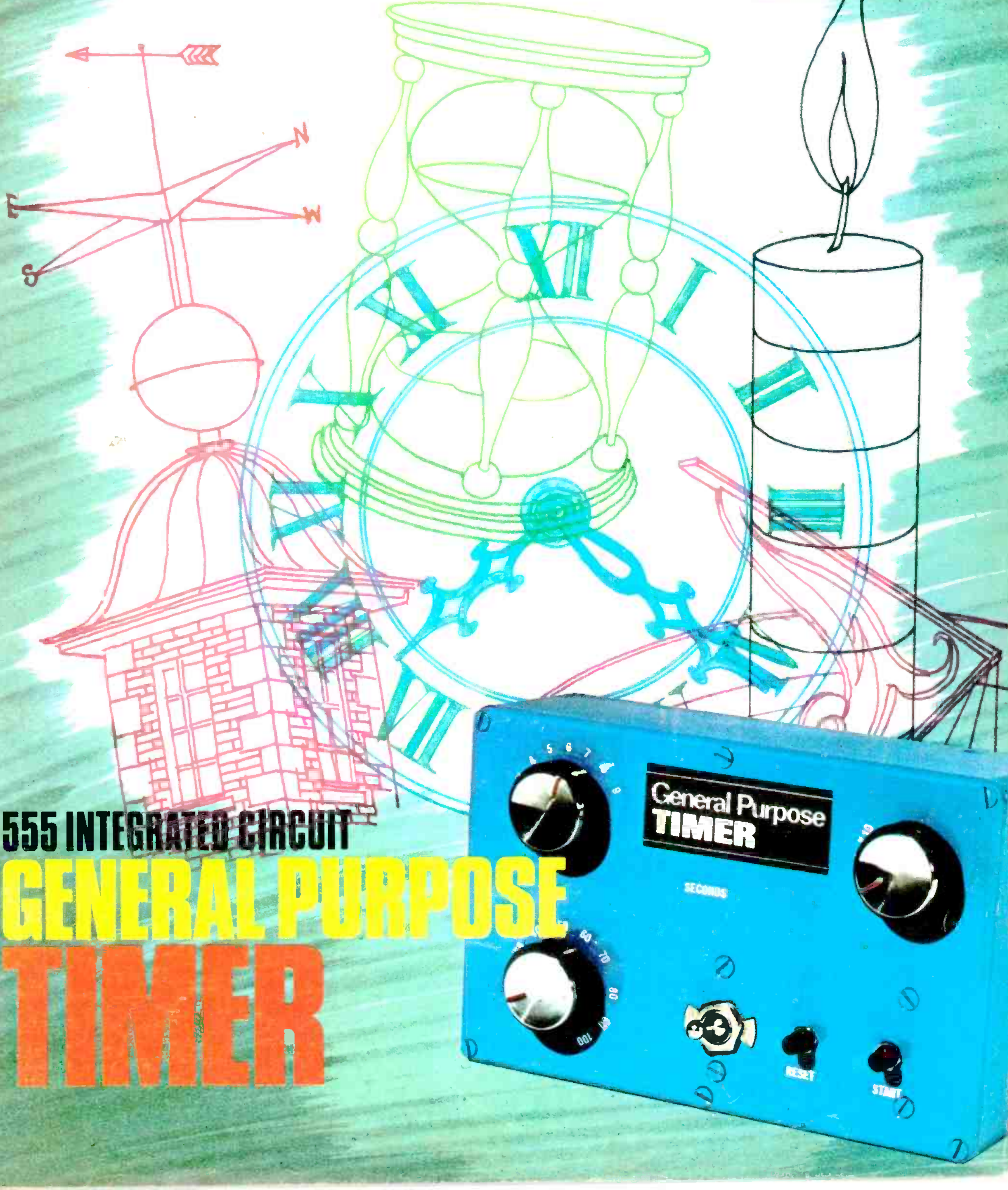
PRACTICAL

ELECTRONICS

JUNE 1973

20p



555 INTEGRATED CIRCUIT

GENERAL PURPOSE TIMER

PRACTICAL
ELECTRONICS
VOLUME 9 No. 6 JUNE 1973

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GENERAL FEATURES

NEWS AND COMMENT

Our July issue will be published on Friday, June 8, 1973

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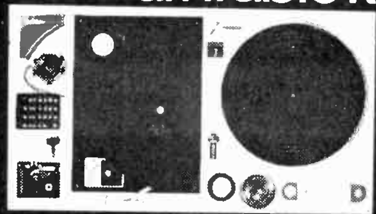
B.D.1 Turntable kit



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AC142	0·16
AC142K	0·19
AC151	0·17
AC154	0·22
AC155	0·22
AC156	0·22
AC157	0·27
AC165	0·22
AC166	0·22
AC167	0·22
AC168	0·27
AC169	0·16
AC176	0·22
AC177	0·27
AC178	0·31
AC179	0·31
AC180	0·19
AC180K	0·22
AC181	0·19
AC181K	0·22
AC187	0·24
AC187K	0·22
AC188	0·24
AC188K	0·22
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ACY18	0·22
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ACY36	0·31
ACY40	0·19
ACY41	0·20
ACY44	0·39
AD130	0·42
AD140	0·53
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AF115	0·27
AF116	0·27
AF117	0·27
AF118	0·39
AF124	0·33
AF125	0·28
AF126	0·31
AF127	0·31
AF139	0·33
AF178	0·33
AF179	0·55
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AF181	0·50
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AF239	0·41
AL102	0·72
AL103	0·72
ASY26	0·28
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2S307	0·93
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BYZ11	0·33
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OA90	0·07
OA91	0·07
OA95	0·08
OA200	0·07
OA202	0·08
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SD19	0·06
1N34	0·08
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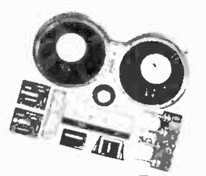

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SN7411	0·28	0·24	0·26
SN7412	0·39	0·34	0·31
SN7413	0·32	0·29	0·27
SN7416	0·48	0·44	0·42
SN7417	0·48	0·44	0·42
SN7420	0·17	0·16	0·13
SN7422	0·55	0·53	0·50
SN7423	0·55	0·53	0·50
SN7425	0·55	0·53	0·50
SN7426	0·50	0·46	0·44
SN7427	0·50	0·46	0·44
SN7428	0·77	0·72	0·66
SN7430	0·17	0·16	0·13
SN7432	0·50	0·46	0·44
SN7433	0·88	0·83	0·77
SN7437	0·71	0·68	0·66
SN7438	0·71	0·68	0·66
SN7440	0·17	0·16	0·13
SN7441	0·74	0·71	0·64
SN7442	0·74	0·71	0·64
SN7443	1·43	1·88	1·32
SN7444	1·43	1·38	1·32
SN7445	1·98	1·95	1·93
SN7446	1·07	1·04	0·97
SN7447	1·10	1·07	1·05
SN7448	1·10	1·07	1·05
SN7450	0·17	0·16	0·13
SN7451	0·17	0·16	0·13
SN7453	0·17	0·16	0·13
SN7454	0·17	0·16	0·13
SN7460	0·17	0·16	0·13
SN7470	0·32	0·29	0·27
SN7472	0·32	0·29	0·27
SN7473	0·41	0·39	0·35
SN7474	0·41	0·39	0·35
SN7475	0·50	0·48	0·46
SN7476	0·44	0·43	0·43
SN7480	0·74	0·71	0·64
SN7481	1·32	1·27	1·21
SN7482	0·96	0·95	0·94
SN7483	1·21	1·16	1·05
SN7484	1·10	1·05	0·99
SN7485	3·96	3·85	3·74

	1	25	100+
SN7486	0·35	0·34	0·33
SN7489	6·05	5·78	5·50
SN7490	0·74	0·71	0·64
SN7491	1·10	1·05	0·99
SN7492	0·74	0·71	0·64
SN7493	0·74	0·71	0·64
SN7494	0·85	0·82	0·75
SN7495	0·35	0·82	0·75
SN7496	0·86	0·93	0·86
SN74100	1·82	1·76	1·71
SN74104	1·07	1·04	0·97
SN74105	1·07	1·04	0·97
SN74107	0·44	0·42	0·40
SN74110	0·51	0·59	0·55
SN74111	1·38	1·27	1·21
SN74118	1·10	1·05	0·99
SN74119	1·40	1·38	1·21
SN74121	0·44	0·41	0·38
SN74122	1·54	1·43	1·21
SN74123	3·08	2·97	2·86
SN74141	0·74	0·71	0·64
SN74145	1·65	1·54	1·43
SN74150	3·30	2·97	2·75
SN74151	1·10	1·05	0·99
SN74153	1·32	1·21	1·05
SN74154	1·98	1·87	1·76
SN74155	1·54	1·43	1·32
SN74156	1·54	1·43	1·32
SN74157	2·09	1·98	1·87
SN74160	1·98	1·87	1·76
SN74161	1·98	1·87	1·76
SN74162	4·40	4·13	3·85
SN74163	4·40	4·13	3·85
SN74164	2·42	2·37	2·31
SN74165	2·48	2·42	2·37
SN74166	3·85	3·58	3·30
SN74174	2·53	2·42	2·31
SN74175	1·76	1·65	1·54
SN74176	2·75	2·64	2·53
SN74177	2·75	2·64	2·53
SN74180	2·20	1·76	1·54
SN74181	6·05	5·50	5·23
SN74182	2·20	1·98	1·76
SN74184	3·85	3·58	3·30
SN74190	2·15	2·09	2·04
SN74191	2·09	2·04	1·98
SN74192	2·15	2·09	2·04
SN74193	2·20	1·98	1·93
SN74194	2·97	2·86	2·75
SN74195	2·20	2·09	1·98
SN74196	1·98	1·87	1·76
SN74197	1·98	1·87	1·76
SN74198	6·05	5·50	4·95
SN74199	6·05	5·50	4·95

LINEAR I.C.'s—FULL SPEC.

Type No.	Price 1–24	25–99	100+
BP201C—SL201C	0·70	0·59	0·50
BP710C—SL701C	0·70	0·55	0·50
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
μA703C	0·31	0·29	0·27
TAA263	0·77	0·66	0·61
TAA293	0·99	0·83	0·77
TAA350	1·87	1·74	1·65
EA1000	2·90		

ROCK BOTTOM PRICES LOGIC DTL 930 Series I.C's

Type No.	Price 1–24	25–99	100 up
BP930	0·13	0·12	0·11
BP932	0·14	0·13	0·12
BP933	0·14	0·13	0·12
BP935	0·14	0·13	0·12
BP936	0·14	0·13	0·12
BP944	0·14	0·13	0·12
BP945	0·28	0·27	0·24
BP946	0·13	0·12	0·11
BP948	0·28	0·27	0·24
BP951	0·72	0·66	0·61
BP962	0·13	0·12	0·11
BP9093	0·44	0·42	0·39
BP9094	0·44	0·42	0·39
BP9097	0·44	0·42	0·39
BP9099	0·44	0·42	0·39

NUMERICAL INDICATOR TUBES

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
I.C. Driver Rec.	BP41 or 141	BP41 or 141	BP47
PRICE EACH	£1·87	£1·70	£1·09

All indicators 0·9 + Decimal point. All side viewing. Full data for all types available on request.

RTL MICROLOGIC CIRCUITS

Epoxy TO-5 case	Price each 1–24	25–99	100 up
μL900 Buffer	38p	36p	29p
μL914 Dual 2i/p gate	38p	36p	29p
μL923 J-K flip-flop	55p	51p	49p

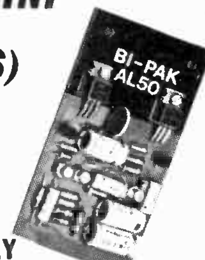
Date and Circuits Booklet for IC's Price 8p.

DUAL IN LINE SOCKETS

(14 & 16 Lead)	1–24	25–99	100+
TSO14	0·33	0·30	0·28
TSO16 16 pin type	0·34	0·35	0·33
BPS14 14 pin type (low cost)	0·17	0·15	0·12
BPS16 16 pin type (low cost)	0·18½	0·16	0·13

BI-PAK DO IT AGAIN!

50W pk 25w (RMS)



0·1% DISTORTION!
HI-FI AUDIO AMPLIFIER

THE AL50

✱ Frequency Response 15Hz to 100,000—1dB.

✱ Load—3, 4, 8 or 16 ohms.

✱ Distortion—better than ·1% at 1KHz.

✱ Signal to noise ratio 80dB.

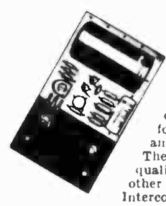
ONLY £3·58 each

✱ Supply voltage 10–35 Volts.

✱ Overall size 63mm × 105mm × 13mm.

Tailor made to the most stringent specifications using top quality components and incorporating the latest solid state circuitry and AL50 was conceived to fill the need for all your A.F. amplification needs.
FULLY BUILT—TESTED—GUARANTEED.

STABILISED POWER MODULE SPM80

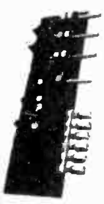


AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs 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

ONLY £13·15

SPECIAL COMPLETE KIT COMPRISING 2 AL50's, 1 SPM80, 1 BMT80 & 1 PA100 ONLY £25·30 FREE p.&p.

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2N414 £1.25 POST FREE

The I.C. Radio in a TO18 can. Supplied complete with data sheet No. 10 which contains specification, circuit and details and prices of components such as ferrite rods, compression trimmers etc.

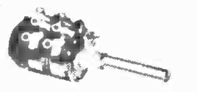
I.C. Sockets

Dual-in-line or Zig-Zag (Quil), 14 and 16 pin
Our Price 1p per pin

VDR's & Thermistors

A15B	75p	GL23	£1·00	VA1005	15p
CZ1	15p	R53	£1·32	VA1026	13p
CZ4	13p	R54	£1·46	VA1033	13p
CZ13A	13p			VA1040	10p
E298 ED/A258	10p			VA1053	10p
E298 ZZ/06	10p			VA1055S	10p
GL16	£1			VA1034	10p

Potentiometers



5KΩ 50KΩ 500KΩ
10KΩ 100KΩ 1MΩ
25KΩ 250KΩ 2MΩ

log or lin less switch (& 1KΩ lin)	12p
log or lin with switch	24p
dual less switch	40p
dual with switch 10K, 100K & 1M log only	52p
10K log 10K antilog less switch	40p

Capacitors

dise ceramic		low voltage		
01µF 18v	5p	0·1µF	30v	5p
022µF 18v	5p	0·22µF	6v	5p
·047µF 12v	5p	0·47µF	3v	5p

ceramic plate		30V	
1000pf	10p	4700pf	10p
2200pf	10p	10,000pf	10p

Ceramic – plate		63V (C333)	
1·8pf	8 2pf	33pf	120pf
2·2pf	10pf	39pf	150pf
3 3pf	12pf	47pf	180pf
3·9pf	15pf	56pf	220pf
4·7pf	18pf	68pf	270pf
5·6pf	22pf	82pf	330pf
6·8pf	27pf	100pf	

all 5p. each

mylar film		100V			
1000pf	2p	·01µF	3p	·068µF	4p
2000pf	2p	02µF	3p	·1µF	4p
5000pf	2p	·04µF	3p	·2µF	5p
		·05µF	3p		

polystyrene **160V**
10pf to 10,000pf in multiples of 10, 15, 22, 33, 47 & 68. **3p each**

metallised polyester		250V (C280)			
01µF	3p	·068µF	3½p	·47µF	8p
015µF	3p	1µF	4p	·68µF	11p
·022µF	3p	15µF	4p	1µF	13p
·033µF	3p	·22µF	5p	1 5µF	20p
047µF	3p	·33µF	6½p	2·2µF	24p

metallised polyester		400V (C281)			
01µF	4½p	047µF	6p	·22µF	10p
015µF	4½p	068µF	6p	·33µF	14p
022µF	4½p	·1µF	7p	·47µF	15p
·033µF	5½p	·15µF	8p		

silvered mica 1% (>50pf) 500V			
2·2pf—820pf	7p	4·7nF—5600pf	19p
1nF—2·2nf	9p	6800pf—·01µF	29p
2·7nF—3·6nF	16p		

mixed dielectric		600V			
·01µF	7p	·047µF	7p	·22µF	16p
·022µF	7p	·068µF	8p	·47µF	24p
033µF	7p	·1µF	8p	1µF	33p

Slider Pots

Single	Dual	log
10K	10 + 10K	or
25K	25 + 25K	lin
50K	50 + 50K	
100K	100 + 100K	Knobs
30p	50p	10p

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COILS AND INDUCTORS	**No. 5**
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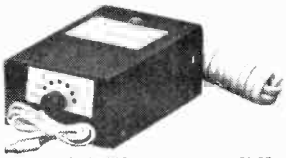
1 W	10% Carbon Composition	3p each
2 W	10% Carbon Composition	6p each
2½ W	5% Wire wound	9p each
5 W	Wire wound	9p each
10 W	Wire wound	10p each

plus p. & p. 7p for up to 25 resistors plus 1p for each additional 25.

Eliminators



9 volt // 20mA (PP3)	£1.25
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9 volt // 50mA	£1.50
6 6 volt, 50mA	£2.50
9 9 volt, 50mA	£2.50
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3, 4½, 6, 7½, 9, 12 // 500mA (illus.)	£3.99
Car Battery Converter fully stabilised to provide 6, 7½ or 9 volts	**£4.99**

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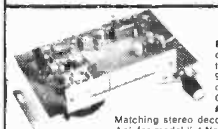
AA119	9p	BA156	15p	BY176	£1·50
AA120	9p	BA243	56p	BY182	£1 50
AA129	9p	OA47	10p	BY250	23p
BA102	25p	OA79	9p	IN4001	6p
BA115	17p	OA90	7p	IN4002	7p
BA130	10p	OA91	7p	IN4003	8p
BA145	20p	OA200	10p	IN4004	8p
BA148	20p	BY100	15p	IN4005	10p
BA154	13p	BY126	15p	IN4006	12p
BA155	14p	BY127	15p	IN4007	15p



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chassis fully transistorised
9 volt operation.
OUR PRICE
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Matching stereo decoder **£4·97**
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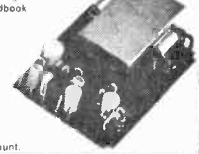
SGS

EA1000

3 Watt Audio Amplifier
Our Price inc. handbook **£2·49**

10 + less 15%
25 + less 25%
100 + less 33⅓%



5 Watt Audio Amplifier
Our Price **£3·99**
Less quantity discount.

Presets

Vertical or Horizontal

0 1 watt **5p**		0 25 watt **7p**		
100	1K Ω	10K Ω	100K Ω	1M Ω
250	2·5K Ω	25K Ω	250K Ω	2·5M Ω
500	5K Ω	50K Ω	500K Ω	5M Ω

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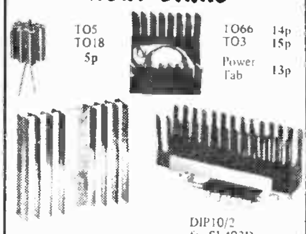
Heat Sinks



Transistors & Integrated Circuits

AC107	25p	BC147	10p	BF196	15p	OC81	19p	2N1304	22p	2N5172	15p
AC126	17p	BC148	10p	BF197	15p	OC140	20p	2N1711	25p	BZY88 ZENERS SERIES	10p ea.
AC127	15p	BC149	10p	BF272	53p	OC170	23p	2N1893	30p		
AC128	15p	BC157	12p	BFY50	24p	OC171	30p	2N2926 all	10p		
AC176	15p	BC158	10p	BFY51	21p	ZTX107	15p	2N3053	23p	LO05TI	£1.50
AC187	25p	BC159	12p	BRY39	36p	ZTX108	12p	2N3054	50p	LO36TI	£1.50
AC187K	25p	BC169	15p	BSX21	26p	ZTX109	15p	2N3055	49p	LO37TI	£1.50
AC188	25p	BC268	15p	BSY95A	14p	ZTX300	12p	2N3702	12p	MC1303L	£1.75
AC188K	25p	BD115	67p	BU105/02	£1.75	ZTX301	15p	2N3703	12p	MC1330	80p
ACY20	20p	BD131	70p	MJE340	67p	ZTX302	20p	2N3704	10p	MC1350	75p
AD140	40p	BD132	70p	MPF192	40p	ZTX303	20p	2N3705	10p	MC1351	£1.00
AD149	40p	BD131/2M P		MPF103	37p	ZTX304	25p	2N3706	10p	MC1352	£1.00
			149p	MPF104	37p	ZTX341	20p	2N3707	15p	MFC4000B	49p
AD161 AD162	60p	BF160	21p	MPF105	40p	ZTX500	15p	2N3708	12p	MFC4010A	55p
AF114	18p	BF167	20p	MPF106	45p	ZTX501	15p	2N3709	12p	LM380	£1.45
AF115	18p	BF173	20p	OC28	40p	ZTX502	20p	2N3710	12p	SL403D	£1.50
AF116	18p	BF180	25p	OC35	40p	ZTX503	17p	2N3711	12p	TAD100	£1.50
AF117	18p	BF181	30p	OC44	15p	ZTX504	50p	2N3819	35p	FILTER LP1175	£1.50
AF139	28p	BF184	25p	OC45	15p	ZTX531	25p	2N3903	15p	[illegible]	34p
BC107	10p	BF185	25p	OC71	11p	2N697	18p	2N3904	17p	[illegible]	[illegible]
BC108	10p	BF194	15p	OC72	17p	2N706	12p	2N3905	21p	[illegible]	95p
BC109	10p	BF195	15p	OC76	15p	2N708	15p	2N3906	12p	[illegible]	47p

mixed dielectric		1000V			
1000pf	6p	6800pf	9p	·1µF	12p
2200pf	6p	·01µF	9p	·22µF	22p
3300pf	6p	·022µF	9p	·47µF	30p
4700pf	6p	·047µF	12p		

Ceramic

12KV.d.c.		8KV.d.c.		HI-K 750V.	
10pf	9p	200pf	9p	1000pf	5p
15pf	9p	220pf	9p	1500pf	5p
22pf	9p	250pf	9p	2000pf	5p
68pf	9p	270pf	9p	3000pf	5p
82pf	9p	300pf	9p	5000pf	5p
100pf	9p	750V DISC		10,000pf	5p
120pf	9p	470pf	5p	feed-through	
140pf	9p	1000pf	5p		
150pf	9p	5000pf	5p		
180pf	9p	10,000pf	5p	1000pf	5p

Veroboard

	Copperclad 0.1"	Copperclad 0.15"	Plain 0.15"
2½" x 1"	6p	6p	—
2½" x 3¾"	20p	16p (9)	10p
2½" x 5"	24p	21p (7)	12p
3¾" x 3¾"	24p	21p (8)	
3¾" x 5"	27p	27p (10)	17p
17" x 2½"	67p	50p	37p
17" x 3¾"	90p	70p	52p
17" x 5"	—	—	75p

Spot-face Cutter	36p
Pin Insertion Tool	47p
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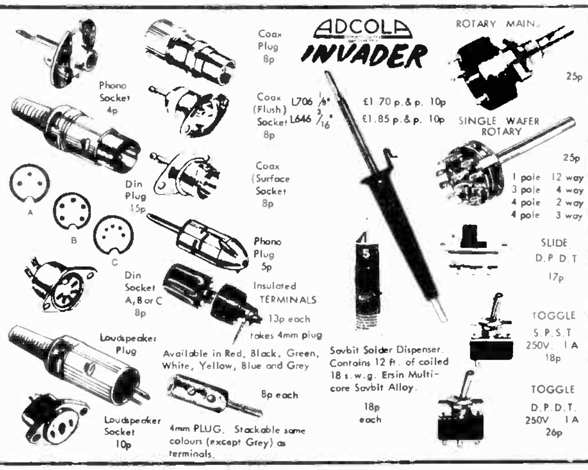
(9)	4"	x 2¾"	x 1½"	35p	8p
(10)	4"	x 5¼"	x 1½"	40p	8p
11	4"	x 2½"	x 2"	35p	8p
12	3"	x 2"	x 1"	32p	9p
13	6"	x 4"	x 2"	50p	10p
14	7"	x 5"	x 2½"	58p	12p
15	8"	x 6"	x 3"	75p	18p
16	10"	x 7"	x 3"	85p	20p



Mullard & Siemens Electrolytics

CAP µF	VOLTAGE 4	6.3	10	16	25	40	63
1	—	—	—	—	—	—	6p
1 5	—	—	—	—	—	—	6p
2 2	—	—	—	—	—	—	6p
3·3	—	—	—	—	—	—	6p
4·7	—	—	—	—	—	—	6p
6 8	—	—	—	—	—	6p	6p
10	—	—	—	—	6p	—	6p
15	—	—	—	6p	—	6p	6p
22	—	—	6p	—	6p	—	6p
33	—	6p	—	6p	—	6p	—
47	6p	—	6p	—	6p	6p	6p
68	—	6p	—	6p	—	—	10p
100	6p	—	6p	—	6p	6p	12p
150	—	6p	—	6p	6p	10p	12p
220	6p	—	6p	6p	10p	12p	18p
330	6p	—	6p	10p	—	—	21p
470	—	6p	10p	—	12p	18p	40p
680	—	10p	—	12p	18p	21p	—
1000	10p	—	12p	18p	21p	40p	60p
1500	—	12p	18p	21p	—	—	—
2200	—	18p	21p	40p	45p	55p	93p
3300	—	21p	—	—	—	—	—
4700	21p	—	—	60p	75p	93p	—

CAP µF	VOLTAGE 16	25	40	64
500			33p	40p
1250			50p	—
1600			—	75p
2000	40p	50p	—	—
2500	—	—	75p	93p
3200	50p	—	—	—
4000		75p	93p	—
6400	75p	93p	—	—

Quantity Prices on application.

Hi~Volt Electrolytics

1, 2, 4, 8µF	450V	14p	32µF	450V	20p
16µF	450V	15p	50µF	350V	20p
8 + 8µF, 450 V.W		18p	32 + 32µF; 350 V.W		25p
8 + 16µF; 450 V.W		20p	32 + 32µF; 450 V.W		43p
16 + 16µF, 450 V.W		25p	50 + 50µF; 350 V.W		35p

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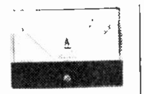
● LOW COST ● QUICK DELIVERY ● OVER 200 RANGES IN STOCK ● OTHER RANGES TO ORDER

CLEAR PLASTIC PANEL METERS

TYPE SW.100 100mm × 80mm Fronts

30µA	£3·80		
50-0-50µA	£3·80		
100µA	£3·80		
100-0-100µA	£3·70		
500µA	£3·50		
1mA	£3·40		
20V d.c.	£3·40		
50V d.c.	£3·40	5 amp. d.c.	£3·40
300V d.c.	£3·40	300V a.c.	£3·40
1 amp. d.c.	£3·40	VU Meter	£4·15

Type SD.830 82·5mm × 110mm Fronts



		10mA	£2·50
		50mA	£2·50
		100mA	£2·50
		500mA	£2·50
		1 amp.	£2·50
		5 amp.	£2·50
		10 amp.	£2·50
50µA	£2·75	5V d.c.	£2·50
50-0-50µA	£2·70	10V d.c.	£2·50
100µA	£2·70	20V d.c.	£2·50
100-0-100µA	£2·70	50V d.c.	£2·50
200µA	£2·70	300V d.c.	£2·50
500µA	£2·55	15V a.c.	£2·75
1mA	£2·50	300V a.c.	£2·75
5mA	£2·50	VU Meter	£3·00

Type SD.640 63·5mm × 85mm Fronts

50µA	£2·60	500mA	£2·35
50-0-50µA	£2·55	1 amp.	£2·35
100µA	£2·55	5 amp.	£2·35
100-0-100µA	£2·55	10 amp.	£2·35
200µA	£2·55	5V d.c.	£2·35
500µA	£2·35	20V d.c.	£2·35
1mA	£2·35	50V d.c.	£2·35
5mA	£2·35	300V d.c.	£2·35
10mA	£2·35	15V a.c.	£2·40
50mA	£2·35	300V a.c.	£2·40
100mA	£2·35	VU Meter	£2·70

Type SD.460 46mm × 59·5mm Fronts

50µA	£2·40	1 amp.	£2·15
50-0-50µA	£2·35	5 amp.	£2·15
100µA	£2·35	10 amp.	£2·15
100-0-100µA	£2·35	5V d.c.	£2·15
200µA	£2·35	10V d.c.	£2·15
500µA	£2·20	20V d.c.	£2·15
1mA	£2·15	50V d.c.	£2·15
5mA	£2·15	300V d.c.	£2·15
10mA	£2·15	15V a.c.	£2·30
50mA	£2·15	300V a.c.	£2·30
100mA	£2·15	VU Meter	£2·55
500mA	£2·15		

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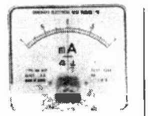
Type MR.85P. 4¼in. × 4¼in. Fronts



		50mA	£3·10
		100mA	£3·10
		500mA	£3·10
		1 amp.	£3·10
		5 amp.	£3·10
		15 amp.	£3·10
		30 amp.	£3·20
		20V d.c.	£3·10
		50V d.c.	£3·10
50µA	£3·95	150V d.c.	£3·10
50-0-50µA	£3·40	300V d.c.	£3·10
100µA	£3·40	15V a.c.	£3·10
100-0-100µA	£3·30	300V a.c.	£3·10
200µA	£3·30	S Meter 1mA	£3·15
500µA	£3·20	VU Meter	£3·95
500-0-500µA	£3·10	1 amp. a.c.	*£3·10
1mA	£3·10	5 amp. a.c.	*£3·10
1-0-1mA	£3·10	10 amp. a.c.	*£3·10
5mA	£3·10	20 amp. a.c.	*£3·10
10mA	£3·10	30 amp. a.c.	*£3·10

Type MR.52P. 2¼in. square Fronts.

