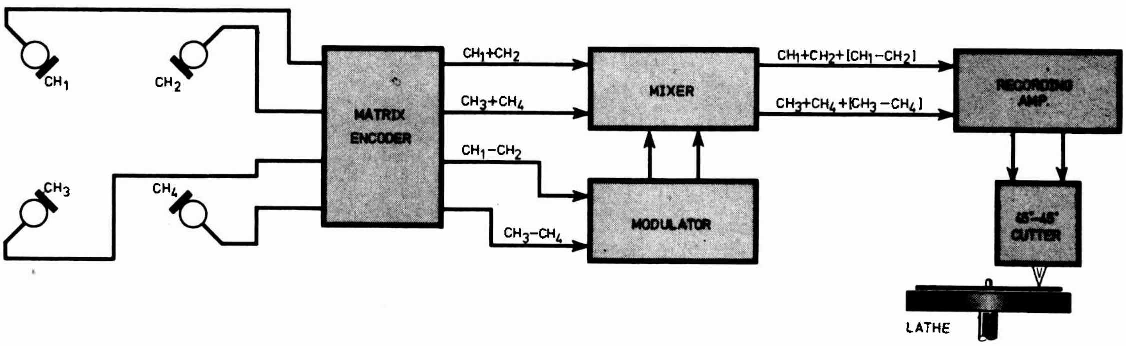


Fig. 1.3. Block schematic of the recording system used when making a CD4 disc

Due to limitations in today's recording technology the base band is limited from 30Hz to 15kHz and the 30kHz carriers are modulated in the range −10kHz to +15kHz. The CD4 specification for discs extends the upper frequency limit to 50kHz in anticipation of improvements in recording technology.

CD4 TECHNIQUES

The basic system has a number of problems which are diminished by the following techniques.

LOWER CUTTING SPEEDS

Cutting lathes have poor frequency response above 20kHz, so CD4 records are cut at half speed to compensate for this deficiency. This results in wider response but higher cost of production.

AUTOMATIC NOISE REDUCTION SYSTEM (ANRS)

A system similar to the Dolby noise reduction system is applied to eliminate noise which is generated in the difference signal path. This noise is primarily f.m. noise and crosstalk distortion.

CARRIER LEVEL CONTROL (CLC)

When the direct signal level is very high, the carrier signal can be degraded with resultant poor sound quality from the difference signals. CLC (Fig. 1.5) automatically increases the carrier level with increased direct signal level, and thus improves signal to noise ratio in the modulated carriers.

It improves abrasion resistance during playback and broadly improves pickup tolerance as well as reducing the base band interference mentioned above.

NEUTREX

This is the name of a new technique which assists the reproducing stylus to accurately trace the complex groove. The higher the baseband amplitude and the higher the frequency, the more pronounced is tracing distortion. Neutrex compensates the groove waveform to avoid the worst effects of tracing distortion as shown in Fig. 1.6 a, b and c.

CD4 STYLUS

Although CD4 records can be played with a spherical stylus of 0·5mm radius at 5 grams without

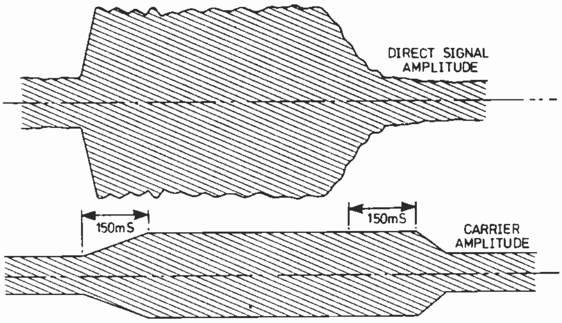


Fig. 1.5. Variations of carrier level which occur in CLC (Carrier Level Control)

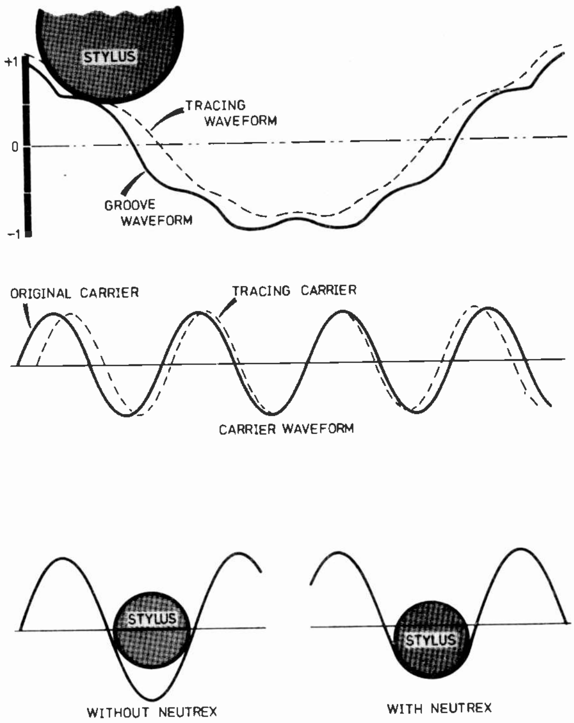


Fig. 1.6. The effects of Neutrex on the waveform traced out by the stylus

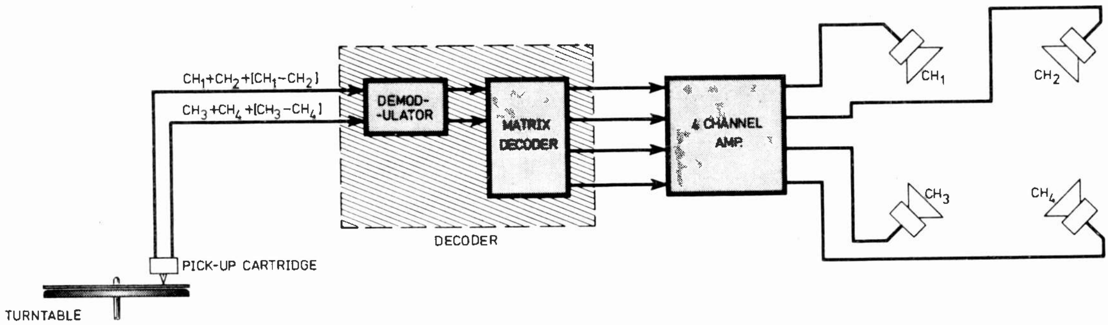


Fig. 1.4. Reversing the process of Fig. 1.3 when playing a CD4 disc

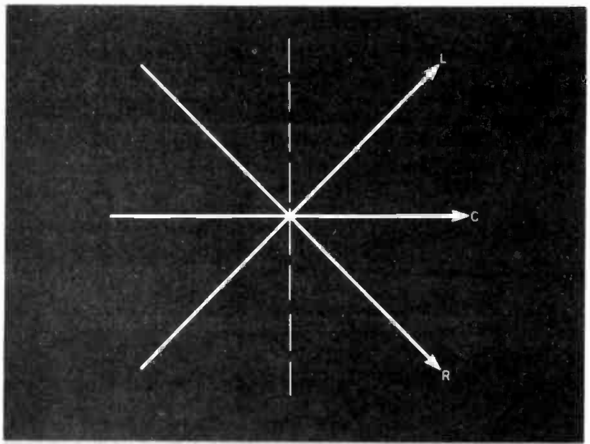


Fig. 1.7. The vector diagram for simple 45-45 stereo where the groove is modulated by two vectors at 90° to each other as shown by the lines L and R

significant wear after 100 playings, the frequency response is poor and distortion is quite high. An elliptical stylus can effect substantial improvement but specially developed styli must be used for really high fidelity reproduction.

The Shibata stylus and the Ichikawa stylus were developed for this purpose. Both are similar in concept and have around four times the contact area with the groove compared with a conventional stylus. They represent the closest practical shape to the original cutting stylus but are quite expensive due to their complexity.

It is also vital that the cartridge has a wide frequency response, up to around 45kHz, to reproduce discs of today's technology. Due to the limitation of the ending diameter of the CD4 disc groove to 5·2in, playing times are somewhat reduced but special plastics have been developed to reduce carrier wear and system deficiencies.

This remarkable technological achievement gives a viable method of quadraphonic reproduction from disc. Reports as to quality are rather varied, the general concensus being that some of the "in-house" recordings from JVC are exceptional, but that most of the commercially available repertoire can only be described as old chestnuts. One can expect a noticeable improvement in all aspects of their software in future.

MATRIX SYSTEMS

A loose definition of matrix systems was given earlier. The precise definition of a particular quadraphonic matrix is only evident when expressed mathematically and such an analysis is outside the scope of this article.

There are also four psycho-acoustic principles which are significant in matrix design; the Haas effect; Front Source Dominance; Back Image Contraction and Quadrature Image Shift. The interested reader is commended for a discussion of these aspects to an article by Bauer, Gravereaux and Gust in the *Journal of the Audio Engineering Society of America,* Volume 19, Number 8, pp. 638-646.

In matrix systems the four channels are not independent and there is crosstalk between channels. The degree of crosstalk, and the channels between which the crosstalk exists, varies from system to system. Depending upon which matrix is used the sound images can be somewhat changed.

The effect of matrixing is best shown on vector diagrams. Two channel stereo can be illustrated simply by Fig. 1·7. The 45-45 groove modulations are represented by two vectors at 90° to each other and shown as the arrowed lines L and R.

If the signal recorded moves the stylus in only one of these two directions the signal passed through the system to the speakers will be only left or only right. If both these basic modulations occur simultaneously the image will appear to lie centre front. It will be seen that such a movement of the stylus is a lateral movement parallel to the record plane and that this is simply mono. Any other angular differences will result in different positional images between the two speakers.

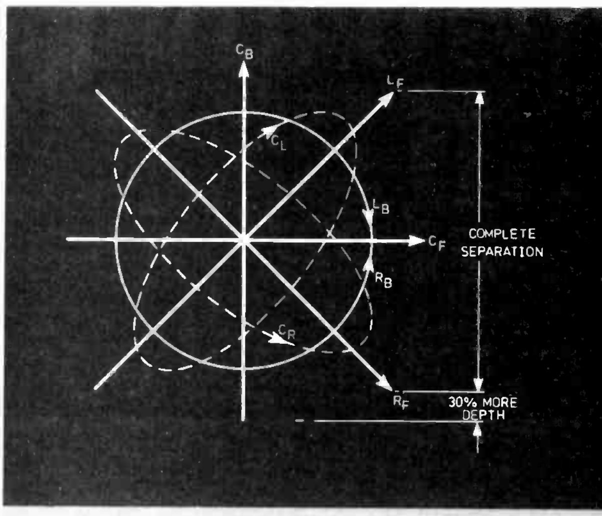


Fig. 1.8a. Vector diagram of the CBS SQ matrix

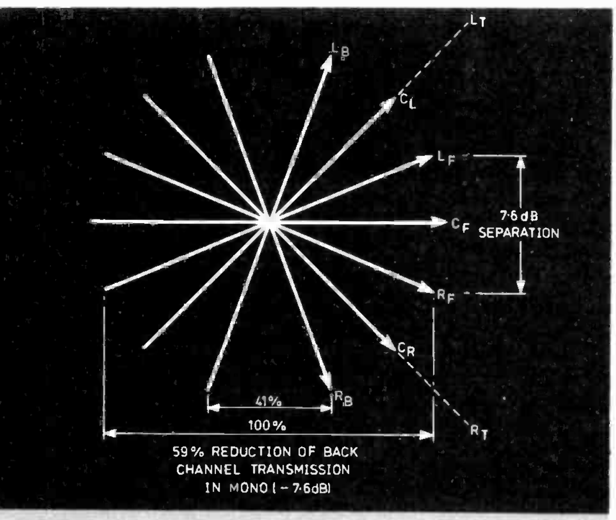


Fig. 1.8b. Vector diagram of Sansui QS-RM matrix

THE CBS SQ MATRIX

Fig. 1.8a shows the vector diagram of the CBS SQ Matrix. SQ simply stands for Stereo-Quadraphonic. It will be seen that the same three basic vectors exist in the SQ diagram as in the two channel stereo diagram of Fig. 1.7. These are the same left front (LF) right front (RF) and centre front (CF), hence the SQ matrix disc provides totally undiluted stereo information to the front loudspeakers with full channel separation.

Stylus movements in the direction marked CB provide centre back images. An additional basic modulation is provided which, for simple tones, is circular about the axis.

Clockwise modulations provide LB information and anticlockwise modulations provide RB information. This modulation appears as a helix due to the forward motion of the record groove.

Further modulations appear as ellipses rotating counter to each other representing centre left (CL) and centre right (CR) positions. LB and RB information is recorded on the left and right walls respectively but with a quarter cycle (90° phase difference)

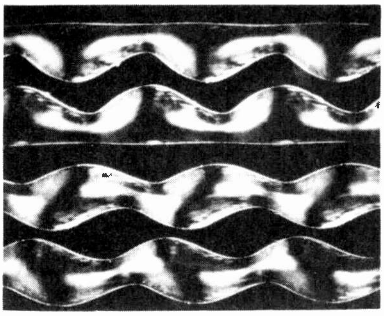


Fig. 1.9. The grooves of a stereo and an SQ modulated disc. (a) and (b) are the same as on a normal stereo disc whilst (c) and (d) show the helical modulation

primarily in classical music, have expressed the opinion that a matrix decoder of the type described above well meets the requirements for quadraphonic surround-sound reproduction.

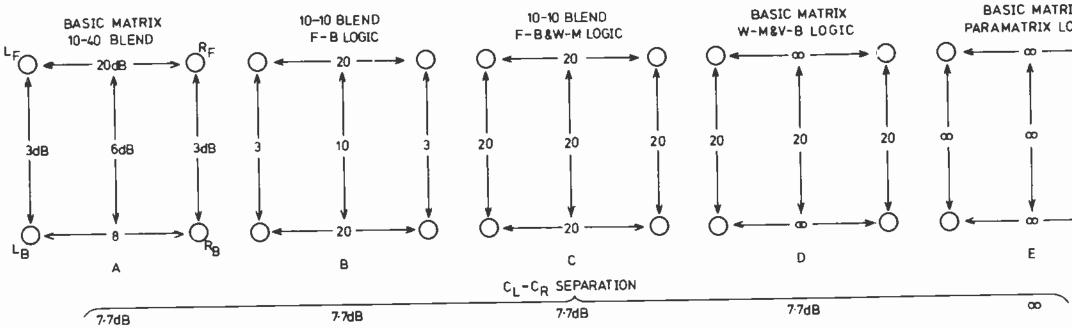


Fig. 1.11. The various stages in SQ decoder development from 10-40 fixed blend (a) to the future possibility of Paramatrix logic (e)

between them, resulting in the apparent circular motion. In recorded music the modulations are very much more complex than the simple tones represented by the helices described.

The photograph of Fig. 1.9 shows magnified grooves of an SQ record. They are all simple tones: (a) and (b) are the same as they would be on ordinary stereo record; (c) and (d) show the additional helical modulation present on an SQ disc to provide back images. The photograph clearly shows the stereo compatibility of the SQ disc which can be played by ordinary stereo cartridges to give full stereo.

The basic SQ matrix exhibits out of phase and unwanted signals at the back speakers when a signal is intended for the left front speaker. These out of phase signals are 0·707 of the level of the intended signal. Similarly out of phase signals appear at the front speakers when signals are directed to the left back speaker. The system is therefore asymmetrical.

Blend resistors added to the front and back signal pairs cancel out some of the unwanted signals with the attendant reduction of back separation to 8 dB. The so far recognised ideal blend is the 10-40 blend, where a 10% front and 40% back blend is used, and is called the 10-40 CBS SQ Matrix (See Figs. 1.10 and 1.11a). Many users, especially those interested

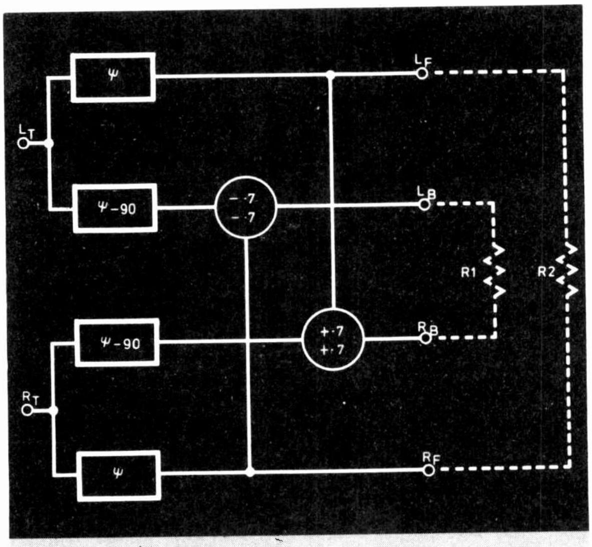


Fig. 1.10. Block diagram of a basic SQ matrix decoder. R1 and R2 provide the channel blend and the values mentioned give the recommended 10-40 blend

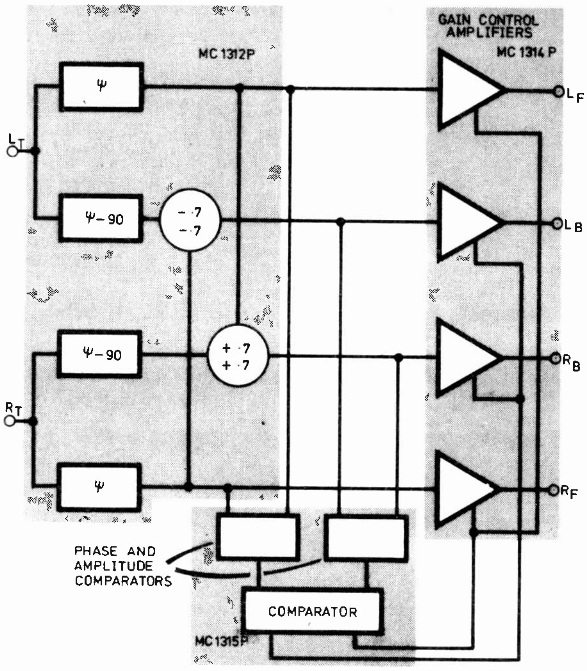


Fig. 1.12. The SQ logic-enhanced decoder using three chips, theMC1312P, the MC1315P and the MC1314P

LOGIC DIRECTED DECODERS

Greatly improved channel separation can be achieved by making use of both electronic logic and three psycho-acoustic phenomena with which we are all familiar. The first phenomenon occurs because of reverberation in a normal living room. This makes it difficult to locate the source of a steady state sound. Secondly, the origin of a varying source of sound, like speech or music, can be easily located. Finally, when there are two or more similar sources present we tend to believe that the one which we hear first is the sole source of the sound.

Logic directed circuits contain output amplifiers with voltage controlled gain characteristics which respond to predetermined amplitude and phase positions of the unwanted transferred signals as sensed by the logic. A signal in one of the front channels causes the production of two signals in the back channels identical in amplitude and in precise quadrature orientation.

This relationship is sensed by a comparator which results in instant enhancement of the front channels and rapid attenuation of the back channels. The converse is equally true and the resultant quadraphonic field approaches that produced by the four independent channels of the master tape.

With a signal to one channel only, this channel is kept open by the logic and any transferred signals are greatly attenuated thereby providing substantially discrete channels of information. These decoders are known as Front-Back (F-B) Logic Directed Decoders (See Figs. 1.11b and 1.12).

Logic directed decoders, in their simplest forms, may exhibit the effect of the logic circuit being confused by complex information. This appears as a "pumping" effect between front and back speakers.

ADVANCED LOGIC DIRECTED DECODERS

The latest advances in SQ Decoder technology have very recently been finalised and the writer thanks Mr. Benjamin B. Bauer, Vice-President C.B.S. Laboratories for his great personal assistance in these matters.

The circuit shown in Fig. 1.13 is the latest logic system and includes Wave Matching (W-M) logic and variable blend (V-B) as options.

The inter-channel separation for the front and back channel pairs is infinite in the basic matrix so only front/back separation needs to be improved.

If, for example, a transient signal is directed to left-front the W-M logic circuits recognise this as a front signal and adjust the levels between front and back so that 20dB separation in this direction is obtained. Another word for W-M is "corner-directed" logic.

If the left-front signal begins to decay and another transient signal is applied to LB the LB signal is emphasised. However, the steady state portion of the remaining LF signal becomes transferred to the LB but the ear assumes continued transmission from LF due to transient source dominance.

Thus the W-M logic can continually emphasise new transient sources in direction whilst maintaining the total power of all the preceding signals. (See Fig. 1.11c F-B and W-M Logic).

DYNAMIC BLEND

It has been previously explained how fixed 10-40 blend can enhance the separation between CF and CB signals. The same principle can be applied to logic but using a dynamic variable blend instead of fixed blend. If a CF signal, e.g. solo voice, is applied the channels at once become blended causing the signal to emerge from its proper centre-front location.

By careful design there will be almost complete front/back signal separation without any significant audible loss between front and back channel pairs. (See Fig. 1.11d W-M and V-B logic).

LATEST DEVELOPMENTS

Perhaps the most significant of the recent advances in SQ technology is the introduction of the integrated matrix chip manufactured by Motorola under CBS sponsorship, see Fig. 1.13. The MC1312 is the basic SQ Matrix Decoder and the MC1315 the Full Logic Module embodying both F-B and W-M logic. A Power Transfer Module MC1314 has the dual purpose of accepting the logic commands and translating them into enhanced quadraphonic action. It can also act as a gain control and loudspeaker balance element.

The circuit in Fig. 1.13 combines all the foregoing functions, including variable blend, which is controlled by means of an f.e.t. 2N5485 and four operational amplifiers. There is additionally provision for volume and balance (F/B, LF/RF, LB/RB) controls and a dimension control to adjust the logic action to suit ambient listening conditions. All of the logic and control functions are optional additions to the basic matrix decoder.

Reference has previously been made to Fig. 1.11 which shows the channel separations obtainable from each variation of the SQ Decoder. CL/CR separation is in all cases 7·7dB, but although an additional logic function could be added, it is found in practice that negligible advantage is gained.

By application of the so-called variable blend to all the logic functions an infinite "round the board" channel separation is feasible. This results in the unwanted output of one decoded channel cancelling the unwanted output of another decoded channel, and vice versa, which is the essence of the technique known as "Paramatrix" shown at Fig. 1.11e.

THE SANSUI QS MATRIX SYSTEM

The Sansui QS system, also known as the R/M or Regular Matrix, was developed by Sansui in 1970. Its modulations in their idealised form are shown in Fig. 1.8b and may be compared with those of the SQ matrix, Fig. 1.8a. The LF and RF modulations are orientated at 22½° with respect to the left and right axis and represent a 7·6dB front separation.

This means that a stereo orchestral recording will shrink to about one-half of the space between the

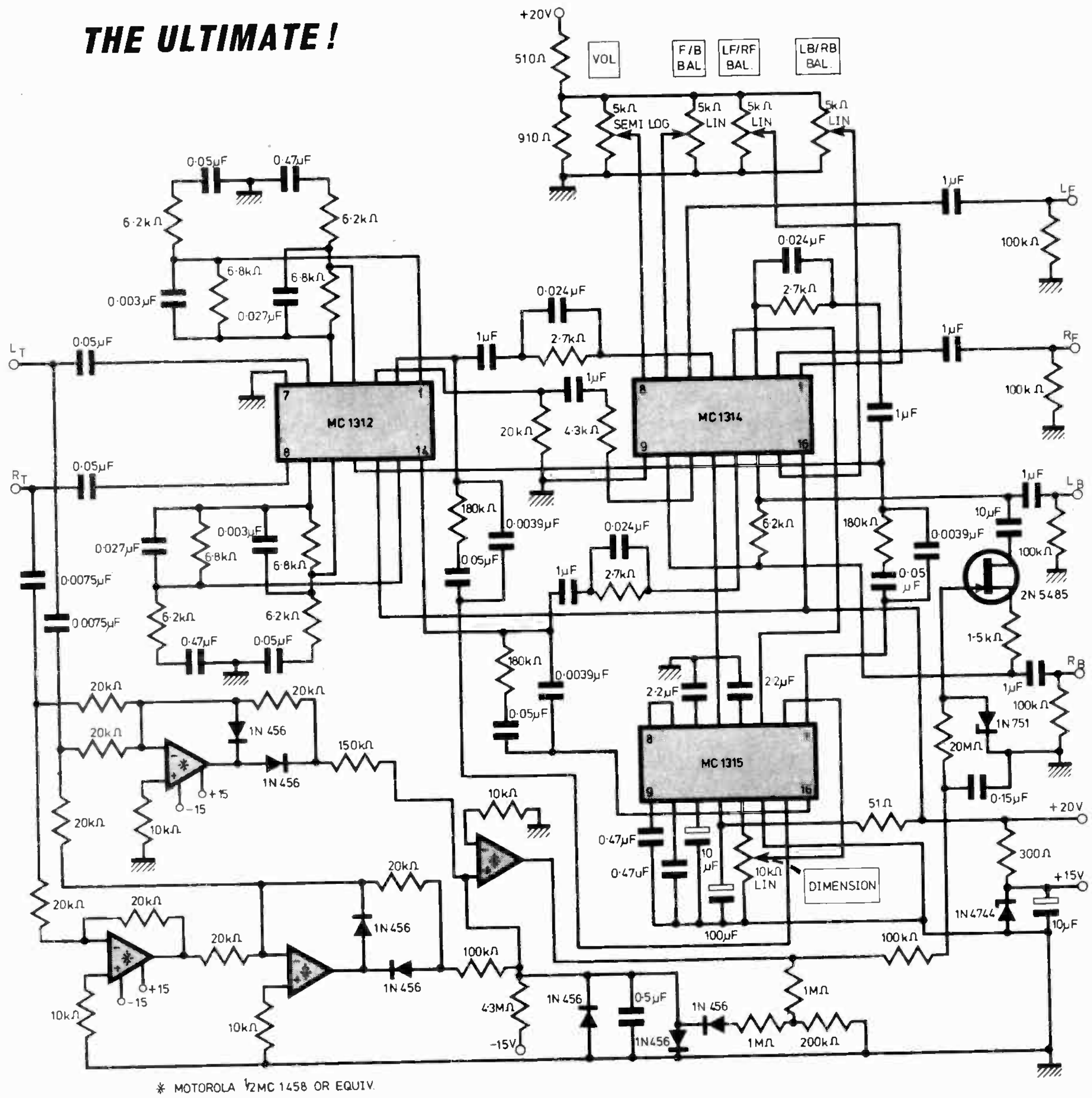


Fig. 1.13. Circuit diagram of the very latest SQ logic system, including front-back, wave matching, and variable blend logic

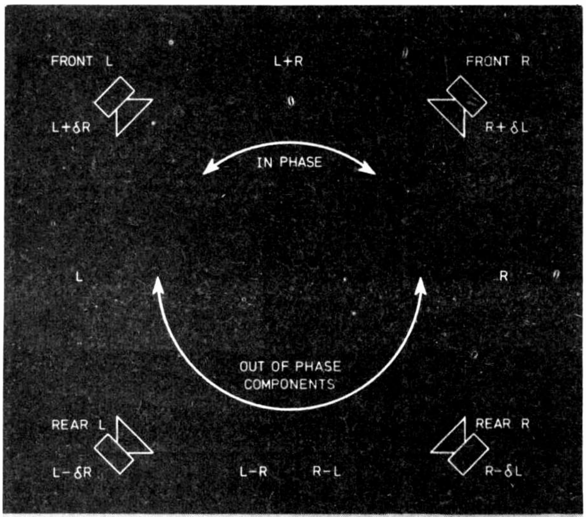
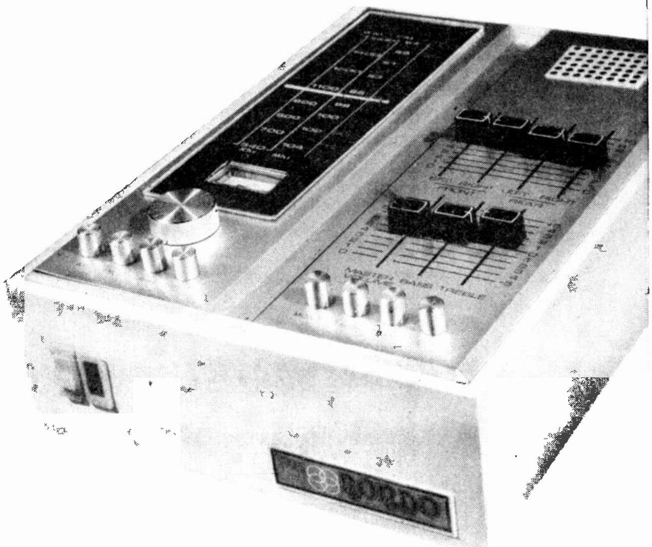


Fig. 1.14. The Sansui QS-RM system



speakers. The unwanted images (out of phase components—see Fig. 1.14) appear in the speakers either side of the speaker to which signals are being directed. This means that images appear somewhat more accurately in the direction intended.

It follows that this matrix is more symmetrical than SQ. The rear channels are also reduced to 41% of their original level for mono signals and heavy back modulations may be reduced by 2·3dB due to the need for around 30% extra cutting depth for back images. The principal loss however is of stereo compatibility.

Within its limitations the system gives acceptable results. Sansui have also developed a technique for reducing unwanted signals with the name Variomatrix.

THE FUTURE

The large companies have made such substantial capital commitments and technical advances in Quadraphonics that the course of this art is "preordained" for some time to come. Work is being carried out by others in methods to reduce the bandwidth necessary for the difference paths in carrier techniques which, although reducing technical difficulties, would seem to be a retrograde step from the quality aspect.

A very interesting technique devised by Duane Cooper (University of Illinois) and Takeo Shiga (Nippon Columbia Co. Ltd.), and called a Phasor matrix, distributes the phase differences in sectors of 45° which means that the speakers either side of the wanted speaker receive signals that are +45° or −45° phase shifted.

This system, called BMX by Cooper, can be made more directionally accurate by the addition of more channels. These channels can be of narrower bandwidth without degrading performance. This matrix is in its early stages and has not been adopted by any recording company to date and only experimental discs have been produced so far.

COMPATIBILITY

Compatibility can be considered from two standpoints; one being compatibility of any quadraphonic system with another, and the other being compatibility with stereo material.

Quite obviously a CD4 record will not be quadraphonically compatible with matrix records. Matrix records are compatible with each other to a degree which, of course, is limited by their differences. It is possible to play an SQ record through a QS decoder or *vice versa* and obtain really enjoyable results which, although inaccurate, do enhance listening pleasure.

All are stereo-compatible but QS has a much reduced stereo separation. All matrix records can be broadcast by v.h.f. stereo radio and when received as stereo, may be decoded into quad.

CD4 records cannot be broadcast by present stereo radio transmitters. Over 200 transmitters in the U.S.A. have broadcast matrix quad and it is hoped that similar broadcasts may be undertaken by the IBA in their test v.h.f. transmissions in the U.K., later this year.

SOFTWARE AND HARDWARE

There are some 40 CD4 recordings available in the U.K. at present, mostly by JVC themselves. CBS SQ records number over 100 and also in excess of 20 have been produced by EMI. The U.S. situation is around the same for CD4 but over 200 SQ LPs are available. About 20 SQ records of European origin are listed. There are at least twelve QS records marketed.

At the June 1973 Chicago Conference more than 40 makes of record playing equipment were exhibited. All of these had built-in SQ circuitry in multiple models. Around a dozen offered facilities, for integral CD4 circuitry. The big volume suppliers, who furnish over 90% of the market, offered SQ capability only.

It seems a reasonable conclusion that the availability of SQ hardware will accelerate the rate at which SQ discs become available compared with CD4.

SPECIFICATION

CBS SQ 10-40 BLEND MATRIX DECODER

Input Impedance
3MΩ typical
Distortion
0·1 per cent typical
Maximum Handling Capability
2·0V r.m.s.
Signal to Noise Ratio
Short circuit −80dB. Bandwidth 20Hz—20kHz
Channel Separation

L_F—R_F	20dB
L_B—R_B	8dB
L_F—L_B	3dB
R_F—R_B	3dB
C_F—C_B	6dB
L_C—R_C	7·7dB

Supply Voltage
+20V d.c. @ 16mA

PREAMPLIFIER

Inputs

F. M. Radio	100mV @ 50kΩ
A. M. Radio	100mV @ 50kΩ
Disc	3mV @ 47kΩ
Tape	100mV @ 50kΩ

Output
100mV @ 10kΩ to amplifier tone controls
100mV @ 10kΩ to tape recorder unaffected by volume and tone controls
Signal to Noise Ratios
Disc −60dB, Others −70dB } unweighted
Crosstalk
−50dB @ 1kHz
Dynamic Range
38dB before clipping
Distortion
0·05 per cent at rated sensitivity
Supply
±15V d.c. at 5mA

TONE CONTROLS AND BALANCE

Inputs
2 × 100mV @ 10kΩ from preamplifier
4 × 100mV @ 50kΩ playback from tape (4 channel) (inserted via balance potentiometers after tone controls)
Outputs
2 × 100mV @ 10kΩ to quad decoder
4 × 100mV @ 10kΩ to tape recorder (4 channel) (into recorder before balance potentiometers and after tone controls)
Gain
Unity
Bass Control
±16dB @ 30Hz
Treble Control
+10dB, −13dB } @10kHz
Balance
Zero to full output on each channel
Crosstalk
−50dB @ 1kHz
Dynamic Range
38dB before clipping
Distortion
0·05 per cent at rated sensitivity
Supply
±15V d.c. @ 5mA

POWER AMPLIFIERS (two per board)

Input Impedance
10kΩ
Frequency Response
At 20W into 8Ω continuous sine wave
−1dB from 10Hz to 20kHz
−3dB from 5Hz to 30kHz
Power Output
20W per channel into 8Ω continuous sine wave
Total Harmonic Distortion
20W into 8Ω <0·1 per cent
50mW into 8Ω <0·1 per cent
Stability
Will drive electrostatic loudspeakers
Damping Factor
120 into 8Ω
Supply
±25V d.c. @ 2·0A, ±15V d.c. @ 5mA } for both amplifier boards

TUNER

F.M. + DECODER
Frequency Range
87·5MHz to 104MHz
Sensitivity
3·0μV I.H.F. (Institute of High Fidelity Manufacturers)
20μV for 58dB signal-to-noise ratio
10μV for full limiting
Total Harmonic Distortion
Mono 0·6 per cent
Stereo 1·0 per cent
Stereo Separation
35dB @ 1kHz

A.M.
Frequency Range
550kHz to 1·6MHz
Capture Voltage
100μV at midband
Distortion
Approximately one per cent total harmonic distortion
Supply
+24V d.c. @ 100mA

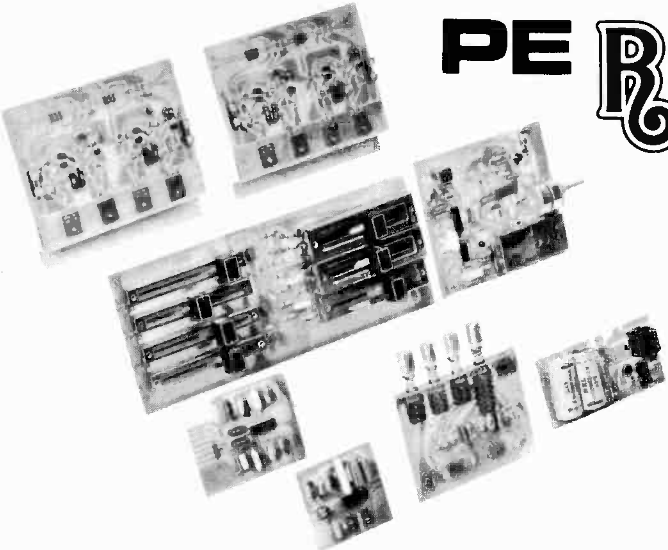
SPEAKER SYSTEMS

Power Handling
20W continuous sine wave
Impedance
8Ω
Loading
Infinite Baffle
Frequency Response
35Hz—22kHz ±5dB
Drive Units
2 × HIF 13E 130mm Long Throw Units
2 × 6·5 TW Bi 65mm Tweeters
Crossover Network
Six-element network dividing at 500Hz and 6kHz

OVERALL DIMENSIONS

Cabinet
254mm (10in) × 120mm (4¾in) (add 15mm for height of knobs) × 326mm (12¾in)
Speaker Enclosures
242mm (9½in) × 405mm (16¼in) × 216mm (8½in)

PE RONDO



PE RONDO

SYSTEM DETAILS AND DECODER MODULE

THE PE RONDO

The current increasing interest in quadraphonics, coupled with the introduction of integrated circuit decoder chips supported by a growing bank of software has created the ideal atmosphere for the home constructor to build his comprehensive Quadraphonic System.

The PE RONDO system has been developed and planned especially for the home constructor and incorporates advanced technology throughout.

Figure 1.15 shows the system in block diagram form and a full technical specification is given elsewhere. The system incorporates power supplies, power amplifiers, both f.m. and a.m. radio tuners, stereo decoder, quadraphonic decoder system, tone, volume, balance controls and selectors, and preamplifiers and characteristic compensation circuits. All this circuitry is incorporated in a neat and compact wooden case with a shallow metal plinth in which are mounted the input and output terminations.

The system is completed with a set of four loudspeakers for those who wish to make their own.

The approximate cost to build is £70 plus V.A.T. for the main unit; and £62 for the loudspeakers (4). (Suitable turntable units can be found in the price range £25-£40).

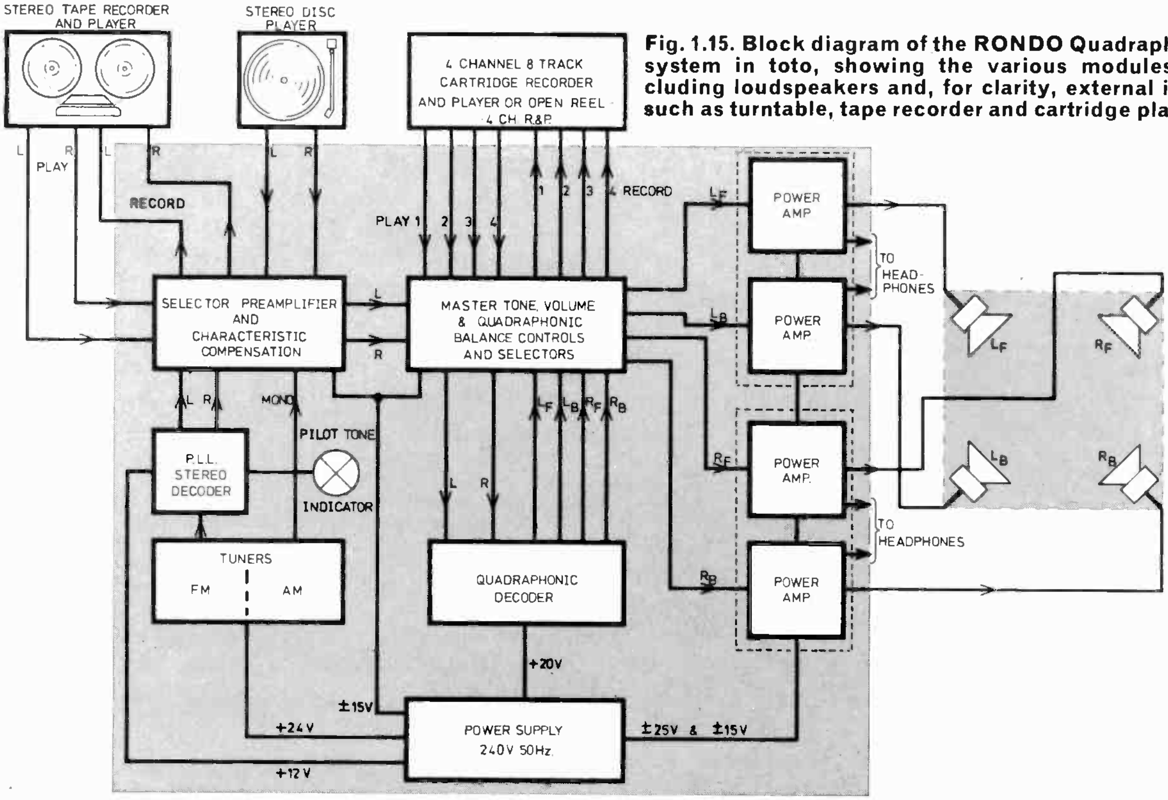


Fig. 1.15. Block diagram of the RONDO Quadraphonic system in toto, showing the various modules, including loudspeakers and, for clarity, external items such as turntable, tape recorder and cartridge player

CBS SQ DECODER MODULE

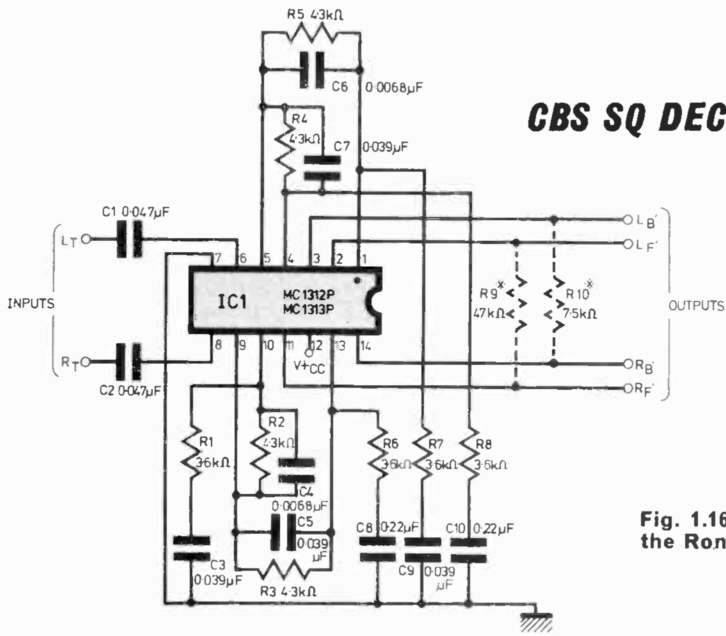


Fig. 1.16. Circuit diagram of the Rondo decoder board

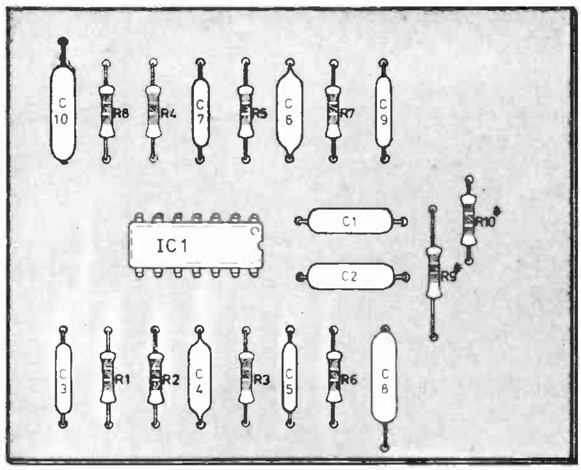


Fig. 1.17. Component layout for the Rondo decoder board

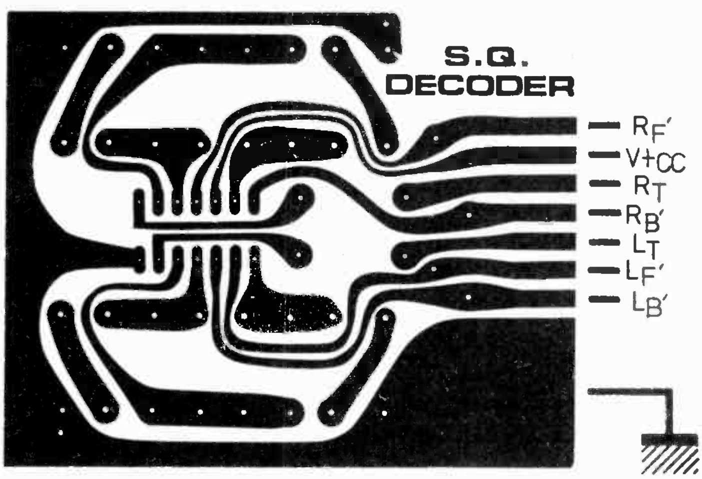


Fig. 1.18. Printed circuit copper layout for the Rondo decoder board

COMPONENTS . . .

CBS MATRIX DECODER

Resistors

R1	3·6k Ω	R6	3·6k Ω	
R2	4·3k Ω	R7	3·6k Ω	
R3	4·3k Ω	R8	3·6k Ω	
R4	4·3k Ω	R9	47k Ω	see text
R5	4·3k Ω	R10	7·5k Ω	see text

All 5% ¼W carbon or metal oxide

Capacitors

C1	0·47μF 20% 63V	C6	0·0068μF
C2	0·047μF 20% 63V	C7	0·039μF
C3	0·039μF	C8	0·22μF
C4	0·0068μF	C9	0·039μF
C5	0·039μF	C10	0·22μF

All 5% 63V polyester except where stated

Integrated circuit

IC1 MC1312P CBS SQ Monolithic Decoder

Available only as part of a complete kit from CBS Licensees or retailers who have purchased as a complete kit from CBS Licensees. This is due to licensing restriction imposed by the Licensor CBS Inc.

Printed Circuit Board

Fibre glass as part of kit of parts from: Sonax Electronics, Spencer House, Brettenham Road, London, N.18.

FLEXIBILITY

Examination of Fig. 1.15 shows clearly that a number of advantages accrue from using a modular construction which integrated circuits and printed circuit boards allow.

In the first place, the system can be built in stages.

Secondly, the system can first be built as a stereo system and later converted. Indeed, the constructor can, if he wishes, make use of an existing stereo system in conjunction with a RONDO stereo section to complete the quadraphonic system.

By including suitable switching circuitry the quadraphonic system can be extended to accept any future, or for that matter existing, decoders which might become available.

The PE RONDO specification is broken down into the various sections for simplicity and ease of understanding.

THE DECODER

This first constructional article deals with the perhaps simplest but most important part of a Quadraphonic system—the decoder.

The CBS SQ 10-40 decoder chip is manufactured by Motorola under licence from CBS Inc. The licence is part of a commercial agreement involving the supply of the products to licensed equipment manufacturers only.

In the present instance CBS have given permission for supply of the i.c. to constructors provided it is sold as part of a kit for making up the decoder. All other parts of the RONDO system are available freely in the normal manner.

CONSTRUCTION

The decoder chip is packaged in a dual-in-line 14-pin package under the code number MC1312P and is marked with a dot to indicate correct orientation of the chip when mounting, as can be seen from Fig. 1.16, the circuit diagram of the decoder.

Most of the components shown external to the chip are phase shift networks referred to earlier. In addition, there are the two input capacitors, C1 and C2, which decouple the chip circuitry and the two fixed blend resistors, R9 and R10, shown dotted.

The phase shift networks have pre-determined time constants and must utilise stable components of ±5% tolerance.

The printed circuit board layout master is shown in Fig. 1.18 and the component layout, the opposite side of the PCB, is shown in Fig. 1.17. It will be seen that two different mounting pitches are provided for C8 and C10. This is so that these capacitors may be selected from several manufacturers offering different lead-out pitch distances.

The components are mounted on the board from the non-plated side in the configuration shown and it is probably best to mount all components and bend the leads slightly, before starting soldering, to hold the components in position. This makes certain the layout is correct before any hard-to-reverse steps are taken.

Don't forget to take care with the soldering operation, only applying the iron for long enough to make a good joint, particularly on the i.c. pins. It's all too easy to damage an i.c. with conducted heat from the pins.

After soldering, the board should be cleaned of any flux and solder splashes with a brush.

TO COME

In following articles we will deal with the construction of power supply, power and pre-amplifiers, volume and balance controls and tone controls. All the r.f. circuitry will be described including both a.m. and f.m. receivers and an associated stereo decoder for the f.m. unit. Finally suitable speakers will be described for those who wish to make their own.

The equipment described so far is, in one form or another, available commercially. However, in the articles to come, one of the very latest ideas in quadraphonics will be described—an extension of the CBS SQ matrix board using the latest logic to give front/back logic, wave matching logic, and variable blend. This latter is so new that PE readers will be amongst the first in Europe to have it.

Of course, this does not detract from the basic matrix board described in the present article, and very exciting results can be obtained with this.

Next Month: Audio amplifiers and power supply

BY FRANK W. HYDE

BOULDERS OF SATURN

There has been confirmation of the reports, mentioned in the June issue, that the rings of Saturn were in fact large boulders. Measurements were made using the emission at 20 micrometre wavelength and the temperatures recorded were 89°K for the inner ring, 94°K for the middle ring and 89°K for the outer ring.

It appears that the measured temperature is dependent upon the angle the Sun makes with the rings. This fact is consistent with the boulders being of the order of 1m in diameter.

The fact that the shadow, which Saturn casts on the rings, affects the results is rather puzzling if the boulders are of the size suggested. However, there is an explanation and that is fine dust also present or alternatively that the inner ring is subject to bombardment by a particle zone similar to the Van Allen belts.

The work in this field was done by R. Murphy at the Mauna Kea observatory in Hawaii.

GRAVITY CONTROVERSY

There has been considerable controversy over the reality of the gravity waves which Weber insists he measures.

Studying new published data from the Bell laboratories, a team has made an analysis of Weber's events and has introduced the known data of geophysical and meteorological measurements and solar activity. So far there has been no confirmation and the work being carried out with new apparatus does not support Weber, in spite of its sensitivity.

This sort of investigation was also suggested by a group from Russia. The Russians have already correlated solar activity and the variations of the magnetosphere as well as other phenomenon,

The results obtained seem to offer another explanation for the events which Weber records. The group at the Bell laboratories under Dr. J. A. Tyson have found evidence of correlation between the magnetosphere ring current and Weber's results. The extent of magnetic effects are global in extent and therefore account for the coincidences that are observed at Weber's two stations at Maryland and Argonne which are 1000km apart.

GEOMAGNETIC FLUCTUATIONS

Although Weber's instruments are magnetically shielded by steel in the form of a vacuum tank, it is suggested by the Bell team that this shielding may not be good enough at the very low frequencies involved in the geomagnetic fluctuations.

This suggestion is plausible because it could explain the daily variations that Weber observes and his interpretation too that these variations are from the galactic centre which is swept by the beams of his detectors every day.

In view of the American and Russian results, the explanation could as easily be that these changes are caused by the daily changes in the ionosphere caused by the Sun.

It is seriously suggested that the careful studies of Weber may be coloured by wishful thinking for no one could doubt the integrity of his work. The cosmologists may feel that the problems that would beset them, if Weber had proved to be right, have now been avoided.

ESRO AND SATELLITES

Magnetospheric studies have been a special programme of the European Space Research Organisation and the progress in this field was revealed recently at a symposium.

Data from the measurements and observations by ten satellites was made available. These included the results from *Heos-2*.

Some of the projects were a combined operation with *Heos-1* and *Iris*. This applied in particular to the penetration of the solar particles ejected when the Sun is active, through the magnetosphere to Earth.

It emerged from the observations that there was a peculiar precipitation pattern which formed over the Earth's polar caps. Using *Heos-1* and *Iris* the particles could be studied in space, as well as close to the polar caps, at the same time.

The major advance in knowledge came from the results of *Heos-2*. The highly eccentric orbit of this satellite enables a region, not previously studied, 240 000km above the north pole to be explored. One of the outstanding discoveries was that the outer boundaries of the magnetosphere are some 30 per cent further out than was indicated by measurements from lower levels.

Another rather unexpected result was that it appeared that the magneto-tail at the magnetopause contains a layer of electrons at energies higher than 1MeV.

Recently the neutral point on the magnetopause boundary has been studied in detail. A discovery was made here that the hot plasma comes down the cusp region at a magnetic latitude of 78°. A few degrees nearer the pole cold plasma in the ionosphere leaves to move into the geomagnetic tail.

JOINT PROJECTS

Future projects have been agreed and there is to be a joint project between ESRO and NASA for launchings in 1978 and 1979. One will be a heliocentric satellite and the data will deal with the interplanetary conditions and these will combine with the results from two others. Known as a mother and daughter pair, they will orbit close together near the Earth.

The correlation of the results of magnetic and particle measurements should resolve some of the present ambiguities. There will also be an intensive study using ground stations, balloon, rocket and satellite.

The satellite will be the *GEOS* to be launched in 1976. This will be the first geostationary satellite for Europe and will study the distribution of the thermal plasma and that of waves and energetic particles.

Many of these projected studies will be assisted by the *Skylab* programme and the shuttle programme.

There is now a great need for a settlement of the various theories and a sorting of the anomalies that exists. It is certain that some of the finer points of nuclear fission may well be revealed by the combined experiments to be made as well as completing knowledge about the interplanetary medium, the solar wind and the underlying basic measurements which are at present obscured by the equatorial electrojet and the auroral current. There are both chemical and mechanical means of achieving such objects.

INGENUITY UNLIMITED

A selection of readers' suggested circuits. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.
This is YOUR page and any idea published will be awarded payment according to its merits.

CAR WIPER CONTROL

THE CIRCUIT in Fig. 1 was designed to overcome the shortcomings of a normal windscreen wiper set-up which does not have the facility for a slow wipe. The normal speed used in very fine rain causes the windscreen to smear and become too dry; the wiper blades judder and squeal, and their life is shortened considerably.

The circuit uses a simple u.j.t. oscillator to determine the wipe periods. The time interval is governed by the values and settings of R1, VR1 and C1. The unijunction fires when the voltage on C1 is approximately 0·7 of the supply voltage; this gives a period equal to the CR product. With the values given this varies from 2 to 22 seconds, a more than adequate range.

A linear potentiometer incorporating a switch, wired for fast wipe on switch-on, was used in the prototype unit. The scales shown in Fig. 2 show typical settings for alternative wiring for both linear and logarithmic potentiometers.

The "monostable" action of self-parking wipers is achieved with a switch connected to the wiper linkage, which is open when the wipers are at rest, see Fig. 3. This action is essential to the operation of the circuit; fortunately the vast majority of cars have self-parking wipers.

The current pulse in L1 is reflected in L2; CSR1 fires and latches on. The wipers start their cycle and switch S3 closes. The action of S3 closing puts a short across CSR1 and the current through it ceases and the thyristor switches off. The wipers continue their cycle and park normally.

As the starting urge of a wiper motor is very large a 16A thyristor was used. A heat sink for CSR1 was not used as it is only conducting for a short period at the start of each cycle and the continuous current is well below the rated value. It was decided to leave CSR1 in circuit all the time as the starting surge is well above the rating of the potentiometer switch.

A suitable pulse transformer can be made from 1¼in of ferrite rod. L1 consists of 100 turns of 26swg enamelled copper wire and is covered with a layer of p.v.c. tape. L2 is wound in the same direction as L1 and consists of 150 turns of 26swg enamelled copper wire. The start of each winding should be marked with a spot of paint.

The indicator lamp could be omitted but was found to be useful, especially at low speeds when one can forget that the unit is operating after 21 seconds of nothing happening.

The only connections that need to be made to the car's electrical system are the negative earth, the positive supply from a convenient point (the "hot" wiper switch terminal), and points "A". In a car with two-speed wipers "A" should be on the lower speed.

N. E. Thomas,
London, S.W.17.

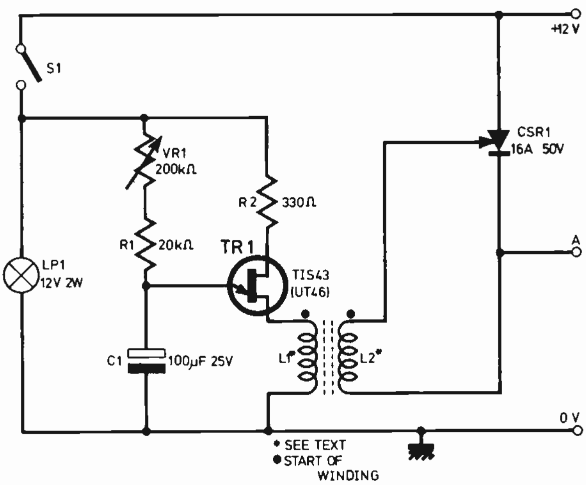


Fig. 1. Circuit diagram for unijunction car windscreen wiper controller

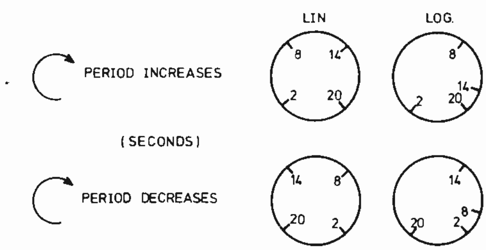


Fig. 2. Typical scale settings for linear and logarithmic potentiometers

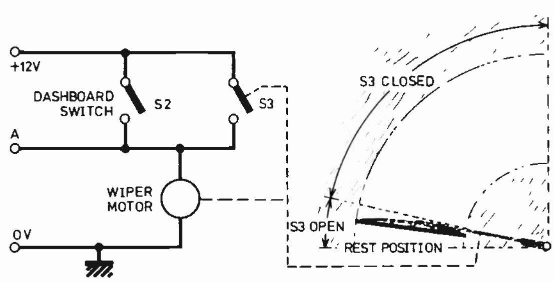
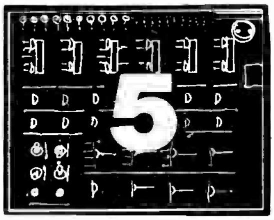


Fig. 3. Showing how the "monostable" action of the self-parking wipers is achieved

LOGIC TUTOR EXPERIMENTS



EXCLUSIVE OR FUNCTION

AN answer to last month's problem is shown in Fig. 5.1. In effect we are making two 3 input OR gates—using NAND logic—and then combining the outputs of these in a third OR gate. We rely on the Boolean Algebraic ASSOCIATIVE rule to permit this operation. As was the case when we simulated a six input AND we need a surprisingly large number of gates to carry out this simple operation. Frequently it is necessary to have a multi-input OR function in a logic system and many designers prefer to use discrete diode resistor logic followed by an inverter rather than integrated NAND gates when more than about four variables have to be ORed together.

EXCLUSIVE OR

This month we look at the EXCLUSIVE OR function. The normal OR truth table shows the output to be level 1 when both inputs are 1. To obtain EXCLUSIVE OR we must arrange that the output is 1 ONLY when one input OR the other is 1; when both are 1 the output must go to level 0 as shown in the truth table of Fig. 5.2. In Boolean terms we say the output (Q) is 1 when A is 1 AND B is 0 or B is 1 AND A is 0. This is written as $Q = A.\bar{B} + B.\bar{A}$.

It is easy enough to formulate a logic circuit that will do this using simple AND/OR/INVERT logic (Fig. 5.2.). This circuit can then be directly converted into NAND logic by substituting a NAND followed by an inverter for each of the AND gates and a NAND preceeded by inverters to give the OR at the output. If you draw out the equivalent NAND circuit in full you will find that you have two pairs of inverters following each other; the effect of this is to cancel the inverting functions and the NAND circuit for EXCLUSIVE OR becomes that shown in Fig. 5.3. You can patch this up on Logic Tutor and verify that the output is 1 only when one or the other of the inputs is 1.

AN ALTERNATIVE CIRCUIT

Because EXCLUSIVE OR is a compound gate function there are various ways of arriving at a circuit that will produce the desired effect. One of the most economic ways—which is not so easy to arrive at—is shown in Fig. 5.4. This uses only four NAND gates but gives the same result as the previous circuit; try it on Logic Tutor and see. Try using Boolean Algebra and De Morgan's Theorem to show that the output is truly $A.\bar{B} + B.\bar{A}$—some of the nodal expressions are given to help you. The full proof will be given next month. As an extra exercise see if you can devise any other circuits that will give the EXCLUSIVE OR function—try not to use more than six gates.

The EXCLUSIVE OR is sometimes called a "NON-EQUIVALENCE" gate. The reason for this is that you can say the output is 1 when the two inputs see different logic levels—when both inputs are the same the output goes to 0. It is thus a simple matter to convert an EXCLUSIVE OR into a comparator by inverting its output. A comparator gives an output of 1 when both inputs are the same.

by M. J. Hughes

Next month we will deal with the WIRED OR function.

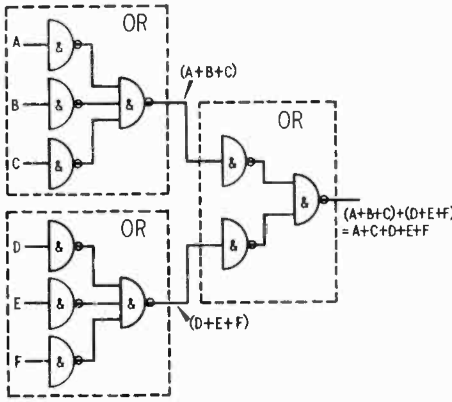
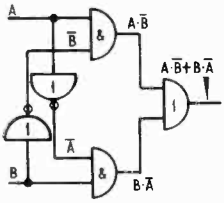


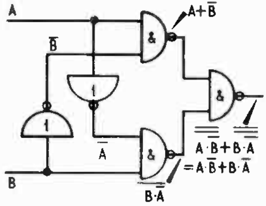
Fig. 5.1. An answer to last month's problem



A	B	Q
0	0	0
1	0	1
0	1	1
1	1	0

$Q = A\cdot\bar{B} + B\cdot\bar{A}$

Fig. 5.2. EXCLUSIVE OR truth table and its representation in AND-OR-INVERT logic



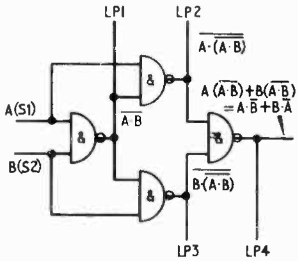


Fig. 5.3. The basic circuit of Fig. 5.2 in NAND logic showing the Boolean expressions at each node

Fig. 5.4. A more economical EXCLUSIVE OR—using four NAND gates. Use the Logic Tutor to verify the circuit is correct

PHASING UNIT

BY D. BENFIELD

THERE is a continual demand for sound effects units which can be put together easily and cheaply by the home constructor. Indeed, it is this last feature, namely cost, which gives such devices an advantage over equivalent commercial units which are usually prohibitively expensive. To this end, the "phase box" about to be described has been made as simple as possible, consistent with an acceptable performance.