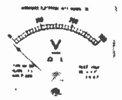
50µA	£3·40	10V d.c.	£2·20
50-0-50µA	£2·85	20V d.c.	£2·20
100µA	£2·85	50V d.c.	£2·20
100-0-100µA	£2·75	300V d.c.	£2·20
500µA	£2·55	15V a.c.	£2·30
1mA	£2·20	300V a.c.	£2·30
5mA	£2·20	S Meter 1mA.	£2·30
10mA	£2·20	VU Meter	£3·50
50mA	£2·20	1 amp. a.c.	*£2·20
100mA	£2·20	5 amp. a.c.	*£2·20
500mA	£2·20	10 amp. a.c.	*£2·20
1 amp.	£2·20	20 amp. a.c.	*£2·20
5 amp.	£2·20	30 amp. a.c.	*£2·20

Type MR.65P. 3¼in. × 3¼in. Fronts

50µA	£3·70	10V d.c.	£2·40
50-0-50µA	£3·00	20V d.c.	£2·40
100µA	£3·00	50V d.c.	£2·40
100-0-100µA	£2·90	150V d.c.	£2·40
200µA	£2·90	300V d.c.	£2·40
500µA	£2·65	15V a.c.	£2·55
500-0-500µA	£2·40	50V a.c.	£2·55
1mA	£2·40	150V a.c.	£2·55
5mA	£2·40	300V a.c.	£2·55
10mA	£2·40	500V a.c.	£2·55
50mA	£2·40	S Meter 1mA.	£2·60
100mA	£2·40	VU Meter	£3·70
500mA	£2·40	50mA a.c.	*£2·40
1 amp	£2·40	100mA a.c.	*£2·40
5 amp	£2·40	200mA a.c.	*£2·40
10 amp.	£2·40	500mA a.c.	*£2·40
15 amp.	£2·40	1 amp. a.c.	*£2·40
20 amp.	£2·40	5 amp. a.c.	*£2·40
30 amp.	£2·55	10 amp. a.c.	*£2·40
50 amp.	£2·75	20 amp. a.c.	*£2·40
5V d.c.	£2·40	30 amp. a.c.	*£2·40

Send for illustrated brochure on SEW Panel Meters—discounts for quantities.

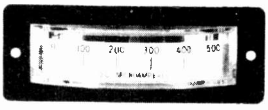
Type MR.38P. 1 21/32in. square Fronts.



		200mA	£1·75
		300mA	£1·75
		500mA	£1·75
		750mA	£1·75
		1 amp.	£1·75
		2 amp.	£1·75
		5 amp.	£1·75
		10 amp.	£1·75
		3V d.c.	£1·75
50µA	£2·30	10V d.c.	£1·75
50-0-50µA	£2·10	15V d.c.	£1·75
100µA	£2·10	20V d.c.	£1·75
100-0-100µA	£1·95	50V d.c.	£1·75
200µA	£1·95	100V d.c.	£1·75
500µA	£1·80	150V d.c.	£1·75
500-0-500µA	£1·75	300V d.c.	£1·75
1mA	£1·75	500V d.c.	£1·75
1-0-1mA	£1·75	750V d.c.	£1·75
2mA	£1·75	15V a.c.	£1·85
5mA	£1·75	50V a.c.	£1·85
10mA	£1·75	150V a.c.	£1·85
20mA	£1·75	300V a.c.	£1·85
50mA	£1·75	500V a.c.	£1·85
100mA	£1·75	S Meter 1mA.	£1·85
150mA	£1·75	VU Meter	£2·30

Type MR.45P. 2in. square Fronts.

50µA	£2·50	5 amp.	£1·85
50-0-50µA	£2·30	10V d.c.	£1·85
100µA	£2·30	20V d.c.	£1·85
100-0-100µA	£2·05	50V d.c.	£1·85
200µA	£2·05	300V d.c.	£1·85
500µA	£1·95	15V a.c.	£2·00
500-0-500µA	£1·85	300V a.c.	£2·00
1mA	£1·85	S Meter 1mA.	£2·05
5mA	£1·85	VU Meter	£2·50
10mA	£1·85	1 amp. a.c.	*£1·85
50mA	£1·85	5 amp. a.c.	*£1·85
100mA	£1·85	10 amp. a.c.	*£1·85
500mA	£1·85	20 amp. a.c.	*£1·85
1 amp.	£1·85	30 amp. a.c.	*£1·85



"SEW" EDGEWISE METERS

Type PE.70. 3 17/32in. × 1 15/32in. × 2¼in. deep.

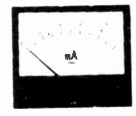
50µA	£3·40	500µA	£3·05
50-0-50µA	£3·30	1mA	£2·70
100µA	£3·30		
100-0-100µA	£3·20	300V a.c.	£2·70
200µA	£3·20	VU Meter	£3·75

"SEW" BAKELITE PANEL METERS

Type MR.65. 3¼in. square Fronts.

		1 amp.	£2·15
		5 amp.	£2·15
		15 amp.	£2·15
		30 amp.	£2·15
		50 amp.	£2·15
		5V d.c.	£2·15
		10V d.c.	£2·15
		20V d.c.	£2·15
		50V d.c.	£2·15
		150V d.c.	£2·15
		300V d.c.	£2·15
25µA	£3·85	50mV d.c.	£2·40
50µA	£3·00	100mV d.c.	£2·40
50-0-50µA	£2·60	30V a.c.*	£2·20
100µA	£2·60	50V a.c.*	£2·20
100-0-100µA	£2·50	150V a.c.*	£2·20
500µA	£2·45	300V a.c.*	£2·20
500-0-500µA	£2·15	500mA a.c.*	£2·15
1mA	£2·15	1 amp. a.c.*	£2·15
1-0-1mA	£2·15	5 amp. a.c.*	£2·15
5mA	£2·15	10 amp. a.c.*	£2·15
10mA	£2·15	20 amp. a.c.*	£2·15
50mA	£2·15	30 amp. a.c.*	£2·15
100mA	£2·15	50 amp. a.c.*	£2·15
500mA	£2·15	VU Meter	£3·40

Type S-80 80mm square Fronts



50µA	£3·50		
50-0-50µA	£3·40		
100µA	£3·40		
100-0-100µA	£3·30		
500µA	£3·05		
1mA	£2·85		
20V d.c.	£2·85		
50V d.c.	£2·85		
300V d.c.	£2·85		
1 amp. d.c.	£2·85	300V a.c.	£2·85
5 amp. d.c.	£2·85	VU Meter	£3·70

"SEW" EDUCATIONAL METERS

Type ED.107. Size overall 100mm × 90mm × 108mm. A new range of high quality moving coil instruments ideal for school experiments and other bench applications. 3in. mirror scale. The meter movement is easily accessible to demonstrate internal working. Available in the following ranges:

50µA	£5·50	10V d.c.	£4·85
100µA	£5·10	20V d.c.	£4·85
1mA	£4·85	50V d.c.	£4·85
50-0-50µA	£5·10	300V d.c.	£4·85
1-0-1mA	£4·85	Dual range	
1A d.c.	£4·85	500mA/5A d.c.	£5·10
5A d.c.	£4·85	5V/50V d.c.	£5·10

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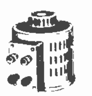
"YAMABISHI" VARIABLE VOLTAGE TRANSFORMERS

S-260 General Purpose Bench Mounting



1 amp.	£7·00
2·5 amp.	£8·05
5 amp.	£11·75
8 amp.	£15·90
10 amp.	£22·50
12 amp.	£23·60
20 amp.	£49·00
25 amp.	£58·00
40 amp.	£82·50

S-260 Panel Mounting

1 amp	£7·00
2·5 amp	£8·05

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ALL MODELS INPUT 230V 50/60 CYCLES OUTPUT VARIABLE 0-260 VOLTS. Special discounts for quantity.

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0/115/230V. Step up or step down. Fully shrouded.

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150W	£2·70	P. & P. 18p
300W	£3·60	P. & P. 23p
500W	£5·25	P. & P. 33p
1000W	£7·50	P. & P. 38p
1500W	£10·20	P. & P. 43p
2250W	£17·25	P. & P. 50p
5000W	£35·00	P. & P. £1

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Can be panel or bench mounted. Basic meter measures 1V d.c. but can be used to measure a wide range of a.c. and d.c. volt, current and ohms with optional plug in cards. Specification: Accuracy: +0·2, +1 digit. Resolution: 1mV. Number of digits: 3 plus fourth overrange digit. Overrange: 100% (up to 1·999). Input impedance: 1000 Meg ohm. Measuring cycle: 1 per second. Adjustment: Automatic zeroing, full scale adjustment against an internal reference voltage. Overload: to 100V d.c. Input: Fully floating (3 poles). Input power: 110-230V a.c. 50/60 cycles. Overall size: 5⅛in × 2$\frac{11}{16}$in × 8$\frac{1}{16}$in. AVAILABLE BRAND NEW AND FULLY GUARANTEED. **£35·50.** Carr. 50p.

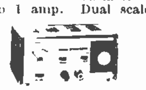
240° Wide Angle 1mA Meters

MW1-6	60mm square	£3·97
MW1-8	80mm square	£4·97

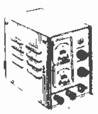
Post extra

RP214 REGULATED POWER SUPPLY

Solid state. Variable output 0–24V d.c. up to 1 amp. Dual scale meter to monitor voltage and current. Input 220/240V a.c. Size 185 × 85 × 105mm. **£8·97** Post 25p.

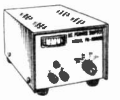


PS.200 REGULATED P.S.U.



Solid state. Variable output 5-20V d.c. up to 2 amp. Independent meters to monitor voltage and current. Output 220/240V. a.c. Size 7¼in. × 5¼in. × 3¼in. **£19·95.** Post 25p.

PS.1000B REGULATED POWER SUPPLY



Solid state. Output 6, 9 or 12V d.c. up to 3 amps. Meter to monitor current. Input 220/240V a.c. Size 4in. × 3¼in. × 6¼in. **£11·97.** Post 25p.

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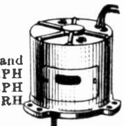
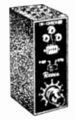


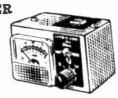
Built in gearbox. All brand new and boxed. 30 RPH CW; 2 RPH CW: 20 RPH CW; 2 RPH ACW: 30 RRH CW. **50p** each, Post 12p.

LB4 TRANSISTOR TESTER



Tests PNP or NPN transistors. Audio indication. Operates on two 1·5V batteries. Complete with all instructions, etc. **£4·50.** Post 20p.

LB3 TRANSISTOR TESTER



Tests ICO and B. *Pnp/npn.* Operates from 9V battery. Complete with all instructions, etc. **£3·95.** Post 20p.

MCA.220 AUTOMATIC VOLTAGE STABILISER

Input 88-125V a.c. or 176-250V a.c. Output 120V a.c. or 240V a.c. 200VA rating. **£11·97.** Post 50p.

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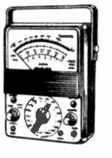
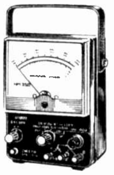
G. W. SMITH & CO. (RADIO) LTD.
Also see next three pages

KAMODEN 72.200 MULTITESTER



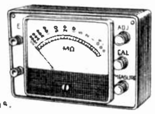
High sensitivity tester. 200,000 o.p.v. Overload protection. Mirror scale. Ranges: 0/0·06/0·3/3/30/120/600/1,200V d.c., 0/3/12/60/300/1,200V a.c. 0/6μA/1·2mA/120mA/600mA/12A d.c. 0/12A a.c. −20 to +63dB. 0/2kΩ/200kΩ/2MΩ/200MΩ. **£16·95.** Post 30p.

KAMODEN HM-350 TRANSISTOR TESTER



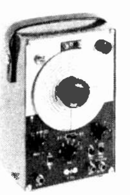
High quality instrument to test Reverse Leak current and D.C. current. Amplification factor of NPN, PNP, transistors, diodes, SCR's, etc. 4" × 4¾" clear scale meter. Operates from internal batteries. Complete with instructions, leads and carrying handle. **£12·50.** Post 30p.

KAMODEN HMG-500 INSULATION RESISTANCE TESTER



Range 0–1,000 Megohms, 500 Volt. Battery operated. Wide range clear meter 4¾" × 4". Complete with de-luxe carrying case, batteries, instructions. **£19·95.** Post 30p.

ARF-300 AF/RF SIGNAL GENERATOR



All transistorised, compact, fully portable. AF sine wave 18 Hz to 220 KHz. AF square wave 18 Hz to 100 KHz. Output sine/square 10v. P-P. RF 100 KHz to 200 MHz. Output 1v. maximum. Operation 220/240v. AC. Complete with instructions and leads. **£29·95.** Post 50p.

HAND HELD 2-WAY WALKIE TALKIES

Industrial quality in robust metal cases. Battery operation. Volume and squelch controls. Call button and press to talk button. Telescopic aerial. Complete carrying cases.

2 channel 300 mW	£52·50	Pair. Post 50p.
3 channel 2 watt.	£79·50	Pair. Post 50p.

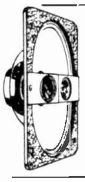
(Note: Licence required for operation in U.K.)

HOMER INTERCOMS

Ideal for home, office, stores, factories, etc. Supplied complete with batteries, cable and free instructions.

2 Station, **£2·97**, 3 Station **£5·25**, Post 15p. 4 Station **£6·62**. Post 17p.

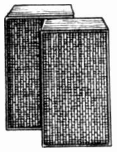
EMI LOUDSPEAKERS



Model 350. 13in × 8in with single tweeter/crossover, 20–20,000Hz. 15W RMS. Available 8 or 15 ohms. **£7·25** each. Post 37p.

Model 450. 13in × 8in with twin tweeter/crossover. 55–13,000Hz. 8W RMS. Available 8 or 15 ohms. **£3·62** each. Post 25p.

SPECIAL OFFER! STEREO SPEAKERS

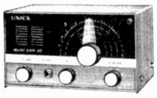


Matched pair of stereo bookshelf speakers. Deluxe teak veneered finish. Size: 14½in × 9in × 7½in. 8 ohms. 8W RMS. 16W peak. Complete with DIN lead. **£12·95.** Carr. 50p.

EA.41 REVERBERATION AMPLIFIER

Self contained, transistorised, battery operated. Simply plug in microphone, guitar, etc., and output into your amplifier. Volume control, depth of reverberation control. Beautiful walnut cabinet. 7¾in × 3in × 4½in. **£5·97.** Post 15p.

UNR-30 RECEIVER

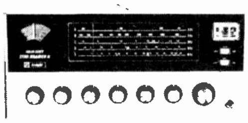


4 Bands covering 550kHz–30MHz. BFO. Built-in Speaker 220/240V a.c. Brand new with instructions. **£15·75.** Carr. 37p.

UR-1A SOLID STATE COMMUNICATION RECEIVER

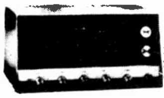
4 Bands covering 550kHz–30MHz. FET. S Meter. Variable BFO for SSB, Built-in Speaker, Bandspread, Sensitivity Control. 220/240V a.c. or 12V d.c. 12¾in × 4½in × 7in. Brand new with instructions. **£25.** Carr. 37p.

SKYWOOD CX203 COMMUNICATION RECEIVER



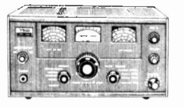
Solid state. Coverage on 5 bands 200–420 kHz and 0·55 to 30MHz. Illuminated slide rule dial. Bandspread. Aerial tuning. BFO, AVC, ANL, "S" meter. AM/CW/SSB. Integrated speaker and phone socket. Operation 220/240V a.c. or 12V d.c. Size 325 × 266 × 150 mm. Complete with instructions and circuit. **£32·50.** Carr. 50p.

LAFAYETTE HA-600 SOLID STATE RECEIVER



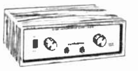
General coverage 150–400kHz, 550 kHz–30MHz. FET front end. 2 mech. filters, product detector, variable BFO, noise limiter. S Meter, Bandspread. RF Gain. 15in × 9¾in × 8½in. 18lbs. 220/240V a.c. or 12V d.c. Brand new with instructions. **£50.** Carr. 50p.

TRIO 9R59DS COMMUNICATION RECEIVER



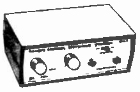
4 band covering 550kHz–30MHz continuous and electrical bandspread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW. ANL. Variable BFO. S meter. Sep. bandspread dial. IF frequency 455kHz. Audio output 1·5W. Variable RF and AF gain controls 115/250V a.c. Size 7in × 13in × 10in with instruction manual. **£49 50.** Carr. paid.

HA-10 STEREO HEADPHONE AMPLIFIER



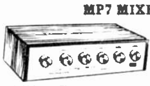
All silicon transistor amplifier operates from magnetic, ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9V battery. Inputs 5MV/100MV. Output 50MW. **£5·97.** Post 15p.

1021 STEREO LISTENING STATION



For balancing and gain selection of loudspeakers with additional facility for stereo headphone switching. 2 gain controls, speaker on-off slide switch, stereo headphone sockets. 6in × 4in × 2½in. **£2·25.** Post 15p.

MP7 MIXER PREAMPLIFIER



5 microphone inputs each with individual gain controls enabling complete mixing facilities. Battery operated. 9¼in × 5in × 3in. Inputs Mics: 3 × 3mV 50K: 2 × 3mV 600 ohm. Phono meg. 4mV 50K. Phono ceramic 100mV 1 meg. Output 250mV 100K. **£8·97.** Post 20p.

HI-FI EQUIPMENT

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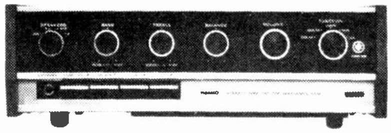
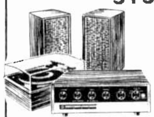
NIKKO TRM50 STEREO AMPLIFIER



17+17W r.m.s. stereo amplifier with inputs for Magnetic and Crystal phono, Tuner, Tape, Aux and Tape Monitor. Outputs for two pairs of stereo speakers and tape. Stereo headphone socket. Full range of controls including loudness control, scratch filter, etc. Size 13in × 9¼in × 3¾in.
Unrepeatable offer—limited stocks!

List price £59·50
OUR PRICE **£39·95**
Carriage 50p

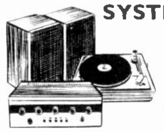
NIKKO TRM 50 SYSTEM



NIKKO TRM50 17+17W rms stereo amplifier, Garrard AP76 plinth and cover, Goldring G800E cartridge, pair of Linton 2 speakers and all leads.

OUR PRICE **£93·95** Carr. and Ins. £1·50

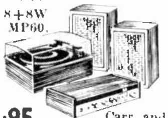
LEAK DELTA 30 SYSTEM



Leak Delta 30 stereo amplifier, Goldring GL75, plinth, cover and G800 cartridge. Pair of Leak 150 speakers and all leads.

OUR PRICE **£110·50** Carr. and Ins. £1·50

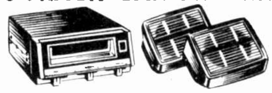
TELETON SAQ206B SYSTEM



Teleton SAQ206B 8+8W amplifier BSR MP60, plinth and cover, Goldring G800 cartridge, pair of Apollo speakers and all leads.

OUR PRICE **£50·95** Carr. and Ins. £1·50

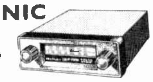
AUDIOTRONIC ACP-8 8-TRACK CAR PLAYER



Attractive black and silver finish. 12V neg. earth. Slider controls for volume, tone and balance. Channel selector button with red pilot lamp. Complete with speakers, mounting brackets and instructions.

ONLY **£12·50** P. & P. 40p.

AUDIOTRONIC ACR3500 CAR RADIO



Manual tuning of Medium and Long waves. 12V pos. or neg. earth. Complete with speaker, mounting brackets and instructions.

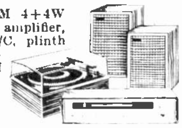
OUR PRICE **£6·50** P. & P. 50p

AUDIOTRONIC ACR. 1 PUSH BUTTON CAR RADIO

Push button tuning of one LW and five MW stations of your choice. 12V Pos. or Neg. earth. Complete with speaker, mounting brackets and instructions.

OUR PRICE **£8·95** P & P. 50p.

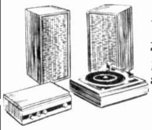
MONOTONE 6750 SYSTEM



Monotone AM/FM 4+4W stereo tuner amplifier, Garrard 2025 T/C, plinth and cover, stereo cartridge, pair of matching speakers and all leads.

OUR PRICE **£30·50** Carr. and Ins. £1

WHARFEDALE LINTON SYSTEM

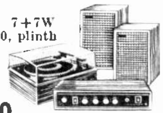


Wharfedale Linton Amplifier, Linton Turntable, pair of Linton 2 speakers and all leads.

OUR PRICE **£95·95** Carr. and Ins. £1·25

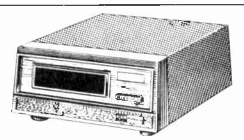
LINTON RECEIVER SYSTEM £125. Carr. and Ins. £1·50.

AMSTRAD 8000 II SYSTEM



Amstrad 8000 II 7+7W amplifier. BSR MP60, plinth and cover, Goldring G800 cartridge, pair of Apollo speakers and all leads.

OUR PRICE **£43·50** Carr. and Ins. £1



B.S.R. TD8S 8-TRACK STEREO TAPE PLAYER DECK

Integrated preamps (output 125mV) to feed into any stereo amplifier. Automatic and manual programme selector. 4 pole synchronous motor. 210/240V a.c.

OUR PRICE **£12·75** Carr. 50p.

G. W. SMITH & CO. (RADIO) LTD.
Also see previous pages and opposite page

SINCLAIR PROJECT 60 PACKAGE DEALS

2 × Z30/Stereo 60/PZ5
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Transformer for PZ8
£3·65 extra
Active Filter Unit
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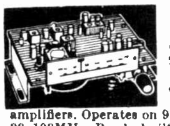
Sinclair Project 605
£20·97. P. & P. 37p

All other Sinclair Products in stock: 2000 Stereo Amplifier, £22·95; 3000 Stereo Amplifier, £28·95; 2000/3000 Stereo Tuner. £26·95; P. & P. 50p.

★ TRANSISTORISED FM TUNER ★

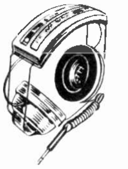


6 TRANSISTOR HIGH QUALITY TUNER, SIZE ONLY 6in × 4in × 2½in. 3 I.F. stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9V battery. Coverage 88–108MHz. Ready built ready for use. Fantastic value for money. £5·95. Post 12p. Stereo multiplex adaptors £4·97.

TE 1018 DE-LUXE MONO HIGH IMPEDANCE HEADSET

Sensitive, soft earpads, adjustable headband. Magnetic, impedance 2,600 ohms. £1·97. Post 15p.

KOSS BARGAIN! SP3XC STEREO HEADPHONES



Extremely sensitive high quality headphones. Impedance 4–16 ohms. 10–15,000Hz. Soft sponge ear cushions. 10ft coiled lead. Brand new and boxed. (List £9·50).
OUR PRICE **£6·50** P. & P. 30p.

HOSIDEN DHO-2S STEREO HEADPHONES

Wonderful value and excellent performance combined. Adjustable headband. 8 ohm impedance. 20–12,000 cps. Complete with lead and plug. ONLY £2·37. Post 12p.

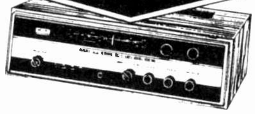
TE-1035 STEREO HEADPHONES

Low cost high performance stereo headphones. Foam rubber ear cups. Adjustable head-band. 8 ohm impedance. 25–18,000Hz. With lead and stereo jack plug. ONLY £1·97. Post 12p.

BH.001 HEAD SET AND BOOM MICROPHONE

Moving coil. Ideal for language teaching, communications. Headphone imp. 16 ohms. Microphone imp. 200 ohms. £4·62. Post 15p.

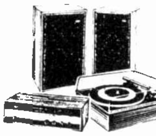
AKAI BARGAINS!



AA6300 AM/FM STEREO TUNER AMPLIFIER

20 + 20 watts rms. Magnetic, ceramic and tape inputs. FM 88–108 MHz. AM 535–1605 kHz. Dual stereo speaker outputs. Headphone socket. (Rec. List Price £117·46)
OUR PRICE **£61·95** P. & P. 75p

AKAI AA6300 SYSTEM



20 + 20 watt AM/FM stereo tuner amplifier. Garrard AP76, plinth and cover. G800 cartridge, pair of Mezzo III speakers.
OUR PRICE **£132·50** Carr. & Pack. £2·00

ROTEL BARGAINS!

STEREO AMPLIFIERS

RA310	15 + 15 watt	£34·95
RA610	32 + 32 watt	£51·95
RA810	40 + 40 watt	£72·95
RA1210	60 + 60 watt	£89·95

P. & P. 50p extra

AM/FM STEREO RECEIVERS

RX150	7½ + 7½ watt	£36·95
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RX400	20 + 20 watt	£57·50

P. & P. 75p

ROTEL RX150 SYSTEM

AM/FM 7½ + 7½ watt stereo tuner amplifier, BSR MP60, plinth and cover, G800, pair of Denton 2 speakers and all leads.
OUR PRICE **£75·95** Carr. & Ins. £1·25

ROTEL BARGAIN!

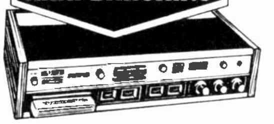
RH700 STEREO PHONES

Soft leather ear cushions. Impedance 8–16 ohm. 20–20,000Hz. 15ft coiled lead. Brand new and boxed.
OUR PRICE **£6·75** P. & P. 30p

HOSIDEN DH-08S DE-LUXE STEREO HEADPHONES

Features unique mechanical 2 way units and fitted adjustable level, controls. 8 ohm impedance 20–20,000cps Complete with spring lead & stereo jack plug £7·97. Post 12p

AKAI BARGAINS



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GXC40T Deck/Receiver	£101·25
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GXC65D Dolby Deck	£93·40
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CR81D Deck	£54·10
CR81T Recorder/Receiver	£93·70
CR80SS 4 channel Recorder	£114·25
CR80DSS 4 channel Recorder	£94·95
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X5000 Recorder	£82·50
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X1810D Deck	£138·40
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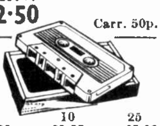
DOLBY SYSTEM NOISE REDUCTION UNIT

Improves the performance of cassette and semi-professional recorders. Reduces tape hiss by 3dB at 600Hz, 6dB at 1200Hz and 10dB for all frequencies above 3000Hz. Controls for input levels and noise reduction on record and replay. 2 meters for Dolby level. Off tape monitoring. Frequency response: 20Hz to 15kHz ± 1dB 19kHz—35dB. Size 15⅞in × 9in × 3¼in. A.c. 200/250V.
OUR PRICE **£32·50** Carr. 50p.

AUDIOTRONIC LOW NOISE TAPE CASSETTES



Top Hi-Fi quality in library cases.

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C60	£1·29	£2·53	£5·99
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	P. & P. 15p	Post Free	Post Free

Tape Head Cleaner 30p each

AUDIOTRONIC 8-TRACK BLANK TAPE CARTRIDGES

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80M	99p	£4·70	£8·90
	P. & P. 5p	Post free	

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PLEASE PRINT NAME & ADDRESS CLEARLY.

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Carriage and Packing 50p

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710	£19·20
810	£24·50
710/810 Plinth and Cover	£8·35
MP60	£7·65
MP60/G800	£10·25
MP60/TPD1	£12·60
MP60/TPD2	£11·25
HT70	£10·97
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SL65B	£11·15
SL72B	£17·75
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401	£23·50
ZERO 100A	£30·30
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LID 75	£3·20
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PLA35	£61·55
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STEREO AMPLIFIER

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BURIED FROM VIEW

THE irresistible march of microelectronics means that more and more circuitry is disappearing from view. Circuitry that often is highly interesting in itself is being buried, not just metaphorically but literally, within the confines of black boxes. An oft-posed question is, should the user attempt to prise the secrets of the black boxes, or should he be content to accept them quite simply at their face value like any other circuit components? The latter is probably the most sensible thing to do. Yet sometimes it is essential to have a certain amount of inside information, though there are degrees of delving, of course.

Two articles in this issue illustrate different approaches to a fairly complex i.c., in order to suit (a) the builder of a detailed project and (b) the designer or experimenter.

The article decribing the General Purpose Timer gives all the information needed to build this complete instrument. The i.c. upon which the design is based is treated purely and simply as a black box. So far as the constructor is concerned it is just one of the 28 circuit components employed.

This approach is perfectly satisfactory in a constructional article where a proven design is presented for the reader to copy, right down to the final detail, circuit-wise. But should the constructor wish to modify or depart from the specified design in any way, he then obviously needs to know quite a bit more about the i.c. As indeed do all those interested in designing and experimenting for themselves.

Such requirements we have met on this occasion by a separate article which describes the technical characteristics of this i.c. and its possible applications. The device is discussed in practical terms and all relevant parameters are given that need to be taken into account when designing a system around it. Even for this purpose, this "closer look" at the i.c. need not extend to a detailed examination of the actual circuitry of the chip. A functional block diagram is perfectly adequate.

Now this brings us back to that interesting and arguable point. Is there any need to peer deeper into the anatomy of an integrated circuit?

Microcircuit manufacturing processes allow quite unusual innovations in the creation of circuit elements. For example, it is quite normal for the active *pn* junction to be employed as a maid-of-all-work, including serving in the humble role of a passive element. Not surprisingly, any normally well-recognised classic circuit configuration becomes less obvious, maybe entirely unidentifiable, to the average eye scanning the equivalent circuit diagram of some monolithic device.

The internal circuit of an integrated device is not likely to be of any practical value to the general user. Admittedly it can be of academic interest and even offer some reward as a technical brain teaser. But we imagine most users will be content for the i.c. to remain an inscrutable black box. The external discrete circuitry which these devices invariably stimulate and within the web of which they become enmeshed, singly or severally, provides enough for designer, experimenter, or constructor to concentrate upon.—F.E.B.

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urpose

THE GENERAL PURPOSE timer discussed here is based on 555 i.c. timer from Signetics which is the subject of the feature commencing on page 514. The unit is constructed in an Eddystone die-cast box of external dimensions 7·39 × 4·703 × 2·062 inches. There is enough space for a mains power pack or a battery to be included inside the box. Whilst construction of the prototype is described in detail, many variations are possible to suit individual needs.

CONTROLS

The control arrangement is shown in the photograph. The eleven-position switch S1 is used to select the first digit of the desired number of seconds, whilst the second digit is selected by the potentiometer VR1. The range switch, S2, is arranged so that the total time selected by S1 and VR1 can be multiplied by 0·1, 1 or 10.

SELECTION OF DELAY

If a time delay of 860 seconds is required, S1 is set to "80", VR1 to "6" and S2 to "×10". A delay of 1·1 seconds can be obtained by setting S1 to "10", VR1 to "1" and S2 to "x0·1". Delays of less than 1 second can be obtained by setting S1 to "0" and S2 to "x0·1". The maximum delay with this unit is about 1100 seconds (18 minutes 20 seconds).

In general the delays are accurate to a few per cent.

OPERATION

The timing period commences at the instant the START button is released after it has been pressed. The internal relay closes at this time, but automatically opens again at the end of the desired delay. It may be found that the timing starts when the START button is pressed down owing to contact bounce. This will not matter provided that the button is pushed quickly and then released.

If the START button has been pressed and one does not wish the timing operation to continue, the RESET button may be pressed. A fresh timing operation can then commence from the beginning when the START button is pushed again. The use of the reset facility prevents having to wait or alter the timing setting after commencing a fairly long timing operation and wishing to terminate it.

THE CIRCUIT

The circuit of the timer is shown in Fig. 1. It is essentially the same as the basic circuit of Fig. 1 of the article commencing on page 514, but some refinements have been added.

The resistance of R_A has been replaced by R1 to R11 in series with VR1. The resistor R11 is of low value and is included to prevent a fairly high current (about 60mA) from flowing to pin 2 of the 555 if S1 and VR1 should both be set for zero resistance. The resistors around S1 are each 1MΩ and their total value (as set by S1) is added to the setting of VR1.

THE TIMING CAPACITORS

The timing capacitor is selected by S2a. It cannot be emphasised too strongly that the electrolytic capacitors C1 and C2 must be good quality components which have a low leakage current. The writer would have expected electrolytic capacitors with a working voltage of about 30V to pass a lower leakage current when 12V is applied to them than similar capacitors with a working voltage rating of 15V. However, measurements of the leakage current of a number of capacitors seems to indicate that this may not be the case.

An additional range of "x100" could have been added using a 1,000µF electrolytic capacitor to give time delays of up to 11000 seconds (over 3 hours), but a capacitor selected for low leakage current would probably be required. A 4-way 2-pole switch would then be required for S2.

COMPONENTS . . .

Resistors

R1 to R10	1MΩ, 5% (preferably 2%)	All 0·5W
R11	4·7kΩ, 10%	All 0·5W
R12, R13	22kΩ, 10%	All 0·5W

Potentiometers

VR1 1MΩ linear
VR2 to VR4 10kΩ, 26 turn rectilinear (RS Components Ltd.)

Capacitors

C1 100µF, 15 to 30V, electrolytic
C2 10µF, 15 to 30V, electrolytic
C3 1µF, 63V, polyester (WIMA or RS Components Ltd.)

Switches

S1 11 way, 1 pole rotary switch
S2 3 way, 2 pole rotary switch
S3, S4 Single pole push-to-make switches (RS Components Ltd.)
S5 Single pole, single throw toggle switch

Semiconductors

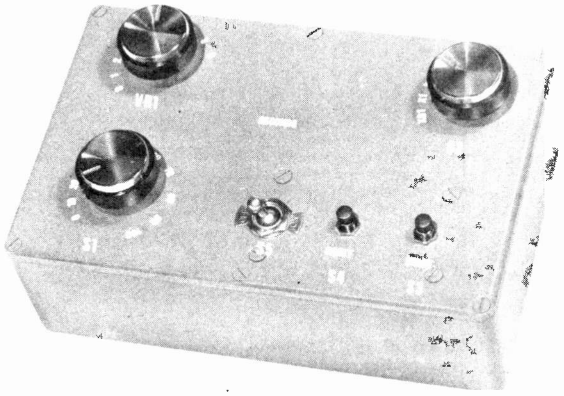
IC1 NE555V integrated circuit (SDS Components Ltd., Gunstore Rd., Hilsea Trading Estate, Portsmouth, Hants.)
D1 OA47 Germanium diode

Miscellaneous

RLA MS1B 12V micro-switch relay (Keyswitch Relays Ltd.)
8 pin dual-in-line socket (RS Components Ltd.)
Eddystone die-cast box 7·39 × 4·703 × 2·062 in external dimensions
1 Lektrokit board
4 BA bolts $1\frac{1}{4}$ to $1\frac{1}{2}$ in long
12 4BA nuts
6 8BA nuts and bolts

TIMER

By J.B. DANCE M.Sc.



Capacitors of a large value have wide tolerances. In addition they pass different leakage currents. Three trimmer potentiometers (VR2 to VR4) are therefore incorporated in the circuit so that each range can be calibrated. S2a and S2b are on the same switch wafer and select the appropriate trimmer potentiometer together with the appropriate capacitor.

CALIBRATION

Adjustment of the preset potentiometers VR2 to VR4 alters the control voltage applied to pin 5 of the 555 timer. When each potentiometer has been adjusted so that the delay is correct at one point on each range, all of the other delay values should be approximately correct. It is best to make the final adjustments to each potentiometer at a setting near to the maximum delay for the range concerned where the timing errors are greatest. A stop watch is desirable (but by no means essential) for the accurate calibration of the x0·1 range.

The tolerance of R1 to R10 in the prototype was a nominal ±5 per cent. The accuracy of the delays was found to be a few per cent, as would be

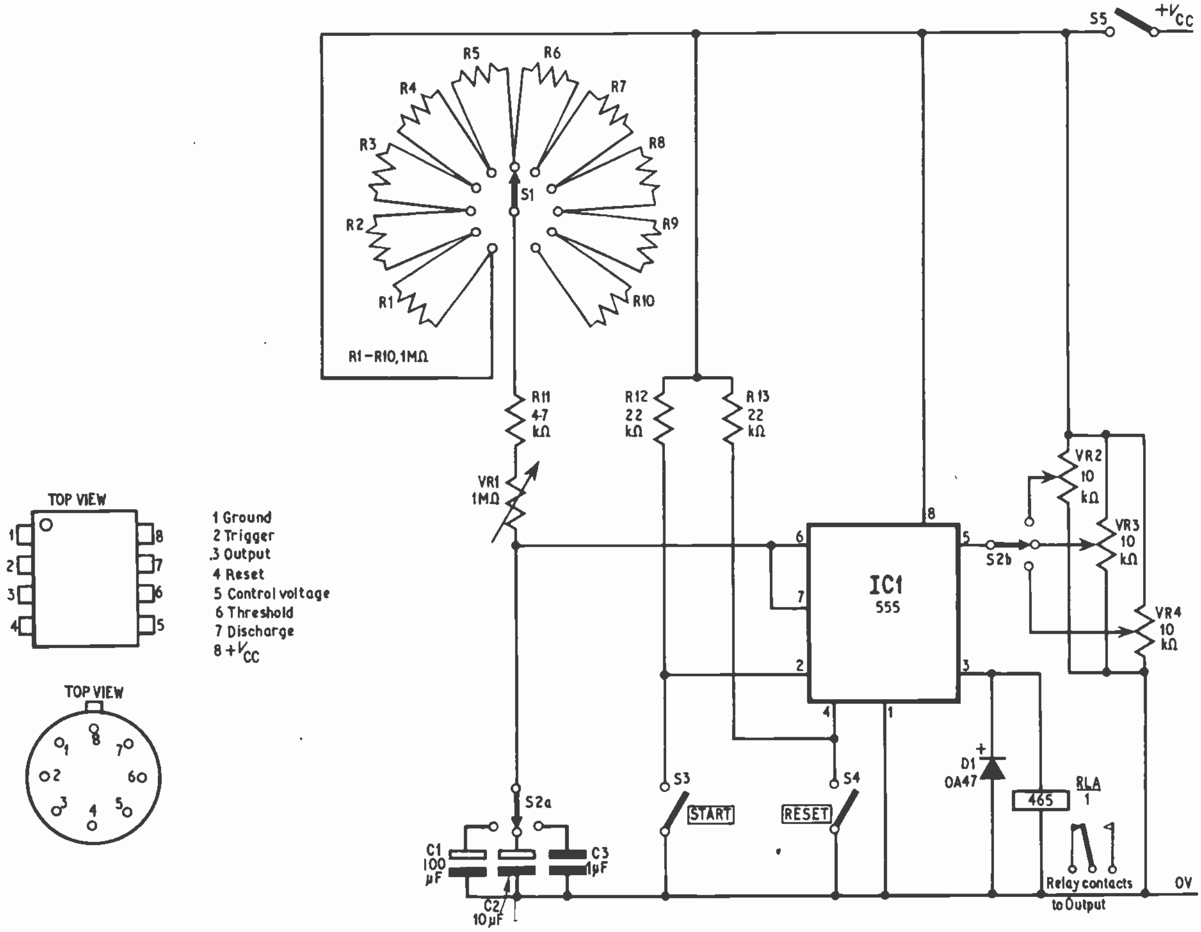
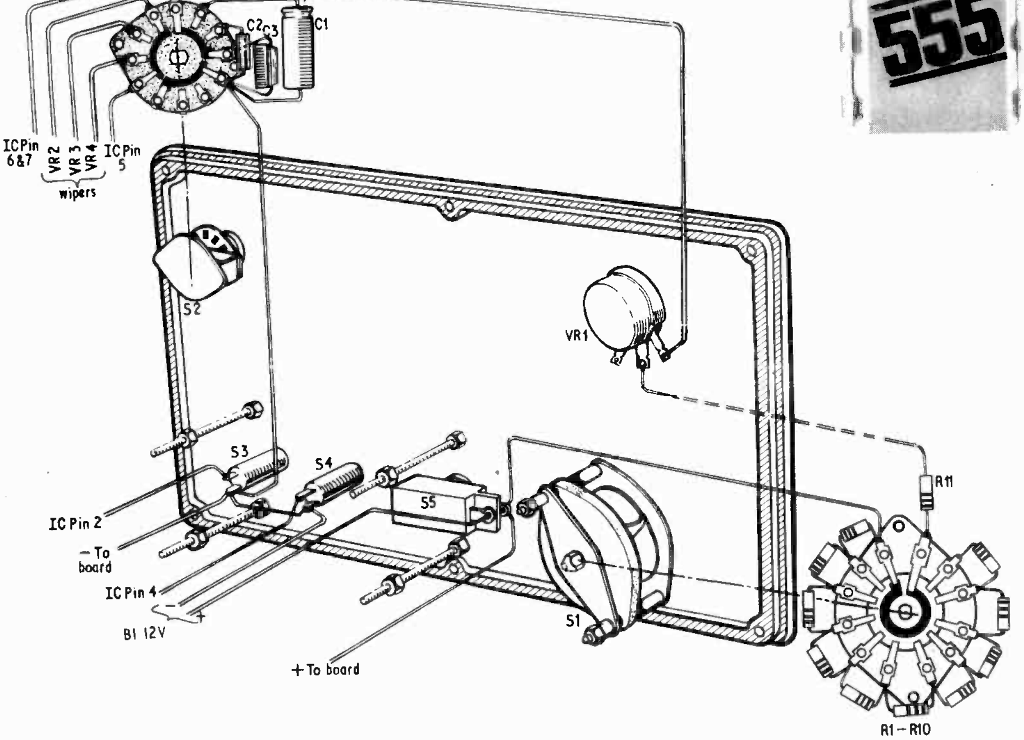


Fig. 1. Circuit diagram of the general purpose timer and the pin connections for the 555 i.c. in both DIL and TO99 case versions



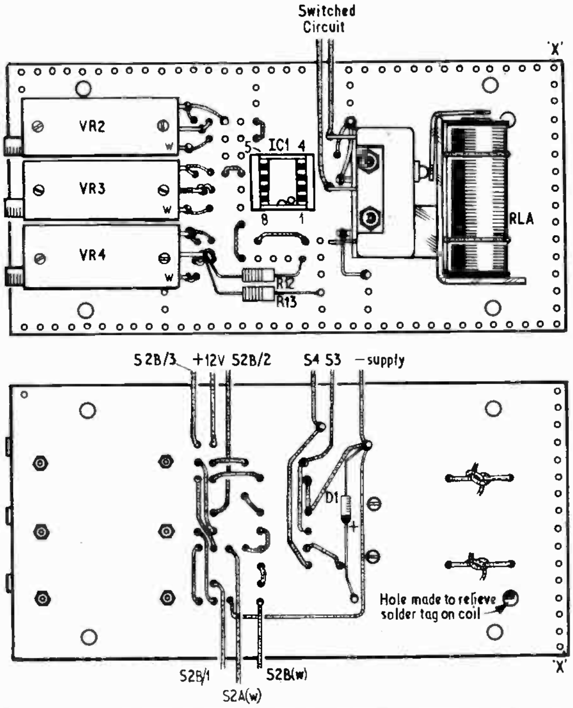
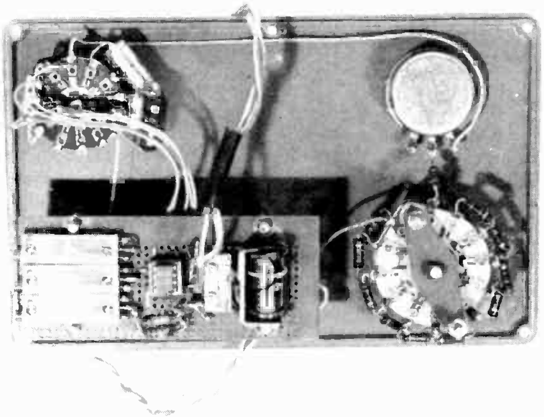


Fig. 2. The front panel layout with switch wiring detached for clarity. The top and bottom views of the circuit board showing disposition of components and interwiring is shown on the left



The completed timer with board and controls mounted in position expected. An error of 30 seconds in 1,000 seconds is therefore reasonable. Resistors of closer tolerance should be used if it is desired that the timing delays shall be as accurate as possible.

The tolerance of the capacitors C1 to C3 can be quite wide, since the potentiometers VR2 to VR4 allow a timing adjustment of over 10:1 on each range. For example, when the time was set to 20 seconds on the x1 range, adjustment of VR3 allowed any delay between 3 and 43 seconds to be obtained with the capacitor C2 used by the writer.

The 26-turn trimming potentiometers enable a very accurate setting to be obtained. The cheaper "skeleton" preset potentiometers could be tried, but it would then be necessary to connect fixed resistors between each side of these potentiometers and the power supply lines to make their adjustment less critical.

In selecting the component values, the factor of 1.1 in equation 1 of the previous article was neglected so that component values with round whole numbers could be employed.

START AND RESET

The trigger pin 2 and the reset pin 4 are normally biased to the $+V_{cc}$ potential through R12 and R13 respectively. This prevents unwanted triggering of the START or RESET functions by spurious voltage peaks.

It is especially important that pin 2 should normally be at the $+V_{cc}$ potential, since the triggering action is extremely sensitive. It has been mentioned earlier that the circuit exhibits spurious triggering at the end of each delay period if R12 is omitted; the relay then fails to open at the end of the delay time.

THE RELAY

The relay is connected so that it is normally open and is energised only during the timing delay. This minimises the current consumption of the circuit.

The relay used is a miniature micro-switch 12V, 465Ω relay, type MS1B which is available (through retailers) from Keyswitch Relays Ltd. The tolerance of the operating voltage is 20 per cent, so it will function with a coil operating voltage of 9·6 to 14·4V. The writer has found that a relay of this type will operate with less than 7V across the coil and the prototype circuit functions satisfactorily from a 9V battery. However, a 12V supply is ideal.

The MS1B is a printed circuit relay, but other versions are available including the totally enclosed plug-in version type MS1P. The MS1B can switch up to 5A at up to 250V in a.c. circuits; this is adequate for most purposes, since it can switch over a kilowatt at the normal mains voltage. In d.c. circuits the maximum recommended currents are 2·5A at up to 24V, 0·25A at up to 100V and 0·2A at up to 250V. Higher alternating voltages can be switched, since these voltages fall to zero many times per second and any arc which is formed is then broken.

THE DIODE

The diode in parallel with the relay coil shorts out the back e.m.f. transient voltages developed when the current ceases to flow through the coil. This prevents damage to the 555 timer.

It should be noted that either the type of diode specified or a similar gold bonded germanium diode should be used. The writer has tried a number of other types of diode in the circuit but many of these do not suppress the transient voltage across the relay coil adequately enough to prevent this pulse from re-triggering the circuit. If, therefore, another type of diode is employed and the relay does not open at the end of the delay period, re-triggering is almost certainly the cause.

CONSTRUCTION

All of the components are mounted on the lid of the die-cast box, since this provides maximum accessibility and ease of adjustment of the trimming potentiometers. The switch S1 is mounted in the position shown in Fig. 2 and the resistors R1 to R10 inclusive are mounted directly onto this switch. VR1 is mounted near to S1 with R11 mounted directly between these components.

The timing capacitors C1 to C3 mount directly onto the switch S2. The push-button switches S3 and S4 automatically open when they are released. They are mounted in line with the ON/OFF switch S5 under the circuit board containing the other components.

CIRCUIT BOARD

The circuit board used is a piece about 4 × 1·7in sawn off a Lektrokit board with holes spaced at 0·1in intervals into which metal pegs can be inserted. The board is supported by four 4BA long bolts at a little over one inch under the lid of the box clearing S3, 4 and 5.

The three trimmers VR2 to VR4 are mounted using 8BA bolts on one edge of the board where they can be easily adjusted as in Fig. 2.

An 8-pin dual-in-line i.c. socket mounts on the board, the solder on the pins holding it in position. R12 and R13 mount by the side of this socket. Care should be taken to ensure that the NE555V is always inserted with the correct orientation in this socket, since it is symmetrical and will fit in either way.

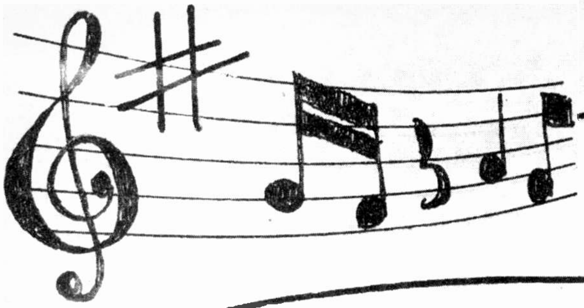
It is convenient to mount the relay on its side, cutting holes in the circuit board to accommodate any small projecting parts of the relay. In fact the wire connections to the relay can hold one side of this component to the board, the coil side being fixed by passing pieces of thin wire around the coil and tying the wire under the board.

The only component placed under the board is the diode in parallel with the relay coil. The wires connected to the board are made long enough to allow the board to be easily removed and turned over if it should require attention at any time.

USES IN PHOTOGRAPHY

The circuit is suitable for use as an enlarger timer in photography. The relay contacts are used to control the power to the enlarger lamp directly. The lamp is illuminated when the START button is released and is automatically switched off after the required time. This is much more convenient than having to estimate times or to peer at a watch in a dark room.

The circuit can also be used for timing the development of plates and films. The relay contacts are used to operate a buzzer or a small bell at the end of the required time. ★



AUTOTONE

By Renny Skagestad

THE making of music automates has been an attractive challenge to inventors for many years. In both the mechanical and electronic versions a variety of ingenious ideas have been applied. However, in general most of the systems are complex and expensive in their realisation.

The circuit to be described has none of these drawbacks.

BLOCK DIAGRAM

A block diagram (Fig. 1) indicates the operating principles of the Autotone. Here an astable pulse generator of fixed frequency switches on and off the supply feeding a shift register of four so advancing conduction from one stage to the next in sympathy with the pulse input.

Each conducting stage in the counter is preadjusted to provide a particular bias voltage to a tone generator so that variable pitch tones are available. The sequenced tones produced are further amplified and fed to loudspeaker.

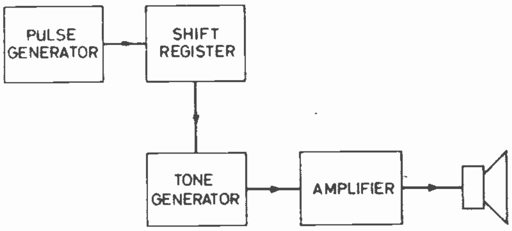


Fig. 1. Block diagram of Autotone

COMPONENTS . . .

Resistors

R1	47k Ω	R15	220 Ω
R2	33k Ω	R16	1k Ω
R3	33 Ω	R17	56k Ω
R4	6·8k Ω	R18	56k Ω
R5	33 Ω	R19	470 Ω
R6	1k Ω	R20	120 Ω
R7	10k Ω	R21	820 Ω
R8	1k Ω	R22	330 Ω
R9	220 Ω	R23	33k Ω
R10–R11	1k Ω (2 off)	R24	10k Ω
R12	220 Ω	R25	1·5k Ω
R13–R14	1k Ω (2 off)	R26	220 Ω

All ½ watt 10% carbon

Potentiometers

VR1–VR3 220k Ω vertical presets

Capacitors

C1	0·5μF to 20μF (see text) elect. 15V
C2	0·01μF elect. 9V
C3	100μF elect. 9V
C4	10μF
C5–C7	0·01μF (5 off)
C8	0·1 to 0·01μF
C9	100μF elect. 9V
C10	500μF elect. 9V
C11	100μF elect. 9V
C12	100μF elect. 9V
C13	200μF elect. 9V

Diodes

D1–D9 ISJ50 (9 off)

Transistors

TR1, TR3, TR4, TR6, TR8, TR10	2S104 (6 off)
TR2, TR5, TR7, TR9	OC200 (4 off)
TR11, TR12	AC126 (2 off)
TR13, TR15, TR16	AC128 (5 off)
TR14	AC127

Miscellaneous

BY1–BY2 9V batteries (PP9) (2 off)

Veroboard as required, LS1, 5in 3 Ω loudspeaker

PULSE GENERATOR

The complete circuit of the Autotone for four note generation is shown in Fig. 2. This can be increased for an eight note diatonic scale or twelve note chromatic scale by adding extra stages to the ring counter.

The pulse generator is made up of transistors TR1 and TR2. When voltage is first applied C1 starts to charge through the emitter of TR1. This transistor switches on TR2 and a regenerative switching action takes place until the voltage on C1 exceeds the base voltage of TR1 when conduction ceases.

C1 now discharges through R1 until conditions are right for the conduction cycle to start again.

The pulsating voltage at TR2 emitter switches TR3 on and off which itself is in series with one of the supply rails to the ring counter so this is also switched.

SHIFT REGISTER

When power is first applied to the shift register none of the stages normally conducts. But when C4 is switched in it starts to charge thereby giving TR5 the necessary base current drive to make the stage

CIRCUIT DIAGRAM

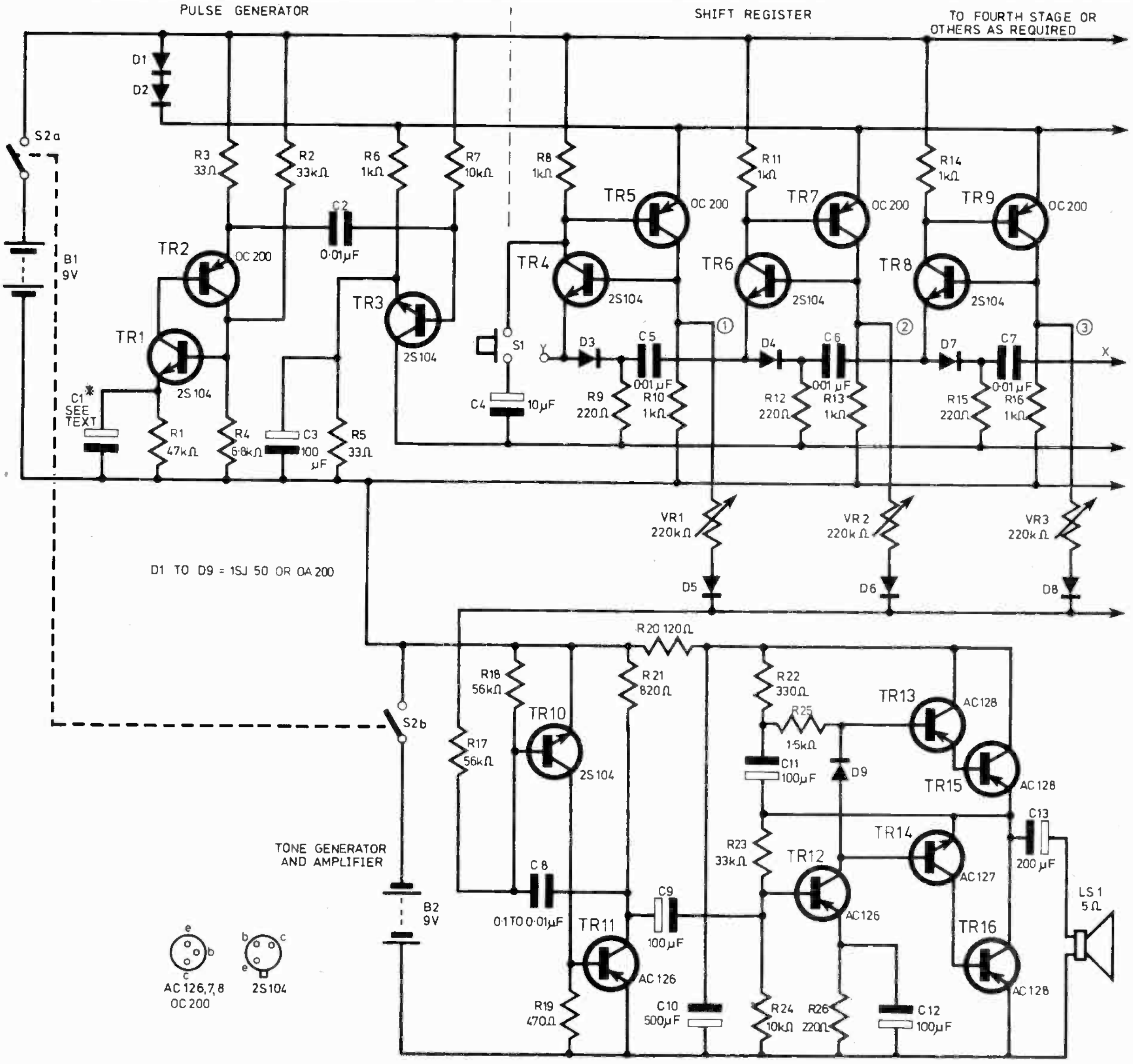


Fig. 2. Circuit diagram of Autotone. Only three stages of the shift register are shown but other identical stages can be added to as required

(TR4/TR5) conducting and an output voltage of about 8V appears at the top of R10. For this condition to exist TR3 must also be switched on.

When TR3 is pulsed off the first stage of the register ceases to conduct. However, since C5 is charged the bias conditions are correct for TR6 to conduct and hence TR7 when TR3 next switches on. This means that the 8V output now advances one stage to appear at the top of R13.

After the fourth shift, to maintain a cycling output, point X can be connected to point Y.

TONE GENERATOR AND AMPLIFIER

The outputs taken from the shift register via the presets (VR1-VR4) are used to give base bias to TR10. Both this and TR11 are wired as a high gain amplifier with C8 providing regenerative feedback for oscillation.

The frequency is partly determined by the base voltage at TR10 which depends in turn on the resistance of the presets with the given value of C8 this frequency can only be varied within a certain range.

WIRING DETAILS

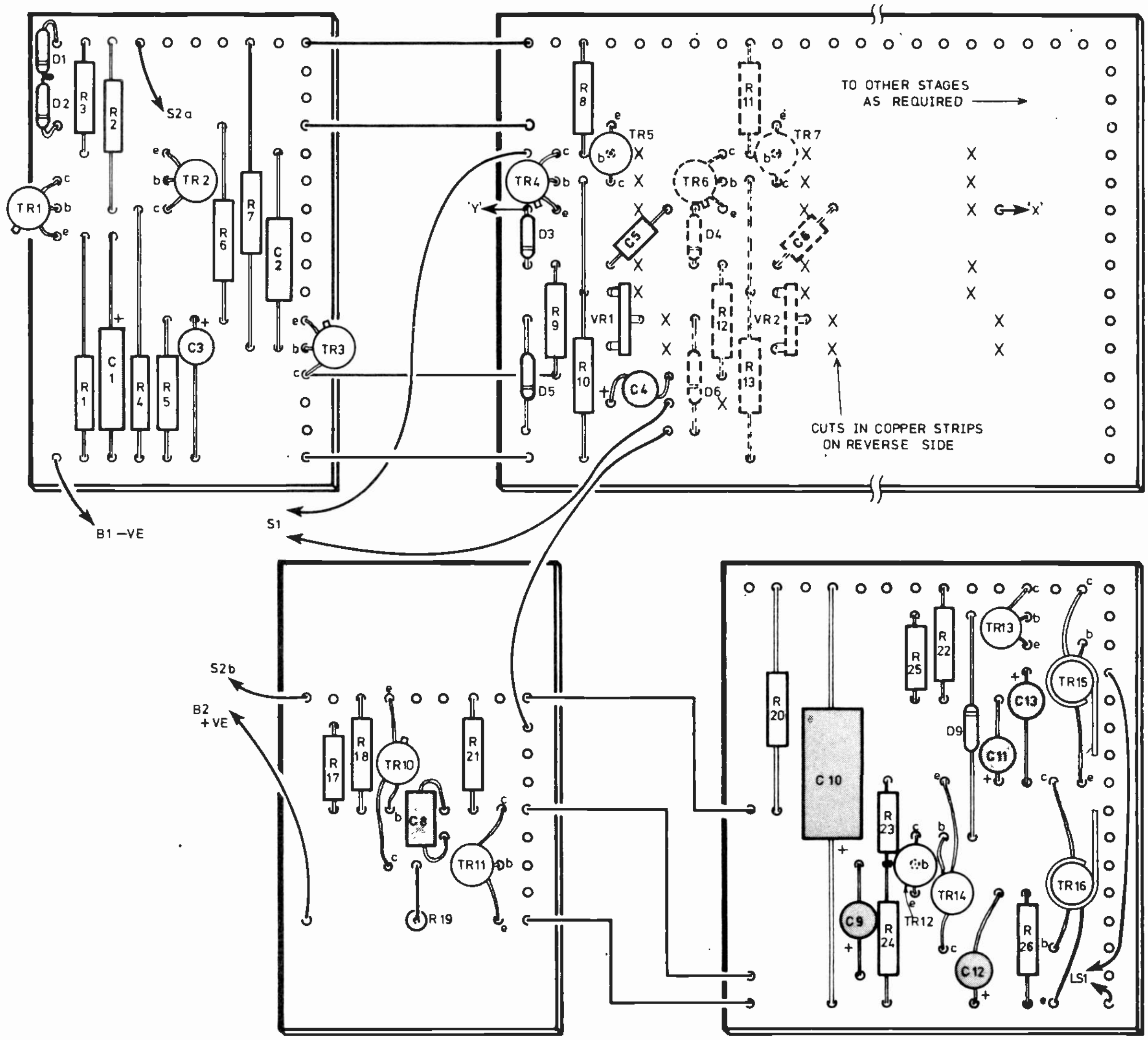
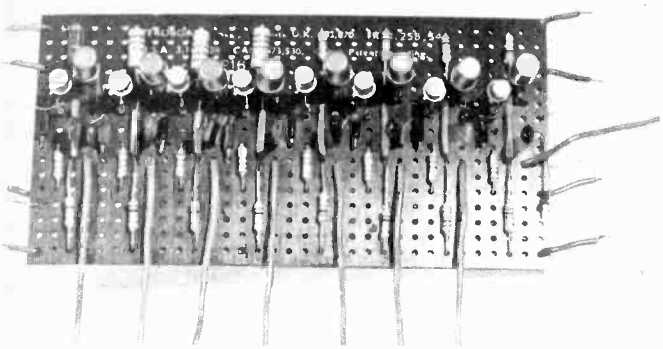


Fig. 3. Assembly and wiring details of Autotone Veroboards



Shift register board containing the eight stages for a diatonic scale. In this example the output potentiometers and diodes have been omitted and transferred to another board

To change this, values of capacitor from 0·1 to 0·1μF can be tried.