PRINCIPLE OF OPERATION

The essence of musical phase effect is to play a piece of music through two channels, with a slight time delay on one input.

To produce the required effect, the input signal is passed through a variable time delay network; the output from this is then mixed with the original signal which formed the input as shown in the block diagram of Fig. 1.

At a certain frequency, depending on the delay introduced, complete cancellation occurs during the mixing process and, by varying this frequency, the well known phasing effect is produced.

THE DELAY NETWORK

The basic circuit used to produce the required phase shift is shown in Fig. 2.

If equal amplitude sinewave inputs, of frequency f, are applied to "A" and "B," but with the input to "B" inverted with respect to "A," then the output will also be of the same amplitude, but will have a phase lag of $2\tan^{-1}(2\pi fRC)$ degrees.

Note that when $2\pi fRC = 1$, then the phase lag is 90 degrees. Thus, assuming we have suitable anti-phase driving signals at our disposal, we can cascade two such networks and, at a frequency given by $f = 1/2\pi RC$ we would get a total phase lag of 180 degrees.

Such antiphase signals are easily obtained by using a single transistor stage with equal emitter and collector resistors. Omitting biasing arrangements, we have the circuit of Fig. 3 for a single stage of our two-stage phase delay network.

The required phasing effect is obtained by varying the frequency at which cancellation occurs in the mixer stage; this is most easily altered by making R a variable component, which means a dual-gang potentiometer since two stages are being used.

FULL CIRCUIT

The phase delay is introduced by the circuitry around TR1 and TR2 as in Fig. 4. TR3 acts as an emitter follower so that a reasonably high impedance is presented to TR2 collector circuit, in order to isolate this stage from the low input resistance of the mixer.

The operating conditions for TR1 are set up by R1 and R2, while direct coupling through VR2a and R5 to TR2 base enables further bias chains and coupling capacitors to be eliminated; similar remarks apply to TR3 stage. This does mean, however, that there is a risk of unpleasant "plops" being produced should a slider of VR2 become momentarily disconnected. To overcome this, the unused ends of VR2a, b tracks should be connected to their respective sliders, and so maintaining a bias path for TR2 or TR3.

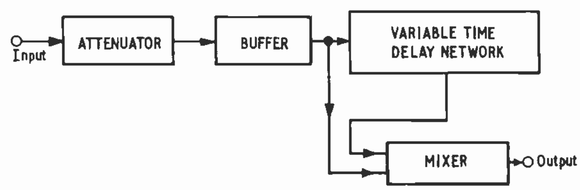


Fig. 1. Block diagram showing principle of operation

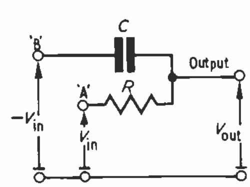


Fig. 2. The basic phase shift network employed

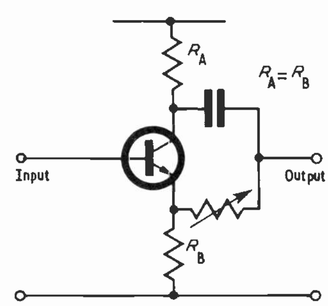
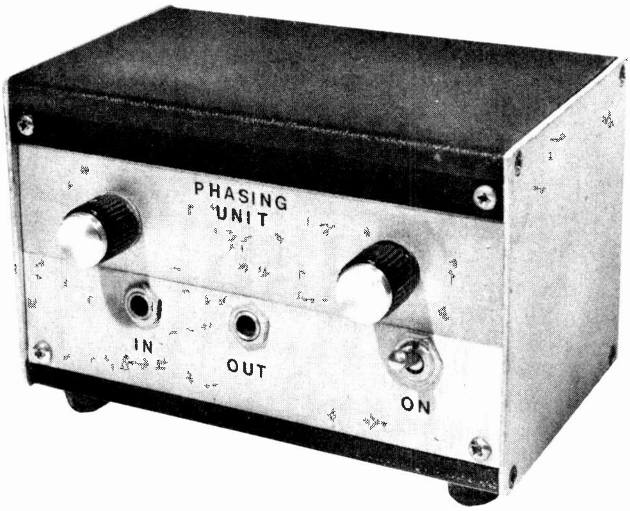


Fig. 3. Circuit for producing antiphase signals



COMPONENTS . . .

Resistors

R1	100k Ω	R7	1k Ω
R2	47k Ω	R8	220 Ω
R3	1·5k Ω	R9	470 Ω
R4	1·5k Ω	R10	15k Ω
R5	220 Ω	R11	100k Ω
R6	1k Ω	R12	2·7k Ω

All resistors are ⅛W 10% carbon

Potentiometers
VR1 5k Ω log pot
VR2a, b 10k Ω + 10k Ω linear dual-gang
VR3 10k Ω linear carbon preset

Capacitors
C1 6·4μF, 25V elect.
C2 6·4μF, 25V elect.
C3 6·4μF, 25V elect.
C4 6·4μF, 25V elect.
C5 0·1μF, mylar
C6 0·1μF, mylar

Transistors
TR1–TR4 BC168 (4 off)

Switch
S1 Double pole on/off toggle

Miscellaneous
JK1, JK2 Standard jack sockets (2 off)
B1 PP3 9V, battery connectors, 0·1in Veroboard
Instrument case 6½in × 4in × 4in (G. W. Smith)

Potentiometer VR1 provides a means of controlling the output level from the unit, by attenuating the input signal. This method is to be preferred here since it enables high level sources to be used without overloading the unit, which could occur if the level control were placed at the output.

The mixer circuit uses a single transistor, TR4. Bias conditions are maintained by the potentiometer formed by R10 and R11. By this means the collector potential is set at approximately five volts, regardless of supply voltage variations.

The inputs—direct signal and phase delayed signal—are appplied to the two capacitors C2 and C3. Compensation for any difference in signal level can be provided by making either or both input resistors variable.

CONSTRUCTION

The original was assembled on a small piece of 0·1in matrix copper clad Veroboard, as this permits a neat and compact layout—see Fig. 5.

The board can now be mounted in a convenient case using 6 B.A. nuts and bolts, making sure the solder pins are well clear of the chassis by using nuts or washers as spacers.

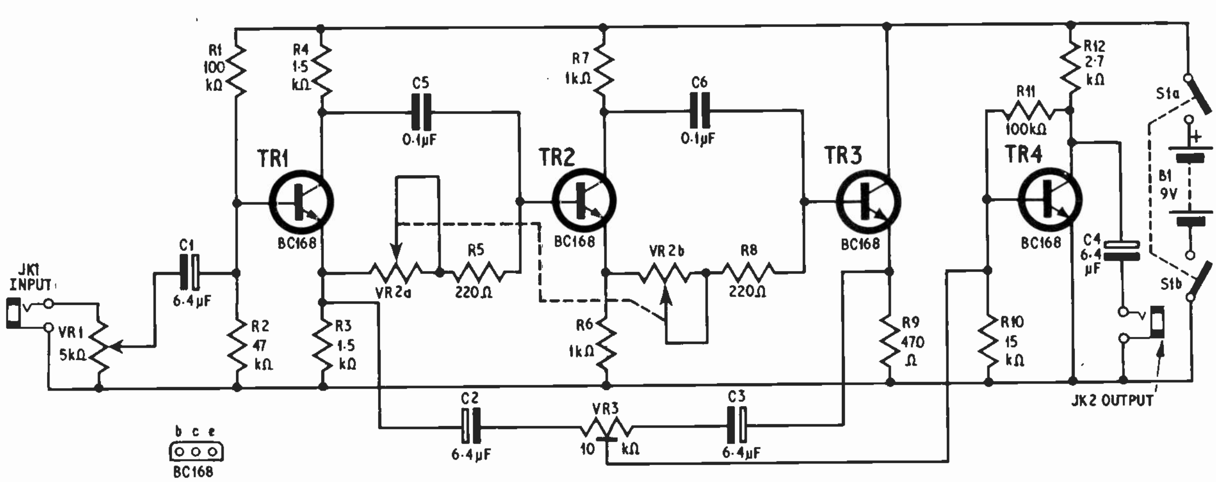
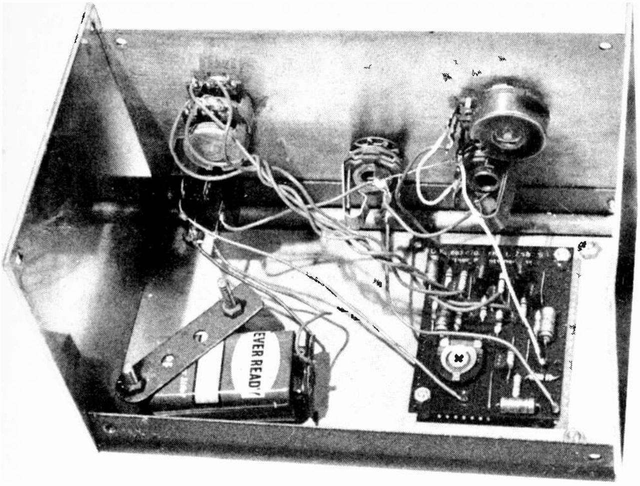


Fig. 4. Circuit diagram of Phasing Unit



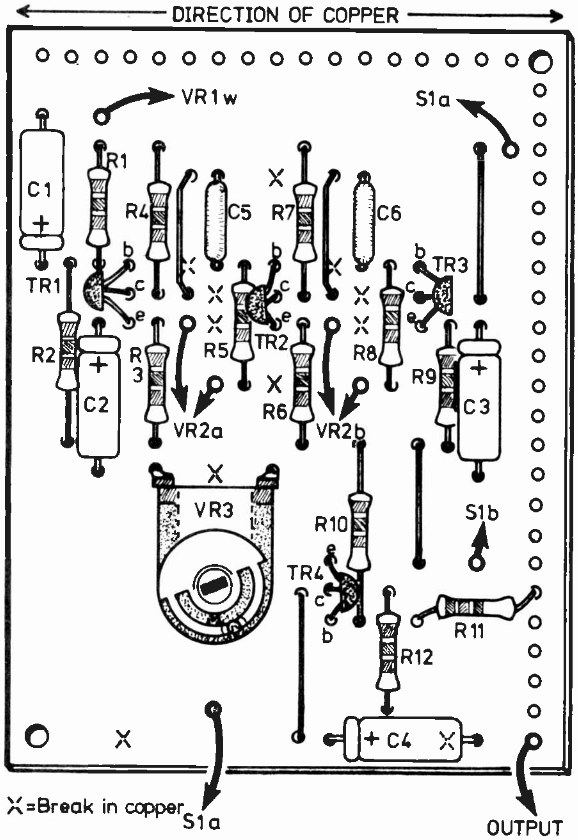


Fig. 5. Component layout and wiring on 0·1in matrix Veroboard

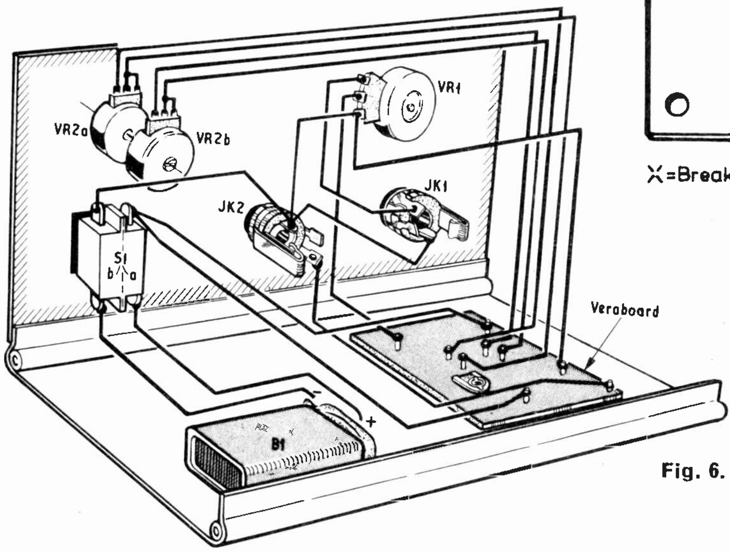


Fig. 6. Complete interwiring detail

The final wiring to input, output, VR1, VR2 and on-off switch can now be carried out; Fig. 6 shows the chassis mounted component connections.

The unit is conveniently powered by a small nine volt battery, but it will work from any supply between six and twenty volts. Current drain is approximately five milliamps from a nine volt supply.

SETTING UP

Initially set VR3 to mid-position and both panel controls to their extreme counter clockwise positions. Switch on and check that current drain is about 5mA, using a suitable meter in series with the supply.

The input should now be connected to a source of "white noise." Failing this however, an f.m. receiver which is not tuned to any station makes a very good substitute here. Set the level control to a convenient position whereupon the characteristic hiss should be heard.

Rotate the "phase" control VR2 to its extreme position; some sort of phasing may be heard but not much. Rotate this control back about $\frac{1}{8}$ of a revolution. Preset VR3 should now be adjusted for a minimum noise level, the correct position being fairly well defined. Upon rotating the phase control VR2 back and forth, the familiar phasing effect should now be heard. If this is not the case, check all connections, especially the links on the circuit board.

The unit may now be tried out with music input from, say, a tape recorder. The final degree of phasing heard depends largely on the content of the music used; Pop records provide a suitable starting point with their varied frequency content, and on some of these the effect can be quite startling. ★

PE Sound Synthesiser 8

ENVELOPE SHAPER

By G.D.SHAW

ONE of the fundamental characterising parameters of a sound is that in which the audibility of the sound varies with time. Some sounds become audible very rapidly and almost immediately die away again whilst others make a relatively slow approach to their full volume and take an even longer period to die away. The loudness modulation of any sound is known generally as the envelope and is very important in providing a feature which allows of recognition. Changes in the envelope format of an otherwise well-known sound can often change the character of the sound completely.

A simple experiment designed to illustrate this latter point involves the use of a tape recorder and a piano. Make a recording of a series of notes or chords selected from various parts of the piano register and repeat these with the sustain pedal held down. The recording should now be replayed backwards. With a four track recorder the simplest way of doing this is to unthread the recorder without rewinding, reverse the position of the spools and thread up again putting a twist in the tape so that the shiny, or backing side of the tape is towards the heads. This particular method results in a considerable loss of sound quality but illustrates the characteristic quite well. If the constructor is fortunate enough to own a mono or two track recorder in addition to a four track the recording should be made on the former machine and replayed, with spool positions reversed, on the latter.

PIANO ENVELOPE FORMAT

The change in the original sound of the piano, on reverse replay, will be found to be quite remarkable and, depending on the octave and sustain given to the original note or chord, will be found to bear a close resemblance to other musical instruments such as the organ or cello.

The piano is particularly suited to this form of experiment due to the nature of its envelope format which is characterised by a rapid rise to full volume followed by a relatively long period, dependent upon sustain pedal use, during which the volume is gradually diminishing. Fig. 8.1 illustrates a simplified form of piano envelope.

The peak volume followed by a rapid partial decay to the gradually diminishing sustain is a characteristic common to many musical sounds which are initiated by a form of percussion. Instruments such as the triangle, timpani, cymbal, glockenspeil and so on, all display similar basic characteristics in their envelopes.

Apart from the particular form of the percussive envelope the majority of sound envelopes will fall somewhere within the range of shapes illustrated in Fig. 8.2 all of which may be considered to be derivations of the basic trapezoid shown in Fig. 8.3.

The Envelope Shaper in the Sound Synthesiser is essentially a trapezoid generator in which the attack, sustain, and decay parameters are all adjustable, within the limits of the controls, to provide a range of formats similar to those illustrated in Fig. 8.2.

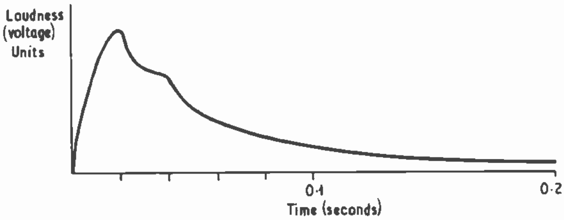


Fig. 8.1. Typical piano envelope

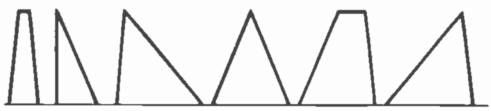


Fig. 8.2. Simplified range of sound envelope formats

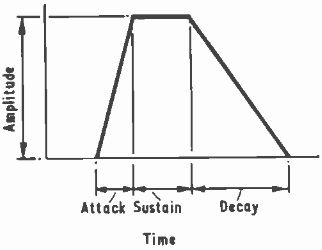


Fig. 8.3. Basic envelope trapezoid

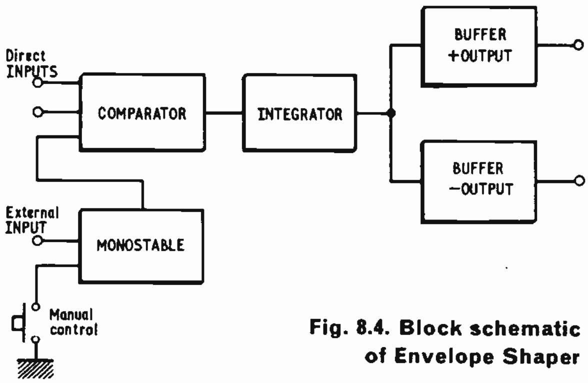


Fig. 8.4. Block schematic of Envelope Shaper

BLOCK SCHEMATIC

A schematic arrangement of the envelope shaper is shown in Fig. 8.4. The heart of the circuit is an integrator which drives two buffer amplifiers providing independent positive and negative going envelopes. The integrator itself is driven by a comparator having a variable reference level and thus any change in the input signal level to the circuit as a whole has no effect on the overall envelope amplitude. The comparator may be triggered directly by an external signal or via a monostable with a variable timing period.

CIRCUIT DIAGRAM

Fig. 8.5 shows the theoretical circuit of the envelope shaper. IC1 is the comparator which has a reference level set by R5–VR1 and ranging between 0V and −5V. Thus the comparator will recognise only negative going signals which exceed the reference level, and, with no signals present, will normally sit at its negative saturation state. Four triggering modes are catered for and selected by S1.

In the first the comparator is triggered directly by external signals arriving at the inverting input via R1 and R2.

Triggering is accomplished in the second mode by means of the keyboard synchronising pulse which is routed via R3. The pulse level swings between ±10V and will thus override any other trigger signal less than −10V arriving at the comparator via R1 and R2. Equally, it is possible to combine keyboard synchronisation with other external signals providing that the peak value of these exceeds −10V.

In the third mode of operation the comparator is triggered by a capacitatively coupled monostable (IC5) which is, in turn, triggered by negative going transitions in signals arriving at the external socket.

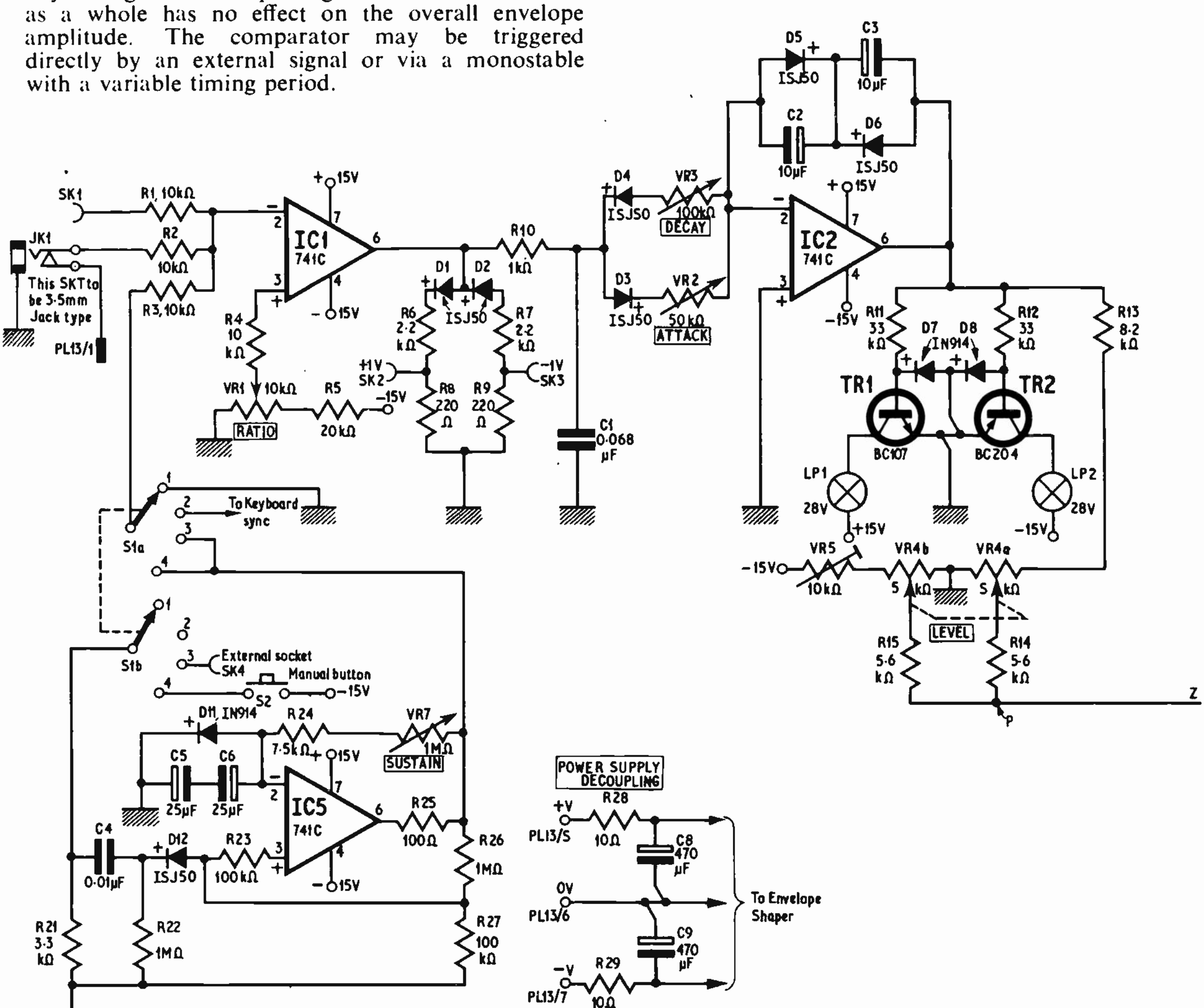


Fig. 8.5. Circuit of Envelope Shaper

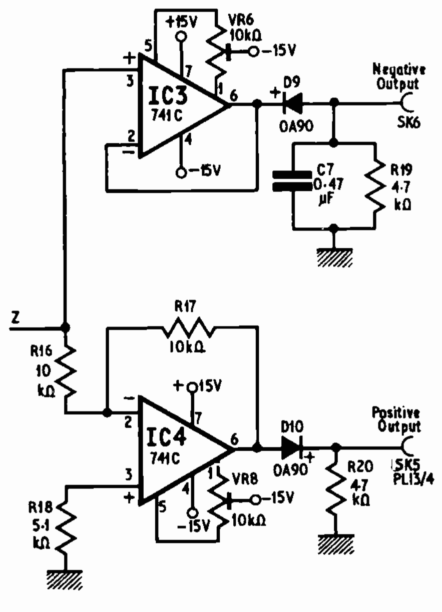
In this latter mode the pulse level of the monostable swings between ±14V and thus effectively overrides all other signals arriving at the comparator inputs.

Finally, in mode four, the monostable is triggered manually by means of a push button. In modes three and four the on period of the monostable is controlled over 100/1 range by means of VR7 and, with the value shown, can be varied between 15mS and 1,500mS. Since the shortest period of sustain is less than the combined fastest attack/decay time of about 20mS the resultant envelope is slightly lower in amplitude than it would otherwise normally be. However, for most purposes this may be adequately compensated for by adjustment of the envelope level control (VR4).

SIGNAL ROUTING

Output signals from the comparator are routed via R10 and D3/VR2 or D4/VR3 to the inverting input of the integrator built around IC2. In the absence of signals into the comparator, the provision of a negative reference level means that the comparator normally sits at negative saturation and the integrator at positive saturation. A negative-going signal greater than the reference level causes the comparator to change states and the positive going pulse is routed into the integrator via D3/VR2 and charges C3. When the trigger signal is removed, or changes polarity, C3 discharges via VR3/D4 and R10 and the original situation is restored.

The rate at which C3 charges and discharges is governed by the setting of VR2 and VR3 respectively. With both controls at minimum the fastest rate of attack or decay is determined by R10 and, with the values shown, is about 10mS. Thus the attack time can be varied by VR2 between 10mS and 500mS while the decay time can be varied by VR3 between 10mS and 1000mS.



The sustain period of the envelope signal may be varied in two ways. In the first, the on time of the comparator output pulse is determined by the period of that part of the input signal which lies above the reference level. The on time may thus be varied by adjustment of the ratio control VR1 in those instances when the comparator is triggered directly by an external signal.

In the second case the comparator is triggered by a monostable either from within the envelope shaper (IC5) or from the keyboard. In each case the on period is determined by adjustment of the monostable sustain control.

BUFFER AMPLIFIERS

The output from the integrator is routed to two buffer amplifiers of unity gain. IC3 is wired as a follower whilst IC4 forms an inverting amplifier. Interposed between the integrator and output buffers is a balancing divider network comprising R13, VR4a/b, VR5, R14 and R15.

The purpose of this network is to drop the integrator output swing to a usable level and to balance its maximum positive transition with an equal value negative voltage supplied via VR5/VR4b. Thus with the integrator sitting at positive saturation the output voltage of the network, measured at point P in the circuit, is effectively zero. Taking into account the forward drops of diodes D9 and D10 the buffer outputs will therefore swing between zero and about 3·2V.

INDICATOR LIGHTS

An indication of the state of the integrator is provided by two lamps which are switched by TR1 and TR2. With the integrator sitting at positive saturation TR1 is turned on and LP1 lights thus indicating an envelope off situation. When the integrator changes state TR1 is biased off thus extinguishing LP1 while TR2 is turned on and LP2 lights up indicating an envelope-on state.

The provision of two indicator lights is useful in those circumstances in which the envelope shaper is being operated by external signals direct into the comparator. Here the lights can provide a visual measure of the envelope on/off times in relation to the frequency of the triggering signal. For the majority of other purposes however the envelope off indicator may be considered superfluous and may be omitted from the circuitry to serve the requirements of economy. The circuit elements involved are LP1, TR1, D7 and R11.

Finally it is often useful to be able to synchronise the beginning and end of an envelope with other modules in the synthesiser. To this end diodes D1 and D2 together with dividers R6–8 and R7–9 provide pulses of 1V amplitude direct from the comparator output. As with the envelope off indicator these particular components are not necessary to the operation of the envelope shaper as such and may be omitted if automatic programming is not to be the principal function of the module.

Fig. 8.6 shows the recommended circuit board layout for the envelope shaper while Fig. 8.7 gives details of front panel and McMurdo plug wiring.

MODULE CONSTRUCTION

Construction of the module is quite straightforward and the only critical requirement lies in the wiring of VR4a/b and the setting up of the associated

COMPONENTS . . .

ENVELOPE SHAPER

Resistors

R1–R4	10k Ω (4 off)
R5	20k Ω
R6, R7	2·2k Ω
R8, R9	220 Ω (2 off)
R10	1k Ω
R11, R12	33k Ω (2 off)
R13	8·2k Ω
R14, R15	5·6k Ω (2 off)
R16, R17	10k Ω (2 off)
R18	5·1k Ω
R19, R20	4·7k Ω (2 off)
R21	3·3k Ω
R22, R26	1M Ω (2 off)
R23, R27	100k Ω (2 off)
R24	7·5k Ω
R25	100 Ω
R28, R29	10 Ω (2 off)

All 5% ½ watt carbon

Capacitors

C1	0·068μF polyester
C2–C3	10μF elect. 25V (2 off)
C4	0·01μF polyester
C5, C6	25μF elect. 25V (2 off)
C7	0·47μF polyester
C8–C9	470μF elect. 25V (2 off)

Potentiometers

VR1	10k Ω linear min. moulded carbon
VR2	50k Ω linear min. moulded carbon
VR3	100k Ω linear min. moulded carbon
VR4	5k Ω linear ganged moulded carbon
VR5–VR6	10k Ω carbon preset (2 off)
VR7	1M Ω linear
VR8	10k Ω carbon preset

Integrated Circuits

IC1–IC5 741C (5 off)

Transistors

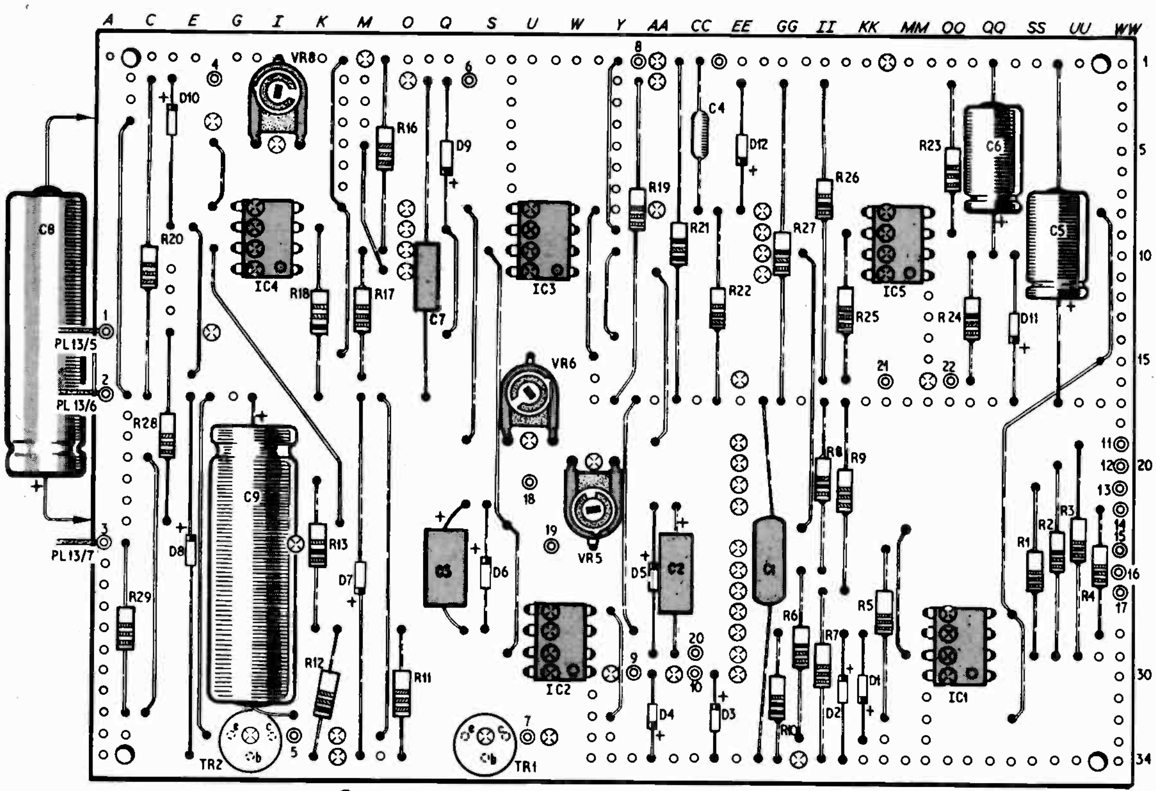
TR1	BC107
TR2	BC204

Diodes

D1–D6	ISJ50 (6 off)
D7, D8	IN914 (2 off)
D9, D10	OA90 (2 off)
D11	IN914
D12	ISJ50

Miscellaneous

LP1, LP2 28V sub-miniature lamps (2 off)
SK1–SK6 2mm miniature sockets (6 off) JK1–3·5mm miniature jack socket, S1–2 pole 6 way switch S2–miniature push button switch.