Tones generated are fed to a four transistor power amplifier. For experimental work the amplifier can be left out and an 80 ohm loudspeaker substituted for R21. In the circuit diagram two power supplies are used to avoid interaction.

CONSTRUCTION

The prototype unit was constructed on separate Veroboards as in Fig. 3. Of course, there is no reason why it could not be assembled on a single board, but it does make testing and servicing simpler to make the circuit elements modular.

TESTING

To test the pulse generator connect a crystal earpiece between the base of TR3 and negative line where a ticking should be heard if all is well.

By connecting a 10V meter (v.o.m.) across one of the output resistors R10, R13, etc., the action of the shift register can be checked by observing that the needle indicates about 8V at regular intervals with X and Y connected.

The tone generator can be tested by connecting a crystal earpiece across transistor TR11, and switch on. A lively oscillation should be heard.

COMPOSING MELODIES

If the shift register is extended to embrace eight or twelve notes there is no need to use all the outputs as the music will become uniform and dull. The melody will be more natural when some of the outputs are left out so achieving breaks or pauses.

In order to make certain tones last longer than others, the presets of two stages may be adjusted to produce the same tone giving the effect of sustain. The speed at which the shift register advances depends upon the value of C1. This may be altered to suit the melody being composed.

If C1 is reduced to around 1μF a special effect is achieved which makes the Autotone suitable as an exciting doorbell alarm. ★

NEXT MONTH

Electronic NOSE

Natural gas, petrol, butane, propane, alcohol and smoke, the Electronic Nose can "smell" them all. Its uses range from a simple breathalyzer to amuse your friends, to a detector for tracing lethal concentrations of odourless gas in the bilges of boats.

This easy to construct device uses a new gas detector and incorporates an audio oscillator for easy interpretation of readings. It also uses battery power for complete portability.

Twin Power Supply

A high quality power supply unit is invaluable in the workshop for testing and evaluating equipment. This design features excellent regulation and extremely low ripple voltage. It also has a feature normally restricted to the most expensive commercial units, an accurate current limit facility, allowing current to be held constant at anything up to the maximum of one amp.

Lighting Controller Unit

A simple thyristor light control circuit provides a variety of switching actions to give effects with lighting circuits including anything from Xmas lights to discotheques. Simple in construction and operation.

PRACTICAL ELECTRONICS

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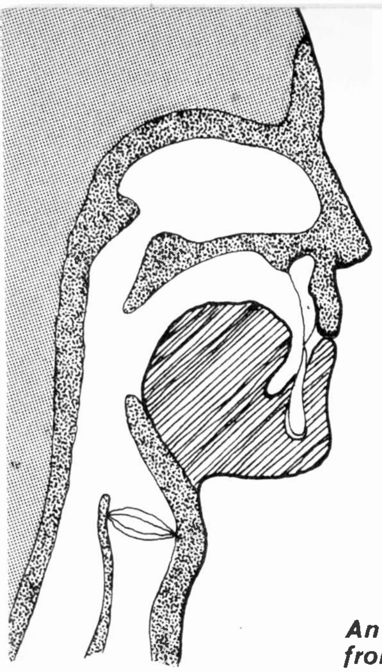


SPEECH SYNTHESIS

An account of the attempts to build a speaking machine from the eighteenth century to the present day.

By A. V. Flatman (North Staffordshire Polytechnic)

THE synthesis of speech is a subject that has preoccupied humanity for a long time. It has been a legendary precept and mystery since the eighteenth century. Today, again, this question conserves a mysterious aspect, because speech is concerned with human activity.

Research contributions date back almost two centuries to the "talking machines" of Kempelen and Faber, who, as pioneers, established a great understanding in the acoustic structure of speech, a science that later became known as *phonetics*. It was unfortunate, however, that the early synthesisers were limited to a purely mechanical and inefficient construction.

The mid-twentieth century arrival of electronics proved to be the technology all researchers were waiting for. The tape recorder and oscilloscope made possible the acoustic spectrogram or "voice print" for analysis and synthesis of speech waveforms, whilst computer automation has effectively "untied" the operator's hands.

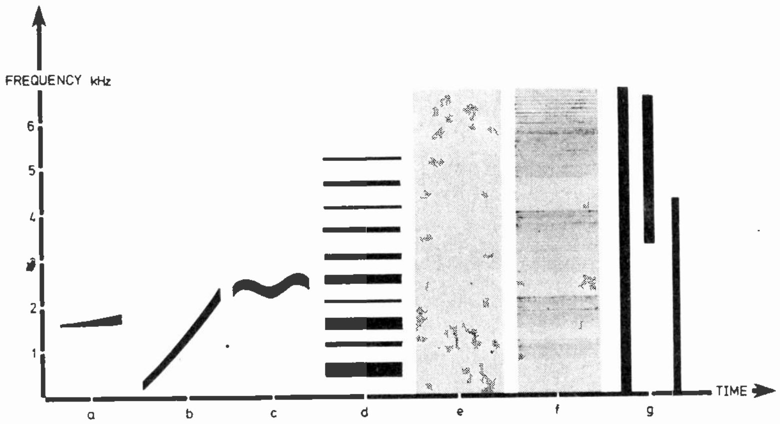
SPEECH ANALYSIS

Before the various techniques of synthesising speech are examined, we must first analyse its acoustic formation.

All acoustical signals can be represented in a *sonogram* or acoustic spectrogram; this is simply a graph of frequency plotted to a base of time, with acoustic intensity shown as line thickness. Fig. 1 gives examples of sonograms for elementary sounds.

When a complex sound enters a resonator, the harmonics near the resonant frequency will be amplified to add a certain "colour" to the sound. This frequency zone is known as a *formant*. Fig. 2 shows the effects of fixed and variable resonant frequencies on several types of acoustical signal.

English spoken in Britain can be broken down into approximately forty fundamental sound units called *phonemes*, the acoustic formation of which may be demonstrated with the aid of the human speech apparatus shown in Fig. 3.



(a) Simple sound of increasing amplitude
(b) Simple sound of increasing frequency
(c) Vibrato
(d) Harmonic sound
(e) White noise
(f) Coloured noise
(g) Noise impulses

Fig. 1. Sound spectrogram for some elementary sounds

The human speech system comprises several resonant cavities which have the ability of superimposing variable formants upon the complex sounds issued from the vocal cords. One particular vocal sound, with suitable formants to produce certain yields of frequency, will acoustically represent the vowels.

Consonants, on the other hand, are a little more complex in formation. Some consonants are purely breathing noises, from the roof (sound "CH"), teeth (sound "S") or in between the teeth and lips (sound "F"); whilst others may be explosive noises produced by sudden releases, from the roof (sound "K"), teeth (sound "T") or lips (sound "P").

Spoken messages may be analysed pictorially with the aid of the acoustic spectrograph. However there are two characteristics of speech which present difficulties. Firstly, speech has a continuous appearance and is rather difficult to segment into its various phonemes. Secondly, the useful or semantic information in speech is modified somewhat by a "tone of speech" reflecting the speaker's mood.

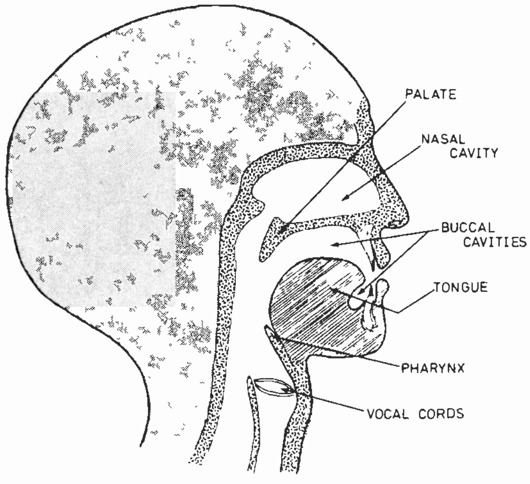


Fig. 3. Diagram of the human speech apparatus

THE KRATZENSTEIN RESONATORS

One of the earliest efforts at speech synthesis was made by Kratzenstein at the Imperial Academy of St. Petersburg in 1779. This mechanical speaking machine comprised a set of acoustic resonators somewhat similar in size and construction to the human mouth. With a vibrating reed similar to that used in the harmonica, he mimicked the vocal chords by interrupting the airstream in each of the resonators to synthesise the five vowels with tolerable accuracy.

THE KEMPELEN SPEAKING MACHINE

Kempelen's speaking machine, which was made in Vienna in 1791, is shown in Fig. 4. One can observe the relative simplicity of the results of Kempelen's research into the problems of speech synthesis. After some practice, the operator could manipulate this machine to synthesise a somewhat limited vocabulary. Whistles are used to give the "S" and "CH" sounds and a reed to give the "R" sound, whilst the rubber mouthpiece is controlled alone to generate the vowels and in conjunction with the bellows to produce a variety of explosive consonants.

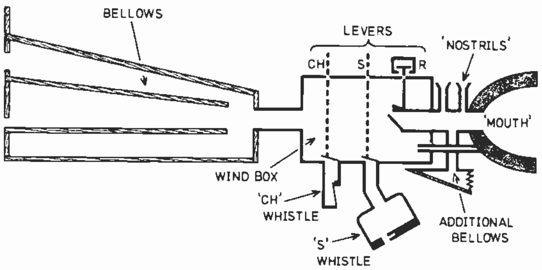
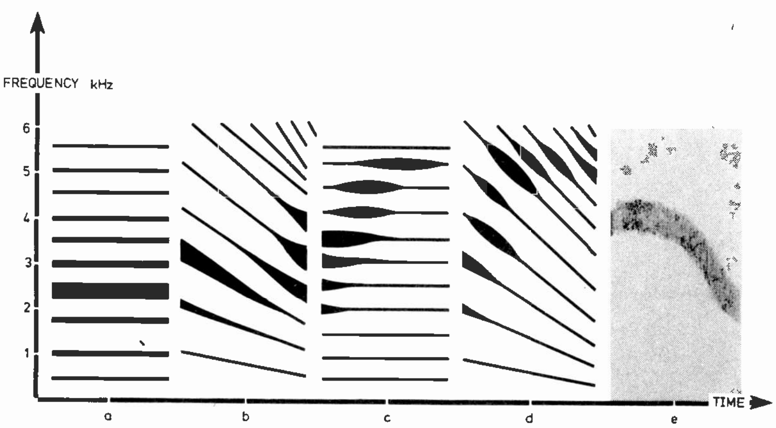


Fig. 4. Cross sectional diagram of Kempelen's speaking machine



(a) Fixed formant on fixed spectrum

(b) Fixed formant on variable spectrum

(c) Variable formant on fixed spectrum

(d) Variable formant on variable spectrum

(e) Variable formant on continuous spectrum (noise)

Fig. 2. Some different ways of representing formants

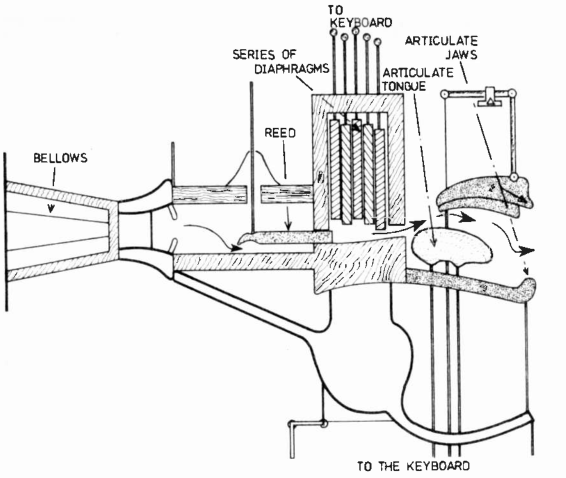


Fig. 5. Cross sectional diagram of Faber's speaking machine

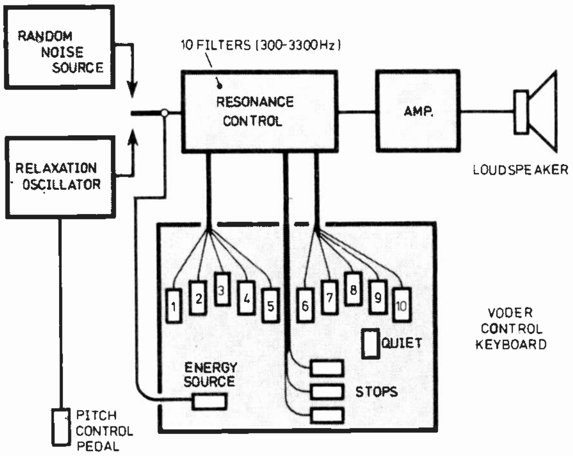


Fig. 6. Diagram showing the basic principles of the Voder

THE MACHINE OF FABER

Faber, professor of mathematics at Vienna, finished a speaking machine in 1835, which created a vast amount of interest and curiosity throughout Europe. Faber put into practice many of Kempelen's theoretical suggestions for improvement, which subsequently contributed to the success of the new machine. The strongest aspect of Faber's research was, however, his consideration of the operator in the use of a keyboard selection technique as shown in Fig. 5. For a century afterwards, many scientists attempted to expand upon the theory of Faber, unfortunately without much success.

THE VODER

The first electrical analogue speaking machine was built by Dudley in 1939. The Voder (VOice DemonstratOR), shown in Fig. 6, comprises ten filters whose passbands are uniformly distributed between 300 and 3,300Hz. The filters are stimulated with white noise or with a signal rich in harmonics. A keyboard controls the frequency and amplitude of the stimulus as well as the filter selection. Manual operation of the machine was again rather complex, and although the phonemes were relatively accurate in reproduction, they could not be linked efficiently to synthesise continuous speech.

Nevertheless, the Voder represents a new and promising approach in speech synthesis. We will examine in sequence the four types of synthesisers which are used at present: the Vocoder; the Analogue Synthesiser; the Playback; and the Units of Verbal Response.

ELECTRONIC SPEECH SYNTHESIS

Dudley's invention of the Voder marked the beginning of several decades of intense research on both sides of the Atlantic. The new understanding of information theory demonstrated that the telephone bandwidth (300 to 3,300Hz) was exceedingly large for transmitting the semantic information of

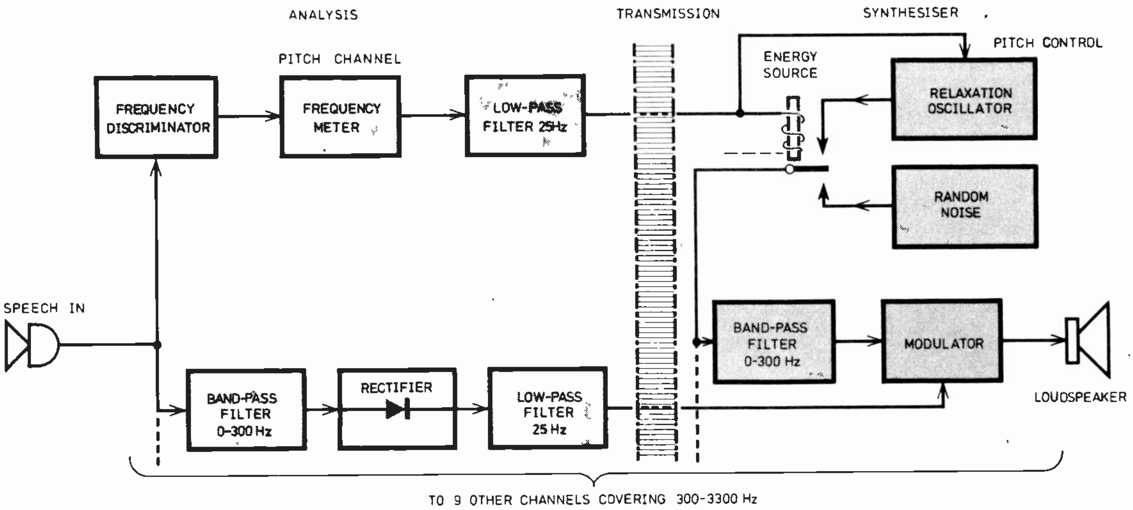


Fig. 7. Block diagram showing the principle of Dudley's Vocoder

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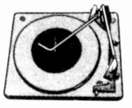

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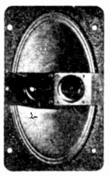

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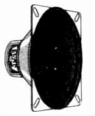

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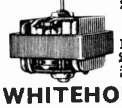

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speech. The telephone allows a data transfer rate of 20,000 binary bits per second, whilst that of the semantic content of speech rarely exceeds 100 bits per second. Speech synthesis then discovered a new field of application in communication system bandwidth reduction, by suitable phoneme encoding.

THE VOCODER

Dudley expanded upon the principle of his Voder to develop a system which greatly reduced the bandwidth of a communication channel. The Vocoder (VOice CODER) analyses incoming speech by initially splitting it into ten frequency bands by suitable filtering and then obtains the modulation "envelopes" of each band by rectifying and low-pass filtering.

Fig. 7 shows how ten separate channels are used to link the analysed or "encoded" speech to the corresponding filters in a Voder. Incoming speech pitch is sensed in a similar way and an eleventh channel is used to select the appropriate energy source in the Voder system.

The Vocoder transmission bandwidth is within 300Hz (11 channels each of 25Hz) and represents a great saving in this respect. Synthesis takes place in the established Voder system, which is now operated electronically to reproduce intelligible speech with tolerable continuity.

THE ANALOGUE SYNTHESISER

The principle of this machine consists more of simulating the function of the phonetic organs, rather than synthesis via analysis. The pharynx and buccal cavities of the human speech apparatus are firstly considered as the three damped resonators shown in Fix. 8; X, Y and Z respectively. Sound is emitted from the vocal cords into the first resonator X, then via the narrow passages to the resonators Y and Z, to result in the emergence of the combined sound, Un + Um.

Fig. 8 also shows the electrical analogue of the resonators X, Y and Z, where electrical properties of resonance; damping, etc., are matched to the properties of the acoustic resonators. The circuit will then act in a similar way to the phonetic organs if stimulated by the appropriate electrical signals, Ug.

Bell Telephone Laboratories have recently developed an extremely useful aid in the study of speech synthesis. It is a simulator in which the value of each component in the electrical analogue is controlled by a computer, at the same time a cross-section of the corresponding phonetic organ state is displayed on a screen.

Programmes have subsequently been written to electrically simulate the phonetic organs with some degree of success. Unfortunately, the rate at which the electrical circuit will deal with successive phoneme simulation is not fast enough for continuous synthesis; however, this technique appears to be very interesting for the physiological study of phonetics.

THE PLAYBACK

Acoustic engineers have demonstrated that all information in speech may be detected on the acoustic spectrogram. Conversely, speech may be reconstructed by careful manipulation of a suitable acoustic spectrogram, as seen in the playback synthesiser. The Icophone, whose principle is shown in Fig. 9, is the most recent synthesiser to use the playback technique.

The principle of the Icophone is quite simple. Opaque zones of the acoustic spectrogram represent zero speech content and allow transmission of a narrow beam of light to the corresponding photoelectric cells. Each cell, in turn, represents a spectrographic frequency zone and controls the continuity between each of the 44 oscillators and the blender. Intonation of the synthesised speech is controlled by the adjustment of each oscillator output level and the switching thresholds.

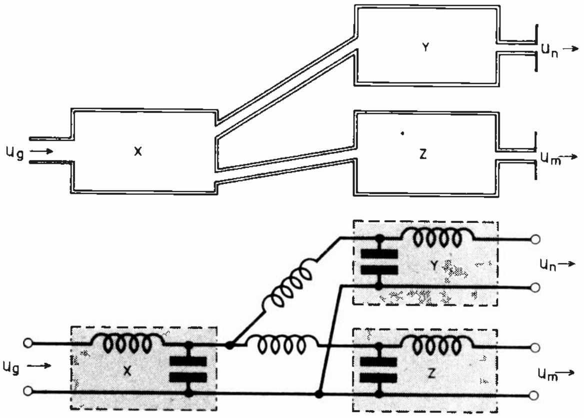


Fig. 8. Analogue synthesis of phonemes by simulation of three formants

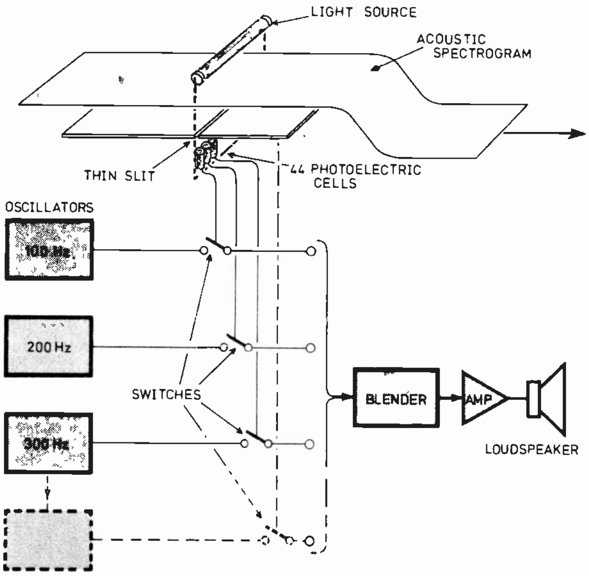


Fig. 9. Diagram showing the principle of the Icophone

Accurate feeding speeds of the acoustic spectrogram result in intelligible synthesis of phonemes and prepared speech. The ultimate and most flexible system of "real time" synthesis from a library of prerecorded phonemes, however, proves to be somewhat inefficient due to the time taken in phoneme selection.

To overcome the inherent drawbacks of electromechanical synthesisers, digital computers have been used to synthesise speech by the playback principle. Semantic information of the basic library of 40 phonemes is digitised in the frequency, time and amplitude domains and held in a digital store (core-store, magnetic drum or disc).

The computer is then programmed to "empty" the contents of certain parts of the store sequentially with sub-millisecond speed, to synthesise a more efficient or continuous speech. Computer synthesis techniques have produced the most accurate subjective results to date, but unfortunately the amount of computing power required is both demanding and costly.

VERBAL RESPONSE UNITS

Certain large makers of calculating machines have commercialised some units of verbal response. These machines allow a computer to answer, in verbal form a question put by the user in coded form, using, for example, the ordinary telephone dial. This system has an immense future in some applications.

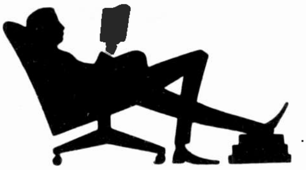
Words and phrases are prerecorded on tape and "linked" by computer programme to form a verbal output of a wide range of systems. Having a somewhat limited flexibility one would usually find this type of synthesiser performing specialised tasks of varying complexity, from the "speaking clock" to a verbal instruction generator in an aircraft flight simulator.

THE FUTURE

We have progressed from the relatively inarticulate, mechanical experiments of Kempelen and Faber to the "talking computers" of today. The recent appearance of electronics and the computer have somewhat altered the design philosophy of speech synthesisers. Dexterity, a prominent operator requirement of the past, has been replaced by the modern tool of computer programming.

Nevertheless there remains much room for improvement of today's synthesisers. Imagine the potential of an efficient, flexible, compact and inexpensive "text to speech converter"! It not only has applications in business and education, but think of the way in which it could make the lives of dumb or blind people that bit more bearable.

Speech recognition, an associated field of speech synthesis, is still relatively unconquered. The automatic recognition of speech is a much more difficult task due to the fact that a machine must cope with the enormous amount of variation in human speech, whereas synthesis of different pronunciations of words is normally not required. Obvious differences occur in accent, but considerable variety in pronunciation is present even with the same speaker. Further problems arise in recognition because the speech wave cannot easily be segmented into appropriate words or phonemes. ★



BOOK REVIEWS

ELEMENTS OF LINEAR MICROCIRCUITS
F. D. Towers, M.B.E., M.A., B.Sc., M.I.E.R.E.
Published by Iliffe Books (Butterworth & Co. Ltd.)
108 pages, 6in × 8½in. Price £2·80

A MAJOR growth area is represented by linear microcircuits. After a late start, following the digital devices that really established the microelectronics industry, the linear form of integrated circuit is now well established and the future holds promise of ever increasing varieties of circuit for all kinds of application.

Therefore, this book is welcome. It is based on a series of articles published in *Wireless World* and provides a compact, readable digest of the subject. Because the rate of development in this field is so rapid it cannot include the very latest developments; nevertheless it is a very useful reference book. It includes practical information in the form of lists of manufacturers, component coding methods, and advice concerning the handling and use of these devices.

A chapter is devoted to each of the major categories of device, e.g. a.f. amplifiers, operational amplifiers, r.f. & i.f. amplifiers, and voltage regulators. The circuit configurations of many typical commercial devices are illustrated and described in considerable detail.

D.D.R.

ELECTRONICS—A COURSE BOOK FOR STUDENTS
G. H. Olsen, B.Sc., M.I.E.R.E., M.Inst.P.
Published by The Butterworth Group
351 pages, 6in × 8½in. Price £2·60

WITH the continuing movement of electronics into almost every other walk of life it is becoming increasingly important for students of all disciplines to be aware of the vagaries of the art. Thus any volume which eases this understanding is to be welcomed and the present document is specifically designed with this end in mind.

In fact the book is a shortened version of the successful "Electronics: A General Introduction for the Non-Specialist" and it manages to take the reader through basics right up to the complexities of integrated circuit operation without any noticeable reference to mathematics and abstruse formulae.

Included, of course, are suitable references to matters of measurement and suitable indicators, power supplies and their construction, amplifiers and oscillators.

Wherever possible the author has illustrated his text with sufficient clarity for the competent to construct many of the items discussed. Indeed, much of the equipment discussed by way of application details is culled from component manufacturers' application notes.

The author is principal lecturer in the Department of Physics and Physical Electronics at the Newcastle upon Tyne Polytechnic and he is concerned with the electronic content of C.N.A.A. degrees, organising post-graduate courses in electronics, and with consultancy in the field of electronic design.

J.V.

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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
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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
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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
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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
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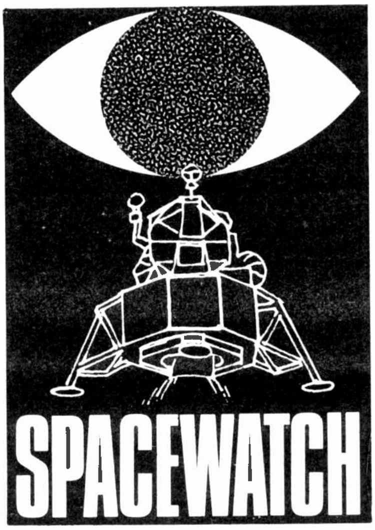


BY FRANK W. HYDE

RINGS OF SATURN

Once again a theory has been challenged by a practical test. The original theoretical study of Saturn's rings was made by Clark-Maxwell. He gave as his opinion that these rings must be dis-continuous and made up of discrete particles.

This view was accepted by astronomers and until recently the generally recognised explanation was that the particles were ice crystals or accretions of dust. This appeared to be a satisfactory conclusion since the thickness of the rings is around 1·0km, although the diameter reaches some 85,000km.

Now as a result of studies made at Goldstone, California, two researchers R. Golstein and G. Norris, have suggested that the rings consist of boulders approximately 1·0m in diameter.

They used the large Goldstone radio dish and a power of 400kW to direct a beam to the planet 700 million miles away. The beam, using a wavelength of 12·5 centimetres, calculated boulder size from the reflected signal.

This new finding represents a considerable hazard to spacecraft and it may well be that there are scattered lumps of rocks at higher and lower latitudes. The discovery prompts the thought that perhaps the rings are after all the debris of a former satellite.

The approach of the present programmed probes will be close enough to check the conclusions that have been made and possibly even photograph the rocks.

ASTEROID BELT

The safe journey of *Pioneer 10* through the asteroid belt has caused a sigh of relief from the scientists planning the missions. The knowledge that the density of the belt and the size of the particles which differs considerably from the former conjectures will enable plans for future probes to go forward with confidence.

The size of the particles in the belt were between 100 micrometres and 1·0mm. Nothing larger than 1·0mm was encountered all the way out from the earth's orbit. Even those of 1·0mm size were rare. It seems, therefore, that the belt is composed of the 17,000 to 20,000 identified asteroids and very fine dust. During the whole period of the transit through the belt *Pioneer 10* did not have one of the known asteroids in view.

COMPUTER INTEGRITY

A short time ago the possibility of a tenth planet was raised again. Observers have been unable to locate it and computation did not supply sufficient information for a search.