Direction of copper track ◎ Indicates Veropins
⊗ Indicates break in copper track

Fig. 8.6. Board layout and wiring

balancing divider. This may be done as follows. With power on, put S1 in the direct mode and set VR1 to its maximum setting. This will ensure that the integrator is sitting at positive saturation. Set VR5 to near mid-position and with VR4 at its maximum setting connect a high resistance voltmeter (5V range) between point P and ground. The voltmeter should read approximately 2·5V negative. Adjust VR5 to bring the voltmeter reading as close to zero as is possible.

Reset VR4 to minimum and progressively reduce the sensitivity of the voltmeter adjusting VR5 as necessary to maintain a zero-volt reading. This latter manipulation serves to adjust and compensate for the minimum end resistance of VR4 which should remain at its minimum setting for the next stage of adjustment. Remove the high resistance voltmeter and re-connect between the output of IC3 and ground. Connect point P directly to ground and adjust VR6 so that the output of IC3 is zero.

Repeat the measurement with the voltmeter connected between the output of IC4 and ground making any necessary adjustments to VR8 in this case. It should be borne in mind that variation of the offset presets VR6–8 will result in an output voltage change of only a few millivolts, a 400 millivolt swing being typical when the amplifiers are run at unity gain. If the voltmeter is insufficiently sensitive it will be necessary to use an oscilloscope for this latter measurement. It is important that the measurement be made at the output pin of the buffer amplifiers as opposed to the output socket. Disconnect point P from ground and, with all other controls as initially set, swing VR4 to its maximum position and observe the change in output voltage, if any, at the output pins of IC3 and IC4.

If the overall change is within 400mV the error may be halved by adjustment of VR5 and the remaining 200mV error reduced, or eliminated, by adjustment of the offset controls VR6 and 8 on IC3 and IC4 respectively. If the error is greater than 400mV it will be necessary to adjust the value of R13 accordingly. This latter course, however, is unlikely to be necessary since the two halves of a ganged pot would normally be expected to be taken from the same batch of stators and consequently the resistive tolerance of both halves is likely to be within fairly close limits.

The adjustments detailed above are only critical if it is envisaged that the envelope shaper be used for v.c.o. programming in addition to its main purpose of amplitude modulation.

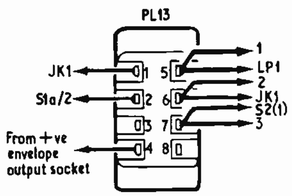
USING THE MODULE

In most commercially available synthesisers the envelope shaper usually incorporates a voltage controlled amplifier as an integral part of the circuitry. In the Sound Synthesiser however the envelope shaper is treated as a discrete entity in the interests of simplicity and thus it is not possible to route signals through it in the same way as is featured in the Moog or EMS range of instruments. Thus the description of usage of the module in this particular article will be restricted to v.c.o. programming and covered at greater length in next month's article which deals principally with the Voltage Controlled Output Amplifiers.

Reverting for a moment to the description of the operation of the Envelope Shaper it will be recalled that the envelope is initiated when the comparator switches from one saturation state to the other and that the period of sustain is essentially governed by the time for which the comparator is in its temporary state. Thus, since the attack period of the envelope occurs during the on time of the comparator, it follows that the overall sustain of the envelope is equal to the on time of the comparator less the period of attack.

This particular point is quite important because under certain conditions the set period of attack could be greater than the on time of the comparator. This means that C3 does not become fully charged and thus the envelope does not achieve its full amplitude. Fig. 8.8a illustrates the effect when, with the comparator being triggered by a repetitive signal, its on time is gradually increased either by increasing the period of the triggering signal or by adjustment of the ratio control.

If the input signal is derived from, say, two Ramp Generators and the Sample and Hold in combination and the combined amplitude adjusted such that only the peaks are greater than the comparator reference level, the resultant signal from the envelope shaper will resemble that shown in Fig.



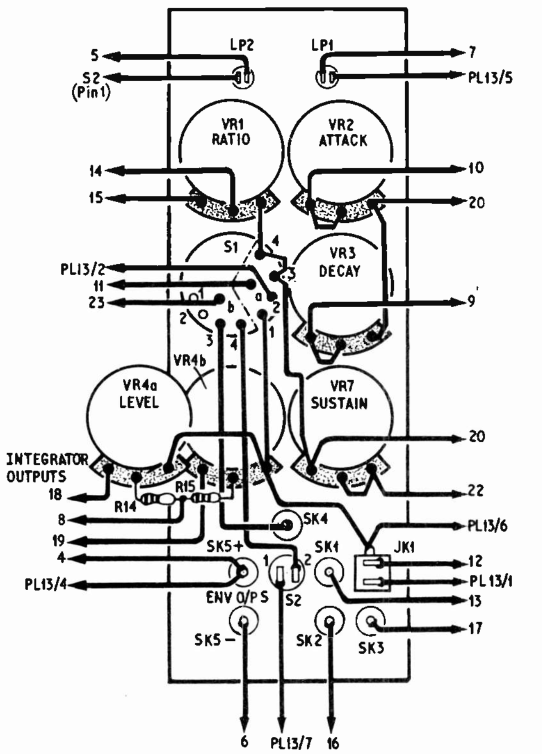


Fig. 8.7. Front panel control layout and wiring

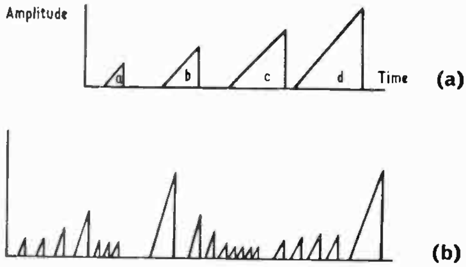


Fig. 8.8(a). Showing the effect when the attack time is longer than the on time of the comparator. Greatest effect is at 'a' and increasing the on period progressively through 'b', 'c' and 'd' increases the envelope amplitude ; (b) typical envelope series resulting from the above

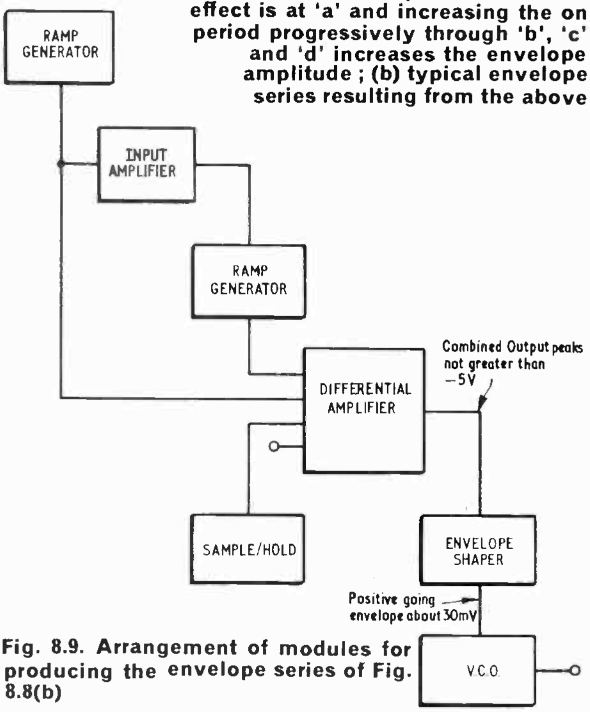


Fig. 8.9. Arrangement of modules for producing the envelope series of Fig. 8.8(b)

8.8b. If the positive going waveform is now used to program a v.c.o. which has been manually set to its maximum frequency the resultant output can be adjusted so as to provide a variety of birdsong which is very realistic. Fig. 8.9 shows a typical arrangement of modules for the provision of this type of sound.

SHIP'S SIREN

Sounds resembling a ship's siren may be synthesised by routing the envelope shaper direct to a v.c.o. and programming the envelope manually. The various controls should be set as follows: SW1 (Mode) = manual; Attack = Maximum; Decay = Minimum; Sustain = Midway; Output Level = 1/20 rotation (0·5 on a ten-point, 270 degree calibration). Use the negative going envelope and adjust the programmed v.c.o. to minimum frequency.

If the v.c.o. output is routed via the reverberation amplifier a high degree of realism may be achieved. Remember that the input to the reverberation amplifier should not exceed 500 mV peak-to-peak.

Next month: The voltage controlled output amplifiers and differential amplifier.

NEWS BRIEFS

Open University Course in Electronics

A NEW post-experience course by the Open University entitled "Electromagnetics and Electronics" aims to provide an understanding of the scientific basis of electronics and electronic circuit design. The course is intended for higher level university study in science and technology and for those who need a knowledge of electronics but who do not intend to study at a higher level.

The course assumes little prior knowledge of electronics or electromagnetics but does assume a background of scientific or technical education beyond GCE "O" level.

The course consists of 17 written correspondence units linked to 17 television and five radio programmes.

Applications are now invited for the course which starts next February and lasts until November. As with all post-experience courses no formal academic qualifications are needed. They are self-contained courses designed to teach new developments or update knowledge of a subject. The course tuition fee is £45 plus £37 for the residential summer school. Application forms are available from the Post-Experience Student Office, P.O. Box 76, Milton Keynes, MK7 6AA.

British Missile Technology for U.S.A.

UNDER a licence agreement signed in London between Marconi Space & Defence Systems Ltd. and the Raytheon Company of Massachusetts, British guided missile technology is to be sold to the U.S.A.

This agreement will enable a joint programme to be conducted between Raytheon and British industry to develop a new, medium-range, all-weather, air-to-air missile based on the U.S.-Raytheon AIM-7E Sparrow, to be built in Britain by Hawker Siddeley Dynamics Ltd.

Improved Accuracy of Electrical Measurements

THE National Physical Laboratory's Division of Electrical Science have announced that, due to recent advances in measurement techniques, they are able to improve the uncertainties they are able to give in respect of a wide range of measurements. These uncertainties are offered for the calibration of high quality reference standards.

For example the uncertainty in the 1V d.c. reference has been reduced from 2 in 10^6 to 1 in 10^6; that of a one ohm resistance from 1 in 10^6 to 4 in 10^7.

Bulgin Distributors

FOR those readers who have difficulty in obtaining Bulgin components we publish below a list of their current distributors for London and the Home Counties:

Cables & Components Ltd., Park Avenue, London, NW10 7XN.

Home Radio (Components) Ltd., 234-240 London Road, Mitcham, Surrey, CR4 3HD.

Lugton & Co. Ltd., 209-212 Tottenham Court Road, London, W1A 2BN.

Norman Rose (Electrical) Ltd., "Norman House", 8 St. Chads Place, Grays Inn Road, London, WC1X 9HJ.

Duval Ltd., 44 George Street, Oxford.

S.D.S. (Portsmouth) Ltd., Hilsea Industrial Est., Portsmouth, PO3 5JW.

IT'S A SELECTIVE ISSUE – NEXT MONTH

FREE IN THE OCTOBER ISSUE P.E. AUDIO I.C. IDENTICHART

Whether you are thinking of building an amplifier or you want some ideas on using i.c.s in audio circuits the P.E. Audio I.C. Identichart is a must for you. It gives comprehensive data on over 80 i.c.s ranging from low level preamplifiers to hybrids rated at 50W. As well as data, the chart contains suggestions for using i.c.s in mixers, tape recorders, record players, etc.

Semiconductor Tester

Select—Match—Compare and measure your discrete semiconductors. A general purpose discrete semiconductor tester capable of measuring the main parameters of transistors, rectifier and signal diodes, Zener diodes, thyristors and unijunctions, as well as providing both voltmeter and ammeter functions as an added bonus.

PRACTICAL ELECTRONICS keeps you abreast of Technology

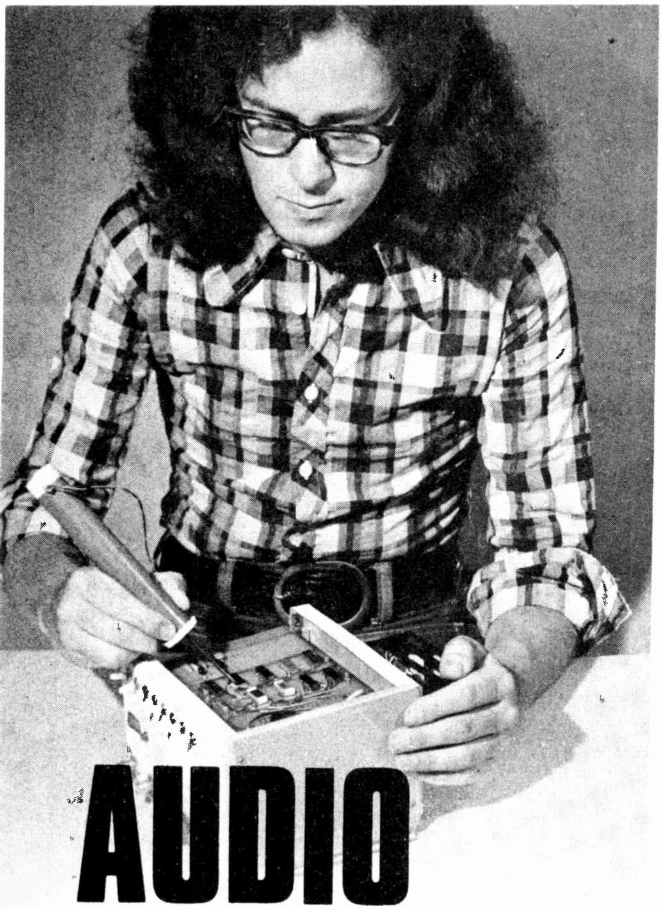
Part Two of the P.E. Rondo Quadraphonic system takes you through the audio amplifier sections of four solid-state 20W power amplifiers.

PLUS

This month we start a new series on Phase Locked Loops, the technology which makes state-of-the-art equipment like the Rondo and other a.m./f.m. systems possible.

PRACTICAL ELECTRONICS

OCTOBER ISSUE ON SALE SEPTEMBER 14, 1973



AUDIO LOGIC PROBE

BY B. WOODLAND

SIMPLE logic probes such as are used for troubleshooting in logic integrated circuit projects generally consist of a single transistor amplifier driving a lamp display. A logical 1 lights the lamp while a logical 0 has no effect.

The major drawback of such probes is the necessity to divide one's attention between the display and the equipment under test. In a complex system it is difficult to watch displays of both probe and equipment, especially if manipulations to the system are necessary to expose the faults.

The probe detailed here was devised to overcome these difficulties whilst retaining relative simplicity and low cost. A high frequency tone is emitted when the probe detects a logic 1 and a lower frequency indicates a logic 0. As a bonus the probe will give positive indication of short duration pulses which are extremely difficult to detect by other methods.

PRINCIPLE OF OPERATION

A complete circuit diagram of the probe is shown in Fig. 1. Four NOR gates are capacitively coupled in pairs to form two free running multivibrators running at two easily distinguishable audio frequencies. Neither multivibrator is able to oscillate unless its unused input (labelled X and Y) is at logical 0.

When the function switch is in the logic position the input to the lower frequency oscillator (G3 and G4) is connected directly to the probe sensor so that a logic 0 input (at Y) will sound the lower tone.

The higher frequency generator input (X) is connected indirectly to the sensor, the transistor TR1 acting as an inverter so that a logic 1 at the sensor causes a logic 0 at point X causing the higher frequency to be generated. (The preset VR1 is used to adjust the logic 0 output of TR1 to less than 0·4V with a 2·4V input, 2·4V being the minimum TTL logic 1).

AUDIO OUTPUT

The outputs of the two audio oscillators are applied to the inputs of a simple gate made from two silicon diodes. The resultant output is amplified by TR2. Strictly speaking no amplifier is needed to drive the recommended transducer (a crystal insert) but its inclusion does allow for the substitution of a medium impedance earphone for more volume.

PULSE POSITION

When the function switch is in the pulse position the probe sensor is connected to the clock input of a TTL bistable (IC2). Even a very short pulse on the sensor will cause the bistable to change state with the accompanying change in tone frequency.

POWER SUPPLY

If the suggested crystal insert transducer is used then the probe needs to be supplied with 5V at 20mA. This quite modest demand is best supplied by the circuit under test and the construction shows two crocodile clips for this purpose.

If a loudspeaker or earpiece is to be used then a separate battery supply is recommended, with the necessary changes in construction to accommodate it.

CONSTRUCTION

The circuit is built on a small piece of 0·1in Veroboard with the strips running across the width, see Fig. 2. The integrated circuits are soldered directly to the board to keep the profile low. Single cored sleeved wire is used for interwiring, the function switch and the insert being the only components not accommodated on the board.

The probe is housed in a 6in aluminium tube of 1in internal diameter. This was in fact a tube used to hold denture cleaning tablets. The crystal insert is glued to the closed end of the tube, its leads passing through holes drilled in the tube. The power supply leads pass through a hole in the side protected by a grommet. Use highly flexible and good length leads as are used on multimeters.

The sensor consists of a 2in length of brass studding bolted to the plastic cap of the tube. The function switch is fixed as shown, and the circuit board is inserted into the tube after first being wrapped in a piece of plastic sheet to act as insulation. Keep leads from the circuit board to the switch and the sensor as short as is practicable. ★

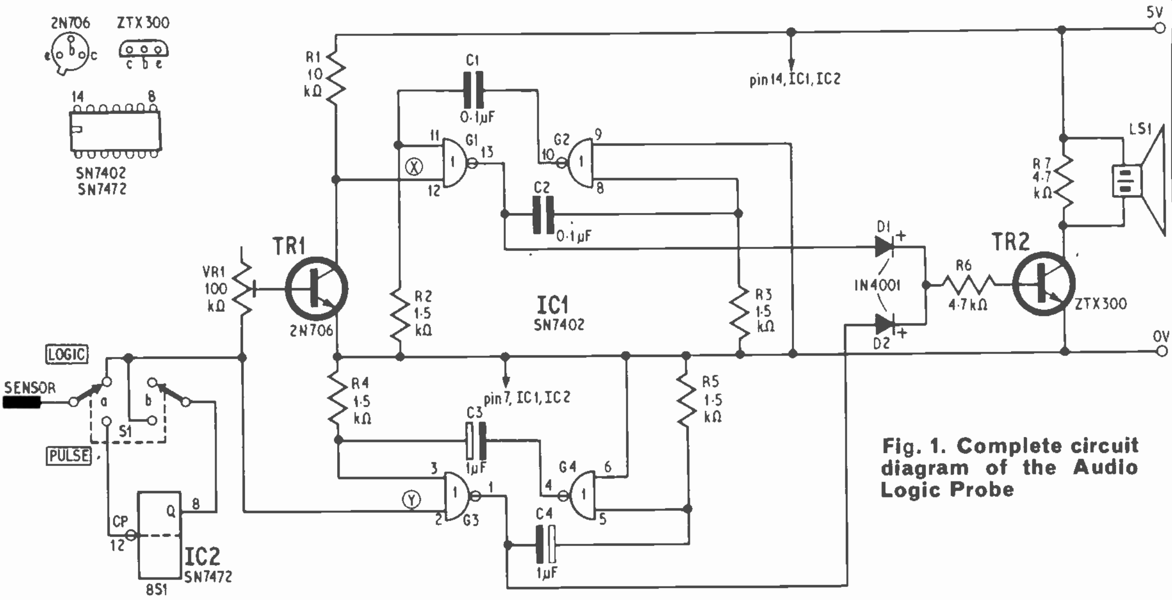


Fig. 1. Complete circuit diagram of the Audio Logic Probe

COMPONENTS . . .

Resistors
R1 10kΩ
R2–5 1·5kΩ (4 off)
R6, R7 4·7kΩ (2 off)
All ±10% ¼W carbon

Potentiometer
VR1 100kΩ miniature preset

Capacitors
C1, C2 0·1µF (2 off)
C3, C4 1 µF 6V electrolytic (2 off)

Semiconductors
TR1 2N706 *or* similar
TR2 ZTX300 *or* similar
D1, D2 1N4001 *or* similar (2 off)
IC1 SN7402N
IC2 SN7472N

Miscellaneous
LS1 1in diameter crystal insert
S1 D.P.D.T. miniature slide switch
3·6in × 1in 0·1in matrix Veroboard, strips running widthwise
Brass studding and nuts, crocodile clips, aluminium container

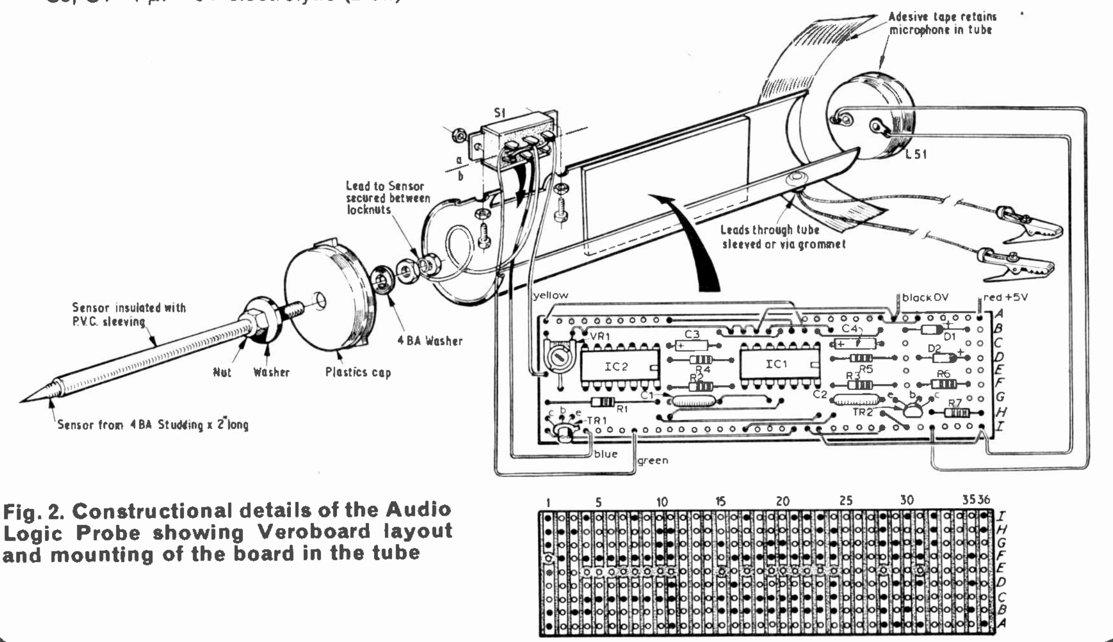


Fig. 2. Constructional details of the Audio Logic Probe showing Veroboard layout and mounting of the board in the tube

The Sinclair Cambridge... no other calculator is so powerful and so compact.

Complete kit–£29·95! (INC.VAT)

The Cambridge – new from Sinclair
The Cambridge is a new electronic calculator from Sinclair, Europe's largest calculator manufacturer. It offers the power to handle the most complex calculations, in a compact, reliable package. No other calculator can approach the specification below at anything like the price – and by building it yourself you can save a further £14!

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With all its calculating capability, the Cambridge still measures just $4\frac{1}{2}$" x 2" x $\frac{11}{16}$". That means you can carry the Cambridge wherever you go without inconvenience – it fits in your pocket with barely a bulge. It runs on ordinary U16 batteries which give weeks of life before replacement.

Easy to assemble
All parts are supplied – all you need provide is a soldering iron and a pair of cutters. Complete step-by-step instructions are provided, and our service department will back you throughout if you've any queries or problems.

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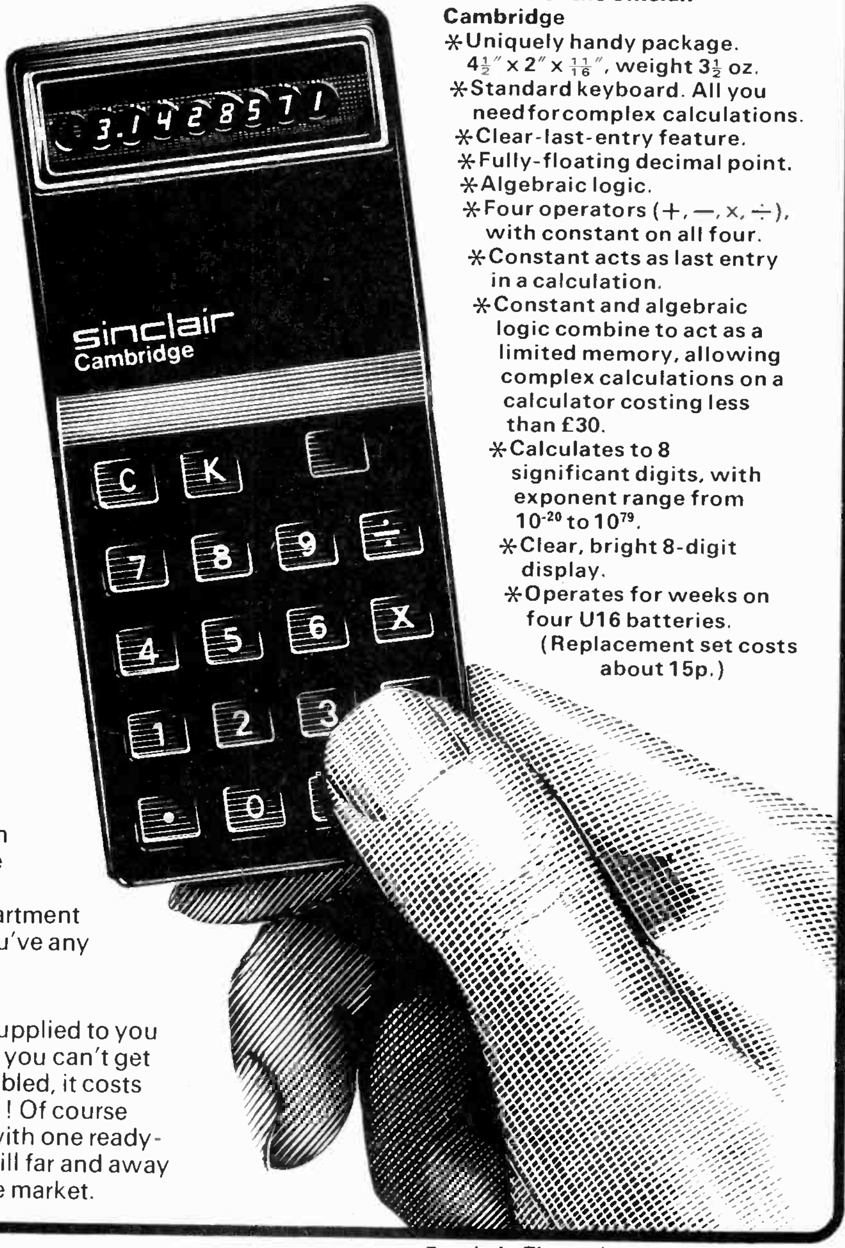
The Sinclair Cambridge kit is supplied to you direct from the manufacturer – you can't get it anywhere else. Ready assembled, it costs £43·95 – so you're saving £14! Of course we'll be happy to supply you with one ready-assembled if you prefer – it's still far and away the best calculator value on the market.



Features of the Sinclair Cambridge

* Uniquely handy package. $4\frac{1}{2}$" x 2" x $\frac{11}{16}$", weight $3\frac{1}{2}$ oz.
* Standard keyboard. All you need for complex calculations.
* Clear-last-entry feature.
* Fully-floating decimal point.
* Algebraic logic.
* Four operators (+, –, x, ÷), with constant on all four.
* Constant acts as last entry in a calculation.
* Constant and algebraic logic combine to act as a limited memory, allowing complex calculations on a calculator costing less than £30.
* Calculates to 8 significant digits, with exponent range from 10^{-20} to 10^{79}.
* Clear, bright 8-digit display.
* Operates for weeks on four U16 batteries. (Replacement set costs about 15p.)

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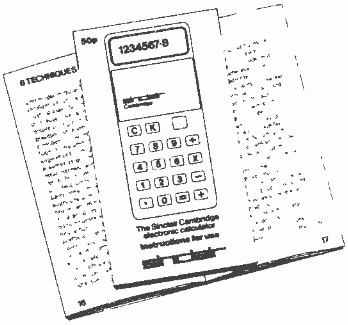
The kit comes to you packaged in a heavy-duty polystyrene container. It contains all you need to assemble your Sinclair Cambridge.
Assembly time is about 3 hours.

Contents:

1. Coil.
2. Large-scale integrated circuit.
3. Interface chip.
4. Thick-film resistor pack.
5. Case mouldings, with buttons, window and light-up display in position.
6. Printed circuit board.
7. Keyboard panel.
8. Electronic components pack (diodes, resistors, capacitors, transistor).
9. Battery clips and on/off switch.
10. Soft wallet.

This valuable book – free!
If you just use your Sinclair Cambridge for routine arithmetic – for shopping, conversions, percentages, accounting, tallying, and so on – then you'll get more than your money's worth.

But if you want to get even more out of it, you can go one step further and learn how to unlock the full potential of this piece of electronic technology.



How? It's all explained in this unique booklet, written by a leading calculator design consultant. In its fact-packed 32 pages it explains, step by step, how you can use the Sinclair Cambridge to carry out complex calculations like:

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NEW DEVICES ...APPLICATIONS

SEMICONDUCTOR GAS SENSOR

In this section we present a selection of both new devices and applications, with news of applications developed for existing devices.

Generally only basic circuit details will be given sufficient for the experimenter to create his own equipment.

THE GAS SENSOR used in the Electronic Nose (July 1973) is a device which is probably new to most readers and thus warrants a more detailed description. The sensor to be described (T.G.S.) is manufactured by Figaro Engineering, a firm based in Japan.

The T.G.S. consists of two electrodes encapsulated in a bead of bulk-type crystalline semiconductor material as shown in Fig. 1. This material is based on tin oxide SnO_2) suitably doped and of *n*-type character.

When heated in the presence of oxygen—as happens when heated in air—anionic absorption of oxygen takes place on the surface of the material leading to a drastic reduction in the number of free electrons available and hence reduced conductivity. In contact with a deoxidising gas or vapour, cationic absorption occurs and the number of free electrons increases as does conductivity.

The sensor can be compared to a "gas dependent resistor" and the circuits built around them are similar to those built around light dependent resistors.

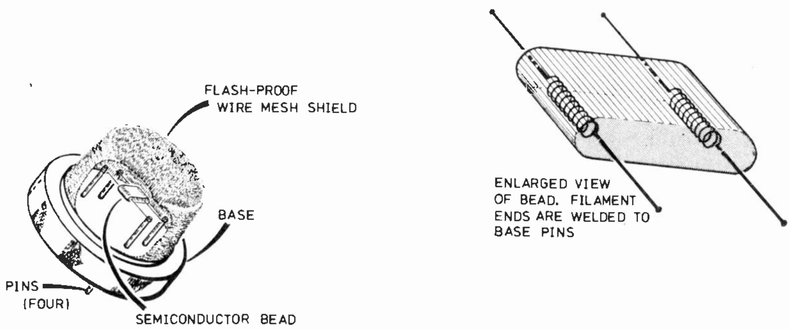


Fig. 1. Construction of the T.G.S. gas sensor

SIMPLE CIRCUIT

The simplest type of circuit is shown in Fig. 2 where it can be seen that one of the electrodes acts as a heater, the driving voltage being between 1·0 and 1·5 volts. The nominal resistance of the filament is 2 ohms. The value shown for R_L is typical for low voltage applications.

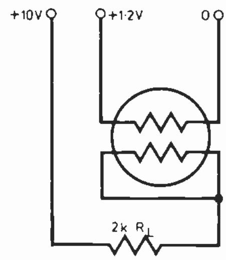


Fig. 2. The simplest circuit for use with the T.G.S

When first switched on the sensor shows high conductivity until warmed up sufficiently for combination with oxygen to occur. It then settles down to a low "in air" output (see Fig. 3).

The T.G.S. will react to all the common combustible gases and vapours, for example hydrogen, propane, butane, petrol fumes, methane (natural gas), acetone benzene, etc. It will also respond to carbon monoxide, making it suitable as a smoke detector.

The sensor will not discriminate between gases but reacts to the total deoxidising effect.

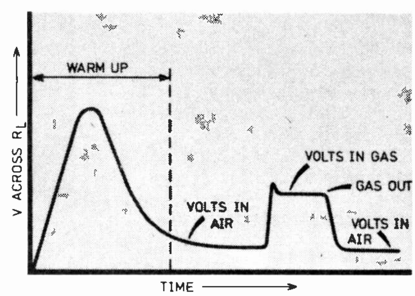


Fig. 3. After switch-on the conductivity of the sensor rises sharply as shown in this graph. After warm-up the typical response to a gas is shown

PRACTICAL POINTS

The device is symmetrical; either filament can be used as the heater. The recommended side for use as the heater is marked with a small circle punched on the screen base. The T.G.S. base will plug into a B7G valve base.

To avoid cooling of its surface the sensor should be shielded from exposure to draughts or high velocity gas flows.

The T.G.S. works equally well on a.c. or d.c., and polarity is unimportant. Fig. 4 shows a basic circuit using a.c. rather than d.c. as the source. For battery operation a dropper resistor is the easiest but the most wasteful way of obtaining a heater voltage. Other methods include d.c./a.c. inverter or separate battery, e.g. NiCad.

If an amplifying circuit is coupled to the sensor, then the total load resistance of the sensor must be kept at the recommended value (2 kilohms), i.e. if the input tends to shunt the load resistor, then the load resistor should be increased to restore the total resistance to the required value.

After storage or when the T.G.S. has been switched off for some hours, the device will conduct heavily at switch-on until its temperature has enabled the semiconductor to stabilise in air. On completion of initial stabilisation the device will only conduct the presence of deoxidising gases (see Fig. 3).

As in all semiconductors some spread of characteristics occurs and so some adjustment should be built into the circuit for calibration purposes.

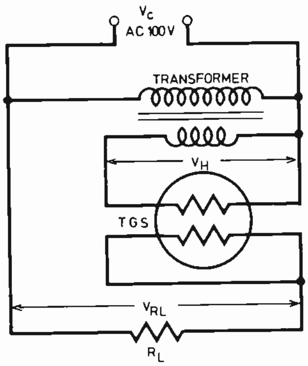


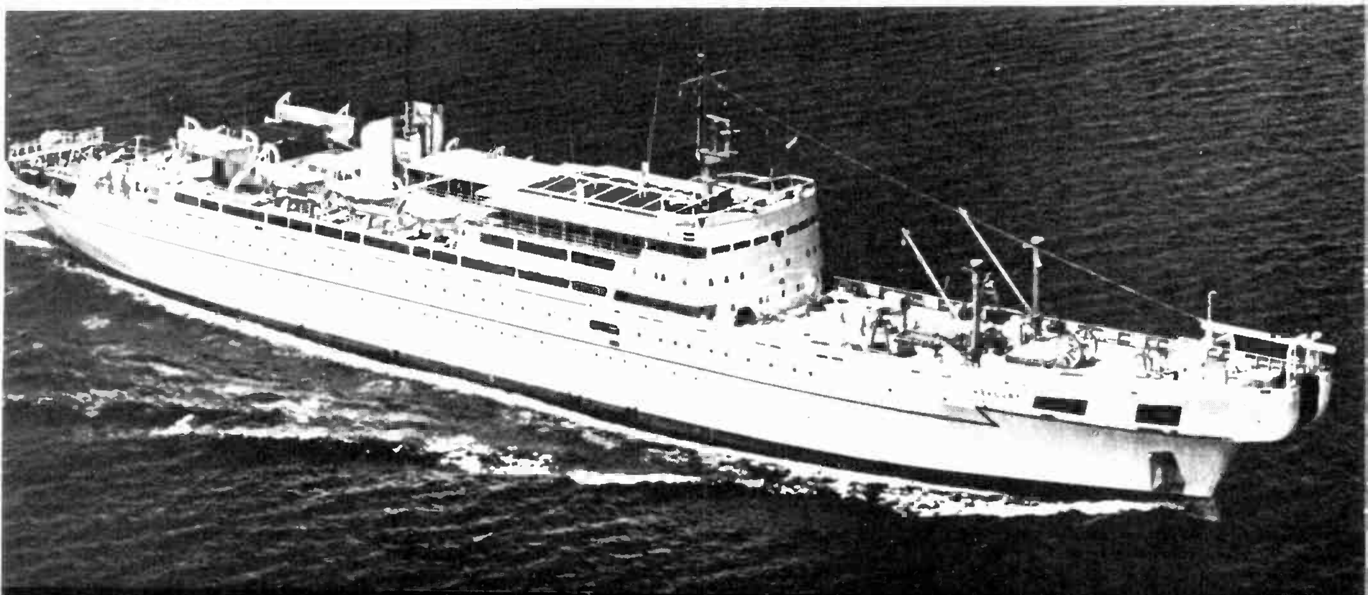
Fig. 4. This circuit shows how the T.G.S. may be used with an a.c. system

ALARM LEVEL

For domestic and marine use an alarm level of 0·2 to 0·3 per cent is recommended. This represents about $\frac{1}{8}$ of the lower explosive level in the case of bottled gas and $\frac{1}{20}$ of the lower explosive level for methane (natural gas).

The gas sensor described in this article is available from the following advertisers in P.E.—Trampus Electronix, Watford Electronics, Yates Electronics.

● Practical Electronics will be publishing another project using the gas sensor in the near future. ★



ELECTRONORAMA

THE loading of the cable ship *Mercury* (8,962 tons) with the first 200 miles of a £30 million telephone cable linking Britain and Canada was completed at Southampton on June 20. Handling more than 1,800 telephone conversations simultaneously the cable, CANTAT-2, will be the biggest single telephone cable across the Atlantic, carrying more telephone calls than all the existing trans-Atlantic cables combined. The cable system will be used for communication between the U.K. and mainland Europe, and Canada and the U.S.A. and will come into service early in 1974.

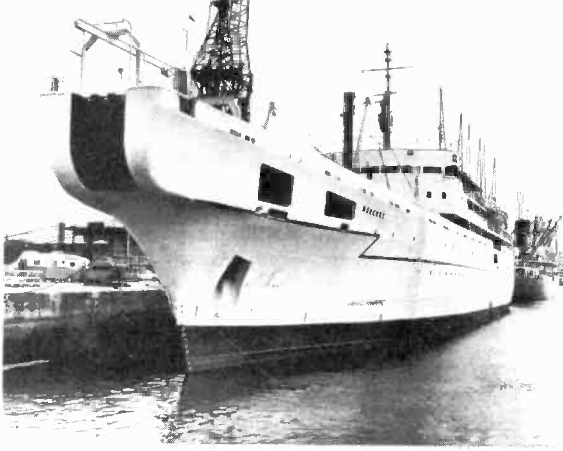
GROWTH IN CALLS

Being financed and operated jointly by the British Post Office and the Canadian Overseas Telecommunications Corporation, the 3,000-mile cable is being provided to meet the massive growth in telecommunications between Britain and North America. In ten years 'phone calls between Britain and Canada have risen eightfold from 135,000 calls a year in 1962 to their present level of more than a million a year. This will rise again to nearly 6 million a year by 1980. Growth in calls between the U.K. and the U.S.A. has risen from half-a-million in 1962 to more than $4\frac{1}{2}$ million in a year in 1972, and by 1980 this will have reached 24 million a year.

The laying of CANTAT-2, which is being manufactured by the submarine systems division of Standard Telephones and Cables Ltd., comes 20 years after Britain and the U.S.A. decided to lay the first telephone cable across the Atlantic.

Each circuit in the first telephone system cost at the time more than £294,000. In CANTAT-2 the application of modern transmission techniques has dramatically reduced the cost of each circuit to £16,500. This has been an important factor in keeping down the cost of trans-Atlantic telephone calls.

The cable ship *Mercury* being loaded at the quayside at STC's Southampton plant



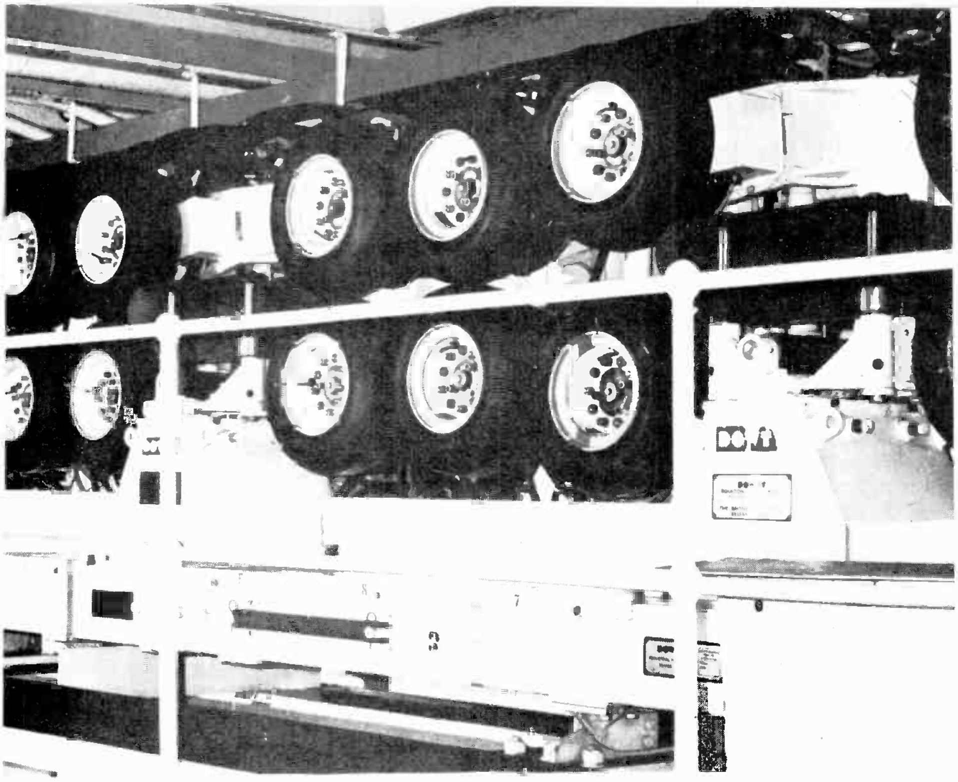
CABLE ROUTE

CANTAT-2 will run from Widemouth Bay, Cornwall to Beaver Harbour, near Halifax, Nova Scotia. It will be laid by two ships, *Mercury* and the Canadian icebreaker/cable layer *John Cabot*. Both ships are fitted with a new design of linear cable engine developed by the Post Office Research Department, and which considerably speeds cable laying.

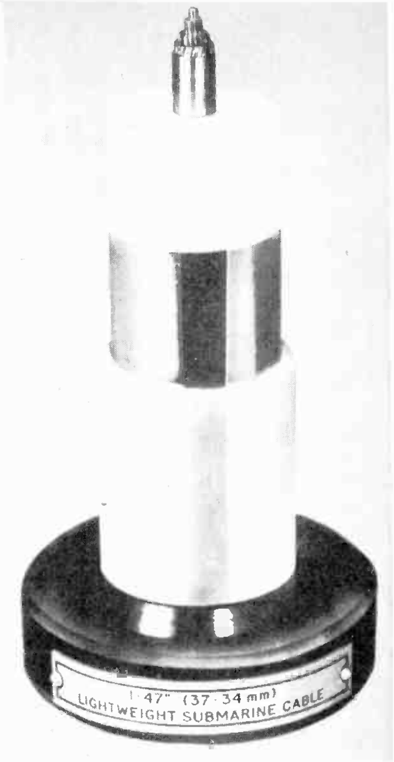
Mercury is to lay more than 2,600 nautical miles from the U.K. and across the North Atlantic Ocean. Because of the high risk of damage by trawlers the cable is to be buried beneath the seabed where it crosses the rich fisheries of the Canadian continental shelf.

The powerful *John Cabot*, equipped with a seabed plough and assisted by a manned miniature submarine, has already started to bury a 170-mile section of the cable. A similar submarine will be used to bury some sections of cable on the U.K. continental shelf.

Mercury, laying the deep-water section of CANTAT-2, has been fitted with one of the most accurate navigation systems commercially available to enable her to chart the cable route with extreme accuracy. The system, called Hydroplot, was developed for the Hydrographic Department of the Royal Navy and uses U.S. Navy navigation satellites to pinpoint the ship's position to within 300 feet. An Elliot 905 computer integrates all the ship's other navigation aids and cable-laying information and provides a visual display unit for the navigator.



The linear cable engine for drawing cable from the ship's storage tank and paying it out to the ocean floor. The wheels can expand to accommodate the torpedo shaped equalisers or repeaters



A sample of the submarine cable for deep water. External armour is added for the shore end lengths.

A specially clothed operative assembling a repeater

REPEATERS AND EQUALISERS

In order to amplify the telephone signals on their long journey, 473 special amplifiers, or repeaters, are used each being spaced at 6 mile intervals. Since these units are expected to work on the ocean floor for periods up to 25 years, quality control and testing is naturally very stringent with manufacture taking place in special clean areas.

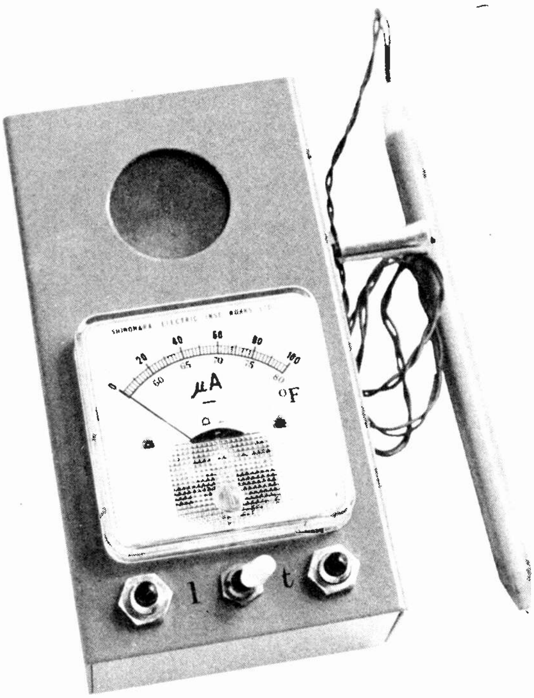
Every 15 repeaters in the cable length an equaliser is used. These are to compensate for the small differences that occur between the gain characteristics of the repeaters and the loss characteristics of the cable sections. These can be affected by sea temperature and pressure. Inserting equalisers into the system approximately every 15 repeaters overcomes such problems. As the system is laid it is continuously monitored and tested and the data collected is used in the design and building of the final circuitry for the equaliser while the cableship is at sea.

Splicing the cable into each repeater also takes place on board.

CIRCUITS

CANTAT-2's 1,840 circuits are arranged as 23 supergroups, transmitting in the frequency band 312–6,012kHz in the U.K.-Canada direction and 8,000–13,700kHz in the Canada-U.K. direction. In addition four speaker circuits of nominally 3kHz bandwidth each, use the frequency bands 6,024–6,036kHz in the U.K.-Canada direction and 7,976–7,798kHz in the Canada-U.K. direction, for system and circuit maintenance.

The cable itself is predominantly of lightweight design and will weigh no more than five tons a mile. Less than two inches in diameter for most of its length the cable has an outer conductor of aluminium. Its strength is centred in a steel rope inside an inner copper conductor. External armour will be used to protect the cable at the U.K. shore end.



ENLARGER EXPOSURE METER & THERMOMETER

BY J.M. BARTLETT

For the photographer who develops and prints his own negatives there are two factors that are vitally important. The first is the temperature of the chemicals, and a thermometer is an absolute must at every stage. Developing, rinsing, fixing, and finally washing must all be done at known and controlled temperatures; in colour developing the entire process must be carried out in five or more separate operations with all the liquids controlled to within half a degree Fahrenheit of each other.

This article describes an electronic thermometer with a sensing time of only two to three seconds and a potential accuracy of 0·2 degree F, so that quick and accurate checking can be made without wondering if the thermometer has "settled down".

Secondly, the exposure time required for enlargements is usually obtained after a time consuming test strip has been made. This unit also incorporates an enlarger exposure meter that senses the amount of light in the centre of interest, or a mid tone grey area, so that a proof print can be obtained first time.

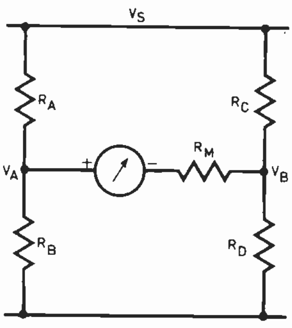


Fig. 1. Basic Wheatstone Bridge circuit

BASIC BRIDGE CIRCUIT

Both circuits have been designed around the basic bridge circuit. In Fig. 1, voltages V_A and V_B are developed in the left arm and right arm respectively. When $V_A = V_B$ no current flows in the meter and the bridge is said to be balanced. (This is when $R_A/R_B = R_C/R_D$.) If V_B falls then current will flow in the meter, the deflection set by R_M (the total resistance in the meter arm, including the internal resistance of the meter).

If the current in the two arms is very much higher than the current through the meter, then the small amount of meter current will have no significant effect on V_A and V_B. Since in these circuits the sensing components draw a current comparable to, or less than, the meter, special circuits are used to ensure that the bridge operates properly.

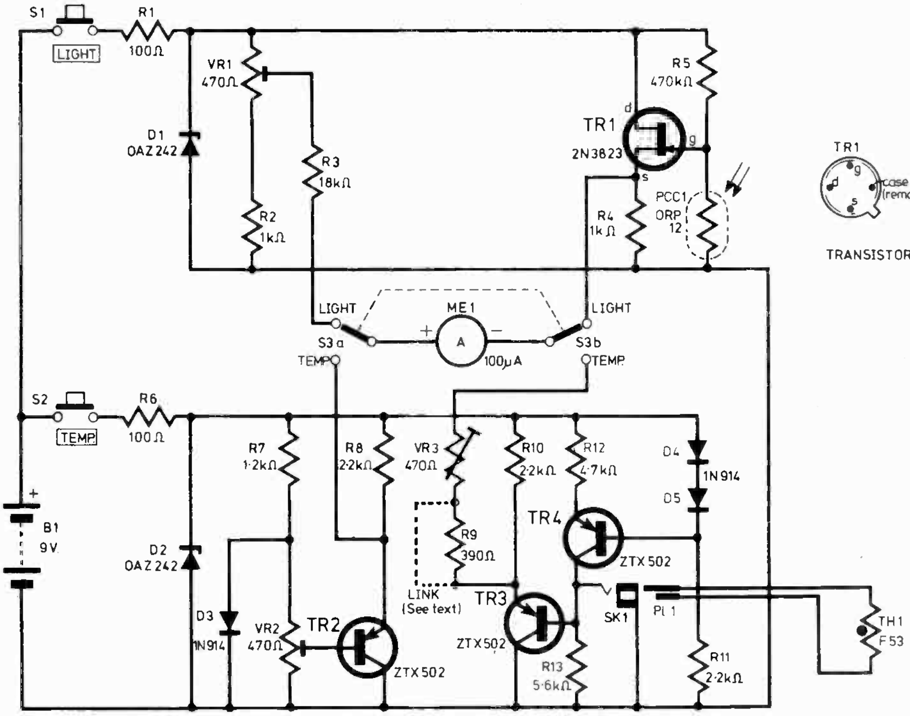
EXPOSURE METER

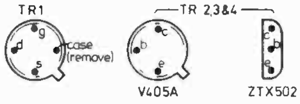
The exposure meter circuit is that part drawn above the meter in Fig. 2. It is operated by S1, a push button which ensures that the circuit is active only when required, and a long battery life is possible.

Zener diode D1 supplies a semi-stabilised voltage of 5·6V (nominal), making the response stable even with an ageing battery. VR1 and R2 form the left side of the bridge circuit (similar to R_A and R_B) but because of the high resistances involved with the light sensor one of the "special circuits" must be used.

The light sensing is done by a photo conductive cadmium sulphide (CdS) cell, an ORP 12, referred to as PCC1 on the circuit diagram, which has a resistance of nearly 10 megohms in total darkness.

As light strikes the sensitive area its resistance drops, but with the very low light intensities of interest (0·01 lux to 0·8 lux) its resistance does not drop below about 100 kilohms. The current through





TRANSISTOR CONNECTIONS (UNDERSIDE VIEWS)

Fig. 2. Complete circuit of the thermometer and exposure meter. The thermometer circuit is that part above the meter and the exposure meter lies below it

R5 and PCC1 is therefore only in the order of a few microamps so a field effect transistor (TR1) is used to follow the voltage without taking current from the sensing device.

The input resistance at the gate (g) of TR1 is several megohms whereas the resistance at the source (s) is low enough to operate the meter. The voltage of TR1 source is therefore equivalent to V_B in Fig. 1.

SETTING UP

To set zero deflection on the meter cover the light cell with black adhesive tape (a finger is inadequate since it is remarkably translucent) and adjust VR1. The response of TR1 and PCC1 will vary and R3 should be selected to give the best working range for the individual user. It will be between 15 and 22 kilohms, with 18 kilohms a good starting point.

If the device gives a high deflection for long exposure times it is too sensitive, and R3 should be increased. If it gives a low reading for short exposures it is not sensitive enough and R3 should be reduced. If a deflection of 60μA for a 10 second exposure is taken as a datum point the response will be similar to the graph given (Fig. 3). Any variation, however, is really irrelevant, as the following paragraph explains.

CALIBRATION OF THE EXPOSURE METER

Select a centre of interest or mid-tone grey on the negative and, placing the unit on the base board, stop the enlarger down to give a deflection of 10μA on the meter.

Make a test strip in the conventional way and record the best exposure time. Increase the stop to give a deflection of 20μA and repeat with another test strip. Continue with several stop settings up to full scale deflection and plot a calibration curve that

COMPONENTS . . .

Resistors

R1	100 Ω	R8	2·2k Ω
R2	1k Ω	R9	390 Ω (see text)
R3	18k Ω (see text)	R10	2·2k Ω
R4	1k Ω	R11	2·2k Ω
R5	470k Ω	R12	4·7k Ω
R6	100 Ω	R13	5·6k Ω
R7	1·2k Ω		

All ±5% ⅛W carbon

Potentiometers

VR1–3 470 Ω miniature horizontal skeleton preset (3 off)

Transistors

TR1 2N3823
TR2–4 ZTX502 *or* V405A *or* similar (3 off)

Diodes

D1, D2 OAZ242 5·6V 230mW Zener (2 off)
D3–5 1N914 (3 off)

Light Dependent Resistor

PCC1 ORP12

Miscellaneous

TH1 F53 thermistor (ITT No. 1129E)
ME1 100μA f.s.d. (ITT No. 8516C *or* SEW MR45P)
S1, S2 Push to make, release to break push-buttons (2 off)
S3 D.P.D.T. miniature toggle
PL1, SK1 3mm Jack plug and socket
Metal or plastic case (ITT No. 27524X)
B1 9V PP3 battery and connector

Printed circuit board as in Fig. 4

The meter for which the printed circuit board is designed, the thermistor and the box are available from ITT Electronic Services, Edinburgh Way, Harlow, Essex.

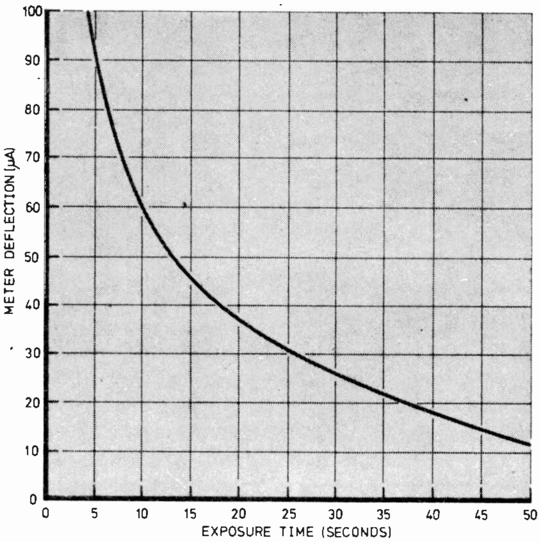


Fig. 3. Graph showing a typical calibration curve for the exposure meter

will give an exposure time against deflection. This will be the calibration curve for that particular meter but will be similar to Fig. 3.

Different paper speeds will give different exposure times but in the majority of cases it will be found that paper speeds vary very little.

DIFFUSER

The argument of "spot" metering or "general" metering is one on which there is room for individual preference. Sampling only a half inch diameter circle was found to be too critical, with small movements of the detector producing wide variations of deflections. Diffusing the whole negative at the enlarger lens can give a false reading if there is a lot of shadow, or a lot of sky, but it was found that sampling a one inch diameter circle is a good compromise. It is small enough to measure the light at the centre of interest but not so small as to be upset by a small dark (or light) patch.

The diffuser is best made from Perspex, rubbed with fine emery cloth if only clear material is available, but can also be made from any translucent material. Draughtsman's tracing film is quite tough and easily cut with scissors, but greaseproof paper is rather fragile for permanent use. It is advisable to leave fixing the diffusing window until the end since there is very little room remaining after the battery is slid into place.

A special note of warning. The light cell is sensitive to *all* light, even darkroom safelights, so the calibration *must* be done with only the enlarger switched on, the meter being read by the fringe light from the projected negative.

Depressing the push button in daylight sends the needle hard against the full scale backstop so should be avoided for obvious reasons!

The beauty of this device is that if a good print is obtained on a small enlargement the same light intensity (and meter deflection) can be reproduced for greater enlargement giving the same print contrast and quality. Alternatively, a new exposure can be measured with the new enlarger/stop conditions.

ELECTRONIC THERMOMETER

The sensing device in this thermometer is a thermistor, which is a glass-encapsulated, thermally sensitive resistor. By passing a constant current through it, a voltage is created across it, so by measuring this voltage we effectively measure its resistance, and hence its temperature.

Again a push button is used and a semi-stabilised voltage created by D2. The left arm of the bridge is R7, VR2 and D3.

Approximately 0·7 volts is developed across D3, a proportion of which is applied via VR2 to the base of TR2 which is used as an emitter follower, thus ensuring that the potential set by VR2 is not upset by the meter current. Thus the potential of TR2 emiter is very stable and at worst is only likely to vary by about 2mV.

The constant current for the thermistor is derived by R12, TR4, D4, D5 and R11. D4 and D5 each drop 0·7 volts, i.e. 1·4V total, and the emitter-base junction of TR4 drops 0·7 volts. This gives a total of 0·7 volts across R12 which is then selected to give the required current which in this case is 0·15mA.

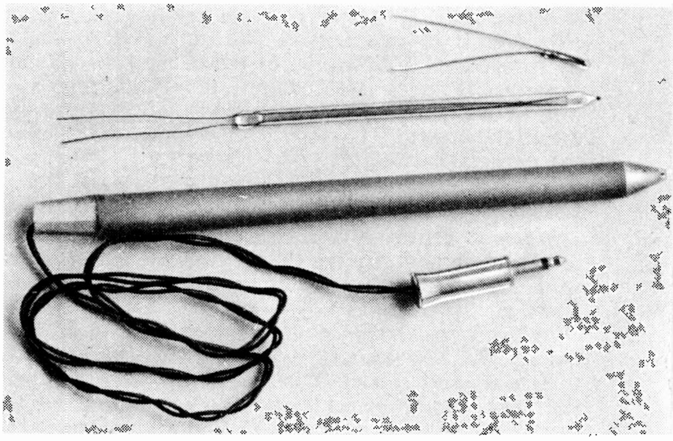
The thermistor chosen was STC type F53 although type GL53 would have been adequate. The "GL" range can dissipate a little extra power but are physically much smaller and in some respects not quite so easy to handle, but are more rugged than the longer "F" range. There is little to choose between them and the final choice could well be left until a probe assembly has been selected.

Resistance of R13 is approximately equal to the thermistor resistance at the mid-range temperature (67·5 degrees F). Either 5·6kΩ or 4·7kΩ could be used since the actual resistance calculated was 5·2kΩ, and there is a 20 per cent tolerance to be added to, and subtracted from that.

CURRENT LIMITATION

When a current is passed through any resistor, power is dissipated within the component and it gets warm. When a thermistor gets warm its resistance falls (that is why one is being used in the first place).