A new attempt at the three body problem was tackled again recently and out of this exercise came the conclusion that residual errors, which are unavoidable in a computer analysis of data, will always predict a planet or body. It seems therefore that this situation rebuts computer integrity for problems such as this.

TECHNICAL EUTHANASIA

At the press of a switch Sir Brian Flowers FRS, Chairman of the Science Research Council put an end of the life of *Atlas 1*. This computer, the most advanced design in the world when it was installed, had come to the end of a useful life because it was old and its transistors germanium. The availability of spares and the high cost of maintenance made the euthanasia decision imperitive.

The computer which dealt with the pilot data from weather satellites, retrieval of data from *UK 3*, and other space projects was designed by a team at Manchester University under Dr (now Prof.) T. Milburn. It contained a supervisory system which has only quite recently been emulated.

The work will now be taken over by a 1906A and a 370/195 which is already dealing with *UK 4* and *Essa 8*. These two computers are, of course, much faster than *Atlas 1*. The main activities of *Atlas* have been concerned with theoretical chemistry and crystallography. There is no doubt that the decision to set up the enterprise of the *Atlas* Laboratory by the Research Council was a wise one and the original investment justified by results.

ORANGE SOIL OF THE MOON

The excitement of the discovery of the orange soil on the moon, thought to be iron oxide, has now been rather dashed by the findings of the investigators. It seems that the soil is made up of grains of glass.

It is thought that the soil has only been exposed to cosmic rays on the surface for about 8 to 10 million years. When the material was formed, which would be about 3,700 million years ago, it was buried deeply and not exposed to cosmic rays. It was thrown up later by meteoric impact and not by volcanic action of the Shorty crater even though it is of recent formation.

The orange soil is the finest grained that has been found on the moon and consists of coloured glass in droplets and fragments. Chemically the samples from the *Apollo 17* mission are the same as those from the *Apollo 11* mission which was several hundred miles away. There is, however, a difference in that the *Apollo 11* samples were not so rich in zinc.

LUNAN PROBE

In the March issue of *Spacewatch* mention was made of the work of D. A. Lunan regarding the possibility of a probe being situated in the orbit of the Moon. This was suggested to have originated from Epsilon Boötes a star in the constellation of that name and at a distance from the Earth of approximately 105 light years. The whole matter has caused some stir and the paper was given before a large audience in Caxton Hall in March this year.

There has been a further development in this matter and America has now taken an interest in the project. Originally a project named *OSMAR* was initiated by Frank Drake and Carl Sagan in America. This was subsequently abandoned but a new project for which a very large Radio System is being set up is to be undertaken. This involves a system of aerials in a line 25 miles long.

A more modest project is being set up in this country based on Lunan's suggestions. It is called *GOLDE* (Ground Observations of Long Delayed Echoes) and is to be operated under the aegis of the British Interplanetary Society. This is a project in which the help of amateurs is required.

The principle of operation is to send a strong signal to the place where calculations show that the probe should be and time the echoes which may come back. EMI have loaned a special set of equipment to help the project, which will be in operation for a long time. From America has come an offer to participate in the programme. This is from Stanford University where a large dish is available.

The British team is lead by D. A. Lunan and A. T. Lawton who would welcome amateurs who are interested to take part in this experiment.

The Transistor and Beyond

By Prof. G. D. Sims, O.B.E., Ph.D. (Head of Dept. of Electronics, Southampton University)

AN APPRECIATION OF THE CHANGES ALREADY BROUGHT ABOUT AND AN EVALUATION OF FUTURE PROSPECTS

1973 marks the 25th anniversary of the announcement of the transistor and few in 1948 would have forecast the immeasurable impact which it was to make on the evolution of our society. Since that time "electronics" has seen the appearance of a continuous stream of new devices and "systems" for communications, data processing and control, and our pattern of living has been affected by these developments in a multitude of ways.

FROM SMALL BEGINNINGS TO A SMALLER FUTURE!

Looking back, it was clear that once the junction transistor had been produced, the day of the thermionic valve was limited, though the uptake of the new technology by U.K. industry was relatively slow. Certainly, at that time, both the educational and practical problems associated with its use were formidable, but since, there has been a steady adaptation to solid state devices in almost all low-power applications.

The new "active devices" were no longer necessarily expensive and as the new "systems" emerged, they grew in complexity, bringing new problems associated with "statistical" device and wiring failures. A solution had to be found and once planar technology had been mastered, the ultimate emergence of the microcircuit was inevitable: this, in its turn, brought still lower cost, greater reliability and, as a bonus, yet smaller size. We were now able to buy a complete amplifier, in a single can, while even more significantly logic families and complete integrated digital sub-systems, such as counters and shift registers were also available.

SYSTEMS

At this point, the revolution in basic electronic techniques took a new turn, for now quite massive systems could be envisaged, of which the control systems for the Apollo missions were perhaps the most challenging and spectacular.

In parallel with these developments new information storage techniques were emerging and "memory", whether in semiconductor or magnetic form, is now another readily purchaseable item.

Memory, together with faster digital techniques, now enables us to envisage future "super-systems" capable of working at data processing rates which were quite inconceivable in 1948. Whereas at that time a microsecond pulse was short, now nanosecond pulses are everyday things and picosecond pulses are beginning to be considered for the communication systems of the future.

These have all been direct effects of the development of the transistor and have often diverted attention from some equally important side-effects, not the least of which was the awakening of interest in the properties of "pure" materials generally.

MATERIALS

The development of semiconductor materials, which first took us from germanium to silicon, soon turned to other materials such as gallium arsenide. This has since given us power devices at microwave frequencies and possibly, of even greater importance, useful infra-red solid state lasers. Subsequently, gallium phosphide has arrived and using much the same *pn*-junction techniques as those employed at low frequencies, we now have compact alpha numeric indicators in this material and its derivatives.

We came to realise, too, that glass could be an important material and "Ovonic" storage devices using switching properties in glass offer great potential, even though, at the moment, they remain little understood and unreliable. We had already accepted that ceramics had their uses, too, whether for substrate materials or in more esoteric combinations such as with ferroelectric glasses, whose interesting optical and piezo electric properties suggest many potential applications.

It would be no exaggeration to say that all of the major device developments which have taken place since 1948 have arisen either from the utilisation of *new materials* or from improvements in *materials technology* which enabled us to use already known materials properties more efficiently than before.

DESIGN CONSIDERATIONS

In order to exploit our devices, in the new systems, it became necessary to marshal a whole new battery of design techniques: the simplest of these were concerned with the design of logical systems, and switching theory has now become an important tool in the hands of almost all electronic engineers. Further, as systems have grown in capability, the designer has had to find other means for carrying out the kind of routine calculations which hitherto had been his main occupations.

If a computer aided design programme could provide details of how to design a filter, or a feedback circuit, it was clearly sensible to use it rather than to waste valuable professional time on "chores".

With the bigger systems, it is seldom practicable to "bread-board" everything in the initial design stages. Thus simulation techniques, in which systems are modelled on computers, have also developed apace.

Finally, and perhaps most important, is the growing pre-occupation with systems reliability, and design for maintenance ("terotechnology"). These considerations have to be taken into account at the outset of the design process and wherever possible systematic calculations must be performed to put *realistic* limits on component life.

Long component life is an expensive commodity and whilst it is essential that the system is *reliable enough*, it is seldom that excessive reliability can be justified. Perfectionism is all very well but it costs money!

THE YEARS TO COME

What then of the future?

At the system level we have already spoken of the "super-system" which will provide a communicating power, exceeding by orders of magnitude that are available at the moment. This, using faster digital techniques and optical fibre waveguides, will open up the almost unlimited bandwidths available at optical frequencies and will allow many new possible applications of video systems, such as information retrieval from the local data bank or library and generally "instant-optical communication".

At the device level it is not easy at the present time to envisage a replacement for the silicon integrated circuit, though as technologies evolve, we are already seeing a noticeable movement from bi-polar techniques to MOS processes, particularly in relation to the new forms of solid state memory.

VACUUM TUBE SURVIVORS

In the area of general electronics, the cathode ray tube and imaging tubes remain apart, as almost the sole survivors of the vacuum tube era—but for how long?

We are already seeing important developments by way of self-scanned solid state silicon arrays which may soon challenge vacuum image tubes for some applications: new ideas are continually emerging in the use of new materials for image storage: new techniques also appear for writing, both with light and electron beams, either on photochromatic materials or thin films, for data recording purposes.

At the moment, notwithstanding, the cathode ray tube as a "picture tube" appears to be secure, for as yet nothing fast enough can challenge it. The same remains broadly true of "power" tubes where as yet solid state devices have made a limited impact—though undoubtedly their time will come, too!

THE ENGINEER AND TECHNICIAN

Implicit in our discussion above is the suggestion that the roles of the engineer and the technician in electronics have also changed. The subjects of fundamental importance to either remain much the same, but the achievable level of complexity is now so great that many engineers must be less-concerned with circuit detail than with the properties and specification of the overall system and its organisation. The technician at the same time has a task which, although it may in some respects be simplified through the microcircuit, is in other ways more complicated, requiring a greater overall understanding of electronics as a whole.

EDUCATION

For those in education, the scene has been changing continually and the challenge is unrelenting. Graduate courses remain at three-years and, somehow or other, competently educated engineers must be produced in that time. As always, the education has to be mainly concerned with fundamentals and with developing, within the student, the ability to continually self-update his knowledge, in his subsequent professional life in Industry. At the same time, however, he requires an awareness of the attitudes and practices of the contemporary world and the task of balancing these needs is a delicate one.

THE VITAL AREAS

The areas above all in which more effort is needed, if the student is to cope with the changes which the future will bring, are probably the two mentioned above, viz. "Materials" and "Systems".

For the man who is going to be concerned primarily with devices, materials have assumed an importance many times greater than was appreciated 25 years ago: while for the designer of "capital goods", the systems considerations which could be overlooked when the radio set represented the ultimate challenge in complexity, are now at the forefront!

Circuit theory, of course, remains as important as ever, but, to it, we have had to add logic design and some indication of how we can check our ideas and translate them into practical terms through CAD and simulation.

Thus the education sector has had to learn and adapt rapidly, too, and it is vital that it should continue to do so, for the industry is critically dependent on an assured inflow of high quality personnel.

PROSPECT

Despite the recession, the half-million strong electronics industry of this country has been remarkably successful and will be of key importance both nationally and to the EEC, in the years to come.

Just as the development, successively, of the telephone, radio, television, and the computer have all marked stages in a revolution which has been social as well as technical, the super-systems of the future will change our habits still more. It has been, above all, the invention of the transistor which has accounted for the continually accelerating pace of this social revolution, which began, so innocently, with the invention of the thermionic valve at the turn of the century! ★

THIS month the module containing the Sample and Hold circuitry and Noise Generator is described together with application details.

SAMPLE AND HOLD

The Sample and Hold shown in block form in Fig. 5.1 is another programming device which is capable of producing formalised staircase waveforms (Fig. 5.2) or random staircase waveforms. In both cases the "rise" of each step in the staircase is dependent upon the amplitude of the voltage being sampled while the "tread" of each step is governed by the sampling rate set by the clock.

The clock itself consists of two separate circuit forms as shown in the theoretical circuit diagram Fig. 5.3. The first is an astable multivibrator (IC1) in which the rate of oscillation is variable between 0·25Hz and 50Hz. The circuit switches alternately between its positive and negative saturation levels so that, for 15 volt supply rails, the output voltage swing is of the order of 28 volts.

The second circuit form is a monostable multivibrator (IC2) which is triggered by the negative going steps of the astable squarewave thus producing a pulse train of the same frequency. This circuit also switches between its positive and negative saturation levels. In the stable condition the output is positive. The introduction of a negative trigger pulse at the input, C3, causes the output to switch to its negative saturation level and to remain there for a period determined by the components R12 and C4.

PRECISION GATE

Clock pulses from the monostable are used to trigger an analogue gate (IC3) which has two summing inputs. One is coupled internally to a d.c. source and the other directly to an external sample socket. The gate will only recognise negative inputs. If the trigger input to the gate is left open circuit or is grounded the gate behaves like a unity gain inverter but only for negative going signals. A positive input signal would tend to swing the output of the gate negative, a tendency which is prevented by the bounding action of diodes D6 and D7.

Under normal conditions overriding control of the state of the gate depends upon the polarity of the signal presented at the trigger input. As has been explained, the gate is closed, that is, passing inverted negative signals, when the trigger input is open circuit or grounded. The same situation exists when the polarity of the trigger signal is negative.

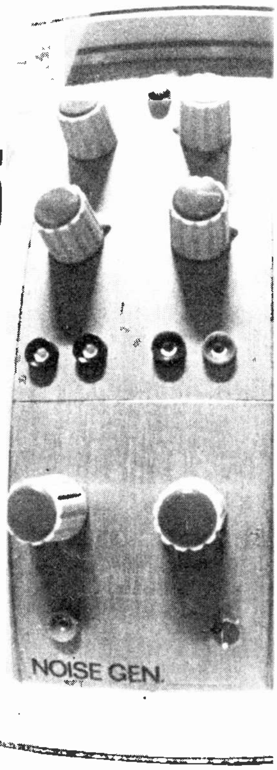
When the trigger signal is positive however the gate opens and its output is zero *provided* that the potential of the sample input is less than the potential of the trigger signal. This latter situation exists for all conditions of internal sampling where the maximum d.c. level attainable is determined by the divider R26–VR4, and for all conditions of external sampling from a single programming source.

When the d.c. and external sampling sources are combined, providing a single programming source only is used, the maximum sampling potential will never exceed 11·5V as compared to a trigger potential of 14V, and thus the closed period of the gate will never exceed 560 microseconds.

In circumstances where two or more programming sources are combined either with, or without, amplification, the situation can exist where the sample potential exceeds the trigger potential. Under these conditions the closed period of the gate is solely dependent upon the period of "high" sample potential.

PE Sound Synthesiser 5 SAMPLE-HOLD and NOISE GENERATOR

By G.D. SHAW



INTEGRATOR

Output from the gate is led to the programming input of an integrator/comparator (IC4/IC5) arrangement which is basically similar to the ramp generator described in last month's article. In this case, however, the time constant of the integrator is much shorter resulting in an extremely rapid integration.

This feature is necessary in order to provide the steep rise between steps if a crisp tone change is to be achieved.

Further additions to the basic ramp generator circuit include an indicator lamp switched by TR1 which serves to indicate the "on" period of the staircase, a clamping diode D1 which serves to limit the integrator output to approximately 650 millivolts in the event that the integrator tends to go into positive saturation, and an input bias control provided by R1, VR1, R2. Input bias is required to compensate for integrator capacitor leakage during the periods of hold between samples, particularly when the sampling rate is low. It also serves to allow the Sample and Hold to be used as another Ramp Generator if required. This is achieved by disabling the trigger socket (JK1) by the insertion of an open-circuit jack plug and setting the ramp rate by adjustment of the d.c. and bias controls. Very high ramp rates may be achieved by this means.

CONSTRUCTION

The circuit board layout of the Sample and Hold is shown in Fig. 5.4. Layout is not critical although space problems may occur if relative component

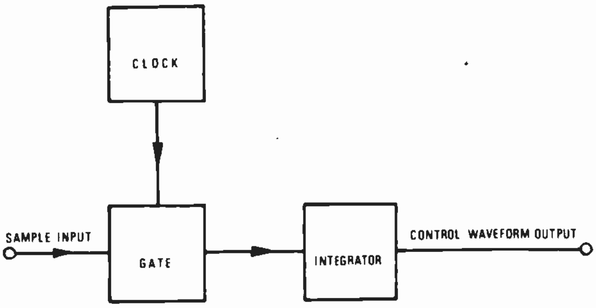


Fig. 5.1. Elements of Sample and Hold in block form

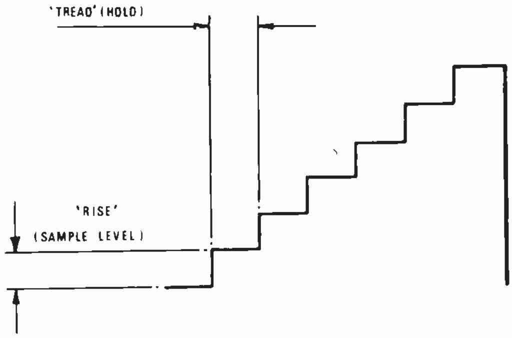


Fig. 5.2. Staircase waveform produced by Sample and Hold circuit. The rise of each step is dependent on the amplitude of the sampled voltage while the tread depends on the clock rate

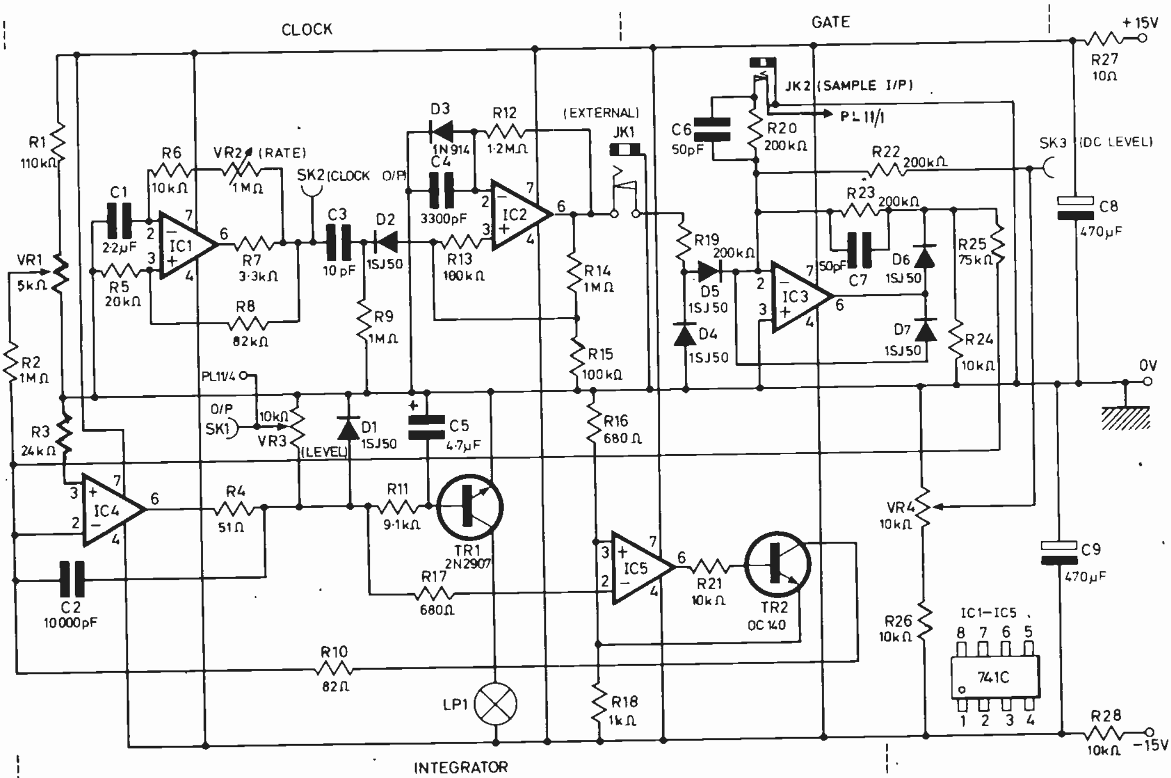


Fig. 5.3. Sample and Hold circuit

SAMPLE AND HOLD BOARD

COMPONENTS . . .

Resistors

R1	110kΩ	R15	100kΩ
R2	1MΩ	R16	680Ω
R3	24kΩ	R17	680Ω
R4	51Ω	R18	1kΩ
R5	20kΩ	R19	200kΩ
R6	10kΩ	R20	200kΩ
R7	3·3kΩ	R21	10kΩ
R8	82kΩ	R22	200kΩ
R9	1MΩ	R23	200kΩ
R10	82Ω	R24	10kΩ
R11	9·1kΩ	R25	75kΩ
R12	1·2MΩ	R26	10kΩ
R13	100kΩ	R27	10Ω
R14	1MΩ	R28	10Ω

All 5% ½ watt carbon

Potentiometers

VR1	5kΩ lin. miniature moulded
VR2	1MΩ lin. miniature moulded
VR3–VR4	10kΩ lin. miniature moulded (2 off)

Transistors

TR1	2N2907
TR2	OC140

Capacitors

C1	2·2μF	35V Tantalum
C2	10,000pF	polystyrene
C3	10pF	polystyrene
C4	3,300pF	polystyrene
C5	4·7μF	40V tantalum
C6	50pF	polystyrene
C7	50pF	polystyrene
C8–C9	470μF	25V elect. (2 off)

Diodes

D1	ISJ50
D2	ISJ50
D3	IN914
D4–D7	ISJ50 (3 off)

Integrated Circuit

IC1–IC5 741C (5 off)

Miscellaneous

LP1–28V sub-miniature indicator lamp
SK1–SK3 2mm miniature sockets (3 off)
JK1, JK2 3·5mm jack socket (2 off)
0·1in matrix Veroboards as required

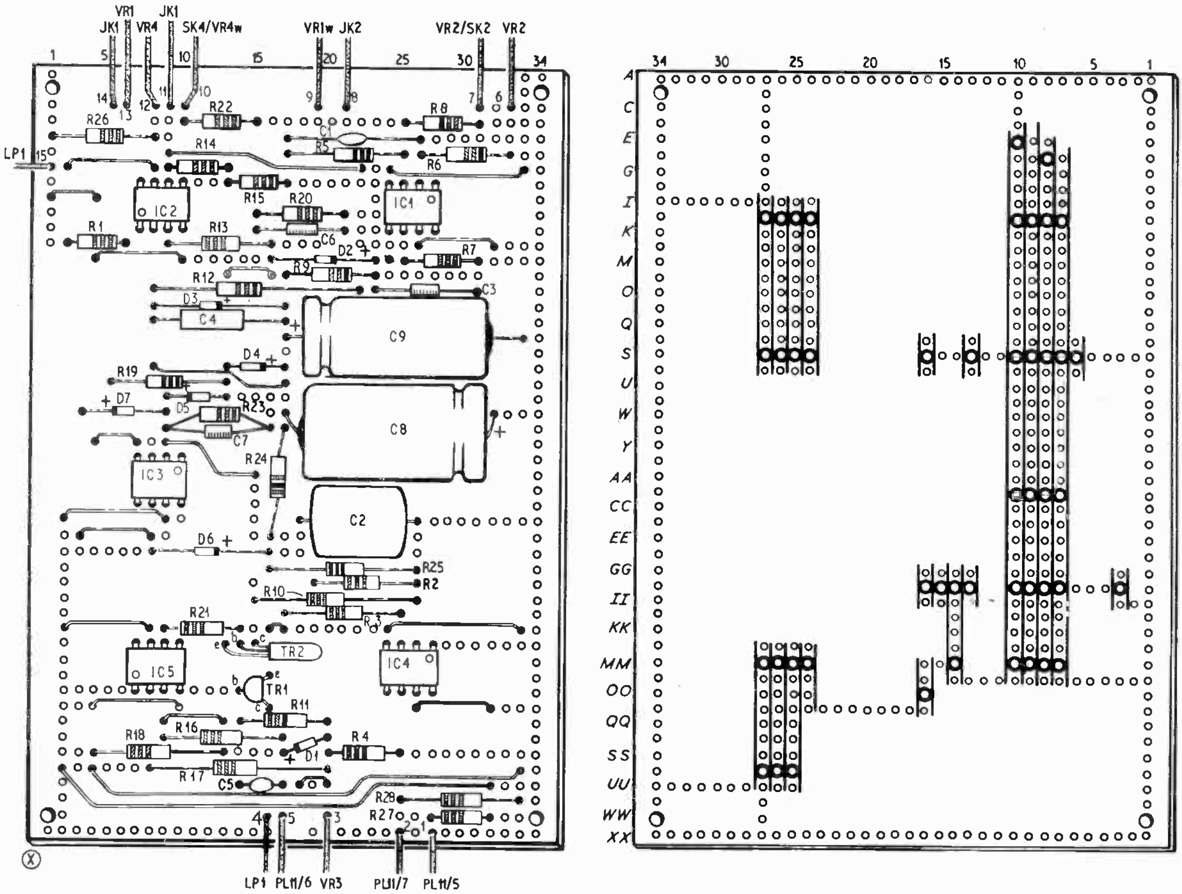


Fig. 5.4. Component layout and wiring of Sample and Hold Board

sizing differs appreciably from those shown. The power supply decoupling electrolytics present the biggest hazard as far as cramping of the board is concerned and these components should not be larger than 32mm in length by 16mm in diameter. R.S. Components Tube type are suitable and comply with the dimensions given.

EXPERIMENTAL CIRCUITS

The Sample and Hold provides the principal means by which the Synthesiser offers its most fascinating feature, that of "playing" by itself. Coupling the output to a v.c.o. and careful adjustment of the sample sources can provide a range of repetitive tone sequences the repeat period of which may be varied from a few seconds to several minutes.

Whether the sequence is truly repetitive or entirely random depends very largely on the choice of sample source. An article in the February issue of Hi-Fi News reviewed a recently issued record in which the "music" had been derived from computer stored data relating to changes in the Earth's magnetic field measured at a series of selected points.

In a similar manner existing data sources may be used to provide sample information. Crystal clocks, binary counters, ring counters, old non-erased computer tape and other digital data sources of various kinds, signal generators—even legitimate recorded music may be pressed into service, amplified, attenuated and blended together in various ways to serve the cause of random programming.

The discerning constructor will have noted that whatever the source of sample information the overall effect of the Sample and Hold is to turn this into a voltage which is progressively increasing, in steps, to a predetermined level at which point it returns to zero only to commence climbing once again. In practice the feature of a regular return to zero of the Sample and Hold output does not become obtrusive except at relatively slow sampling rates when the sample voltage shows very little variation between successive samples.

NOISE GENERATOR

White noise, defined in some circles as unwanted sound, is a very useful addition to the aural facilities provided by the synthesiser. It is a known fact that a great many sounds otherwise considered to be "pure" actually contain a relatively high noise content. The edge-tone in a wind organ is a typical example.

For imitative synthesis the addition of noise in greater or lesser degree is essential if the greatest approach to realism is to be achieved. This factor applies particularly to the synthesis of naturally occurring sounds such as rainfall, surf on the beach, storms, etc., and also to certain man-made sounds such as gunfire, explosions, train whistles, steam engines and so on.

Fig. 5.5 shows the theoretical circuit of the noise generator. The circuit is really quite simple. R5–R9; C3–C4 and D1 represent the noise generation section. The noise diode D1 is a specially selected noisy Zener marketed only by Semitron Ltd., and in the circuit configuration shown provides an output of about 75mV.

The noise bandwidth and level may be adjusted to a certain extent by varying the values of C4 and R6 respectively although it will be found, in practice, that the values shown are suitable for most purposes. C3 serves to decouple the noise diode from the inverting amplifier based around IC1.

Cost reduction can be achieved by omitting the offset adjustment preset VR3 and substituting a capacitor between the values of 0·01 and 0·1μF in the output of the operational amplifier as shown dotted.

LOW-PASS FILTER

R1, VR2 and C2 serve as a simple yet severe low-pass filter in order to provide a degree of control over the colouration of the noise. With VR2 at its minimum setting the output of the noise generator is reduced to a rough triangular waveform with a frequency in the region of 6kHz. Under these con-

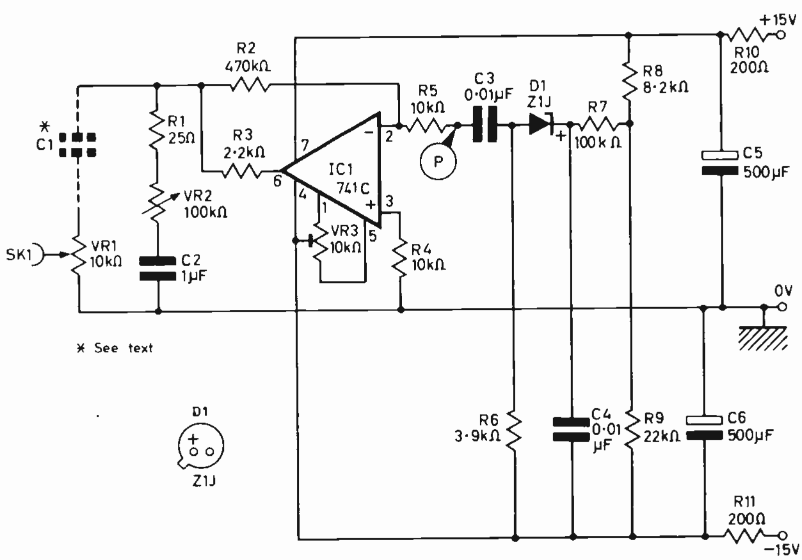


Fig. 5.5. Circuit diagram of Noise Generator

ditions the loading on the output of the operational amplifier is quite heavy and R3 is therefore included to limit the output current drain. Power supply decoupling is essential if noise is to be prevented from leaking back to the power distribution busbars.

In the circuit shown the current requirements are 2·5mA per rail and the addition of 200 ohm decoupling resistors will therefore result in a voltage drop of about 0·5V. If noise leak-through continues to be a problem these latter resistors may be increased in value quite considerably although if values over 500 ohms are used some adjustment of the values of R8 and R9 may be necessary to maintain their junction voltage at about +20V with respect to the negative rail.

Fig. 5.6 shows the circuit board layout of the noise generator. A piece of Veroboard or similar of 17 × 34 ways is suitable. Note that screened leads are used to connect this board's outputs with its associated components on the front panel. These leads should go direct to their respective components and not be bound into the wiring harness.

CONSTRUCTION

In general the construction of this module should follow the pattern adopted with those already described. The wiring harness for the Sample and Hold should pass out at the top of the front panel and down the length of the circuit board support plate to join the circuit board which is mounted adjacent to the McMurdo plug. The noise generator circuit board should be mounted over the lower pair of supports adjacent to the base of the front panel. Details of the front panel layout and module wiring are given in Fig. 5.7.

SETTING-UP

It is recommended that setting-up and testing be established as a continuing process during construction of this module. With the noise generator, for example, it is suggested that the noise generating section consisting of R5–R9; C3–C4 and D1 be built first and tested by making temporary connections to the power supply rails and observing the output by connecting an oscilloscope between point "P" and the negative rail.