Photograph showing the F53 thermistor used in the thermometer. Also shown is a GL53 thermistor (top) and the thermometer probe



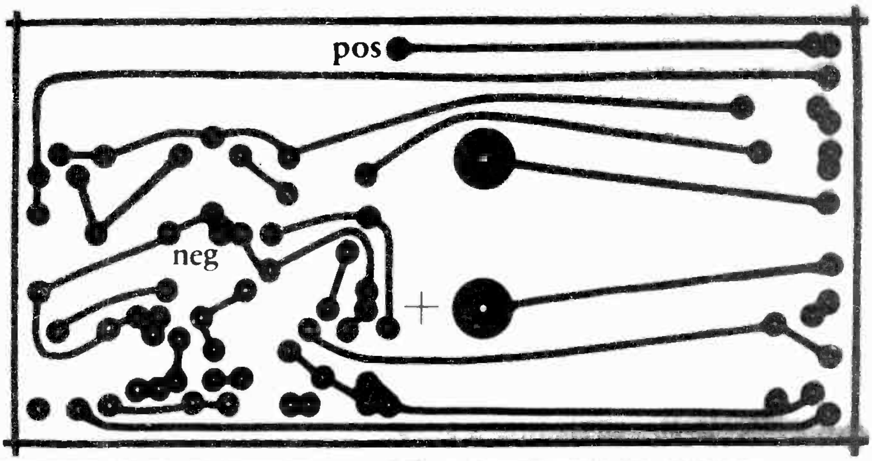


Fig. 4. Full size printed circuit board. The black areas indicate copper

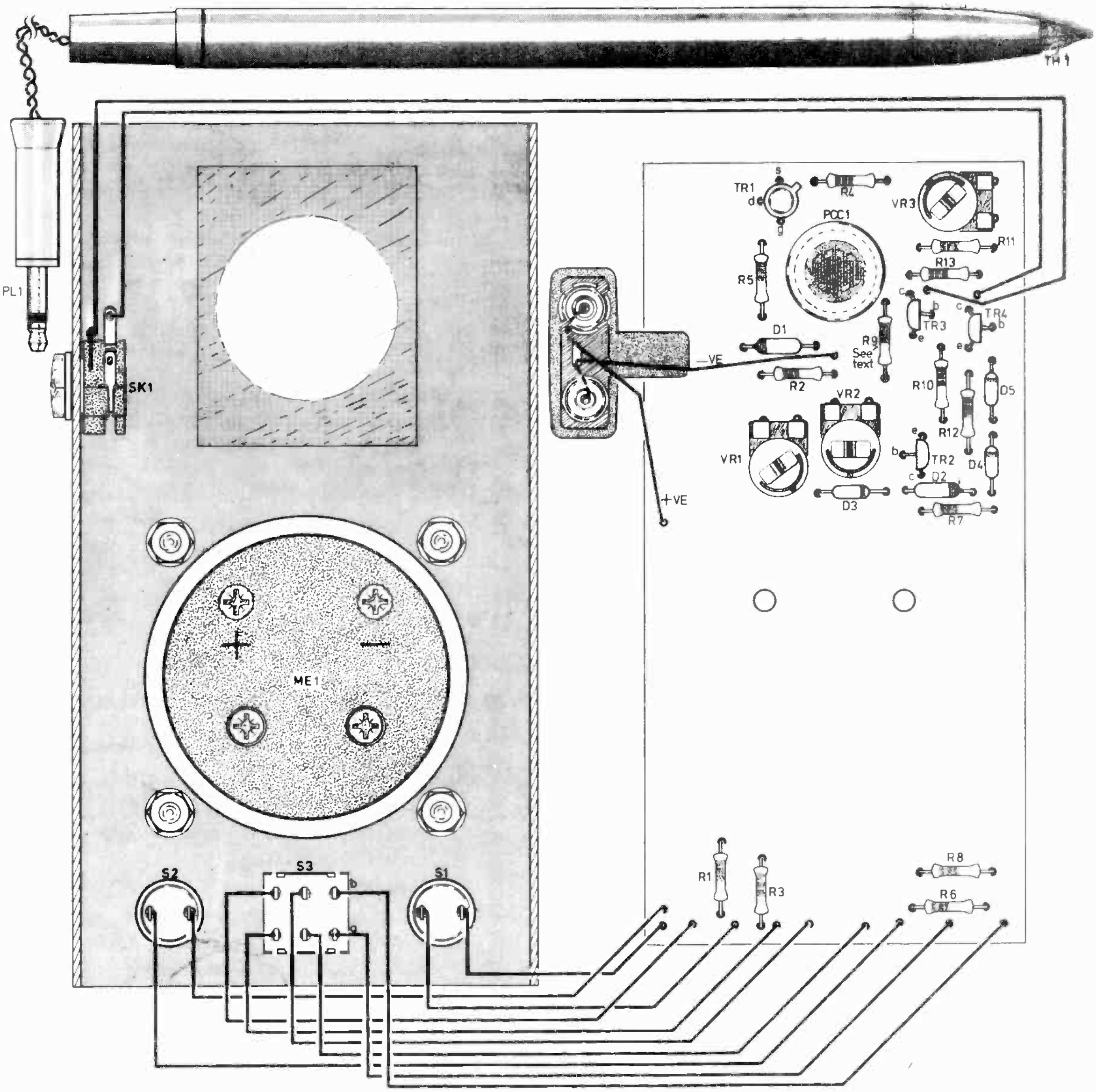
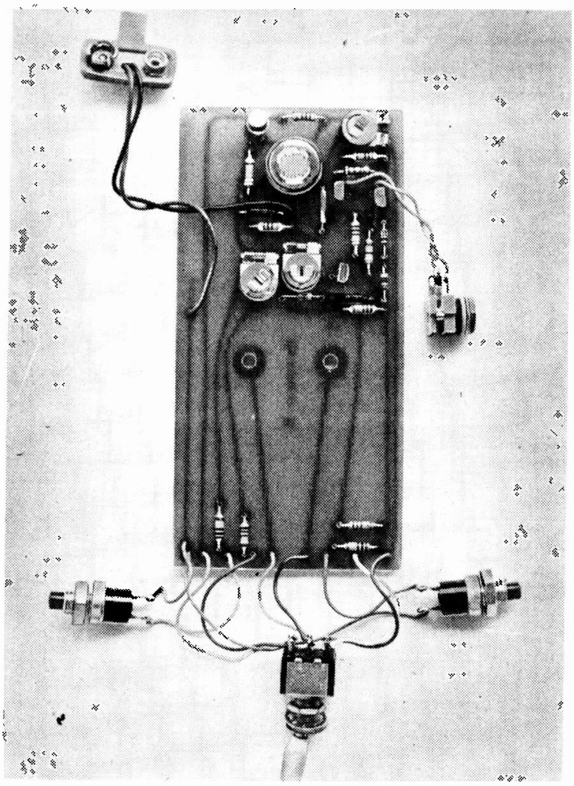


Fig. 5. Constructional details of the complete unit. The ITT meter has screw terminals which the printed circuit board is designed to fit. The probe is an old felt pen body



Photograph showing the internal layout of the unit

Provided it is small it matters little since the error is constant, and if it is calibrated in air and used only in air it will have no significant effect.

Similarly, if calibrated and used in liquids only the error is "calibrated out". But if a thermistor is calibrated in liquids and then used in air, the heat generated within the bead cannot be dissipated as efficiently and the bead resistance drops, making it appear hotter than it really is. The current must therefore be kept to the lowest possible if both liquid and air temperatures are to be measured.

Although primarily designed for liquids this unit might be used for air measurements as well, and by using only 0·15mA in the constant current source the air temperature registers a mere 0·05 degree F higher than the liquid temperature.

Using this small current means that another emitter follower must be used to drive the meter, with VR3 and R9 setting the full scale deflection. With these stabilising features and calibrated at zero and f.s.d. a mid point error of less than 0·2 degree F can be expected.

CALIBRATION OF THE THERMOMETER

It is intended that this should be used over a 25 degrees F change from 55 degreesF to 80 degrees F. This gives ample resolution within the 60 degrees F to 70 degrees F range which is the most popular area for photographic work, yet enables solutions to be mixed quickly by monitoring the wider range. Also the meter scale was already subdivided into five increments, so it was easy to read a temperature range that could be divided into five increments also.

The best thermometer available to the constructor must be used to calibrate the instrument since this unit can only be as good as the "standard". With the probe tip immersed in a liquid of 55 degrees F the meter is set to zero using VR2, and at 80 degree F the full scale deflection is set by VR3; R9 will probably not be required in which case a wire link can be used in its place. Space was left for it, however, in case the voltage across the meter is low and further resistance was required to limit the current; 390 ohms will probably suffice but in rare cases it may be necessary to insert a larger value.

The fronts of SEW meters unclip, exposing the dial, whereby the temperature range can be added either with Letraset or careful printing.

MECHANICAL DETAILS

The box photographed is available from ITT Electronic Services (see Components List), and comes ready painted in a two-tone blue/grey eggshell, and the printed circuit board (Fig. 4) was designed to fit this box. Being a rather well-packed board it precluded the use of Veroboard or similar construction. However, a small plywood box could be made to take a larger board, and, if suitably polished, could still look attractive though less compact.

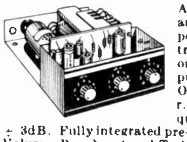
The one inch hole for the diffuser window was easily punched out with a "Q-max" punch, but the meter hole was a little more tricky. Unfortunately "Q-max" do not make a punch to suit so for this drill a circle of $\frac{1}{16}$in holes and join them up with a needle file, finishing with a run round with a scraper, a slow process but an effective one.

The thermometer probe utilises a disused felt tip pen with the felt removed. The thermistor was slid down the barrel until the tip emerged, then the barrel was filled with silicone bath tub caulk which held both the wiring and thermistor firmly in place. The pen cap was retained as a tip protector for when the unit is not in use.

Components are shown mounted on the board in Fig. 5 which also shows interwiring details. The battery lies alongside the "window". The printed circuit board is held by screws to the meter.

The total cost of this unit is about £8, for which the constructor will have an instrument which would cost very much more commercially—if such an instrument existed. ★

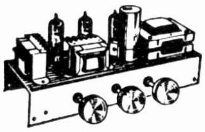
SUPERSOUND 13 HI-FI MONO AMPLIFIER



A superb solid state audio amplifier. Brand new components throughout. 5 silicon transistors plus 2 power output transistors in push-pull. Full wave rectification. Output approx. 13 watts r.m.s. into 8 ohms. Frequency response 12Hz-30KHz ± 3dB. Fully integrated pre-amplifier stage with separate Volume, Bass boost and Treble cut controls. Suitable for 8-15 ohm speakers. Input for ceramic or crystal cartridge. Sensitivity approx. 40mV for full output. Supplied ready built and tested, with knobs, escutcheon panel, input and output plugs. Overall size 3in high × 6in wide × 7½in deep. AC 220/250V.

PRICE £11·60. P. & P. 25p.

DE LUXE STEREO AMPLIFIER



A.C. mains 200-240V. Using heavy duty fully isolated mains transformer with full wave rectification giving adequate smoothing with negligible hum. Valve line up:—2 × ECL86 Triode Pentodes. 1 × EZ80 as rectifier. Two dual potentiometers are provided for bass and treble control, giving bass and treble boost and cut. A dual volume control is used. Balance of the left and right hand channels can be adjusted by means of a separate 'Balance' control fitted at the rear of the chassis. Input sensitivity is approximately 300m/v for full peak output of 4 watts per channel (8 watts mono), into 3 ohm speakers. Full negative feedback in a carefully calculated circuit, allows high volume levels to be used with negligible distortion. Supplied complete with knobs, chassis size 11in × 4in d. Overall height including valves 5in. Ready built and tested to a high standard. **PRICE £9·90** P. & P. 45p.

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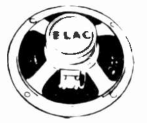

SPECIAL OFFER!

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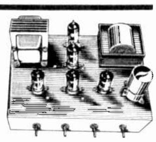
10/14 WATT HI-FI AMPLIFIER KIT



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and EZ80 rectifier. Simple instruction booklet 15p + SAE (Free with parts). **All parts sold separately. ONLY £8·80** P & P. 55p. Also available ready built and tested **£12·10** P. & P. 60p.

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MARKET PLACE

Items mentioned in this feature are usually available from electronic equipment and component retailers advertising in this magazine. However, where a full address is given, enquiries and orders should then be made direct to the firm concerned.

NEW 'SCOPES

Two new scopes from recently formed **Scopex Instruments,** are low cost precision instruments; the 4D-10 with a vertical bandwidth of 10MHz and the 4D-25 with a bandwidth of 25MHz. Both have been designed with the philosophy of combining performance with simplicity of operation. To further the philosophy Scopex introduced the "easy where it counts" triggering where the triggering point and the polarity are selected on just one control. This facility is available on both 'scopes.

The 4D-10 sells for £95 and the 4D-25 for £175. On a cost/performance basis they are both excellent value. Further details can be obtained from Scopex Instruments, Pixmore Avenue, Letchworth, Herts.

I.C. ACCESSORIES

Accessories in the integrated circuit field is a vastly growing market and readers may be interested in two new aids from **Ultra Electronics Components Ltd.**

The first item is a versatile printed circuit board for i.c.s and DIL devices. Basically it is a standard circuit card with rows of single-way connectors which will accept DIL devices.

Ideal for "knocking-up" experimental circuits, interconnection between devices is achieved by the use of patching leads. A distribution block connects to the board edge pads and enables the board to be plugged into racking systems if required.

The second item is a multi-contact "peg" or pincer which can be clamped over i.c.s and the lead-out pins in the handle used for test points. Contacts on the inside of the jaws automatically align with the i.c. pins.

When the need for desoldering i.c.s from printed circuits arises the "peg" as been found to be very useful as an extraction tool.

Two types are available at the moment, type OEC370 for 14 or 16 DIL packages with 0·1in pitch between contacts and type OEC371 for 24 to 60 contact devices with 0·1in pitch contacts.

Further particulars for both devices can be obtained from Ultra Electronic Components Ltd., Fassetts Road, Loudwater, Bucks.

STEREO KIT

A compact, new stereo record system that can be simply assembled has been introduced by **Radio & T.V. Components.** At £17·95 the Stereo 21 System provided excellent sound quality on demonstration and the near 6W total output should prove more than adequate for the average living-room.

The complete system includes a BSR 3-speed deck, ceramic cartridge and twin 8in × 5in eliptical speakers. None of the units are sold separately.

Two factors have contributed in keeping down the price; direct selling from R & TV to the public and simple d.i.y. assembly. You don't need to know anything about electronics in the construction; you simply enclose the speaker components in their wrap-around casings, wire the plug, plug in and you are enjoying stereo sound.

Further information can be obtained from Radio & T.V. Components (Acton) Ltd., 21 High Street, Acton, London, W.3.

CARTRIDGE PLAYER

One of the side effects of the booming in-car entertainment market lies in the problem of utilising the same source of sound for home listening. Growth in the sales of pre-recorded 8-track, stereo cartridges has not been matched by the introduction of an economic sound system capable of being used in conjunction with existing stereo equipment in the home.

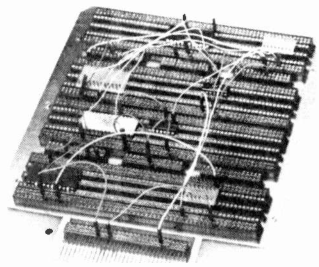
Now with the Budget 8, R & T-V C has introduced a reliable, British engineered, cartridge player which retails for £9·90. Based on the latest BSR T 145 8-track cartridge playing mechanism, and incorporating its own stereo pre-amplifier stages the unit simply plugs into the auxiliary socket on most stereo audio systems to provide high quality reproduction in the home from the same cartridges used in the car.

LITERATURE

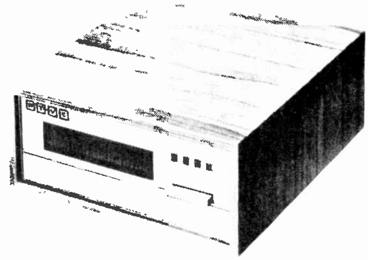
Next month P.E. is including a special i.c. audio chart which, we hope, readers will find very useful.

Whether you are thinking of building an amplifier or you want some ideas on using i.c.s. in audio circuits, the P.E. Audio I.C. Identichart gives comprehensive data on over 80 i.c.s. ranging from low level pre-amplifiers to hybrids rated at 50W.

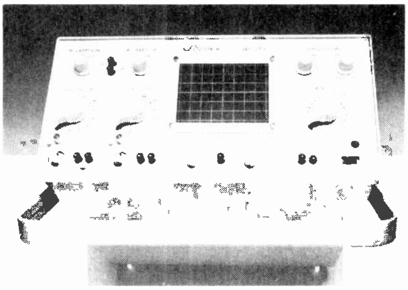
As well as data, the chart contains suggestions for using i.c.s. in mixers, tape recorders, record players etc.



Universal circuit card from Ultra Electronics



RTVC Budget 8 player



4D25 'scope from Scopex Instruments

Completed stereo 21 kit by RTVC

INDUSTRY NOTEBOOK

By Nexus

EXPANSION

The current boom is by no means uniform in impact across the whole of the electronics industry but there are welcome signs of expansion in many quarters.

Even conservative Ferranti is looking for a Stock Exchange listing as a way of raising more capital. Ferranti is one of the largest private companies in business in the UK and, according to reports, has no intention of "going public" in the generally accepted sense. It is still expected that the Ferranti family interests will control more than 50 per cent of voting rights.

High-flying Unitech Group has also been looking for more capital to finance the recent acquisition of Rathdown Industries and Lee Green Precision Industries. These two companies have broadened the Unitech base by adding component manufacture (mechanical counters, small pressings, precision machinings and co-axial connectors) to the Group's other activities.

One of the rising stars in the Group is Weir Electronics, acquired by Unitech in 1963 when it first moved to Bognor with a staff of only four people. I was recently at the opening, by local M.P. and Minister for Industrial Development, Christopher Chataway, of a new 30,000 sq ft production unit. Staff is now 300 and turnover £1·5 million. Extrapolating the growth curve suggests that Weir will hit £3 million turnover by 1975.

Weir is one of those fascinating companies that are honest with themselves as well as with their customers — a rare combination. They admit to having had some expensive diversions into fields (for example, in instruments) where there was little chance of success. Present (and profitable) tack is to stay a low-technology company turning out a first-class engineering job. Huge OEM orders for stabilised power supplies for companies like Rank Xerox, ITT and Business Computers are now the backbone of the business.

But one of the really big successes for Weir could come from a comparatively low-cost electronic seat-belt interlock for cars which is now being evaluated by British and overseas car manufacturers. The new Weir development is in time for the US market where the interlock will be mandatory on all cars registered next year and thereafter.

Other new products in the pipeline include motor speed control, electronic lighting control and an as yet unspecified incursion into telecommunications.

How about unstoppable Electrocomponents Associated Group, basically our old friend Radiospares wearing a new hat? Turnover has rocketed to £7·24 million up 20 per cent, with profits up 25·8 per cent to over £1·5 million. The Electroplan subsidiary which was set up to supply instruments as a complementary operation to the component business is not yet in profit, I understand, but should be making a contribution by the end of the year.

BULLSEYE

I haven't fired a shot in anger for close on 30 years and if someone had told me when I last squeezed a trigger that one day I should destroy a tank using a laser beam I should have thought them mad. It wasn't likely that such a suggestion should have been made because the laser lay some years in the future.

Anyway, your scribe, somewhat nervous before an audience of British Army top brass, not to mention a couple of dozen foreign military attaches, successfully polished off a couple of Chieftains at 700 metres on the tank range at Bovington Camp. There was all the excitement of seeing the "enemy" going up in smoke with the added satisfaction of knowing that nobody was getting hurt.

The equipment was Solartron's SIMFIRE tank gunnery simulator which has brought the company back into the simulator business with a bang and has already scored a sales bullseye with 16 armies, while another 25 armies are evaluating it. Even the United States Army is ordering it.

Solartron started the project as a private venture but the Ministry of Defence soon became interested and backed it with a £250,000 development contract. The big payoff is now at hand.

RESEARCH

Commercial pressures over the past few years have tended to direct research men into avenues of investigation which have some identifiable end-product in mind. But there is still plenty of "pure" research in the Philips laboratories at Eindhoven which I recently visited. As an example, I can quote the work on surfaces and surface layers which, despite the advent of the scanning electron microscope and other techniques, is still little understood and has great significance in the production process of semi-conductor devices.

But one of the most interesting developments I saw and, incidentally, of great commercial potential, was the electrochromic display. This was in 7-segment form and although passive in the sense that it is not light-emitting like gas discharge tubes or LEDs, has the enormous advantage that, once formed by the application of the appropriate voltage, the character remains when the voltage is removed until erased by re-applying the voltage with reversed polarity.

Several such devices have been described in the literature but, until now, all have had substantial disadvantages. The Philips team on the project has now reached a stage where the new device has been fully patented and so I can reveal that the principle of operation is based on the oxidation-reduction reaction of diheptylviologendibromide in water. Difficult to pronounce, perhaps, but it's a formula that works. The display is a cheerless purple-blue in colour but has excellent contrast and needs only half a volt to activate it.

To be in the top league of R and D is not easy. Philips has been in research since the early '90s (last century) when founder Gerard Philips did some of the pioneer work on filament lamps. The present score is 4,000 people in the research laboratories in Holland, France, England, Belgium and West Germany.

To keep up with the inventions and innovations that pour out of the labs, the Eindhoven patents department alone employs 200 people of which 60 are scientists. The mind boggles!

KEYBOARD KING?

In contrast to mighty Philips with 350,000 employees, watch Sammy Zilkha's bid for the throne as keyboard king. Keyboards is one of the fastest growing areas of electronic industry activity and his new but still tiny company, Alphameric Keyboards, looks all set to win a big share of it. Hardly had he announced the product, the electronic heart of which is a Zilkha-designed MOS LSI, than a joint venture agreement was being completed with an American company.

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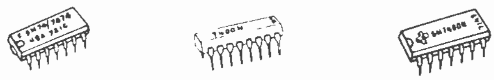

Type	1/11 p	12/24 p	25/99 p
SN7400	0·20	0·18	0·16
SN7401	0·20	0·18	0·16
SN7402	0·20	0·18	0·16
SN7403	0·20	0·18	0·16
SN7404	0·20	0·18	0·16
SN7405	0·20	0·18	0·16
SN7406	0·30	0·27	0·25
SN7407	0·30	0·27	0·25
SN7408	0·20	0·19	0·18
SN7409	0·45	0·42	0·35
SN7410	0·20	0·18	0·16
SN7411	0·23	0·22	0·20
SN7412	0·42	0·40	0·35
SN7413	0·30	0·27	0·25
SN7416	0·30	0·27	0·25
SN7417	0·30	0·27	0·25
SN7420	0·20	0·18	0·16
SN7422	0·48	0·44	0·40
SN7423	0·48	0·44	0·40
SN7425	0·48	0·40	0·35
SN7427	0·42	0·39	0·35
SN7428	0·50	0·45	0·42
SN7430	0·20	0·18	0·16
SN7432	0·42	0·39	0·35
SN7433	0·70	0·61	0·44
SN7437	0·65	0·60	0·50
SN7438	0·65	0·60	0·50
SN7440	0·20	0·18	0·16
SN7441AN	0·75	0·72	0·70
SN7442	0·75	0·72	0·70
SN7443	1·00	0·95	0·90
SN7445	2·00	1·75	1·60
SN7446	2·00	1·75	1·60
SN7447	1·75	1·60	1·45
SN7448	1·75	1·60	1·45

Type	1/11 p	12/24 p	25/99 p
SN7450	0·20	0·18	0·16
SN7451	0·20	0·18	0·16
SN7453	0·20	0·18	0·16
SN7454	0·20	0·18	0·16
SN7460	0·20	0·18	0·16
SN7470	0·30	0·27	0·25
SN7472	0·30	0·27	0·25
SN7473	0·40	0·37	0·35
SN7474	0·40	0·37	0·35
SN7475	0·55	0·52	0·50
SN7476	0·45	0·42	0·39
SN7480	0·80	0·75	0·67
SN7481	1·25	1·15	1·10
SN7482	0·87	0·80	0·70
SN7483	1·00	0·90	0·85
SN7484	0·90	0·85	0·80
SN7486	0·45	0·41	0·38
SN7490	0·75	0·70	0·65
SN7491AN	1·00	0·95	0·90
SN7492	0·75	0·70	0·65
SN7493	0·75	0·70	0·65
SN7494	0·80	0·75	0·70
SN7495	0·80	0·75	0·70
SN7496	1·00	0·97	0·95
SN7497	6·25	5·50	5·00
SN74100	2·50	2·30	2·00
SN74104	1·45	1·35	1·20
SN74105	1·45	1·35	1·20
SN74107	0·50	0·45	0·40
SN74110	0·80	0·70	0·60
SN74118	1·00	0·95	0·90
SN74119	1·90	1·78	1·65
SN74121	0·60	0·55	0·50
SN74122	1·35	1·25	1·10
SN74123	2·70	2·55	2·47
SN74141	1·00	0·95	0·90

Type	1/11 p	12/24 p	25/99 p
SN74145	1·50	1·40	1·30
SN74150	3·35	2·95	2·15
SN74151	1·10	0·95	0·90
SN74153	1·35	1·27	1·20
SN74154	2·00	1·75	1·55
SN74155	1·55	1·47	1·35
SN74156	1·55	1·47	1·35
SN74157	1·80	1·70	1·50
SN74160	2·60	2·40	2·25
SN74161	2·60	2·40	2·25
SN74162	3·40	3·25	2·70
SN74163	3·40	3·25	2·70
SN74164	2·75	2·30	2·10
SN74165	4·00	3·50	3·00
SN74166	4·00	3·50	3·00
SN74167	6·25	5·60	5·10
SN74170	4·10	3·55	3·05
SN74174	2·00	1·75	1·30
SN74175	1·35	1·27	1·15
SN74176	1·60	1·35	1·20
SN74177	1·60	1·35	1·20
SN74180	1·55	1·30	1·20
SN74181	7·00	6·00	5·50
SN74182	2·00	1·80	1·60
SN74184	2·40	2·00	1·80
SN74185A	2·40	2·00	1·80
SN74190	1·95	1·85	1·75
SN74191	1·95	1·85	1·75
SN74192	2·00	1·90	1·80
SN74193	2·00	1·90	1·80
SN74194	2·50	2·25	1·90
SN74195	1·85	1·70	1·60
SN74196	1·50	1·40	1·30
SN74197	1·50	1·40	1·30
SN74198	4·60	3·70	3·35
SN74199	4·60	3·70	3·35

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£1.50 each

TRIACS

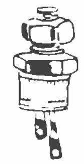
STUD WITH ACCESSORIES

Type	Volts P.I.V.	Price 1-11
3 AMP RANGE		
SC35A	100	75p
SC35B	200	79p
SC35D	400	85p
6 AMP RANGE (TO48)		
SC40A	100	85p
SC40B	200	90p
SC40D	400	£1·00
SC40E	500	£1·20
10 AMP RANGE (TO48)		
SC45A	100	95p
SC45B	200	£1·00
SC45D	400	£1·25
SC45E	500	£1·45
15 AMP RANGE (TO48)		
SC50A	100	£1 25
SC50B	200	£1·35
SC50D	400	£1·65
SC50E	500	£1·85

DIAC D32 25p

TRIACS— Additional Types
40430 (TO66) 85p
40669 (Plastic) £1·00
40486 (TO5) 80p

3 Amp T048

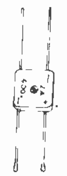


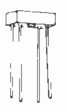
15 Amp T048

NEW BRIDGE RECTIFIERS

SMALL SIZE AND LOW COST

Type	Volts P.I.V.	Price 1-11
HALF AMP		
BO5/05	50	20p
BO5/10	100	25p
ONE AMP ¼ × ⅜ H TUBULAR		
B1/05	50	25p
B1/10	100	25p
B1/20	200	30p
B1/60	600	35p
ONE AMP (G.I.) TUBULAR		
W005	50	30p
W01	100	35p
W02	200	40p
W06	600	45p
TWO AMPS ½ H × ½ L × 3/16		
B2/05	50	35p
B2/100	100	40p
B2/200	200	45p
B2/600	600	50p
B2/1000	1000	60p
FOUR AMPS ½H × ½L × 3/16		
B4/100	100	60p
B4/200	200	65p
B4/400	400	70p
B4/600	600	75p
B4/800	800	£1·00
SIX AMPS ½H × ½L × 3/16		
B6/100	100	70p
B6/200	200	75p
B6/400	400	90p
B6/600	600	£1 00





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Any one type.

1½ Watt 5%
Wire Ends
Metal Case
All voltages
6·8 – 100 Volts
20p each

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100+	16p
500+	12p
1000+	10p

Any one type.

3 Watt Plastic
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3EZ Range

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30p each.

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702C	TO5	75p
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741C	D.I.L.	55p
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747C	D.I.L.	£1 10
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SINCLAIR IC12 £1·80

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Type	P.I.V.	1-11
1 amp miniature		
IN4001	50	6
IN4002	100	7
IN4003	200	8
IN4004	400	8
IN4005	600	10
IN4006	800	12
IN4007	1000	15
1·5 amp miniature		
PL4001	50	8
PL4002	100	9
PL4003	200	10
PL4004	400	10
PL4005	600	12
PL4006	800	15
PL4007	1000	16

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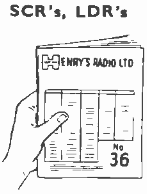

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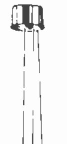
SILICON CONTROLLED RECTIFIERS

Type	Volts P.I.V.	Price 1-11
ONE AMP		
CRS 1/05	50	25p
CRS 1/10	100	30p
CRS 1/20	200	30p
CRS 1/40	400	35p
CRS 1/60	600	45p
THREE AMP (TO48)		
CRS 3/05	50	30p
CRS 3/10	100	30p
CRS 3/20	200	35p
CRS 3/40	400	45p
CRS 3/60	600	55p
FIVE AMP (TO66)		
CRS 5/400	400	60p
SEVEN AMP (TO48)		
CRS 7/100	100	60p
CRS 7/200	200	65p
CRS 7/400	400	70p
CRS 7/600	600	95p
SIXTEEN AMP		
SCR 16/100	100	65p
SCR 16/200	200	70p
SCR 16/400	400	80p
SCR 16/600	600	£1 00



1 Amp T05

3 Amp T048

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2N1307 25p
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2N1613 20p
2N1671 1·00
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2N2369A 15p
2N2906 20p
2N2926 (all cols) 10p
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2N3054 50p
2N3055 55p
2N3440 75p
2N3442 1·25
2N3525 75p
2N3614 59p
2N3615 75p
2N3702 10p
2N3704 10p
2N3705 10p
2N3714 1·80
2N3771 1·75
2N3773 2·00
2N3790 2·25
2N3819 35p
2N3820 50p
2N3866 85p
2N3903 15p
2N3906 12p
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Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	P & P £	p
07	20	1	11	7·0 × 6·0 × 6·5	1·77	30
100	60	3	8	8·9 × 8·0 × 7·7	2·62	36
61	100	5	12	10·2 × 8·9 × 8·3	2·88	52
30	200	9	8	12·0 × 10·3 × 10·0	4·83	52
62	250	12	4	9·5 × 12·7 × 11·4	6·38	67
55	350	15	0	14·0 × 10·8 × 12·4	8·55	82
63	500	27	0	17·1 × 11·4 × 15·9	12·32	*
92	1000	40	0	17·8 × 17·1 × 21·6	22·70	*
128	2000	63	0	24·1 × 21·6 × 15·2	37·50	*

PLEASE NOTE NEW ADDRESS AS BELOW

AUTO SERIES (NOT ISOLATED)

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Auto Taps	P & P £	p
113	20		11	7·3 × 4·3 × 4·4	0-115-210-240	0·93	22
64	75	1	14	7·0 × 6·4 × 6·0	0-115-210-240	1·82	30
4	150	3	0	8·9 × 6·4 × 7·6	0-115-200-220-240	2·20	36
66	300	6	0	10·2 × 10·2 × 9·5	,, ,,	4·28	52
67	500	12	8	14·0 × 10·2 × 11·4	,, ,,	6·35	67
84	1000	16	0	11·4 × 14·0 × 14·0	,, ,,	11·54	82
93	1500	28	9	13·5 × 14·9 × 16·5	,, ,,	16·72	*
95	2000	40	0	17·8 × 16·5 × 21·6	,, ,,	21·82	*
73	3000	45	8	17·4 × 18·1 × 21·3	,, ,,	29·70	*

TOTALLY ENCLOSED 115V AUTO TRANSFORMERS
115V 500 Watt totally enclosed auto transformer, complete with mains lead and two 115V outlet sockets. £8·63. P & P 67p.
Also available a 20 Watt version. £1·84. P & P 22p.