The expected output of the noise amplifier can be calculated at this stage by measuring the noise output of the diode with respect to signal ground and multiplying this by the gain of the amplifier.

In the prototype the total noise output was 3·5V maximum which is more than adequate. If the performance of this stage is satisfactory construction of the amplifying section can go forward being similarly tested on completion and before mounting the finished board into the module.

There is no actual "setting-up" to be done with the Sample and Hold and the purpose of testing is merely to establish that the circuit performs within the previously described limits.

NOISE GENERATOR BOARD

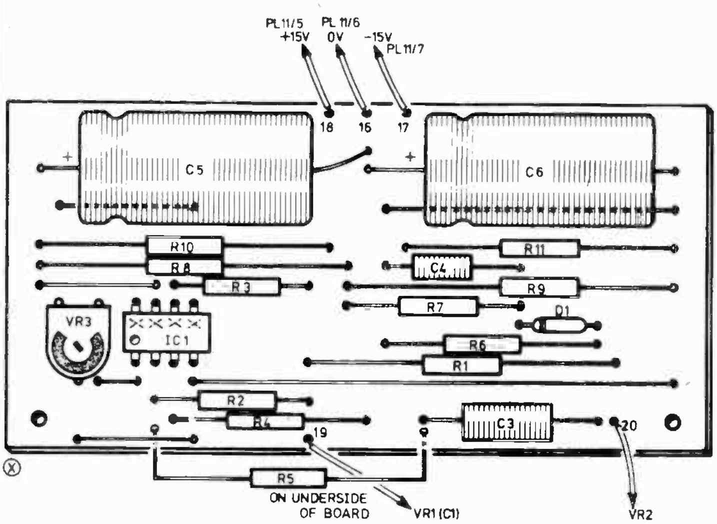


Fig. 5.6. Board layout and wiring for Noise Generator

COMPONENTS . . .

Resistors

R1	25Ω	R5	10kΩ	R9	22kΩ
R2	470kΩ	R6	3·9kΩ	R10	200Ω
R3	2·2kΩ	R7	100kΩ	R11	200Ω
R4	10kΩ	R8	8·2kΩ		

All ½ watt 5% carbon

Capacitors

C1* See text
C2 1μF polyester
C3 0·01μF
C4 0·01μF
C5 500μF elect. 16V
C6 500μF elect. 16V

Diode

D1 Z1J Zener (Semitron Ltd)

Potentiometers

VR1 10kΩ lin. miniature moulded
VR2 100kΩ lin. miniature moulded
VR3 10kΩ lin. horizontal carbon preset

Integrated Circuit

IC1 741C

Miscellaneous

SK1 2mm miniature socket
0·1in Veroboard as required

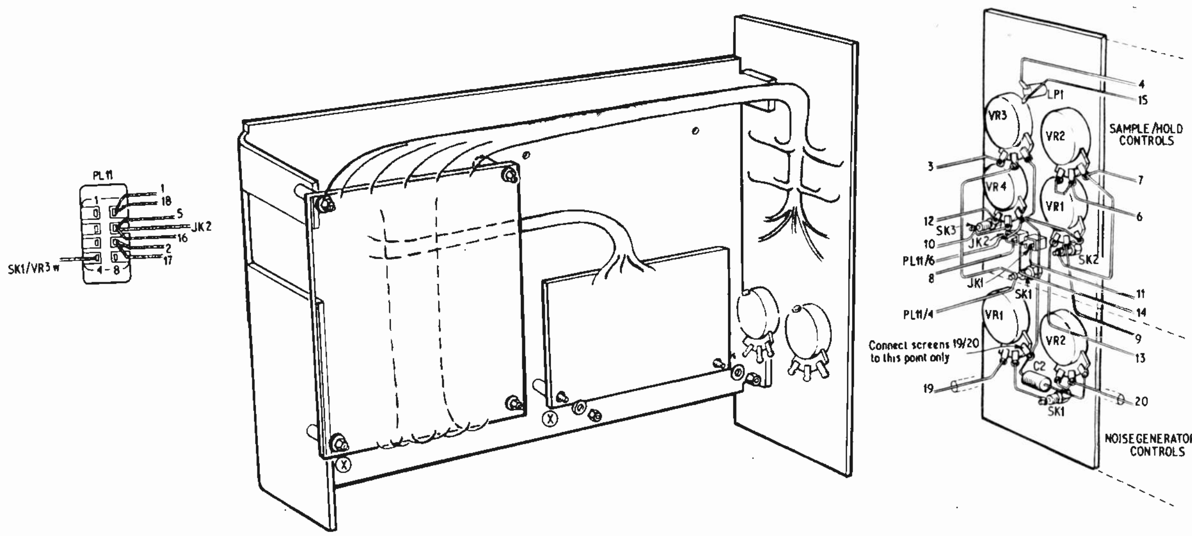


Fig. 5.7. Front panel component assembly with details of mounting and disposition of board on the module support plate. The small ringed X on the board edges indicates orientation. (See board assembly figures) For direct programming from the v.c.o. module connect SK11/4 to SK8/2

USING THE SAMPLE AND HOLD

It is best to confine initial experiments with the Sample and Hold to the formation of relatively simple staircase patterns, derived from the sampling of fixed d.c. voltages, in order to become familiarised with the effect of the adjustment of the various controls. Adjustment of the bias control, for example, can be quite critical when slow sample rates are being used and it is helpful to observe the output waveform on the oscilloscope so that drift between successive samples can be more easily balanced out.

When the Sample and Hold is programming a v.c.o. changes in "tread" voltage can be clearly discerned by ear but this becomes progressively more difficult as the sampling rate is increased. Note that it is difficult, if not impossible, to eliminate drift on the first step of a multi-step staircase due to the low charge on the integrating capacitor. This is not necessarily a disadvantage since it is possible to programme out the first step of the staircase by means of the envelope shaper which is to be described in a future article.

Progression to the sampling of varying voltages is the next logical step. Fig. 5.8 shows the effect of sampling a negative ramp having a period of about 0·1Hz. Note how the "rise" between "treads" increases in proportion to the increase in the ramp voltage. Variation in the ramp level by means of the input amplifier can cause remarkable changes in the output rhythm. A low ramp level and rapid sampling rate gives rise to an arpeggio-like sound in which the separation between the first few "treads" is barely discernible.

A high ramp level, on the other hand, causes the output of the integrator to reach its reset point fairly rapidly but since the sampling is continuing on an ever increasing ramp level the next staircase will have fewer steps and reach its reset point even more quickly. If the second reset is still well within the ramp period the third staircase will demonstrate even fewer steps while the fourth and subsequent staircases may consist of only one step, i.e. a square wave.

Variation of the sample voltage (ramp level) and sampling rate can ring the changes over a very wide range and produce some very interesting results.

SAMPLING A POSITIVE RAMP

Fig. 5.9 illustrates the effect of sampling a positive going ramp. In this case an initial condition of sampling fixed d.c. should be set and the ramp level adjusted so as not to exceed the d.c. sample voltage.

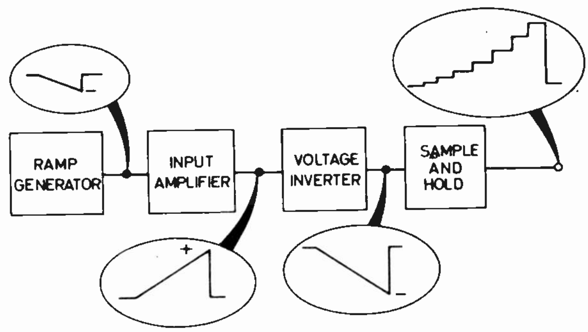


Fig. 5.8. Variable voltage programming. Note how the rise on consecutive steps at the output increase in proportion to the ramp level. Here d.c. level is zero

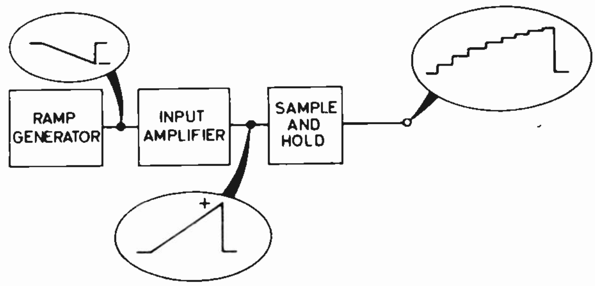


Fig. 5.9. Variable voltage programming. Here consecutive rises on the staircase output decrease with increase in ramp level. D.C. level is equal to or greater than the ramp level

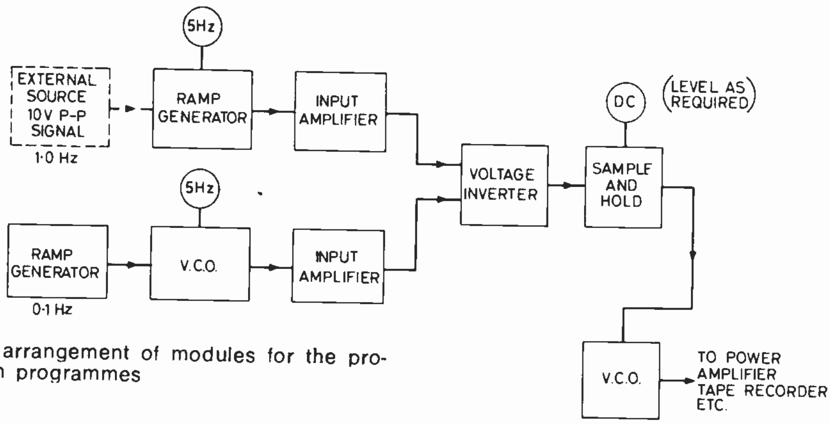


Fig. 5.10. Typical arrangement of modules for the production of random programmes

The effect of these settings is shown, i.e. a relatively large "rise" on the first few samples which gradually decreases as the ramp level rises. In other words a reversal of the situation illustrated in Fig. 5.8.

FURTHER EXPERIMENTS

Further experiments may be carried out in which the sample voltage is derived from two or more sources simultaneously and a typical arrangement is shown in Fig. 5.10.

The sample sources used need not, of course, be centred within the Synthesiser itself. Almost any device producing a varying output voltage may be used providing that the voltage amplitude concerned is compatible with the devices used in the synthesiser.

The output from a pick-up cartridge, tape recorder or radio can be amplified to a suitable level and used as sample material. Music which has wide and fairly rapid changes in dynamic range gives the best results.

Next month: Some general views on the establishment of an experimental sound studio and the construction of the Tone Control module will be described.

SOUND '73

SOUND 73 INTERNATIONAL, organised by the Association of Public Address Engineers and held again this year at the Bloomsbury Centre, London, ran from 13 to 15 March under what can only be described as "Luxury" conditions with deep pile carpets, a warm inviting atmosphere and the sound of happy music welling up around one.

In addition to the main exhibition, the event included lectures on each day, a number of social activities, and public demonstrations of some of the available equipment.

It is as well that the environment was conducive to communications since the sheer quantity of microphones, loudspeakers, amplifiers, Discos and so on to be seen must have led many into a feeling of confusion.

To add to this, the growing availability of semiconductor equipments and the adoption of current stylings have certainly led to a degree of similarity of gear from stand to stand.

On the lecture front the subjects covered included microphones and their circuitry; limiters and compressors, their application and use; the industrial design of PA equipment; and finally the marketing of this equipment. Of course the event is basically directed to the professional sound engineer and the manufacturer but for all that there is invariably something of interest for the casual visitor at such an event.

FROM THE PAST

An interesting contrast with the past was provided in the presence of a public address caravan once the property of Cecil Clarabut of Bedford. The van, equipped with horn speakers, a rack of amplifiers and associated microphones and 78RPM turntables, started operating in 1927 and although the current amplifiers and other items to be seen in the van were installed in the mid 1940's the contents are no less interesting for that.

Apparently the outfit was used as recently as June of 1958 and since then it has been in store. Now it has been restored and Mr. Clarabut has donated it to the Association for Museum purposes.

Returning to a more modern theme, two points come to mind from the show. In the first place the fairly universal adoption of slider controls in tone and volume circuits. This has tended to give much of the equipment similarity of appearance which is emphasised with items like a Disco unit where the layout can be little else but symetrical if it is to work successfully.

A second point is the tendency to place wattage ratings at 100 or 200 nowadays. Apart from the obvious dangers to the listener's hearing when faced with power at this level coming from one speaker, there seems to be the question of this type of high level being fashionable rather than necessary. One or two of the loudspeaker suppliers made this point with surprise but no doubt at the same time with a degree of pleasure at increased sales.

Whilst much of the equipment was of the type one might see in any Discotheque or audio supply house, one or two items caught the eye. For example there was a portable speaker unit intended for indoor or outdoor use mainly in PA applications.

Called the Electrovoice Sonocaster portable extension speaker, the unit uses an 8-inch transducer, can handle up to 30 watts peak and, whilst limited in frequency response to 70Hz to 13kHz, gives a very good showing in comparison to a £400 unit from the same source, Goulton Europe Ltd. Priced at between £11 and £16 (figure not yet finalised) this plastic-housed unit will no doubt collect its fair share of interest.

The latest news from the APAE is that John Robins, MD of SNS Communications Ltd., has been elected President. This year's President elect is Keith Monks of Fleet and John Weed of Uxbridge is again Treasurer.

PATENTS REVIEW...

MAGIC WIPERS

BP 1 287 752

Motorists who like the idea of triggering their windscreen wipers as if by magic should read BP 1 287 752 from Joseph Lucas Industries.

The Lucas circuit Fig. 1 shows a vehicle battery supplying power to an oscillator coupled to a transmitting aerial. Usually the aerial will be in the form of a wire loop built into the driver's seat belt. The receiver aerial, in the form of an electrode built into the vehicle dashboard, is connected to the gate of the field effect transistor TR1.

The circuit is physically and electrically constructed such that the coupling between aerials is insufficient to cause TRI to conduct. To operate the load (e.g. the windscreen wipers) the driver touches the receiver aerial to increase capacitive coupling between the two aerials. Transistor TRI conducts, base current reaches transistor TR2 and thereby also transistor TR3. Relay RLA then latches, due to the rectified current flow through the transistor, and "Hey Presto!" the wipers start up.

Because a self-latching relay is used it will hold the wipers working until next time the aerial is touched. A non-latching relay could of course be used for on/off touch control.

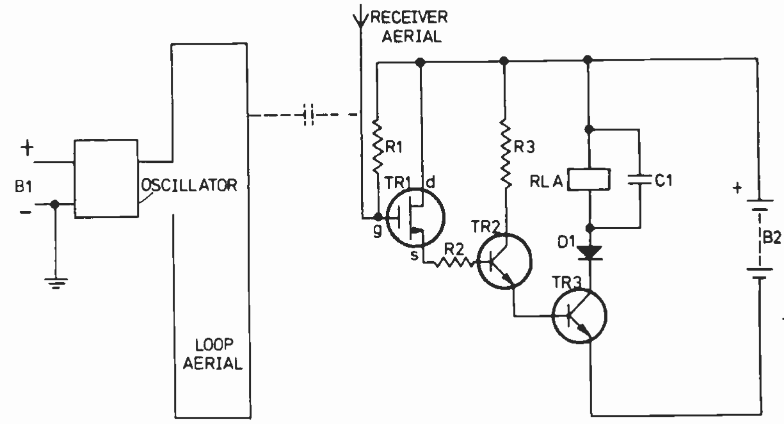


Fig. 1

ULTRASONIC GUIDE STICKS FOR THE BLIND

Geoffrey Mowat in BP 1 284 027 provides interesting details for the construction of a walking stick for the blind with ultrasonic guide capabilities. In his patent Mowat shows a transmitter formed from an oscillator, TR7, and amplifier, TR8, see Fig. 2. These produce ultrasonic electrical oscillations which are converted into ultrasonic sound waves by transducer X2.

No details are given of this fairly routine arrangement, but it is suggested that initially oscillation trains should be transmitted 8 times per second. The transducer X2 is directional in that it transmits only over a beamed path.

For reception a transducer X1 converts received ultrasonic soundwave pulses into electrical pulses and applies them to the receiver amplifier, TR1, 2 and 3. The amplified echo pulses are then fed to an astable multivibrator (TR5, 6) which, when no reflected signal is received, is free running.

When an object is close enough to the transducers to cause the latter to receive a reflection, the multivibrator will be triggered from its original to its alternative state for a predetermined length of time, and in which state it is insensitive to any subsequent pulses. When the multivibrator reverts to its original state it will cause the transmitter to emit a train of pulses again. Simultaneously an indicator amplifier TR10 will activate a vibrator which the subject can feel.

Thus when the transducer X1 receives a reflected pulse, the multivibrator will "flip" over and control a fixed cycle of events. As the transmitted pulse will be received back in a shorter time as the reflecting object gets closer, the repetition rate felt at the vibrator will vary with the distance of the reflecting object, i.e. the vibrator will vibrate at a frequency which increases as the object gets closer. And, of course, because the multivibrator is triggered by the first received pulse, the unit as a whole will respond only to the nearest object in its path. Transistor TR4 attenuates direct path (non reflected) pulses.

The inventor claims that with the arrangement fitted in a walking stick, the system will allow ready distinction between objects such as a telegraph pole and a building behind it.

BP 1 284 027

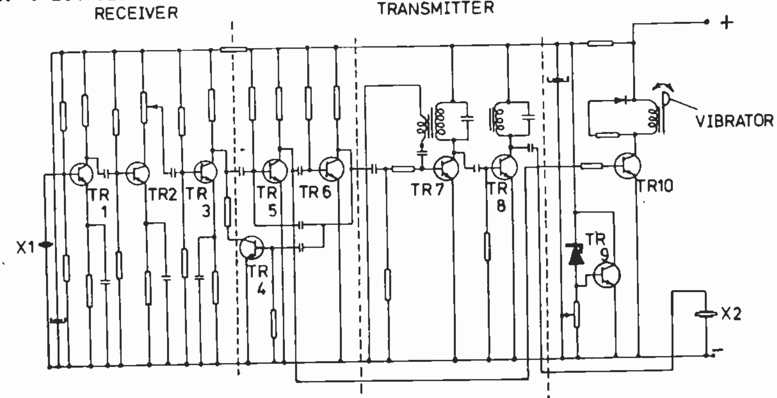


Fig. 2

The 555 Timer IC

By J.B. DANCE M.Sc.

SIGNETICS International Corporation has recently introduced a new economical integrated circuit, the 555, which can be employed in simple timing circuits for an extremely wide range of applications and is equally suitable for use by both the professional equipment designer and the amateur enthusiast.

The 555 devices can be employed to provide accurate time delays from microseconds to hours. The time delay is almost independent of the power supply voltage. The device can also be employed as an astable oscillator for pulse-width modulation as one of a series of timers or a frequency divider.

THE INTEGRATED CIRCUIT

The integrated circuit and its mode of operation will be described in some detail so that readers may gain an understanding of the circuit and thus be able to devise their own applications. Full constructional details of a general purpose timer appear on page 486 of this issue and show how this monolithic integrated circuit can be employed for automatically timing the exposure in photographic enlarging or as an industrial timer.

TYPES

The 555 timer is available in two types of package. An eight lead dual-in-line encapsulation with a silicon moulded body material is used for the NE555V, and the NE555T has a circular TO-99 case with eight leads. The connections to both types are shown in Fig. 2. The electrical characteristics of the two types are identical.

The SE555T is a close tolerance version of the 555 device and is available only in the circular TO-99 package at present. The connections are as in Fig. 1. The SE device can operate over the temperature range −55°C to +125°C, whilst the NE types can operate only over the narrower temperature range from 0°C to 70°C. The SE555T is considerably more expensive than the NE types and it generally provides a somewhat smaller drift of the time delay with the supply voltage and with temperature.

The writer feels that the dual-in-line construction of the NE555V is rather more convenient to use than the TO-5 encapsulation and it is the cheapest type of 555.

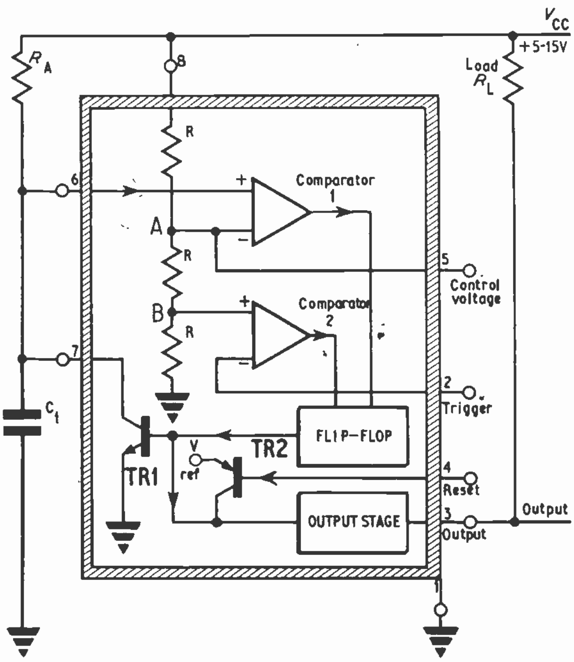


Fig. 1. General schematic of the 555 timer chip showing external circuit connections for monostable operation

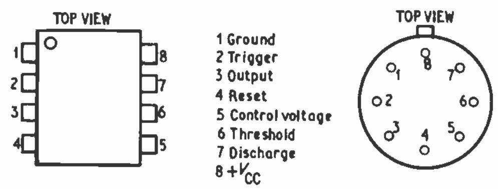


Fig. 2. Pin number connections for 8-pin DIL and TO99 can

The NE555V has therefore been used in the applications which will be described, but the NE555T or the SE555T are equally suitable.

MONOSTABLE OPERATION

In the monostable mode the timer is triggered by an input pulse or by the operation of a switch. This causes the output voltage to change for a pre-determined time (the delay) after which this voltage returns to its former value. The delay is determined by the product of the values of a capacitor and resistor connected externally to the integrated circuit.

The integrated circuit is shown connected as a monostable in Fig. 1 with the operational functions of the timer shown as blocks.

Initially the external capacitor, C_1, is kept in a discharged state by the transistor TR1 inside the timer. This transistor is held in a fully conducting state by the bias applied to its base by the flip-flop stage.

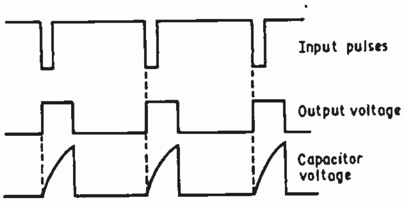


Fig. 3. Waveforms associated with the operation of the circuit of Fig. 1

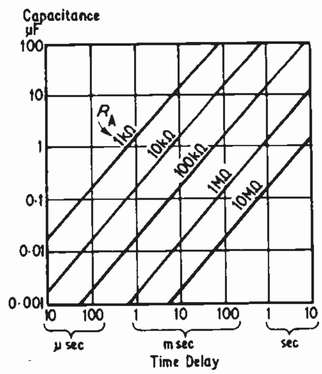


Fig. 4. Time delays obtainable with various values of C_1 and R_A

The point B is held at a potential of $V_{cc}/3$ by the potential divider containing three resistors of equal value R. When a negative-going trigger pulse causes the potential of pin 2 to fall below the value $V_{cc}/3$, comparator 2 causes the flip-flop to be switched. This results in the output voltage rising and in TR1 being cut off.

This sequence of operations may generally be started by momentarily connecting pin 2 of the timer to ground instead of applying a negative-going pulse to it. However, triggering will then normally occur at the instant the connection with ground is broken and this may introduce an appreciable error if the delay period is short.

WAVEFORMS

The voltage across C_1 now increases exponentially with a time constant R_AC_1 as current flows to it via R_A; the waveforms are shown in Fig. 3. When the voltage across C_1 becomes equal to that at point A (that is, to $2V_{cc}/3$), comparator 1 of Fig. 1 resets the flip-flop. The output from the latter causes the voltage at the output (pin 3) to return rapidly to its quiescent low value. In addition, TR1 is biased so that it conducts and the capacitor C_1 is rapidly discharged.

SUPPLY VOLTAGE

If the value of the supply voltage, V_{cc}, is increased, the potential of point A and the rate of charge of the capacitor C_1 at any given point in the charging cycle are both increased in proportion. The time at which the two inputs to comparator 1 become equal (that is, the time at which the end of the delay occurs) is therefore almost unaffected by the value of V_{cc}.

RESET

Once the circuit has been triggered by a negative going pulse to pin 2, it will remain in this state until the pre-set time has elapsed, no matter whether it is triggered again during this time or not. If, however, a negative going pulse is applied to the reset terminal, pin 4, before the circuit has returned to its quiescent state, the capacitor C_1 will be discharged and the circuit will be reset.

The output is in its low voltage state during the time the reset pulse is applied to pin 4. Resetting can also be effected by momentarily connecting pin 4 to ground. The reset current is about $100\mu A$.

In applications where the reset terminal will not be used, it is advisable to connect it to the positive supply line to avoid any possibility of undesired resetting.

TIME DELAY

The time, t sec, for which the output is in its high voltage state is given by the equation:

$$t = 1{\cdot}1 R_AC_1 \qquad \text{Equation 1}$$

where R_A is expressed in ohms and C_1 in farads.

Equation 1 may be deduced in the following way. When a capacitor C_1 charges from a voltage V_{cc} through a resistor R_A, the voltage V across the capacitor after a time t is given by the equation:

$$V = V_{cc}(1 - e^{-t/R_AC_1})$$

In order to find the delay, t, we put $V = 2V_{cc}/3$, since this is the voltage at which the flip-flop is reset.

$$2V_{cc}/3 = V_{cc}(1 - e^{-t/R_AC_1})$$

$$e^{-t/R_AC_1} = 1/3$$

$$t/R_AC_1 = -\log_e(1/3) = \log_e 3 \simeq 1{\cdot}1.$$

If one requires the output to remain in its high voltage state for one millisecond (10^{-3}s), one may choose a reasonable value of C_1, say $0{\cdot}1\mu F$ ($=10^{-7}$F), and calculate R_A using equation 1 to see if a reasonable value is obtained:

$$R_A = t/1{\cdot}1C_1 = 10^{-3}/(1{\cdot}1 \times 10^{-7}) \simeq 9{\cdot}1 k\Omega.$$

Similarly, if $R_A = 100k\Omega$ and $C_1 = 100\mu F$, $t = 1{\cdot}1 \times 10^5 \times 10^{-4} = 11$ seconds. The chart of Fig. 4 shows the time delays obtainable for values of C_1 from $0{\cdot}001\mu F$ to $100\mu F$ and for values of R_A from $1k\Omega$ to $10M\Omega$.

It should be noted that reasonable values of R_A and C_1 must be selected. A typical current of $0{\cdot}1\mu A$ (maximum $0{\cdot}25\mu A$) flows through R_A to pin 6 of the 555 timer. If R_A is $20M\Omega$, this current alone will produce a voltage drop of up to 5V (typically 2V). Thus this value of R_A is about the maximum which should be employed.

If R_A is chosen as $10M\Omega$ and C_1 as $10{,}000\mu F$, t can be calculated as about 30 hours. However, the leakage current passed by the capacitor might well be so large that a much longer delay occurs before the voltage across the capacitor reaches a value of $2V_{cc}/3$.

Apart from the fact that capacitor leakage current can affect the calculated time values, one should remember that the values marked on many capacitors are only very approximate. This is especially true in the case of electrolytic and Hi-K ceramic capacitors. The actual value may exceed the marked value by as much as 50 per cent.

currents of 100mA, the output voltage is usually within 2V of the potential of one of the supply lines.

An output current of up to 200mA can be obtained in either the high or low voltage states.

The output pulses rise and fall rapidly, typical rise and fall times being $0{\cdot}1\mu s$. The output pulses can be used to drive a high power transistor (such as the common *npn* type 2N3055 or the somewhat smaller *npn* types 2N3054 or RCA 40250). The high power transistor can then control a high current.

RELAY OPERATION

If the delay time exceeds about 0·1 sec, a small relay connected between pin 3 of the 555 and one of the supply lines can be operated directly from the timer circuit. The relay coil should be designed so that it operates from a voltage approximately equal to V_{cc} at a current which does not exceed 200mA.

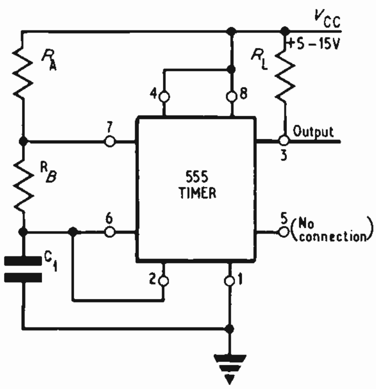


Fig. 5. Circuit of the 555 connected for astable operation

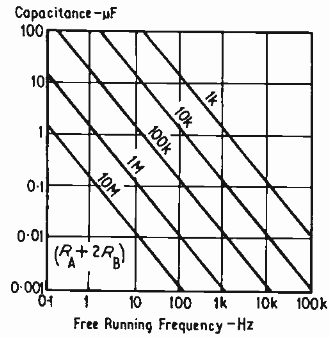


Fig. 6. Variation of frequency with component values in the astable mode

CONTROL VOLTAGE

In the previous discussion it has been assumed that pin 5 of the timer circuit has been left unconnected. However, the time delay may be changed over a range of about 10:1 by applying various control voltages to this pin. The impedance at pin 5 is a few thousand ohms. The time delay will still be independent of the value of V_{cc} if the control voltage is derived from V_{cc} by means of a potential divider so that it is proportional to V_{cc}.

OUTPUT

If one merely requires an output pulse at the end of the delay time, one may connect the output pin 3 to a resistor (perhaps $4{\cdot}7k\Omega$) which is returned to the positive supply line, as in Fig. 1. The output pulses are taken directly from pin 3.

When the output voltage is high, it is near to that of V_{cc}. When it is low it is only very slightly greater than the ground potential of the negative supply line. If the output voltage is low and the current passing to pin 3 is 10mA or less, the output voltage will normally be within 0·2V of the ground potential. At output

It is necessary to connect a diode across the relay so that the back e.m.f. generated when the current ceases to flow through the inductive relay coil is shorted out by the diode. This prevents possible damage to the timer circuit by the fairly high reverse transient voltage which appears across the relay coil. The diode must be connected so that it is reverse biased when the relay conducts. A fast switching diode is ideal.

TRIGGERING

The writer has found that the use of an inductive load (such as a relay) can cause the timing circuit to automatically re-trigger itself at the end of the delay time. This occurs so rapidly that the output voltage appears to stay quite constant and the relay remains closed. In the general purpose timer to be discussed, this problem is avoided by connecting pin 2 of the 555 through a resistor to the $+V_{cc}$ line.

The triggering action in the 555 is extremely sensitive. If one touches pin 2 with one's finger, triggering will occur. Even moving one's hand near to a wire connected to pin 2 is adequate to trigger the circuit by a capacitive effect. The trigger current required is only about $0{\cdot}5\mu A$ for a period of $0{\cdot}1\mu s$.

The NE555V&T = 4.5V→16V but SE say up to 15V. (perhaps 18)

POWER REQUIREMENTS

The integrated circuit itself requires a current of about 3mA (maximum 6mA) from a 5V supply, increasing to about 10mA (maximum 15mA) from a 15V supply. Any current passed by the load is additional to the current shown. The absolute maximum permissible power dissipation is 0·6W, but this should not be reached if the correct voltage is applied even if the maximum permissible output current of 200mA is passed.

The NE555V and NE555T should be operated from a su[illegible] de[illegible] rating [illegible] 15V as the upper limit so as to allow for supply voltage tolerances.

Variations of the delay time with the supply voltage are typically 0·01 per cent per volt and with temperature 0·005 per cent, per deg C.

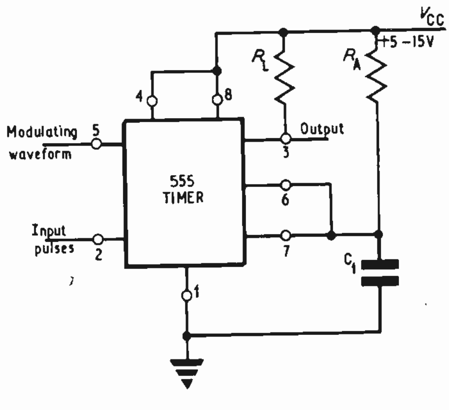


Fig. 7. Using the 555 for pulse width modulation

ASTABLE OPERATION

If a 555 timer circuit is connected as in Fig. 5, it will "free run" and operate as an astable multivibrator. The trigger pin 2 is connected to pin 6 so that when C_1 discharges the resultant negative going pulse is used to trigger a new cycle automatically.

The current required to charge the capacitor C_1 flows through R_A and R_B in series. However, when TR1 (see Fig. 1) conducts, a current from C_1 flows through R_B into pin 7. Thus the charging time is proportional to $(R_A + R_B)C_1$, but the discharging time is proportional to R_BC_1. The charging time cannot be made smaller than the discharging time.

TIMING

In the astable mode of operation, the capacitor C_1 charges and discharges repeatedly between the potentials $V_{cc}/3$ and $2V_{cc}/3$ provided that pin 5 is left unconnected. The charge and discharge times (and therefore the frequency of operation) are almost independent of the supply voltage, V_{cc}. The output voltage is high during the charging time.

$$\text{Charging time} = t_c = 0{\cdot}693(R_A + R_B)C_1 \qquad \text{Equation 2}$$

$$\text{Discharging time} = t_d = 0{\cdot}693R_BC_1 \qquad \text{Equation 3}$$

$$\text{Total period} = t_c + t_d = 0{\cdot}693(R_A + 2R_B)C_1 \qquad \text{Equation 4}$$

$$\text{Frequency} = 1/t = 1{\cdot}44/(R_A + 2R_B)C_1 \qquad \text{Equation 5}$$

The variation of frequency with component values is shown in Fig. 6.

Equation 2 can be deduced using the equation $V = V_{cc}(1 - e^{-t/RC})$ for a capacitor C charging through a resistor R from a voltage source V_{cc}. One requires the time for V to increase from $V_{cc}/3$ to $2V_{cc}/3$ when charging through a resistor of value $R = R_A + R_B$. The discharging time is the time for V to decrease from $2V_{cc}/3$ to $V_{cc}/3$ when a resistor R_B is connected across the capacitor.

The charging and discharging times can be altered by the application of a control voltage to pin 5. Both of these times are affected, since an alteration of the potential of point A in Fig. 1 will affect the potential of point B.

OTHER APPLICATIONS

The astable mode of operation can be employed when a series of operations must be repeated at preset intervals many times. For example, one application occurs when one wishes to have the windscreen wipers of a car make single sweeps with a certain delay between successive sweeps. The circuit continues to operate with this delay until the timing is adjusted or until the current is switched off. Another application using the 555 in the astable mode involves the periodic switching of lights.

If a series of regularly spaced pulses is fed into pin 2 of Fig. 7, the mark/space ratio of the output from pin 3 is dependent on the instantaneous modulating voltage applied to pin 5. As the voltage at pin 5 increases, the time for which the output remains in its high voltage state increases until it becomes so long that alternate input pulses produce no output.

A number of the 555 timers can be connected in the monostable mode so that the output of the first triggers the second and the output of the second triggers the third, etc.

The operation of the first timer is started by connecting pin 2 momentarily to earth or by applying a negative pulse to it. The first 555 returns to its quiescent state after 1 sec (see equation 1) and triggers the second timer. This circuit produces an output pulse perhaps 100 sec later (owing to the higher values of R_3 and C_3) and triggers the third 555 circuit.

The output pulses from each of the timer circuits can be used to carry out any desired operation at the preset times after the first timer is started. If desired, the output from the last circuit may be used to trigger the first circuit so that output pulses continue to be generated at set intervals indefinitely.

On page 486 a general purpose timer constructional article discusses the use of the 555 in practical circuitry suitable for use in, say, a darkroom timer. ★

POINTS ARISING

NOVEL BATTERY ELIMINATOR *(April 1973)*

To prevent the possibility of any electrical accidents the cover and base of this unit should be made up of 18 s.w.g. aluminium. Alternatively an Ever-Ready 3-way 13A adaptor can be used.

For 6V use a 6·2V 400mW Zener diode can be substituted such as the BZY88.

CAMERA SHUTTER TESTER *(August 1972)*

In Fig. 4; page 643, there should be a break in the copper strip between the end of R1 and the link wire which is close to VR1. The presence of this incorrect link will probably damage the integrated circuit. Fig. 3, page 642, the reference to the integrated circuit as 7410PA should in fact read 741 operational amplifier.

GEMINI TUNER *(April 1972)*

The Gemini Tuner described over a year ago, in April 1972 has raised considerable interest and several hundred tuner heads have been supplied. Unfortunately these are made in Japan for an American company (thus keeping the cost down) who has now withdrawn the line because of shortage of some components and a changing product line. Both the importers and Practical Electronics have made extensive investigations to discover an alternative source or replacement product. Neither

LOGIC TUTOR EXPERIMENTS..

SOMETIMES one finds it necessary to invert logical functions—particularly when interfacing one stage of a piece of equipment to another. Logic inversion simply means that whenever we get a logical 1 we have to convert it to a level 0. The simplest way of doing this is by means of a grounded emitter amplifier stage (Fig. 2.1). Using our convention of positive logic a logical 1 on the input is represented by +5V at point A—this causes base current to flow in the transistor and hence collector current is drawn and the output at the collector Q falls to approximately zero volts, or logic level 0.

DEMONSTRATING IT

A simple application of inversion can be demonstrated on the Logic Tutor. Normally a level 1 will cause the lamps to be illuminated. Let's say we want a level 1 to extinguish a bulb; the first thing that has to be done is convert the 1 level to a 0. We have no simple transistor stages available to us on the tutor but we can simulate inversion by using one of the 2-input NAND gates. All you have to do is short both inputs together (next month's description of the NAND gate will make the reason for this clearer).

Connect the shorted inputs to one of the toggle switch outputs and also connect this node to one of the indicator lamps: also connect the output of the NAND to another lamp (Fig. 2.2). Set the switch to 1 and LP1 will indicate level 1 at the input but LP2 will be extinguished indicating 0. Apply a 0 on the input and you will see a 1 appear at the output.

The symbol for invert is shown in Fig. 2.3 and we say that the output Q is $\bar{A}$ (said NOT A). The truth table is very straightforward—whatever A is, Q is the opposite.

Invert is often used in logic systems but its occurence is sometimes disguised by the fact that it is mainly used in conjunction with AND gates to give us the NOT AND or NAND function that will be explained fully in the next issue.

by M. Hughes

In Part 1 last month the figures given should be transposed.

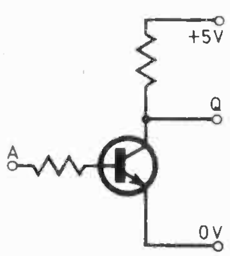


Fig. 2.1. A grounded emitter stage acts as a logic inverter

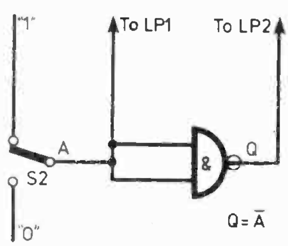
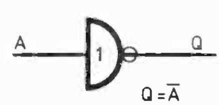


Fig. 2.2. The NAND gate with logic inputs shorted demonstrates the invert function



A	Q
0	1
1	0

Fig. 2.3. The symbol and truth table for the invert function

PRACTICAL ELECTRONICS "SCORPIO" ELECTRONIC IGNITION SYSTEM

This Capacitor-Discharge Electronic Ignition system was described in the November and December issues of Practical Electronics. It is suitable for incorporating in any 12V ignition system in cars, boats, go-karts, etc., of either pos. or neg. earth and up to six cylinders. The original coil, plugs, points and contact-breaker capacitor fitted in the vehicle are used. No extra or special components are required.
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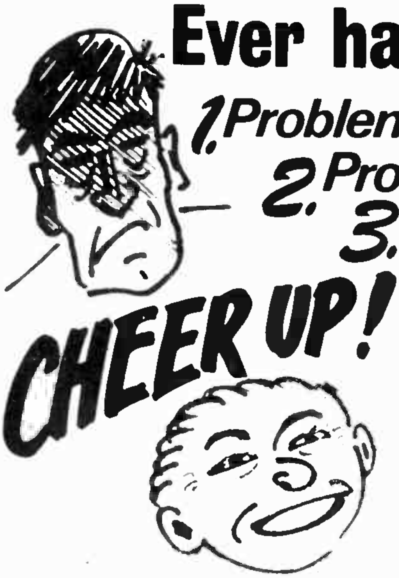

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INDUSTRY NOTEBOOK

By Nexus

FAMINE AHEAD?

It seems to be a flaw in our human character, perhaps even an immutable law, that we are unable to govern our affairs smoothly and sensibly. After the glut comes the famine—at least in professional components. Delivery times are lengthening all the while and prices are hardening and this trend is noticeable throughout Europe and the United States. The trend is that much more irritating because it is in such contrast to even a few months ago.

The Paris Components Show, still the world's biggest and best, showed a buoyancy in April unmatched since the boom year of 1969. And the London show which opens on May 21 will, according to pre-show gossip, be a much happier business event than the last, two years ago.

Some reports give lead times for deliveries of up to six months for capacitors, five months for potentiometers, up to four months for transistors.

Much of the trouble in Europe stems from the big upsurge in colour TV demand which has created an almost unprecedented call on components. And component manufacturers who burnt their commercial fingers by over-expanding production facilities and then had to cut back with heavy losses are quite naturally cautious about expanding again to meet what might only be a temporary boom period.

Component distributors in Britain who belong to the Association of Franchised Distributors of Electronic Components and therefore subscribe to an ethical standard in their businesses, are almost as embarrassed by the present upsurge in business as when it was bad. The more sensitive of them are tormenting themselves on the ethics of switch selling (i.e. the supply of an equivalent component from a different manufacturer from that actually ordered) and suchlike niceties. Another of their problems is the so-called wheeler-dealer who scours the world for job lots and then unloads them on a component-hungry market. The maxim is let the buyer beware and to trade only with reputable suppliers.

UNION CARBIDE EXPANSION

The solid tantalum capacitor was a hard-to-make sophisticated component which sold almost exclusively to the exotic space and defence market where price is secondary to performance and reliability. I was somewhat surprised, therefore, to discover on a visit to the Union Carbide plant at Aycliffe, Co. Durham, that the big expansion just completed is largely the consequence of tantalums having penetrated the consumer electronics market. Here is another company that has benefited from colour TV.

They have spent £250,000 beefing up production with new machinery and processes, much of it developed at the US production base at Greenville, South Carolina. The Aycliffe plant now turns out 2·5 million capacitors a month, a threefold expansion over one year ago. Marketing manager, Andy Thomson, was in jubilant mood explaining that the big take-off was in low-cost dipped resin types which had opened up an entirely new and still expanding market.

The Aycliffe plant opened in 1952 with 17 employees and now has 230. Watch out for further developments. In the pipeline is a new range of monolithic ceramic capacitors which is forecast to make an important contribution to Union Carbide's European operations. Ceramic and tantalum chips will be included to meet the demands of the fast-growing hybrid market.

Jogging along in the background is a little-publicised activity—the manufacture of barium getters for TV tubes and radio valves which Aycliffe workers can turn out at the rate of 120 million a year, phew!

STILL DROPPING

The huge mark-ups of some manufacturers of pocket calculators are slowly being eroded as more types come on the market, competition increases, production problems are ironed out and the cost of expensive tooling is amortised. This is one area where prices are not hardening.

Nearly 40 models are currently on sale in London shops, most of them carrying big discounts from the "recommended" price. One British manufacturer has chopped his "recommended" price by £20, and it is generally agreed that the simpler types will ultimately become available for a little over £20.

Shrewd buyers are holding off waiting until the market bottoms and some even shrewder people have been working on how to solve complex calculations on the simpler machines which are basically only four functions, add, subtract, multiply and divide.

Square roots, cube roots and other calculations are possible by using a number of discrete stages according to extensive correspondence in the US journal "Electronics" which has printed a number of ingenious methods of expanding calculator capability without paying for it.

POCKET BREATH ANALYSER

The annual Physics Exhibition in London is not normally the best place to look for good commercial ideas. But one item I spotted this year has good commercial prospects if the price is right.

It is a pocket breath alcohol meter which uses a fuel cell developed at the University of Wales Institute of Science and Technology, Cardiff. Breathing into the cell develops a potential which is amplified and displayed on a voltmeter. Accuracy is claimed to be within 5 per cent and sensitivity is such that 0·005mg of alcohol per litre of air can be detected. Size is a modest 6 × 10 × 2cm and weight is only 60g—a truly pocket sized instrument.

I also noted that Standard Communications Laboratories are gamely pressing on with optical waveguide communications. A liquid core fibre using tetrachlorethylene as the transmission medium is said to have sufficiently low attenuation for practical use and another solution is to use a single glass fibre waveguide instead of the conventional fibre optic bundle.

The single fibre, say STL engineers, is better from all points of view from production which can be carefully monitored during extrusion through to more robust connection to the laser source and detection unit.

Wide Range PULSE GENERATOR

By M. J. Trand

A COMPACT and lightweight source of fast pulses is frequently required for testing. Integrated circuits can meet this need and the pulse generator described here uses only TTL i.c.s as active devices with the addition of a few extra resistors and capacitors. The unit may be powered by a standard mains supply, but a battery operated version can easily be adopted without any modifications to the circuitry.

INTEGRATED CIRCUITS

As mentioned, two 74 series i.c. chips produce the rectangular shaped pulses. Type SN7404, which is a sextuple single-input inverter, uses three of its inverters as part of the oscillator section. The second circuit block, type SN74121, is a monostable multivibrator connected to provide pulses of variable widths. These two integrated circuits can be obtained for well under £1 from many electronic components distributors.

It should be mentioned at this stage that although several firms market i.c.s of the 74 series, similar devices such as the Mullard FJH241 and FJK101 will do equally well.

CIRCUIT

The block circuit diagram of the pulse generator is shown in Fig. 1. On switching on, the output of inverter A tends to go up to a logical 1 while the output of inverter B is pulled down to a logical 0, charging the capacitor C1. The speed of this action will be governed by the time constant C_1R_1 in the circuit. The output of inverter C will then gradually go to a 1 and also transmit the transient to the input of inverter A, whose output in turn follows to a 0, and so on, thus producing an oscillatory action. The fourth inverter D in the line acts simply as a buffer stage.

The pulses are next fed to a monostable block which will vary their duration according to the value of the external time constant applied by C2 and R2.

At the last stage pulses from the monostable complementary outputs are passed on to the remaining two inverters E and F, providing simultaneous positive and negative going pulses.

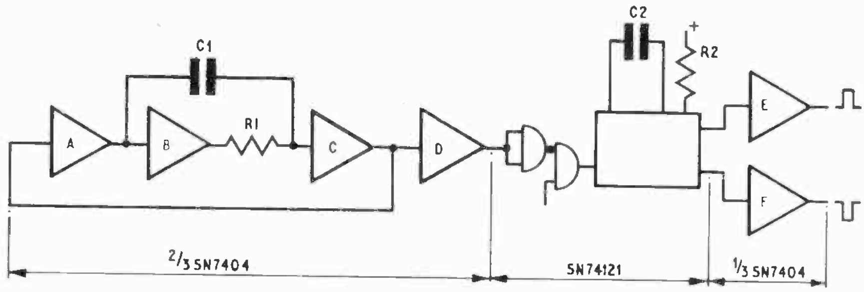
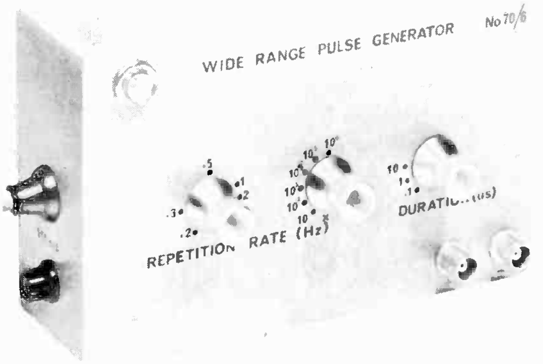


Fig. 1. Block schematic of the pulse generator with the i.c. SN7404 split for ease of illustration



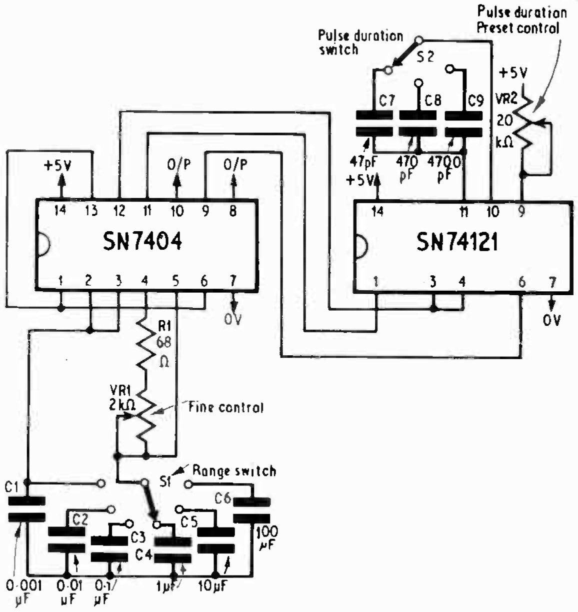


Fig. 2. Circuit diagram of the components external to the integrated circuits. VR1 is, in the final model, a 2·2kΩ linear potentiometer with an 8·2kΩ resistor connected from wiper to the end proximate R1

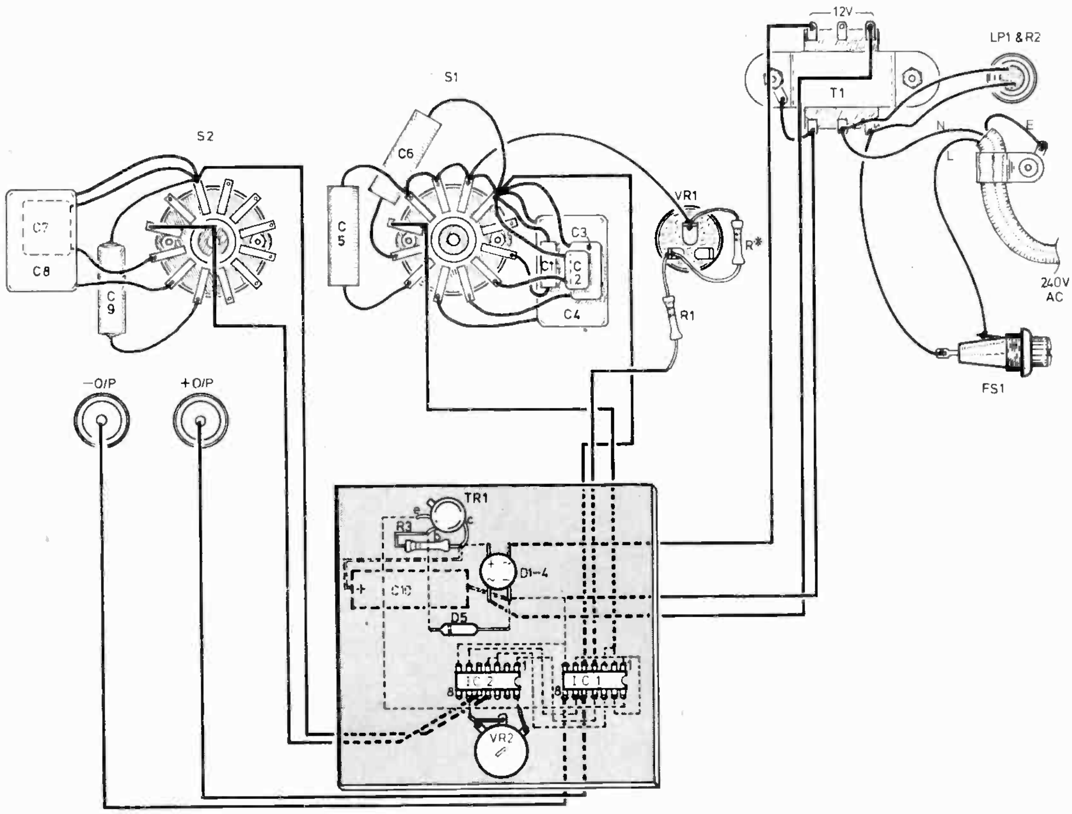


Fig. 3. Physical wiring diagram for board and mounted components

Components

GENERATOR

Resistors
R1 68Ω ($\frac{1}{4}$W)

Potentiometers
VR1 2kΩ Lin
VR2 20kΩ Lin

Capacitors
C1 0·001μF
C2 0·01μF
C3 0·1μF
C4 1·0μF
C5 10μF
C6 100μF
C7 47pF
C8 470pF
C9 4700pF

Switches
S1 Rotary, single pole, 6-way
S2 Rotary, single pole, 3-way

Integrated circuits
IC1 SN7404
IC2 SN74121

Miscellaneous
Die-cast box and suitable knobs

POWER SUPPLY

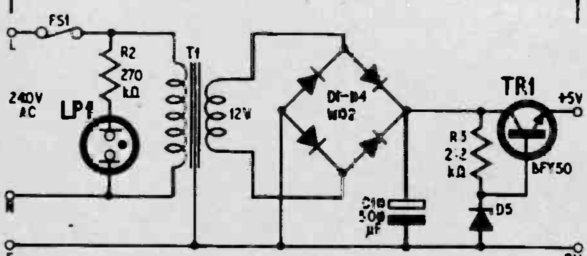


Fig. 4

Resistors
R2 270kΩ ($\frac{1}{4}$W)
R3 2·2kΩ ($\frac{1}{4}$W)

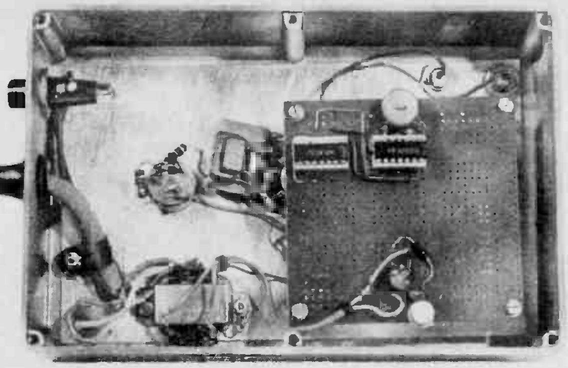
Capacitors
C10 500μF. 25V elect.

Diodes
D1–4 WO2 (Bridge)
D5 5·6V Zener

Transistors
TR1 BFY50

Transformer
T1 12V output mains transformer

Miscellaneous
FS1 100mA fuse and panel-mounting holder
LP1 Neon indicator and panel-mounting holder



CONSTRUCTION

A circuit diagram is shown in Fig. 2. and a wiring diagram in Fig. 3. In practice the two 14-pin i.c. holders are soldered on a small piece of perforated p.c.b. as shown, keeping wiring lengths small. The value of potentiometer VR1 should not exceed 2kΩ, as this would attenuate the feedback signal and stop oscillations.

A series resistor R1 of about 80Ω increases the stability of the oscillator when VR1 is at minimum. The value of capacitors C1 to C6 can be chosen from 0·001μF to 100μF giving a frequency range from 1Hz to above 1MHz in six steps.

To fit in with the frequency range chosen, C7 to C9 can have any reasonable value between 10pF and 10,000pF giving pulse durations from 0·1μs to 10μs.

If longer pulse durations are needed at lower frequencies then larger values of capacitor can be added. When electrolytic capacitors are used connect the negative terminal to pin 11 of the monostable.

The switches S1 and S2 are ordinary single-pole rotary type.

SETTING UP

Calibration of the pulse generator, particularly VR1 the repetition rate fine control and VR2 the pulse duration preset control, can easily be done with a reference source such as the time base of commercial oscilloscope. This should be sufficiently accurate to enable a fairly precise marking of the front panel.

Pulses of 4V amplitude with a rise time of 40ns, and fall time of 20ns into about 150Ω are obtained provided stray capacitance is kept at a minimum. If necessary pulses with smaller amplitudes can be obtained using a set of plug-in attenuators.

POWER SUPPLY

A positive 5V stabilised d.c. supply is required. The diagram of such a circuit is shown in Fig. 4. The series transistor Zener diode (TR1–D5) arrangement provides sufficient stabilization against mains variations of ±10 per cent (nominal 230V a.c.). The d.c. current requirement is about 30mA.

If the instrument is to be battery operated it is recommended that the low power types of TTL be used (e.g. 74 L) in conjunction with a rechargeable battery—nickel cadmium for instance. ★

The new EMI 1515 stereo amplifier and smaller EMI SQ1500 quadraphonic decoder shown here with two LE2 15W loudspeakers forming a complete "add-on" package for converting an existing stereo system for SQ quadraphonic operation

SONEX 73

The Saba 544G stereo reel-to-reel unit illustrates the modern styling current in today's equipment

PROBABLY the main theme of this year's Sonex exhibition, Sonex 73, held at the Excelsior Hotel, London Airport, was quadraphonic or 4-channel sound. Of course, much of the exhibition and the associated lectures was concerned with the more mundane things of life like the mechanics of disc reproduction, listening room acoustics, and so on.

But, as at any gathering of Hi-Fi enthusiasts, and Sonex was certainly that, the tendency is to discuss the latest development available on the market. Currently quadraphonics falls into this category, with all the usual arguments as to benefits of different systems and methods.

Many of the exhibitors were prepared to comment on the validity of 4-channel sound but only a few offered equipment and, of course, in the small hotel rooms used by the exhibitors it was impossible to demonstrate the effects available decently.

In fact, this is one of the problems with using a hotel for an event of the nature of Sonex 73. Unlike RECMF or IEA or, for that matter any show held in a large hall-type space, not only is it difficult for the visitor to scan the field in general for his particular interest but hotel corridors have a habit of all looking the same.

Thus there is a tendency to miss items of interest and to get "lost" or disoriented. The only solution being the heavy reliance on the handbook. And we all know how impossible it is for all the information to be present there.

Of course, the hotel environment does have advantages. As the sound-making equipment was housed in separate rooms it was possible for the exhibitor to give an almost private demonstration of his gear. The usual problem of interference from stand to stand was avoided.

Really Sonex is directed to the audiophile with the desire to purchase already-built equipment, with only a scattering of items such as Richard Allan speaker kits and Connoisseur turntable products for the more practically minded. However, it is always interesting to see how the professionals do things.

LOUDSPEAKERS

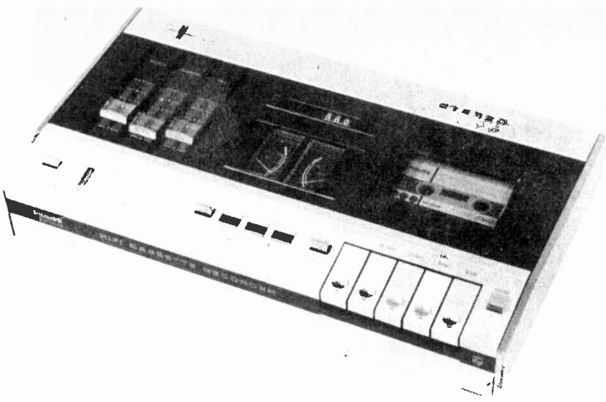
It is an accepted fact that the loudspeaker is one of the weakest links in the chain of sound reproduction and many of the exhibits showed just how far one can go with money and good intentions to put the orchestra in the sitting room. Anything up to several hundred pounds per unit can be spent. However, there must be a rational level between TV sound standards and using the dining room as a sound box for the rest of the house.

An interesting demonstration of loudspeaker performance was given by Acos using the Martin range from America. At the low price end was the Micro Dan, a prototype baby unit which is expected to sell here for about £30 plus VAT per pair. The Mini Dan, already available here at £56·28 plus VAT per pair also gave a good performance for the price. But most impressive were a pair of Laboratory Mk. 2 units and although these sell at £57·95 each plus VAT the performance was perhaps more "musical" than anything else at the show.

Of course, these comments are governed by personal hearing to a degree but when it is remembered that the Laboratory Mk 2 units include three speakers and controls to set mid and high frequency balance, allowing "tuning" of the equipment to a room, a hearing test is in the end, the only valid method left.

In fact it was commented by someone at the show that if you provided an audience with "flat" response speakers then most people would not appreciate the resulting sound at all.