LOW VOLTAGE SERIES (ISOLATED)
PRIMARY 200-250 VOLTS 12 AND/OR 24 VOLT RANGE

Ref. No.	Amps. 12V	24V	Weight lb	oz	Size cm.	Secondary Windings *	P & P £	p
111	0·5	0·25		12	7·6 × 5·7 × 4·4	0-12V at 0·25A × 2	0·93	22
213	1·0	0·5	1	0	8·3 × 5·1 × 5·1	0-12V at 0·5A × 2	1·11	22
71	2	1	1	0	7·0 × 6·4 × 5·7	0-12V at 1A × 2	1·46	22
18	4	2	2	4	8·3 × 7·0 × 7·0	0-12V at 2A × 2	2·04	36
70	6	3	3	12	10·2 × 7·6 × 8·6	0-12V at 3A × 2	2·46	42
108	8	4	5	4	10·0 × 8·3 × 8·2	0-12V at 4A × 2	2·73	52
72	10	5	6	3	7·9 × 10·8 × 10·2	0-12V at 5A × 2	3·23	52
17	16	8	7	8	12·1 × 9·5 × 10·2	0-12V at 8A × 2	4·99	52
115	20	10	11	13	12·1 × 11·4 × 10·2	0-12V at 10A × 2	6·35	67
187	30	15	16	12	13·3 × 12·1 × 12·1	0-12V at 15A × 2	11·73	82
226	60	30	34	0	17·0 × 14·5 × 12·5	0-12V at 30A × 2	21·57	*

30 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	P & P £	p
112	0·5	1	4	8·3 × 3·7 × 4·9	0-12-15-20-24-30V	1·11	22
79	1·0	2	0	7·0 × 6·4 × 6·0	,, ,,	1·48	36
3	2·0	3	2	8·9 × 7·0 × 7·6	,, ,,	2·21	36
20	3·0	4	6	10·2 × 8·9 × 8·6	,, ,,	2·72	42
21	4·0	6	0	10·2 × 10·0 × 8·6	,, ,,	3·23	52
51	5·0	6	8	12·1 × 10·0 × 8·6	,, ,,	4·02	52
117	6·0	7	8	12·1 × 10·0 × 10·2	,, ,,	4·80	52
88	8·0	10	0	14·0 × 11·7 × 10·0	,, ,,	6·20	67
89	10·0	12	2	14·0 × 10·2 × 11·4	,, ,,	7·85	67

50 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	P & P £	p
102	0·5	1	11	7·0 × 7·0 × 5·7	0-19-25-33-40-50V	1·46	30
103	1·0	2	10	8·3 × 7·3 × 7·0	,, ,,	2·13	36
104	2·0	5	0	10·2 × 8·9 × 8·6	,, ,,	2·96	42
105	3·0	6	0	10·2 × 10·2 × 8·3	,, ,,	4·01	52
106	4·0	9	4	12·1 × 11·4 × 10·2	,, ,,	5·31	52
107	6·0	12	4	12·1 × 11·1 × 13·3	,, ,,	7·85	67
118	8·0	18	9	13·3 × 13·3 × 12·1	,, ,,	10·25	97
119	10·0	19	12	16·5 × 11·4 × 15·9	,, ,,	12·85	97

60 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	P & P £	p
124	0·5	2	4	8·3 × 9·5 × 6·7	0-24-30-40-48-60V	1·48	36
126	1·0	3	0	8·9 × 7·6 × 7·6	,, ,,	2·06	36
127	2·0	5	6	10·2 × 8·9 × 8·6	,, ,,	3·23	42
125	3·0	8	8	11·9 × 9·5 × 10·0	,, ,,	4·92	52
123	4·0	10	6	11·4 × 9·5 × 11·4	,, ,,	6·35	67
120	6·0	16	12	13·3 × 12·1 × 12·1	,, ,,	9·20	82
122	10·0	23	2	16·5 × 12·7 × 16·5	,, ,,	15·23	*

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Ref. No.	Amps.	Weight lb	oz	Size cm.		P & P £	p
45	1·5	1	9	7·0 × 6·0 × 6·0	Please note, these units do not include rectifiers	1·47	30
5	4·0	3	11	10·2 × 7·0 × 8·3		2·23	42
86	6·0	5	12	10·2 × 8·9 × 8·3		3·37	52
146	8·0	6	4	8·9 × 10·2 × 10·2		3·84	52
50	12·5	11	14	13·3 × 10·8 × 12·1		5·72	67

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BFS96	15p	ZTX313	11p	ZTX531	22p	ZS174	17p
BFS97	23p	ZTX314	13p	ZTX550	17p	ZS176	23p
BFS98	20p	ZTX320	31p	ZTX551	17p	ZS178	38p
ZTX107	9p	ZTX330	15p	2N3055	72p	ZS270	11p
ZTX108	8p	ZTX331	16p	* DIODES *		ZS271	16p
ZTX109	11p	ZTX382	13p			ZS272	18p
ZTX212	14p	ZTX383	15p	ZS120	8p	ZS274	19p
ZTX213	14p	ZTX384	18p	ZS121	10p	ZS276	26p
ZTX214	15p	ZTX450	17p	ZS122	13p	ZS278	37p
ZTX300	12p	ZTX451	17p	ZS123	16p	* ZENERS *	
ZTX301	13p	ZTX500	12p	ZS124	18p		
ZTX302	17p	ZTX501	13p	ZS140	25p	KS030A to	
ZTX303	14p	ZTX502	17p	ZS141	43p	KS180A—	
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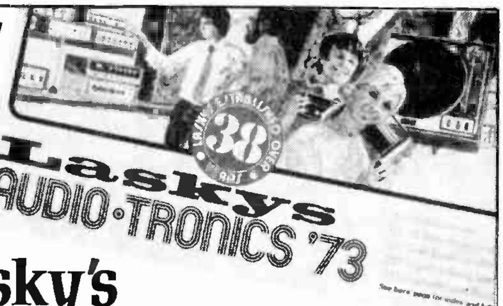

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PATENTS REVIEW...

WIND DIRECTION INDICATORS

Direction indicators are used on small sailing boats to show the wind direction relative to the heading of the boat and so help the helmsman choose the best angle to sail. Conventionally an electrical transmitter is connected to a wind vane on the masthead and the transmitter produces signals which are fed to a receiver and rotor in the cockpit. But such systems have to date been relatively insensitive.

In BP 1 290 331 from EMI a refined system is describd. In Fig. 1 a star wound transmitter transformer T1 has three windings spaced by angles of 120 degrees and signals are taken from points 1, 2 and 3. A rotor winding is fed by a 400Hz signal from a converter powered by the boat's battery. The rotor is ganged to a wind vane on the boat's mast.

BP 1 290 331

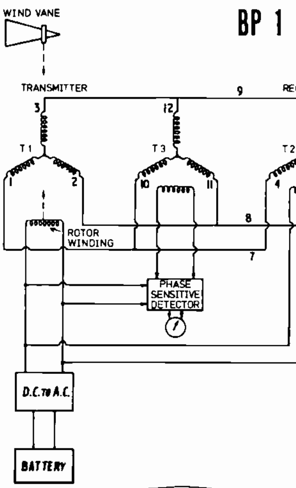

Fig. 1.

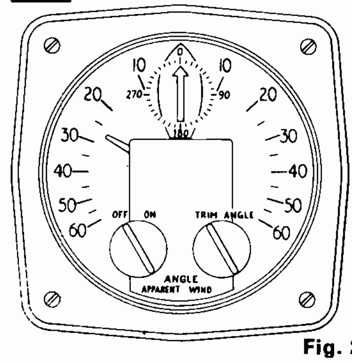

Fig. 2.

The signals from points 1, 2 and 3 are fed to points 4, 5, 6 on a second star wound transformer T2, which functions as a receiver. This receiver also has a rotor winding supplied with the 400Hz signal.

As the rotor turns with the wind direction changes the amplitudes of the a.c. currents in the leads 7, 8, 9 vary with sine and cosine functions. Corresponding fields are set up in the receiver transformer T2 and its rotor follows these. The receiver rotor is coupled to a direction pointer on a cockpit indicator (Fig. 2).

All this is conventional and the invention proper concerns the provision of a second transmitter which is formed as a third star wound transformer T3. Points 10, 11, 12 on this transformer are connected to the leads 7, 8 and 9 and this transformer has a rotor winding which is normally stationary but can be pre-set by a knob on the cockpit indicator.

The signal produced by the T3 rotor is fed to a phase sensitive detector with the 400Hz signal as its reference. For any position of T1 rotor there is one angular position of T2 rotor which produces zero voltage.

The output of the phase detector is fed to a milliammeter with a pointer which moves over an apparent wind scale on the indicator. Scale calibration is such that the pointer shows the angular deviation to one side or another of the null, determined by the angular setting of T3 rotor and represented as scale zero, see Fig. 2. The milliammeter therefore provides a highly sensitive indication of deviation with angular amplification.

Usually T3 rotor is adjusted by the trim/angle control so that the pointer reads zero when the boat is heading directly into the wind. Thereafter the pointer gives a very sensitive and very accurate indication of the wind direction relative to the boat heading.

COUGH MONITORING

Some fairly simple circuitry from Abbott Laboratories in the USA is described in BP 1 312 846. Although the main intention is to monitor the rate of coughing of a patient for diagnostic purposes, the basic principle of the invention will be applicable to many other fields where it is desired to monitor and count the number of similar sounds above a threshold value which have occurred during a predetermined time.

The patient wears a small microphone either on his shirt collar or taped to his throat. The microphone feeds a small f.m. transmitter which transmits the cough noises to a remote receiver. See Fig. 1.

The receiver is coupled to counting circuitry and a monitoring loudspeaker by the secondary of transformer T1. The loudspeaker can also be brought temporarily into circuit to assist accurate and mutual tuning of the transmitter and receiver.

The secondary of T1 feeds the full-wave rectifier of the threshold circuit. The output of the rectifier bridge is connected across VR1.

Adjustment of VR1 slider allows the threshold level to be set so that only cough signals above a predetermined power level are passed, via C1, to the gate of CSR1. The thyristor CSR1 is normally biased into its non-conductive state.

The anode of CSR1 is connected to a conventional electrical step counter which records the number of pulses supplied to its input. Thus, the counter displays the number of coughs above the pre-set threshold level.

BP 1 312 846

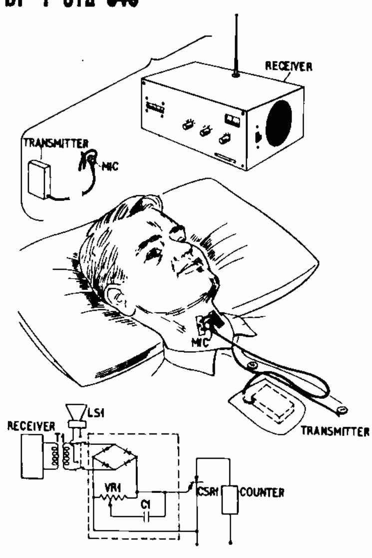

Fig. 1.

Readout—
A SELECTION FROM OUR POSTBAG

Correspondents wishing to have a reply must enclose a stamped addressed envelope. We regret we are unable to guarantee a reply on matters not relating to articles published in the magazine. Technical queries cannot be dealt with on the telephone.

First experience

Sir—Regarding Mr. Baily's letter in the July issue of P.E., I am inclined to agree with him on the subject of log-law applied to v.c.o.s.

My first experience of synthesisers was a small set up comprising three linear oscillators and two filters coupled to a spare keyboard. The intention at that time was to use it in conjunction with an organ, but at no time could it be matched to the organ. I was then informed that a "log-tuned" oscillator was the better circuit since it distributed the frequency evenly over the keyboard virtually to any range.

Having now acquired, what I call, a log-tuned synthesiser, I find no problem at all in matching it with other instruments.

Brett Ross,
Redditch, Worcs.

Extremely versatile

Sir—I have been following the P.E. Synthesiser design with interest since its advent, with a view to using the circuits in my own synthesiser which I had been designing for some time when your synthesiser came out. Whilst on the whole the circuits have been designed very well, there are some points which could be improved upon.

The most important of these is the choice of linear v.c.o.s. I am fortunate in that I have been able to play on nearly all the commercially available synthesisers, and although they vary greatly in many respects, they are united in the use of log v.c.o.s.

With log v.c.os a keyboard can be adjusted to accompany out of tune guitars and flat pianos, and I have fitted fifth, third, tone and semitone transpose switches, as on the Synthi AKS, to accompany tunes played in a different key to which I have learnt the tune. The range of my keyboard can be 1Hz bottom C, 16Hz top C, or with top C nearly ultrasonic, and it is in tune over the entire range (except for a slight droop in frequency at the upper limit caused by the slow switching time of 741's). A linear keyboard is limited to the 4 octaves for which it was tuned. With all the evidence pointing to the necessity of a logarithmic response, it seems a false economy to leave out a log converter from the otherwise excellent v.c.o. design.

Regarding Mr. Baily's letter, although I agree with him in general, I must defend the use of integrated circuits and dual-rail power supplies. The 741, despite drawbacks concerning frequency response, is an extremely versatile device well suited to use in complex analogue systems like synthesisers, considerably simplifying construction of circuits in which it is used.

To use a control as a signal, or vice versa, both must cover the same voltage range. If the signals are a.c. about OV, the controls should also be centred on earth, entailing ± power supplies. This is another feature common to all commercial synthesisers.

The patching system is the heart of a synthesiser, and although patchcords are the best choice for a modular system, I dislike them because they are inconvenient, requiring two insertions to make one link, they allow only 1-to-1 patches unless parallel inputs are provided, obscure the face of the machine and are prone to hum loops. There are also advantages, the system is easily extendable and signals can be brought in from external sources directly into the system.

The patchboard arrangements in Fig. 6.9b will not work as a resistor is required to mix outputs if more than one is connected to an input. Output impedance should be as low as possible to minimise unwanted crosstalk via outputs, and ideally all inputs should be virtual earths for good mixing, but this is of little importance for all inputs except v.c.o. frequency control.

This needs a virtual earth so that each input plugged to it has the same effect regardless of what else is connected. With the VCS3 the oscillator input impedance is 10k, and if a programming source other than the keyboard, say joystick or vibrato oscillator is added, then the octave width needs adjusting.

Although I disagree with parts of the design, some of the modules are as good, if not better than those in any other synthesiser and I will be incorporating these without modification into my own synthesiser.

R. Gwinn,
Surbiton, Surrey.

A little unfair

Sir—Having commenced building the P.E. Synthesiser I would like to add my own comments to those of Mr. Baily in the July issue, when he criticises Mr. Shaw's designs.

Firstly, Mr. Baily is being a little unfair in his cost comparison. Agreed, we could obtain a more versatile instrument for £200 using Dewtron modules, but one must take into account the lavishly expensive external shell recommended by Mr. Shaw to house his own Synthesiser. Any prospective constructor should note that Mr. Shaw's recommended cabinet, other metalwork, nuts, bolts, McMurdo plugs and panel knobs cost about £60.

I costed the project very carefully against commercial instruments (biased naturally towards my particular requirements) and opted to work from Mr. Shaw's circuits. After all, one doesn't have to use the recommended cabinet work—the project is expensive enough without using it to exploit modular construction of dubious modular value. An additional benefit, however, is that Mr. Shaw's designs are impressive to say the least, and I should learn a lot from them.

Having said that, I must agree with Mr. Baily regarding Mr. Shaw's dismissal of logarithmic voltage/frequency relationship in the v.c.os. It is not so much the loss of chord facilities as in the reduction of the instrument's versatility. In fairness Mr. Shaw wanted to reduce setting up difficulties and did mention the SN76502 log amp for those who wanted to try their hands at log control.

Otherwise, my only two criticisms are: (1) the absence of a sine wave source. Electronic music composition does occasionally demand this peculiarly pure tone. (2) The absence of a band pass filter whose central frequency and spread can be controlled even manually—a necessity for composition based only on a controlled noise source.

I. Stuart-Colwill,
London, S.W.16

We have received many reader's letters in a like vein requesting a log v.c.o. design. To satisfy this, G. D. Shaw is currently designing a circuit which will be published in the near future.

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1N85	0·88	ASY27	0·30	BYZ12	0·40	OAZ211	0·40	ZT21	0·25
1N253	0·50	ASY28	0·25	BYZ13	0·35	OAZ222	0·45	ZT43	0·25
1N256	0·50	ASY29	0·30	BYZ15	1·25	OAZ223	0·45	ZTX107	0·12
1N645	0·25	ASY36	0·25	BYZ16	0·60	OAZ224	0·45	ZTX108	0·10
1N725A	0·20	ASY50	0·20	BYZ88C3V3		OAZ241	0·22	ZTX300	0·14
1N914	0·05	ASY51	0·40		0·10	OAZ242	0·23	ZTX304	0·24
1N4007	0·12	ASY53	0·20	BZY88C3V3		OAZ244	0·25	ZTX500	0·15
1S113	0·15	ASY55	0·20		0·10	OAZ246	0·23	ZTX503	0·16
1S131	0·13	ASY62	0·25	C111	0·55	OAZ290	0·38	ZTX531	0·25
1S202	0·23	ASY66	0·33	CRS1/05	0·30	OC16	0·85		
2G371	0·40	ASZ21	1·00	CRS1/40	0·45	OC16T	0·38	**INTEGRATED CIRCUITS**	
2G381	0·25	ASZ23	0·75	CS4B	2·50	OC19	0·50		
2G414	0·30	AC101	1·50	CS10B	3·13	OC20	1·25		
2G417	0·25	AUY10	0·98	DD000	0·15	OC22	1·00	7400	0·20
2N404	0·22	BC107	0·12	DD003	0·15	OC23	1·25	7401	0·20
2N697	0·15	AC108	0·12	DD006	0·18	OC24	1·10	7402	0·20
2N698	0·30	BC109	0·12	DD007	0·40	OC25	0·40	7403	0·20
2N706	0·10	BC113	0·16	DD008	0·38	OC26	0·35	7404	0·20
2N706A	0·12	BC115	0·20	GD3	0·33	OC28	0·65	7405	0·20
2N708	0·15	BC116	0·20	GD4	0·10	OC29	0·65	7406	0·40
2N709	0·40	BC116A	0·23	GD5	0·33	OC30	0·40	7407	0·40
2N1091	0·55	BC118	0·15	GD8	0·25	OC35	0·55	7408	0·25
2N1131	0·25	BC121	0·20	GD12	0·10	OC36	0·65	7409	0·33
2N1132	0·25	BC122	0·20	GET102	0·50	OC41	0·35	7410	0·20
2N1302	0·18	BC125	0·68	GET103	0·40	OC42	0·40	7411	0·23
2N1303	0·18	BC126	0·65	GET113	0·35	OC43	0·70	7412	0·28
2N1304	0·22	BC140	0·55	GET114	0·30	OC44	0·18	7413	0·30
2N1305	0·22	BC147	0·12	GET115	0·75	OC44M	0·17	7416	0·30
2N1306	0·28	BC148	0·10	GET116	0·85	OC45	0·18	7417	0·30
2N1307	0·28	BC149	0·12	GET120	0·50	OC45M	0·18	7420	0·20
2N1308	0·28	BC157	0·14	GET872	0·30	OC46	0·27	7422	0·28
2N2147	0·75	BC158	0·12	GET875	0·40	OC57	0·60	7423	0·40
2N148	0·60	BC160	0·63	GET880	0·55	OC58	0·60	7425	0·37
2N2160	0·61	BC169	0·14	GET881	0·25	OC59	0·60	7427	0·37
2N2218	0·23	BCY31	0·45	GET882	0·35	OC66	0·50	7428	0·43
2N2219	0·25	BCY32	0·85	GET885	0·35	OC70	0·18	7430	0·20
2N2369A	0·15	BCY33	0·38	GEX44	0·08	OC71	0·15	7432	0·37
2N2444	1·99	BCY34	0·45	GEX45/1	0·45	OC72	0·25	7433	0·43
2N2613	0·28	BCY38	0·55	GEX941	0·30	OC73	0·50	7437	0·43
2N2646	0·50	BCY39	1·00	GJ3M	0·50	OC74	0·30	7438	0·43
2N2904	0·20	BCY40	0·80	GJ4M	0·38	OC75	0·30	7440	0·20
2N2904A	0·25	BCY42	0·30	GJ5M	0·25	OC76	0·30	7441AN	0·85
2N2906	0·20	BCY70	0·15	GJ7M	0·50	OC77	0·55	7442	0·85
2N2907	0·23	BCY71	0·20	HG1005	0·50	OC78	0·25	7450	0·20
2N2924	0·23	BCZ10	0·60	HS100A	0·20	OC79	0·30	7451	0·20
2N2925	0·15	BCZ11	0·65	MAT100	0·20	OC81	0·28	7453	0·20
2N2926	0·10	BD121	1·00	MAT101	0·25	OC81D	0·28	7454	0·20
2N3054	0·45	BD123	1·00	MAT120	0·20	OC81M	0·20	7460	0·20
2N3055	0·45	BD124	0·80	MAT121	0·25	OC81DM	0·18	7470	0·33
2N3702	0·10	BDY11	1·45	MJE520	0·65	OC81Z	0·45	7472	0·38
2N3705	0·12	BF115	0·22	MJE2955	1·10	OC82	0·28	7473	0·44
2N3706	0·11	BF117	0·50	MJE3055	0·75	OC82D	0·25	7474	0·48
2N3707	0·13	BF167	0·23	NKT128	0·45	OC83	0·25	7475	0·59
2N3709	0·10	BF173	0·25	NKT129	0·30	OC84	0·25	7476	0·45
2N3710	0·11	BF181	0·33	NKT211	0·25	OC114	0·38	7480	0·80
2N3711	0·11	BF184	0·22	NKT213	0·25	OC122	1·00	7482	0·87
2N3819	0·35	BF185	0·22	NKT214	0·24	OC123	1·10	7483	1·20
2N5027	0·53	BF194	0·13	NKT216	0·40	OC139	0·40	7484	1·00
2N5088	0·33	BF195	0·13	NKT217	0·45	OC140	0·65	7486	0·50
2S301	0·59	BF196	0·15	NKT218	1·13	OC141	0·80	7490	0·75
2S304	1·15	BF197	0·15	NKT219	0·33	OC169	0·20	741AN	1·10
2S501	0·37	BFS61	0·25	NKT222	0·30	OC170	0·25	7492	0·75
2S703	1·00	BFS98	0·25	NKT224	0·25	OC171	0·30	7493	0·75
AA129	0·20	BFX12	0·20	NKT251	0·24	OC200	0·55	7494	0·85
AAZ12	0·75	BFX13	0·25	NKT271	0·20	OC201	0·80	7495	0·85
AAZ13	0·10	BFX29	0·28	NKT272	0·20	OC202	0·90	7496	1·00
AC107	0·35	BFX30	0·28	NKT273	0·20	OC203	0·55	7497	4·32
AC126	0·25	BFX35	0·98	NKT274	0·20	OC204	0·65	74100	2·16
AC127	0·25	BFX63	0·50	NKT275	0·25	OC205	1·00	74107	0·51
AC128	0·20	BFX84	0·25	NKT277	0·20	OC206	1·10	74110	0·57
AC187	0·20	BFX85	0·28	NKT278	0·25	OC207	1·00	74111	0·86
AC188	0·20	BFX86	0·25	NKT301	0·85	OC460	0·20	74118	1·00
ACY17	0·35	BFX87	0·25	NKT304	0·75	OC470	0·30	74119	1·92
ACY18	0·27	BFX88	0·22	NKT403	0·70	OCP71	1·00	74121	0·57
ACY19	0·27	BFY10	1·00	NKT404	0·60	ORP12	0·55	74122	0·80
ACY20	0·22	BFY11	1·25	NKT678	0·30	ORP60	0·45	74123	1·44
ACY21	0·22	BFY17	0·25	NKT713	0·30	ORP61	0·48	74141	1·00
ACY22	0·16	BFY18	0·45	NKT773	0·25	S19T	0·30	74145	1·44
ACY27	0·25	BFY19	0·55	NKT777	0·38	SAC40	0·25	74150	2·80
ACY28	0·25	BFY24	0·45	O78B	0·38	SFT308	0·38	74151	1·15
ACY39	0·65	BFY44	1·00	OA6	0·12	ST722	0·38	74154	2·30
ACY40	0·22	BFY50	0·20	OA47	0·08	ST7231	0·63	74155	1·15
ACY41	0·22	BFY51	0·20	OA70	0·10	SX68	0·20	74156	1·15
ACY44	0·32	BFY52	0·20	OA71	0·10	SX631	0·45	74157	1·09
AD140	0·50	BFY53	0·17	OA73	0·15	SX635	0·55	74170	2·88
AD149	0·50	BFY64	0·45	OA74	0·15	SX640	0·75	74174	1·80
AD161	0·31	BFY90	0·75	OA79	0·10	SX641	0·75	74175	1·29
AD162	0·39	BSX27	0·50	OA81	0·10	SX642	0·60	74176	1·44
AF106	0·30	BSX60	0·98	OA85	0·15	SX644	0·85	74190	2·30
AF114	0·25	BSX76	0·18	OA86	0·15	SX645	0·85	74191	2·30
AF115	0·25	BSY26	0·18	OA90	0·07	V15/30P	0·75	74192	2·30
AF116	0·25	BSY27	0·18	OA91	0·07	V30/201P	0·75	74193	2·30
AF117	0·20	BSY51	0·50	OA95	0·07	V60/201	0·50	74194	1·72
AF118	0·50	BSY95A	0·12	OA200	0·08	V60/201P	0·75	74195	1·44
AF119	0·20	BSY95	0·12	OA202	0·10	XA101	0·10	74196	1·58
AF124	0·30	BT102/500R		OA210	0·25	XA102	0·18	74197	1·58
AF125	0·30		0·75	OA211	0·30	XA151	0·15	74198	3·16
AF126	0·30	BTY42	0·92	OAZ200	0·50	XA152	0·15	74199	2·88
AF127	0·30	BTY79/100R		OAZ201	0·45	XA161	0·25		
AF139	0·33		0·75	OAZ202	0·45	XA162	0·25		
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AF181	0·50	BY126	0·14	OAZ205	0·45	XB103	0·35	14 pin DIL	
AF186	0·40	BY127	0·15	OAZ206	0·45	XB113	0·30		0·15
AFY19	1·13	BY182	0·85	OAZ207	0·45	XB121	0·43	16 pin DIL	
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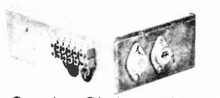

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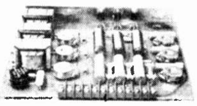

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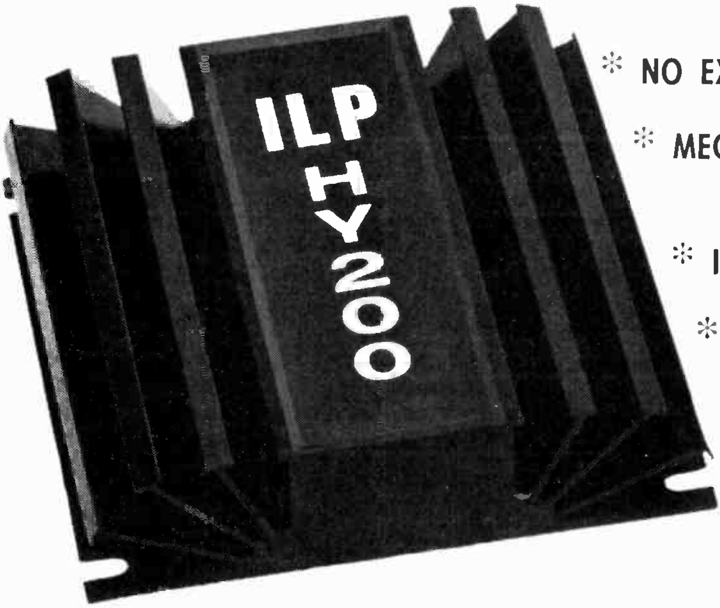

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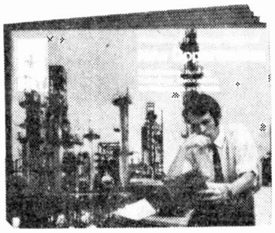

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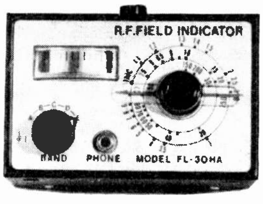

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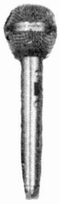

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NAS206A	0·340	6A	100
NAS206B	0·405	6A	200
NAS206D	0·653	6A	400
NAS306F	0·313	8A	50
NAS306A	0·380	8A	100
NAS306B	0·460	8A	200
NAS306D	0·725	8A	400
NAS406F	0·350	10A	50
NAS406A	0·434	10A	100
NAS406B	0·504	10A	200
NAS406D	0·812	10A	400
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NAS6520	0·440	6·5A	200
NAS6540	0·700	6·5A	400
NAS8510	0·430	8·5A	100
NAS8520	0·480	8·5A	200
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NASQ4520	0·440	4·5A	200
NASQ4540	0·710	4·5A	400
NASQ6510	0·420	6·5A	100
NASQ6520	0·480	6·5A	200
NASQ6540	0·780	6·5A	400
NASQ8510	0·480	8·5A	100
NASQ8520	0·580	8·5A	200
NASQ8540	0·830	8·5A	400
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N7022	6A	100PIV	0·430
N7023	6A	200PIV	0·540
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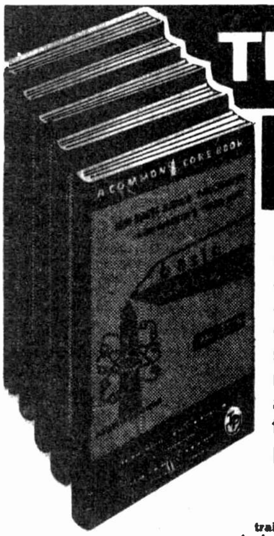

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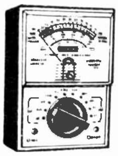

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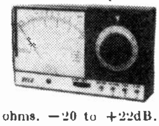

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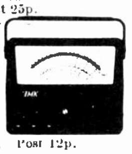

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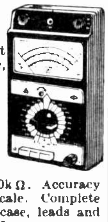

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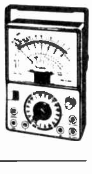

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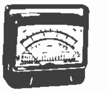

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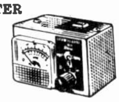

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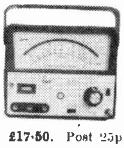

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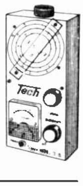

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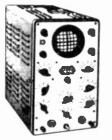

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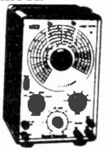

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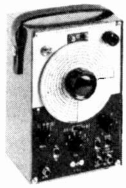

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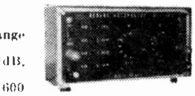

Frequency range 0-200kHz. Attenuator 0-111dB, 0·1dB step. Impedance 600 ohms. Max. Input power 30dBm. Size 180mm × 90mm × 55mm. **£12·50.** Post 37p.

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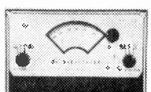

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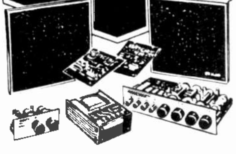

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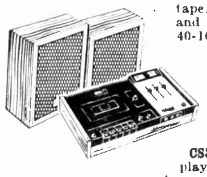
CS35 STEREO CASSETTE RECORDER



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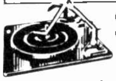
STEREO 1025T



4 speed autochanger unit fitted with stereo ceramic cartridge.

OUR PRICE **£4·95** Carr. & Ins. 50p

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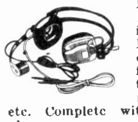
OUR PRICE **£1·95** P. & P. 30p

BH001 HEADSET AND BOOM MICROPHONE



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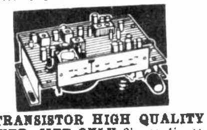
FM TUNER CHASSIS



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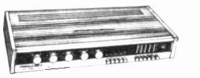

3408 STEREO TUNER AMP.

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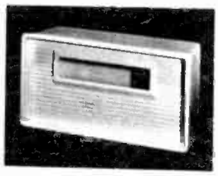
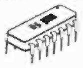


This 4 digit 24 hour clock is available to readers at this special price for 1 month only. Parts would normally cost over £25. Kit of parts includes twelve IC's, indicators, and a smart white plastic case.

74 Series TTL



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SN7413	32p	29p	SN7444	1·43p	1·37p	SN7482	97p	95p	SN74111	1·37p	1·27p
SN7416	47p	43p	SN7445	2·00p	1·92p	SN7403	1·20p	1·15p	SN74118	1·10p	1·05p
SN7417	47p	43p	SN7446	1·07p	1·02p	SN7484	1·10p	1·05p	SN74119	1·47p	1·37p
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68μF	6½p
150μF	6½p
470μF	11p
680μF	13p
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47μF	6½p
100μF	6½p
220μF	8p
330μF	10p
470μF	10p
1000μF	11p
1500μF	20p
2200μF	24p

16 VOLT

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33μF	6½p
68μF	6½p
150μF	8p
220μF	9p
680μF	17p
1000μF	17p
1500μF	25p
2000μF	43p

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22μF	6½p
47μF	6½p
100μF	8p
150μF	8p
220μF	10p
470μF	13p
680μF	20p
1000μF	22p
2200μF	39p
5000μF	68p

40 VOLT

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33μF	6½p

40 VOLT

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100μF	9p
150μF	10p
220μF	11p
470μF	19p
680μF	25p
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2200μF	44p

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AC141K	20p	BC147	9p	BFX85	35p	OC81	14p
AC176	15p	BC148	9p	BFX86	22p	OC83	22p
AC187	13p	BC149	9p	BFX87	28p	OC84	28p
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AF116	14p	BC268	15p	NKT217	55p	2N2926	10p
AF117	14p	BC300	40p	NKT261	23p	2N3053	26p
AF118	92p	BC301	32p	NKT271	20p	2N3054	55p
AF124	27p	BC302	30p	NKT274	20p	2N3055	52p
AF139	39p	BC303	50p	NKT275	25p	2N3405	44p
AF239	41p	BC304	40p	NKT403	71p	2N3663	57p
AL100	77p	BCY70	17p	NKT405	83p	2N3702	9p
AL102	66p	BCY71	37p	NKY603F	66p	2N3703	9p
AL103	55p	BCY72	17p	NKT613G	33p	2N3704	9p
ASY26	31p	BD123	66p	NKT674	26p	2N3705	9p
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BC113	15½p	BF159	33p	OC28	33p	2N3819	28p
BC116	16p	BF173	29p	OC29	33p	40361	50p
BC125	16p	BF177	28p	OC35	38p	40362	50p
BC126	25p	BF178	29p	OC36	38p	40636	50p
BC132	16p	BF179	35p	OC41	14p		
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18940	6p
AA119	11p
AA129	11p
AAZ13	11p
AAZ15	14p
AAZ17	14p
BA100	16p
BA102	25p
BA115	8p
BA144	14p
BA145	22p
BA154	14p
BAX13	14p
BAX16	14p
BAY18	19p
BAY31	9p
BY100	19p
BY126	16p
BY127	19p
BYX10	24p
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800	49p	—	—	—

THYRISTORS

PIV	50	100	200	300	400
1 Amp	28	25	41	44	53
3 Amps	44	50	60	—	66
7 Amps	—	96	1·01	—	1·24

RESISTORS
¼ watt 5% carbon 1p each
½ watt 10% carbon 1p each
1 watt 10% carbon 2½p each
Range 10 ohms to 4·7 meg.
½ watt m/o 2% 3p each
Range 10 – 1 meg ohms

YATES ELECTRONICS
(FLITWICK) LTD.
ELSTOW STORAGE DEPOT
KEMPSTON HARDWICK
BEDFORD

C.W.O. PLEASE. POST AND PACKING PLEASE ADD 10p TO ORDERS UNDER £2.

Catalogue which contains data sheets for most of the components listed will be sent free on request. 10p stamp appreciated.

OPEN ALL DAY SATURDAYS

ALL PRICES SUBJECT TO V.A.T.

RESISTORS

½W Iskra high stability carbon film—very low noise—capless construction.
¼W Mullard CR25 carbon film—very small body size 7·5 x 2·5mm.
½W 2% ELECTROSIL TR5

Power watts	Tolerance	Range	Values available	Price 1–99	Price 100+
½	5%	4·7Ω–2·2MΩ	E24	1p	0·8p
½	10%	3·3MΩ–10MΩ	E12	1p	0·8p
½	2%	10Ω–1MΩ	E24	3·5p	3p
¼	10%	1Ω– 3·9Ω	E12	1p	0·8p
¼	5%	4·7Ω–1MΩ	E12	1p	0·8p
4	10%	1Ω–10Ω	E12	6p	5·5p

Quantity price applies for any selection. Ignore fractions on total order.

DEVELOPMENT PACK

0·5 watt 5% Iskra resistors 5 off each value 4·7Ω to 1MΩ.
E12 pack 325 resistors **£2·40**. E24 pack 650 resistors **£4·70**.

POTENTIOMETERS

Carbon track 5kΩ to 2MΩ, log or linear (log ¼W, lin ½W).
Single, **12p**. Dual gang (stereo), **40p**. Single D.P. switch **24p**.

SKELETON PRESET POTENTIOMETERS

Linear: 100, 250, 500Ω and decades to 5MΩ. Horizontal or vertical P.C. mounting (0·1 matrix).
Sub-miniature 0·1W, **5p** each. Miniature 0·25W, **6p** each.

TRANSISTORS

AC107	15p	AF125	20p	BD132	75p	OC28	50p	2N3702	13p
AC126	12p	AF126	20p	BD133	75p	OC35	50p	2N3703	12p
AC127	12p	AF127	20p	BF115	25p	OC42	12p	2N3704	13p
AC128	12p	AF139	32p	BF173	20p	OC44	12p	2N3705	12p
AC131	12p	AF178	32p	BF177	28p	OC45	12p	2N3706	11p
AC132	12p	AF180	40p	BF178	32p	OC70	12p	2N3707	12p
AC176	12p	AF181	40p	BF179	32p	OC71	12p	2N3708	10p
AC187	22p	8C107	9p	BF180	32p	OC72	12p	2N3709	11p
AC188	22p	BC108	9p	BF181	32p	OC81	12p	2N3710	11p
AD140	50p	BC109	9p	BF194	15p	OC82D	12p	2N3711	11p
AD149	45p	BC147	13p	BF195	15p	2N2904	20p	2N4062	12p
AD161	33p	BC148	13p	BF197	15p	2N2926R	9p	40360	35p
AD162	36p	BC149	13p	BF200	32p	2N2926O	9p	40361	35p
AF114	20p	BC157	14p	BFY50	20p	2N2926Y	9p	40362	40p
AF115	20p	BC158	14p	BFY51	20p	2N2926G	10p	40408	40p
AF116	20p	BC159	14p	BFY52	20p			ZTX302	15p
AF117	20p	BC187	22p	BU105	225p	2N3054	58p	ZTX500	15p
AF117	38p								
AF124	22p	BD131	75p	OC26	45p	2N3055	60p	ZTX502	20p

ZENER DIODES

400mW 5% 3·3V to 30V, **12p**.

WIRE WOUND POTS, 3W. 10, 25,

50Ω and decades to 100kΩ, **35p**.

DIODES

RECTIFIER

BY127	1250V	1A	12p
BZY10	800V	6A	25p
BZY13	200V	6A	20p
IN4001	50V	1A	7p
IN4004	400V	1A	8p
IN4007	1000V	1A	10p

SIGNAL

OA85	7p
OA90	5p
OA91	5p
OA202	7p
IN4148	5p
BA114	8p

BRUSHED ALUMINIUM PANELS

12in × 6in = **25p**; 12in × 2½in = **10p**; 9in × 2in = **7p**

SLIDER POTENTIOMETERS

86mm × 9mm × 16mm, length of track 59mm.
SINGLE 10K, 25K, 100K log. or lin. **40p**.
DUAL GANG, 10K + 10K etc. log. or lin. **60p**.
KNOB FOR ABOVE **12p**.
FRONT PANEL **65p**.
18 Gauge panel 12in × 4in with slots cut for use with slider pots. Grey or matt black finish complete with fixings for 4 pots.

THERMISTORS

VA1055S	15p
VA1066S	15p
VA1077	15p
R53	£1·35

THYRISTORS

2N5060 50V 0·8A **30p**, 2N5064 200V 0·8A **47p**, CRS1/40 400V 1A **25p**, 106F 50V 4A **40p**, 106D 400V 4A **55p**.

MULLARD POLYESTER CAPACITORS C296 SERIES

400V: 0·001μF, 0·0015μF, 0·0022μF, 0·0033μF, 0·0047μF, **2½p**. 0·0068μF, 0·01μF, 0·015μF, 0·022μF, 0·033μF, **3p**. 0·047μF, 0·068μF, 0·1μF, **4p**. 0·15μF, **6p**. 0·22μF, **7½p**. 0·33μF, **11p**. 0·47μF, **13p**.
160V: 0·01μF, 0·015μF, 0·022μF, 0·033μF, 0·047μF, 0·068μF, **3p**. 0·1μF **3½p**. 0·15μF **4½p**. 0·22μF, **5p**. 0·33μF, **6p**. 0·47μF, **7½p**. 0·68μF, **11p**. 1·0μF, **13p**.

MULLARD POLYESTER CAPACITORS C280 SERIES

250V P.C. mounting: 0·01μF, 0·015μF, 0·022μF, **3p**. 0·033μF, 0·047μF, 0·068μF, **3½p**. 0·1μF, **4p**. 0·15μF, 0·22μF, **5p**. 0·33μF, **6½p**. 0·47μF, **8½p**. 0·68μF, **11p**. 1·0μF, **13p**. 1·5μF, **20p**. 2·2μF, **24p**.

MYLAR FILM CAPACITORS 100V

0·001μF, 0·002μF, 0·005μF, 0·01μF, 0·02μF, **2½p**. 0·04μF, 0·05μF, 0·068μF, 0·1μF, **3½p**.

CERAMIC DISC CAPACITORS

100pF to 10,000pF, **2p** each.

ELECTROLYTIC CAPACITORS—MULLARD 015/6/7 RANGE REPLACES C426, C457 RANGES.

(μF/v) 1·0/63, 1·5/63, 2·2/63, 3·3/63, 4·7/63, 6·8/40, 10/25, 10/63, 15/16, 15/40, 15/63, 22/10, 22/25, 22/63, 33/6·3, 33/40, 47/4, 47/10, 47/25, 47/40, 47/63, 68/6·3, 68/16, 100/4, 100/10, 100/25, 100/40, 150/6·3, 150/16, 150/25, 220/4, 220/10, 220/16, 330/4, 330/10, 470/6·3, **5p** each. 68/63, 150/40, 220/25, 330/16, 470/10, 680/6·3, 1,000/4, **9p**. 100/63, 150/63, 220/40, 470/25, 680/16, 1,000/10, 1,500/6·3, **12p**. 220/63, 470/40, 680/25, 1,000/16, 1,500/10, 2,200/6·3, **15p**. 330/63, 680/40, 1,000/25, 1,500/16, 2,200/10, 3,300/6·3, 4,700/4, **18p**.

SOLID TANTALUM BEAD CAPACITORS — 12p

0·1μF	35V	2·2μF	35V	22μF	16V
0·22μF	35V	4·7μF	35V	33μF	10V
0·47μF	35V	6·8μF	25V	47μF	6·3V
1·0μF	35V	10μF	25V	100μF	3V

VEROBOARD

	0·1	0·15
2½ × 3¾	22p	16p
2½ × 5	24p	24p
3¾ × 3¾	24p	24p
3¾ × 5	27p	27p
17 × 2½	75p	57½p
17 × 3¾	100p	78p
17 × 5 (plain)	—	82p
17 × 3¾ (plain)	—	60p
17 × 2½ (plain)	—	42p
2½ × 5 (plain)	—	12p
2½ × 3¾ (plain)	—	11p
Pin insertion tool	52p	52p
Spot face cutter	42p	42p
Pkt. 50 pins	20p	20p

JACK PLUGS AND SOCKETS

Standard screened	18p	2·5mm insulated	8p
Standard insulated	12p	3·5mm insulated	8p
Stereo screened	35p	3·5mm screened	13p
Standard socket	15p	2·5mm socket	8p
Stereo socket	18p	3·5mm socket	8p

D.I.N. PLUGS AND SOCKETS

2 pin, 3 pin, 5 pin 180°, 5 pin 240°, 6 pin
Plug 12p. Socket 8p.
4 way screened cable, **15p**/metre.
6 way screened cable **22p**/metre.

BATTERY ELIMINATOR — £1·50

9V mains power supply. Same size as PP9 battery.

LARGE (CAN) ELECTROLYTICS

1600μF	64V	74p	2500μF	64V	80p	4500μF	16V	50p
2500μF	40V	74p	2800μF	100V	£2·60	4500μF	25V	£1·68
2500μF	50V	58p	3200μF	16V	50p	5000μF	50V	£1·10

HIGH VOLTAGE TUBULAR CAPACITORS—1,000 VOLT

0·01μF	10p	0·047μF	13p	0·22μF	20p
0·022μF	12p	0·1μF	13p	0·47μF	22p

POLYSTYRENE CAPACITORS 160V 2½%

10pF to 1,000pF E12 Series Values **4p each.**

SMOKE AND COMBUSTIBLE GAS DETECTOR—GD1

The GD1 is the world's first semiconductor that can convert a concentration of gas or smoke into an electrical signal. The sensor decreases its electrical resistance when it absorbs deoxidizing or combustible gases such as hydrogen, carbon monoxide, methane, propane, alcohol, North Sea gas, as well as carbon-dust containing air or smoke. This decrease is usually large enough to be utilized without amplification. Full details and circuits are supplied with each detector.
Detector GD1, **£2**. Kit of parts for detectors including GD1 and P.C. board but excluding case. Mains operated detector **£5·20**. 12 or 24V battery operated audible alarm **£7·30**. As above for PP9 battery, **£6·40**.

PRINTED BOARD MARKER — 97p

Draw the planned circuit onto a copper laminate board with the P.C. Pen, allow to dry, and immerse the board in the etchant. On removal the circuit remains in high relief.

LARGE RANGE ITT/TEXAS IC's NOW IN STOCK

PRICES ARE CALCULATED ON TOTAL NUMBER ORDERED REGARDLESS OF MIX

	1–11 p	12–24 p	25–99 p	100+ p
7400	18	16	14	13
7401	18	16	14	13
7402	18	16	14	13
7403	18	16	14	13
7404	20	18	16	14
7405	20	18	16	14
7406	50	45	40	35
7407	56	50	44	38
7408	36	30	27	23
7409	36	30	27	33
7410	18	16	14	13
7411	23	21	20	18
7412	36	30	27	23
7413	34	28	26	22
7416	45	43	39	34
7420	18	16	14	13
7421	36	30	27	23
7426	32	29	23	20
7430	20	18	16	14
7432	40	36	32	28
7440	20	18	16	14
7441	80	75	70	65
7442	80	75	70	65
7443	125	120	115	115
7447	175	165	150	120
7448	185	175	170	165
7450	18	16	14	13
7451	18	16	14	13
7453	18	16	14	13
7454	18	16	14	13
7460	18	16	14	13
7470	30	28	25	24
7472	30	28	27	23
7473	40	38	36	30
7474	40	36	32	28
7475	55	52	50	49
7476	40	36	32	30
7480	100	95	90	85
7481	125	115	110	105
7482	100	96	90	85
7483	100	97	95	92
7484	120	115	110	105
7485	250	245	240	230
7486	45	42	37	33
7490	75	67	60	52
7491A	100	92	85	79
7492	75	70	65	60
7493	75	68	60	52
7494	95	90	85	80
7495	105	100	95	90
7496	100	95	90	85
74100	250	240	235	230
74118	100	82	73	64
74121	43	40	38	36
74141	100	95	90	85
74145	150	140	135	130
74150	330	280	250	220
74151	110	100	95	89
74153	120	110	105	95
74154	200	180	170	160
74155	150	120	100	86
74156	130	120	100	96
74180	155	136	112	105
74190	195	190	185	180
74191	195	190	185	180
74192	200	190	180	164
74193	200	180	170	150
74196	200	190	180	170
74197	200	195	180	170

LINEAR IC's

709	14 pin DIL	32p
741	8 pin DIL	34p
741	14 pin DIL	28p
723	14 pin DIL	95p
747	14 pin DIL	85p
748	8 pin DIL	35p
DIL socket,	14 pin and 16 pin	16p

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FOUR CHANNEL DECODER

As specified in the

P.E. RONDO

COMPLETE QUADRAPHONIC HI-FI SYSTEM

*REGD. CBS INC.

- COMPLETE KIT OF HIGH GRADE SPECIFIED PARTS
- FIBREGLASS BOARD—COMPONENT POSITIONS MARKED
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- DESPATCH GUARANTEED WITHIN 72 HOURS

ONLY £8·80

Including Postage, VAT and CBS licence fee

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P.O. BOX No. 18, HARLOW, ESSEX CM18 6SH
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PLEASE SUPPLY ONE P.E. RONDO CBS SQ DECODER KIT
I ENCLOSE £8·80

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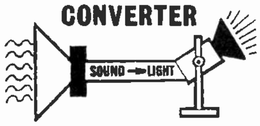
P.E.9

SINGLE CHANNEL SOUND-TO-LIGHT CONVERTER



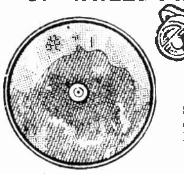
WITH LIGHT DIMMER
Max. Load 2kW at 250V a.c.

Price includes ready built and tested module, edge connector/mounting bracket, dimmer potentiometer, audio sensitivity potentiometer, full connecting data. **Price £7·90** inc. VAT + 25p P. & P.
EXTRA FACILITIES. Push-button for Manual Pulsing, **25p** extra. Photocell for turning on the lights as the ambient light decreases, **75p** extra.

THREE CHANNEL FILTER UNIT

When used with three single channel modules this unit filters the sound into bass, middle and top frequencies enabling three coloured light displays to be shown. Independent sensitivity controls on each channel. Ready built and tested.
Price £8·40 inc. VAT + 15p P. & P.

OIL WHEEL PROJECTOR



Build your own using our **MULTI-COLOURED OIL WHEEL AND MOTOR KIT** Suitable for mounting on virtually all Slide Projectors.

Kit contains:
★ 6in dia. or 4in dia. OIL WHEEL (please state size required when ordering).
★ Suitable Miniature mains motor.
★ Full instructions.
For Professional Discotheque use or home enjoyment. **Price £7·15** inc. VAT & P. & P.

ELECTRONIC COMPONENTS
BARGAIN COMPONENT PACKS

Pack No.
1 500 Carbon resistors, ¼, ½, 1, 2W.
2 100 Electrolytic Condensers.
3 250 Ceramic, Polystyrene, Silver Mica, etc. Condensers.
4 250 Polyester, Polycarbonate, Paper, etc. Condensers.
5 25 Potentiometers, assorted.
6 250 High-stab. 1%, 2%, 5% resistors.
7 50 Assorted Tagstrips.
8 1lb wt. Assorted Nuts, bolts, washers, spacers, etc.
9 25 Assorted switches, rotary, lever, micro, toggle, etc.
10 50 Preset Potentiometers.

ALL COMPONENTS NEW AND UNUSED
£1 + 25p P. & P. per pack £5 for 5 packs post free.

C.T. ELECTRONICS

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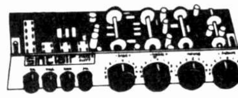
SINCLAIR EQUIPMENT

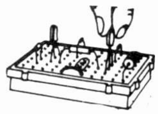


Project 60 FM Tuner		**£15**	(£1·70)
2 Z30/Stereo 60/PZ5		**£16·75**	(£2·05)
2 Z30/Stereo 60/PZ6		**£18·85**	(£2·25)
2 Z50/Stereo 60/PZ8/Trans		**£23·20**	(£2·70)
Z30 **£3·50** (55p)	Stereo 60	**£7·80**	(98p)
Z50 **£4·30** (63p)	Trans for PZ8	**£2·95**	(50p)
PZ5 **£3·87** (59p)	2000 Amp	**£24·50**	(£2·65)
PZ6 **£6·30** (83p)	3000 Amp	**£31·50**	(£3·35)
AFU **£4·50** (65p)	2000 Tuner	**£27**	(£2·90)
PZ8 **£6·40** (84p)	3000 Tuner	**£27**	(£2·90)
Q16 **£5·90** (79p)	Project 605	**£20·98**	(£2·40)

PROJECT 60 KIT **£2·50** (36p)
Our extremely popular kit contains the extra capacitors, din plugs and sockets, cable and fuse-holder needed to complete Project 60.

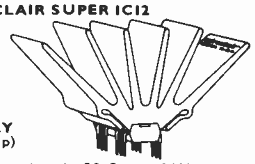
IC RADIO CHIP TBA651 **£2·10** (32p)
The world's most advanced IC radio chip. Contains RF Amp, oscillator, mixer, IF Amps, wide range AGC circuitry and voltage stabilizer. With data **£2·10** (32p). Send S.A.E. for free leaflet. A kit of resistors, capacitors and IF filters is available to go with the chip for **£1·75** (29p).

S-DECS AND T-DECS



S-DECS **£1·44** (25p)
T-DECS **£2·88** (39p)
μ-DEC A **£3** (41p)
16 dil IC carriers **£1·20** (17p)

SINCLAIR SUPER IC12



ONLY
£2 (31p)

Max. supply volts 28. Power 6 Watts rms. Complete with free printed circuit board and 44-page instruction book.

SWANLEY IC TOMORROW **£2·50** (36p)
The World's most powerful IC amplifier. Similar to the above but operates at 35 volts max, supply and gives 12 Watts rms output. Manufactured for us by a leading semiconductor company. Supplied with our instructions and a 6-month guarantee, but no printed circuit.

KITS FOR IC12 AND IC TOMORROW
Except for the power kits and speakers, all items suit both integrated circuits.

DELUXE KIT
Includes all parts for the printed circuit and volume, bass and treble controls needed to complete the mono version **£1·45** (25p). Stereo model with balance control **£3·30** (44p).

IC12 POWER KIT
A set of components to construct a 28V 0·5A power supply **£2·27** (45p).

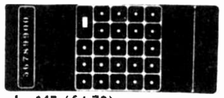
IC TOMORROW POWER KIT
A set of components to construct a 35V 1A power supply **£2·97** (52p).

LOUDSPEAKERS FOR THE IC12
5in 8 ohm **£1** (21p). 5in × 8in 8 ohm **£1·45** (26p). 10in × 6in 15 ohm **£2·20** (44p).

PREAMPLIFIER KITS
Type 1 for magnetic pickups, mics and tuners, with 3 position equalization switch. Mono model **£1·30** (24p). Stereo model **£2·30** (34p). Type 2 for ceramic or crystal pickups. Mono **60p** (17p). Stereo **£1·20** (23p).

SEND S.A.E. FOR FREE LEAFLET ON KITS

SINCLAIR EXECUTIVE CALCULATOR



Now only £45 (£4·70)

SWANLEY ELECTRONICS

32 Goldsel Road, Swanley, Kent

Please add the sum shown in brackets after the price to cover the cost of post and VAT. Official credit orders from schools, etc., welcome. Send S.A.E. for free leaflet on kits, IC Tomorrow and TBA651. Mail order only. No callers, please.

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ALL ITEMS ARE BRAND NEW AND FULLY GUARANTEED

AA119	8p
AC107	50p
AC126	20p
AC127	25p
AC128	24p
AC128/AC176	44p
AC151	20p
AC152	25p
AC153	28p
AC176	20p
AC153/176K	52p
AC187K	17p
AC188K	23p
AC187/188K	40p
ACY17	27p
ACY18	20p
ACY19	20p
ACY20	20p
ACY21	18p
ACY22	10p
AD140	55p
AD149	50p
AD161	37p
AD162	37p
AD161/162	74p
AF106	32p
AF114	25p
AF115	25p
AF116	25p
AF117	25p
AF118	44p
AF124	25p
AF125	24p
AF126	17p
AF139	47p
AF186	40p
AF239	50p
AF279	55p
ASY26	25p
ASY27	30p
ASY28	22p
ASY29	30p
BA138	15p
BAX16	8p
BB103	18p
BB104	28p
BB105	32p
BC107	13p
BC107/BC177	33p
BC108	12p
BC108/BC178	28p
BC109	13p
BC109/BC179	33p
BC109C	14p
BC117	15p
BC140	30p
BC147	10p
BC148	9p
BC149	10p
BC157	12p
BC158	11p
BC159	12p
BC147/157	22p
BC148/158	20p
B149/159	22p
BC167	11p
BC168	10p
BC169	11p
BC169C	12p
BC177	20p
BC178	18p
BC179	20p
BC182	10p
BC182L	10p
BC183	8p
BC183L	10p
BC184	13p
BC184L	12p
BC212	12p
BC212L	12p
BC238	10p
BC238/308	20p
BC257	8p
BC258	8p
BC259	8p
BC307	12p
BC308	10p
BCY30	25p
BCY31	48p
BCY32	50p
BCY33	20p
BCY34	25p
BCY38	30p
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BZY88C7V5	13p
BZY88C8V2	13p
BZY88C9V1	13p
BZY88C10V	13p
BZY88C11V	13p
BZY88C12V	13p
BZY88C13V	13p
BZY88C15V	13p
BZY88C16V	13p
BZY88C18V	13p
BZY88C20V	13p
BZY88C22V	13p
BZY88C24V	13p
BZY88C27V	13p
BZY88C30V	13p
BZY93C9V1	70p
BZY93C12V	70p
BZY93C15V	70p
BZY93C18V	70p
BZY93C24V	70p
BZY93C47V	70p
BZX61C7V5	23p
BZX61C8V2	23p
BZX61C9V1	23p
BZX61C10V	23p
BZX61C11V	23p
BZX61C12V	23p
BZX61C13V	23p
BZX61C15V	23p
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2N697	17p
2N698	30p
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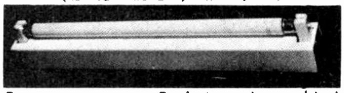

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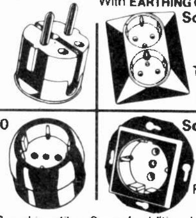

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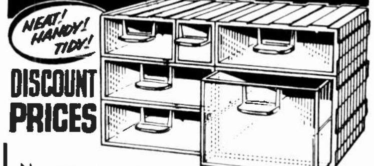

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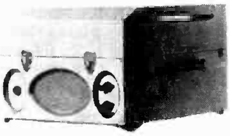

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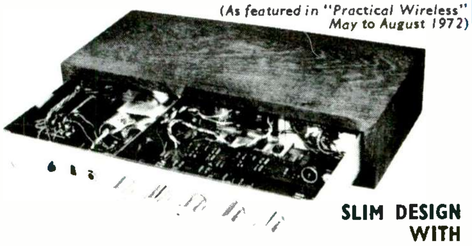

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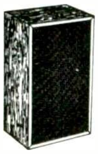

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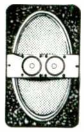

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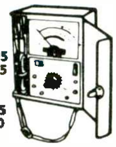

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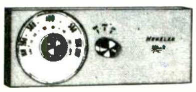

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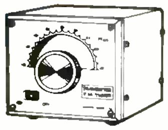

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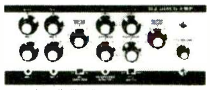

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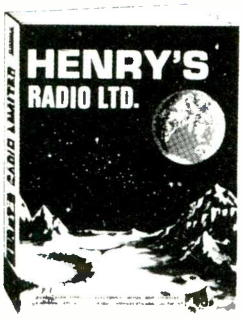

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