Again on the subject of speakers, Richard Allan were displaying their well-known range of kits and assembled Hi-Fi units. Whilst they have not added to the kit range they were demonstrating an interesting professional/monitor unit, still in the prototype stages, called the Academy. This is physically a large item and not at all of the kittable type. It is expected to appear on



The Phillips N2510 stereo cassette unit, to DIN 45500 standards, is intended for use with Chromium Dioxide tapes

the market some time in July when the price will be settled. At the moment it is envisaged that £70 to £80 will be about right.

MADE OVERSEAS

Much of the equipment on show is made overseas. We have already mentioned American sourcing. From Norway comes the Tandberg line handled in the UK by Farnell-Tandberg Ltd. Included are a wide selection of tape and deck units, loudspeakers, separate amplifiers, tuner units and composites of various denominations. It is interesting to note the adoption by Tandberg, as almost everyone else, of a cassette deck which meets 45500 DIN requirements and includes a Dolby noise reduction system.

Japanese equipment was fairly in evidence and, as is to be expected, set a standard of appearance which some sources near home are having difficulty meeting. Again the emphasis was on 4-channel sound with specially designed controllers for remote handling of the output of each channel and special headphones designed for quadraphonics.

Of course, the Japanese exhibits included many examples of casette units, some claiming performances equal if not superior to reel-to-reel equipments.

SIDE SHOW

Perhaps one of the problems of an event of this type is the consistency of the exhibits. Whilst not quite an "If you've seen one you've seen them all" situation, there is certainly a tendency to feel this after a matter of hours looking at the exhibits.

Thus it was somewhat of a relief to vacate the Excelsior for a while and go to see a demonstration of quadraphonics put on by EMI at a separate hotel. Intended to launch two of their latest products for the Hi-Fi market, the EM 1515 stereo amplifier and the SQ 1500 quadraphonic decoder, this side-show (as it were) took the cake as a demonstration of the abilities of quadraphonics to enhance the realism of reproduced sound.

In addition to announcing and displaying the amplifier and decoder, EMI showed a new small eliptical speaker unit which is expected to come on the market soon at about £30/pair cased.

The amplifier is to sell at £46·50 including VAT and includes a claimed performance in excess of most equipments in this mid-price area. 15 watts per channel at 0·2 per cent distortion, and the ability to control power supply to ancillary equipment are some factors of interest.

The decoder is designed to give one the ability to handle the new SQ 4-channel records in conjunction with four channels of amplification. The 1515 is suited to this and EMI are to offer a kit including the decoder and one amplifier to those already possessing a stereo unit. ★

NEWS BRIEFS

Advanced Motorway Communication System

A new data transmission system to control the roadside telephones on the M2 has been ordered by the Northern Ireland Ministry of Development. Designed and manufactured in Britain by AP Electronics of Chiswick, the system will be capable of replacing a 185 core cable with just two wires.

The heart of the system is a complex logic network constructed from Motorola MCMOS units. With the new system the operator will be able to dial any of the roadside telephones so that emergency situations can be handled before the less urgent breakdowns.

Underwater Detection of Aircraft Wreckage

Trials to improve the techniques for the detection of aircraft wreckage by sonar have just been carried out in Torbay. Designed to test the limitations of sonar detection, the trials covered a four-week period and the results should help in developing more effective systems.

A unique feature of the trials is the use of magnetic tape for the recording of the raw data required later for numerical analysis. More sensitive magnetic tape allows easier measurement of signal strength and hence easier differentiation between different types of wreckage.

Apart from the underwater detection of aircraft wreckage the techniques under trial could also be useful in such areas as location of ship wrecks, tracking of oil pipes and the assessment of inshore sediment accumulation.

Aircraft Tactical Simulator Takes Off

What is described as the world's most advanced simulator is now being "flown" by RAF crews after completion by the manufacturers, Marconi Space and Defence Systems. Built as the first of a number to be supplied to RAF Strike Command under a Ministry of Defence contract worth approximately £5 million, the simulator will reproduce for all 12 trainee crewmen, every operational facet of the world's most advanced anti-submarine aircraft, the Hawker-Siddeley NIMROD.

All operational equipment, including the radar, sonar, tactical navigation and weapon delivery systems, is fitted in a replica NIMROD, to reproduce actual missions, even down to engine noise and low-level buffeting.

PO Contracts for 120 Mbit/s Digital Line System

As a first step to developing a digital trunk network and preparing for new facilities, the Post Office has placed contracts with STC, GEC and Plessey to develop digital transmission systems enabling pulse code modulation (PCM) to be used on Britain's trunk network.

The decision to develop a digital system for the UK trunk network stems from the results of feasibility studies carried out for the Post Office by GEC and Plessey in 1970-71. These studies confirmed that it is technically possible to introduce a digital system using the standard 1·2/4·4mm coaxial cable already in use for multichannel frequency division multiplex transmission.

Under development contracts STC, GEC and Plessey have been commissioned to design, develop, manufacture and install systems transmitting information at a rate of 120 Mbit/s. Links between Guildford and Portsmouth, and Portsmouth and Southampton are to be set up, each system capable of transmitting up to 1,680 telephone conversations simultaneously.

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.

VARIABLE STABILISER FOR POWER SUPPLIES

THE need often arises for a stabilised power supply having an output which is continuously variable between two predetermined limits.

Considering the circuit in Fig. 1 and for the moment ignoring the inclusion of VR1 and VR2, it can been seen that we have a conventional stabiliser consisting of a voltage reference source, a differential amplifier TR1 and TR2, a power output stage TR3 and TR4 and a negative feedback loop provided by R5 and R6 in conjunction with the setting of VR2.

The ideal conditions for stability are as follows. The current through R3 should be equally divided between TR1 and TR2, thus implying that the base potential of TR2 should be the same as that of TR1, namely V_{ref}. From this we can deduce that

$$V_{ref} = V_0 \frac{R_5}{R_5 + R_6}$$

$$V_0 = V_{ref} \frac{R_5 + R_6}{R_5}$$

From the last equation it can be seen that there are two alternative methods of varying V_0; both are shown in Fig. 1. Firstly we can vary the ratio of R_5 to R_6 by means of VR2. This suffers from the disadvantage that as V_0 changes so does the loop gain, invariably to the detriment of circuit performance.

The second alternative is to vary the value of V_{ref} by means of VR1. However, examination of the circuit discloses yet another disadvantage. For low values of V_{ref} the current through TR1 is relatively low but there must be a large voltage drop across R4 thus implying a high current through TR2. The converse applies for high values of V_{ref} and it should not be difficult to see that there is only one setting of VR1 that fulfills the fundamental condition for stability.

If, however, we replace R4 with another transistor stage TR5 (Fig. 2), which receives its base bias via the collector load resistor R8 of TR1 (Fig. 2) then this problem is resolved. If for all settings of VR1, the voltage across R8 is large compared with the emitter-base voltage of TR5 and the value of R8 is roughly the same as R4, then the current flowing through these two resistors will be substantially the same.

This circuit has the inherent advantage that TR2 has for its load the intrinsic collector resistance of another transistor which, having an extremely high incremental resistance, increases the loop gain to a value of several hundreds.

Since, at high frequency the base emitter junction of a transistor can be regarded as an RC network there will be a frequency at which this circuit will oscillate, although the frequency of oscillation is difficult to predict, depending largely on component layout and the types of transistors used. Instability can be prevented by making the output the dominant time constant by means of a capacitor, the minimum value of which in the prototype was found to be around 10μF.

This circuit has an output which is continuously variable from 6V to 18V at currents up to 1 amp with the output transistor suitably mounted on an adequate heat sink.

J. Davies,
London W.14.

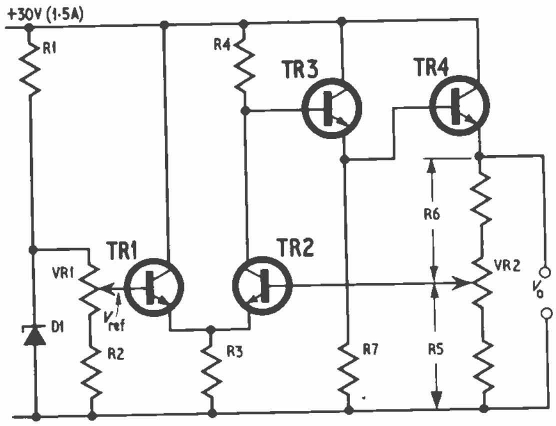


Fig. 1. Circuit for a conventional stabiliser

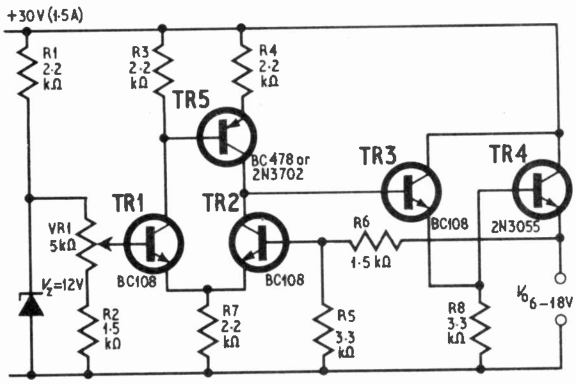


Fig. 2. Final circuit for a variable stabiliser for power supplies

LAMP STROBE

I BUILT the lamp strobe (*Ingenuity Unlimited*, April 1972) but found the multivibrator in my circuit was unstable and tended to lock at mains (50Hz) frequency. This was overcome by decoupling the supply and adding two more diodes to the bridge rectifier allowed pulsating d.c. to reach the gating transistor and hence trigger the thyristor. See Fig. 1.

The speed control circuit was also modified and now gives a range of about 2–12Hz, with 10μF timing capacitors, which gives a good strobe effect when using several low power lamps in parallel. Coloured 15W "pigmy" bulbs are very suitable for this application, giving a fair amount of light when mounted in simple reflectors.

A "one-shot" facility was added by switching out the multivibrator and arranging for a microswitch S2 to discharge a capacitor through the gate giving one bright light pulse from the lamp for every press of the micro-switch.

Transformer T2 is a 1:1 isolating transformer consisting of about 20 turns of 36 s.w.g. enamelled copper wire wound on a ferrite core twice, preferably overlapping.

H. N. Jarman,
Tunbridge Wells.

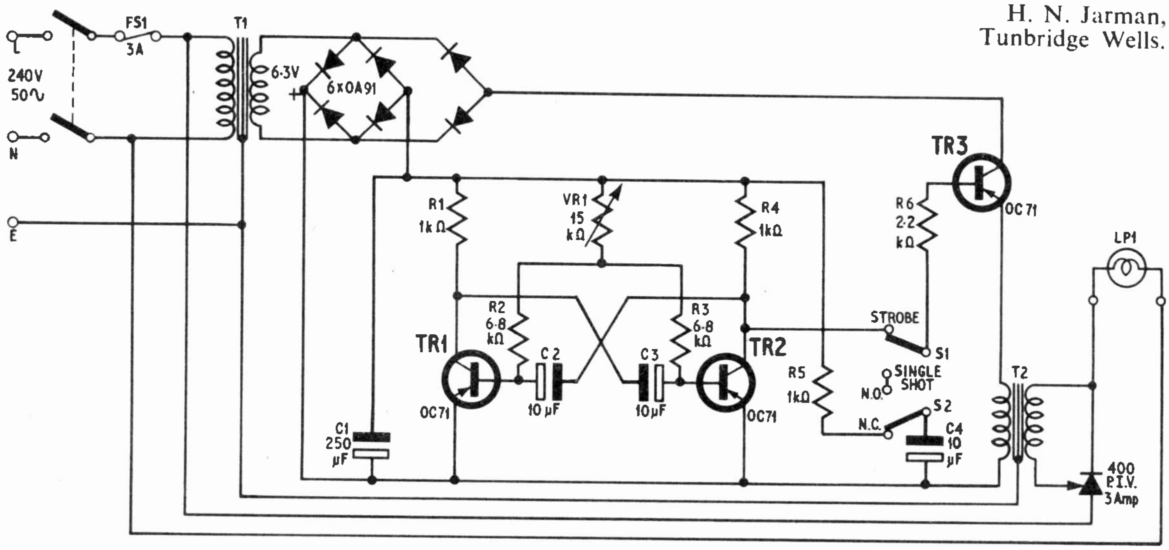


Fig. 1. Lamp strobe circuit diagram

TIMING CIRCUIT

THE main requirements of the timing circuit in Fig. 1 were that it should be cheap to build and run, while retaining reasonable accuracy.

In circuits of this kind it is usual to see a field effect transistor in the place of TR1, the main objection to a bipolar transistor being the low input resistance. In this circuit a bipolar transistor has been used for economy, the input resistance being increased by R2. Although this does not offer an input resistance comparable with that of a field effect transistor, the timing is accurate enough for many applications. The value of R2 should be found by experiment, but should not lie below 2MΩ.

When S1 is pressed TR1 will conduct, driving TR2 into saturation. This energises the relay which disconnects R1 and connects the emitter of TR2 to the power supply. C1 charges up through VR1 at a rate depending on its setting. When C1 has charged up enough, TR2 will no longer be able to hold the relay on, and the circuit will reset itself, C1 being discharged via R1.

The components specified will give a maximum timing period of a few minutes. If longer periods are required, the value of C1 can be increased.

The maximum current consumed by the prototype is about 25mA just after switching on, this value decreasing as the timing cycle progresses. The current consumed depends mainly on the relay chosen, one with a large coil resistance being most suitable.

The choice of power supply is left up to the constructor; the circuit can be run ecnomically from a small 9V battery if desired.

P. Chappell,
Weston-Super-Mare

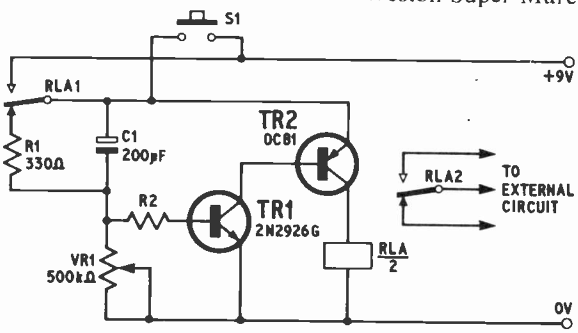


Fig. 1. Simple timing circuit

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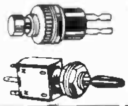
SW4—1 pole, 12 way
SW5—2 pole, 6 way
SW6—3 pole, 4 way
SW7—4 pole, 2 way
SW8—4 pole, 3 way



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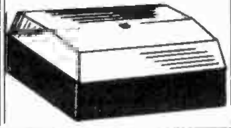

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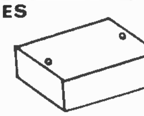
for constructional projects. White, with lid and screws.
BP1 4½ins × 3ins × 1½ins—**37p.**
BP2 6ins × 4ins × 2½ins—**37p.**



EQUIPMENT CASES

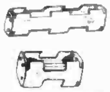
in plain aluminium with sloping front panel.

Type	H.	W.	D.	Price	p. & p.
SF1	2in	5¼in	2½in	50p	13p
SF2	2in	7¼in	3½in	66p	17½p
SF3	2in	9¼in	4½in	83p	20p

BATTERY HOLDERS

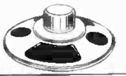
for 4 × HP7.
Long or short—**22p.**

Press studs, ready wired PP3 size—**10p**; PP9 size—**13p.**



MINIATURE SPEAKERS

2½in 8 Ω
2¾in 8 Ω
2¾in 80 Ω
All at **68p** each.



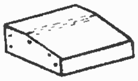
EA 1000 BARGAIN!

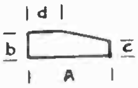
This popular 3W AMPLIFIER complete with comprehensive data book showing circuits for mono, stereo, tone controls, power supply, etc. Our price **only £2·35** plus 13p p.& p.

CONSOLE CASES

in plain aluminium, ideal for mixers, instruments, etc.

Type	W. in	A in	B in	C in	D in	Price	p. & p.
GB20	8	9	3½	2	3	£1·56	33p
GB21	10	9	3½	2	3	£1·74	33p
GB22	12	9	3½	2	3	£1·89	33p





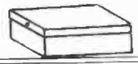
GROOV-KLEEN

de luxe model 42 **£1·83**

ALUMINIUM BOXES

with lids and screws

Type	L.	W.	D.	Price	p. & p.
GB7*	5¼in	2¾in	1½in	42p	16p
GB8*	4in	4in	1½in	42p	16p
GB9*	4in	2¾in	1½in	42p	14p
GB10*	5¼in	4in	1½in	49p	19p
GB11	4in	2½in	2in	42p	14p
GB12	3in	2in	1in	36p	15p
GB13	6in	4in	2in	57p	20p
GB14	7in	5in	2½in	69p	21p
GB15	8in	6in	3in	89p	29p
GB16	10in	7in	3in	£1·00	29p

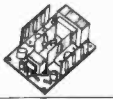


* These sizes fit standard veroboards

STEREO HEADPHONES

Eagle SE5. 8 Ω
40–16,000Hz
Complete with cable and stereo jack plug.
£3·43 Plus **24p** p.&p.

10 WATT AMPLIFIER module

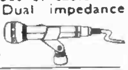


Input: 30mV into 10kΩ for 10W, 40 – 16,000 Hz. Output: 3-8-16Ω Power Supply 12V **£4.70** plus **24p** p. and p.

DYNAMIC MICROPHONE UD130HL

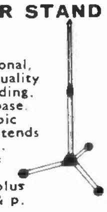
This sensitive, quality microphone is uni-directional and is complete with mute switch and 20 feet of cable and plug. 100–12,000Hz. Dual impedance 600Ω and 50kΩ.

£6·60 plus **24p** p. & p.



MICROPHONE FLOOR STAND

Professional, heavy quality with folding, tripod base. Telescopic stem extends to 59ins. Chrome finish. **£6·20** plus 45p p. & p.



MINIATURE ELECTROLYTICS

1·0μF	63V	7p	150μF	25V	8p
1·5μF	63V	7p	150μF	40V	13p
2·2μF	63V	7p	150μF	63V	15p
3·3μF	63V	7p	220μF	4V	7p
4·7μF	63V	7p	220μF	10V	7p
6·8μF	40V	7p	220μF	16V	8p
6·8μF	63V	7p	220μF	25V	13p
10μF	25V	7p	220μF	40V	15p
10μF	63V	7p	220μF	63V	22p
15μF	16V	7p	330μF	4V	7p
15μF	40V	7p	330μF	10V	8p
15μF	63V	7p	330μF	16V	13p
22μF	10V	7p	330μF	63V	26p
22μF	25V	7p	470μF	6·3V	8p
22μF	63V	7p	470μF	10V	13p
33μF	6·3V	7p	470μF	25V	15p
33μF	16V	7p	470μF	40V	22p
33μF	40V	7p	680μF	6·3V	13p
47μF	4V	7p	680μF	16V	15p
47μF	10V	7p	680μF	25V	22p
47μF	25V	7p	680μF	40V	26p
47μF	40V	7p	1000μF	4V	13p
47μF	63V	8p	1000μF	10V	15p
68μF	6·3V	7p	1000μF	16V	22p
68μF	16V	7p	1000μF	25V	26p
68μF	63V	13p	1500μF	6·3V	15p
100μF	4V	7p	1500μF	10V	22p
100μF	10V	7p	1500μF	16V	26p
100μF	25V	7p	2200μF	6·3V	22p
100μF	40V	8p	2200μF	10V	26p
100μF	63V	15p	3300μF	6·3V	26p
150μF	6·3V	7p	4700μF	4V	26p
150μF	16V	7p			

VEROBOARD

Size	0·1 Matrix	0·15 Matrix
2½in × 3¾in	25½p	18½p
2½in × 5in	28½p	28½p
3¾in × 3¾in	28½p	28½p
3¾in × 5in	32p	35p
17in × 2½in	87p	66p
17in × 3¾in	£1·18	94p

Spot face cutter—**44p**
Pins, either size, pack of 36—**21p**
Edge connectors:
24 way, 0·1 —**37½p**
24 way, 0·15—**37½p**
36 way, 0·1—**48½p**
16 way, 0·15—**25p**

BONDED ACRYLIC FIBRE

B.A.F. wadding, 18in wide, 1in thick. The ideal lining for speaker enclosures. **33p** per yard. P. & p. 1yd 14p; each extra yard 4p.

MICROPHONE HOLDER

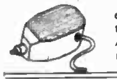
with swivel (as supplied with the mic. above). Fits most tubular mics. and stands. **57p.**

CATALOGUE

15p

POST FREE

TAPE ERASER



erases a whole reel of tape in seconds. 240V. A.C. Full instructions. **£2·20** plus **22p** p. & p.

CONTROLS

Log. or Lin.
Single, less switch, **15p**
Single, D.P. switch, **26p**
Tandem, less switch, **44p**
5kΩ, 10kΩ, 25kΩ, 50k Ω, 100kΩ, 250kΩ, 500kΩ, 1MΩ, 2MΩ

SCREENED CABLES

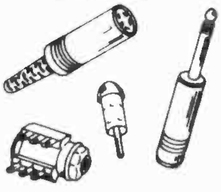
Single for mics, audio leads, etc. **5½p** yd.
Twin, as above, common screen **10p** yd.
Stereo, two cores, individually screened **11p** yd.
Four core with common screen **23p** yd.
Four core, individually screened **30p** yd.
Coiled screened leads, 20 feet long **£1·05** each.

BATTERY ELIMINATORS

suitable for transistor radios and similar light current equipment. Input 240V. A.C. Output: PP6—6V D.C.; PP9—9V D.C. Price **£1·65** plus **15p** p. & p.

PLUGS

Car aerial	15½p
Co-axial	10p
D.I.N. 2 pin (speaker)	11p
D.I.N. 3 pin	15p
D.I.N. 4 pin	15½p
D.I.N. 5 pin, 180°	14½p
D.I.N. 5 pin, 240°	16½p
D.I.N. 6 pin	16½p
Jack, 2½mm unscreened	10p
Jack, 2½mm screened	11p
Jack, 3½mm unscreened	9p
Jack, 3½mm screened	13p
Jack, ¼in unscreened	13p
Jack, ¼in screened	22p
Jack, stereo, unscreened	22p
Jack, stereo, screened	38p
Phono, plastic top	5½p
Phono, plated metal	13p
Wander, red or black	3½p
Banana 4mm, red or black	6½p



SOCKETS

Car aerial	9p
Co-axial, surface	9p
Co-axial, flush	10p
D.I.N. 2 pin (speaker)	11p
D.I.N. 3 pin	10p
D.I.N. 5 pin, 180°	10p
D.I.N. 5 pin, 240°	10p
Jack, 2½mm	11p
Jack, 3½mm	11p
Jack, ¼in unswitched	16½p
Jack, ¼in switched	18½p
Jack, stereo, switched	26p
Phono, single	5½p
Phono, 2 on a strip	7½p
Phono, 3 on a strip	10p
Phono, 4 on a strip	11p
Wander, single, red or black	5½p
Wander, twin strip	7½p
Banana 4mm red, or black	6½p

LINE SOCKETS

Car aerial	15½p
Co-axial	19p
D.I.N. 2 pin (speaker)	16½p
D.I.N. 3 pin	17½p
D.I.N. 5 pin, 180°	17½p
D.I.N. 5 pin, 240°	17½p
Jack, 3½mm	16½p
Jack, ¼in screened	54p
Jack, stereo, screened	37p
Phono, plated metal	15½p

TRANSFORMERS

all with 0-250 Volt primaries.

Miniature
MM6 6V, 500mA + 6V, 500mA.
MM12 12V, 250mA + 12V, 250mA.
MM20 20V, 150mA + 20V, 150mA.
£1·42 plus **14p** p. & p.

L.T.
LT1 6·3V, 1·5A—**82p** plus 20p p. & p.
LT2 6·3V, 3A—**96p** plus 28p p. & p.
LT3 12V, 1·5A—**96p** plus 28p p. & p.
LT4 12V, 3A—**£1·45** plus 33p p. & p.
LT5 9-0-9V, 0·5A—**83p** plus 23p p. & p.
LT6 12-0-12V, 1A—**£1·04** plus 29p p.&p.

Multi-tapped
MT30/2 0–12–15–20–24–30V, 2A— **£2·15** plus 33p p. & p.
MT60/1 0–5–20–30–40–60V, 1A—**£2·31** plus 33p p. & p.
MT60/2 0–5–20–30–40–60V, 2A—**£3·25** plus 37p p. & p.

Charger
CT/01 1A—**£1·16** plus 28p p. & p.
CT/02 2A—**£1·43** plus 33p p. & p.
CT/03 4A—**£1·76** plus 33p p. & p.
Secondaries 0–5–11–17V.
Speaker Matching 3–8–16 Ω
Example: 16 Ω speaker to 8 Ω amplifier. **99p** plus **22p** p. & p.

CASSETTE OWNERS!

For Philips and similar cassette recorders.
PU12 power unit for connection to 12V + or – E cars, giving 7½V stabilised output—**£3·55** + 16p p. & p.
PP75 mains power supply, output 7½V D.C.—**£2·15** + 16p p. & p.
Both units are complete with cables and 5 pin D.I.N. plug.

CASSETTE MICROPHONE

Low impedance dynamic with remote control switch. Fitted 2½mm and 3½mm plugs. **£2·20** plus **15p** p. & p.

ELECTROLYTICS

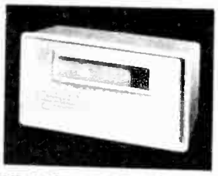
1μF	450V	21p	1000μF	50V	46p
2μF	450V	22p	2000μF	25V	43p
4μF	350V	15½p	2000μF	50V	58p
8μF	450V	18½p	2500μF	25V	50p
16μF	450V	20p	2500μF	50V	66p
25μF	25V	7½p	3000μF	25V	53p
25μF	50V	11p	5000μF	25V	66p
32μF	450V	30p	5000μF	50V	£1·21
50μF	50V	11p	8–8μF	450V	20p
100μF	50V	12p	8–16μF	450V	22p
250μF	25V	15½p	16–16μF	450V	30p
250μF	50V	19p	16–32μF	450V	69p
500μF	25V	20p	32–32μF	450V	54p
500μF	50V	27½p	50–50μF	350V	42p
1000μF	25V	30p			

TRANNIES

I DOCKYARD, STATION ROAD, OLD HARLOW, ESSEX
Phone Harlow 37739

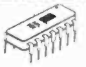
P/P 10p. Price list S.A.E. (Saturday callers welcome)
ALL PRICES INCLUDE VAT

£19·50 ELECTRONIC DIGITAL CLOCK
(For complete kit of parts including case.)



This 4 digit 24 hour clock is available to readers at this special price for I 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

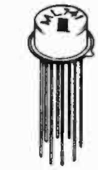


	1	25		1	25		1	25		1	25
SN7400	16p	15p	SN7423	55p	50p	SN7450	16p	15p	SN7489	6·05p	5·85p
SN7401	16p	15p	SN7425	55p	50p	SN7451	16p	15p	SN7490	74p	72p
SN7402	16p	15p	SN7427	49p	46p	SN7453	16p	15p	SN7491	1·10p	1·04p
SN7403	16p	15p	SN7428	77p	72p	SN7454	16p	15p	SN7492	74p	72p
SN7404	16p	15p	SN7430	16p	15p	SN7460	16p	15p	SN7493	74p	72p
SN7405	16p	15p	SN7432	49p	46p	SN7470	33p	29p	SN7494	85p	72p
SN7406	38p	35p	SN7433	94p	82p	SN7472	33p	29p	SN7495	85p	72p
SN7407	38p	35p	SN7437	72p	69p	SN7473	41p	39p	SN7496	95p	92p
SN7408	20p	18p	SN7438	72p	69p	SN7474	41p	38p	SN74100	1·80p	1·75p
SN7409	20p	18p	SN7440	16p	15p	SN7475	50p	47p	SN74104	1·09p	1·06p
SN7410	17p	15p	SN7441	74p	70p	SN7476	44p	43p	SN74105	1·09p	1·06p
SN7411	27p	25p	SN7442	74p	70p	SN7480	73p	70p	SN74107	44p	42p
SN7412	38p	35p	SN7443	1·43p	1·37p	SN7481	1·32p	1·26p	SN74110	61p	59p
SN7413	32p	29p	SN7444	1·43p	1·37p	SN7482	97p	95p	SN74111	1·37p	1·27p
SN7416	47p	43p	SN7445	2·00p	1·92p	SN7483	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
SN7420	16p	15p	SN7447	1·10p	1·03p	SN7485	3·96p	3·85p	SN74121	44p	41p
SN7422	55p	50p	SN7448	1·10p	1·03p	SN7486	36p	35p	SN74122	1·54p	1·43p

* Devices may be mixed to qualify for Price Breaks
* 100 Plus less 10% off 25 plus break

Linear Integrated Circuits

301	DIL	50p	723c	DIL	99p
301	TO99	55p	723c	TO99	95p
301	8 PIN DIL	46p	741c	8 PIN DIL	38p
301A	DIL	69p	741c	14 PIN DIL	39p
301A	TO99	69p	741c	TO99	41p
301A	8 PIN DIL	66p	747c	DIL	46p
307	DIL	69p	748c	DIL	39p
307	TO99	69p	748c	TO99	41p
307	8 PIN DIL	66p	1437	DIL	1·27p
308	TO99	6·45p	1458	TO99	1·27p
308A	TO99	6·40p	3046	DIL	84p
709c	DIL	35p	7503	DIL	1·27p
709c	TO99	31p			



Electrolytic Capacitors

4 VOLT	
47μF	6½p
100μF	6½p
220μF	6½p
330μF	6½p
1000μF	13p
4700μF	29p

6 3 VOLT	
33μF	6½p
68μF	6½p
150μF	6½p
470μF	11p
680μF	13p
1500μF	18p
2200μF	18p
3300μF	26p

10 VOLT	
22μF	6½p
47μF	6½p
100μF	6½p
220μF	8p
330μF	10p
470μF	10p
1000μF	11p
1500μF	20p
2200μF	24p

16 VOLT	
15μF	6½p
33μF	6½p
68μF	6½p
150μF	8p
220μF	9p
680μF	17p
1000μF	17p
1500μF	25p
2000μF	43p

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

40 VOLT	
6·8μF	6½p
15μF	6½p
33μF	6½p

40 VOLT	
47μF	6½p
100μF	9p
150μF	10p
220μF	11p
470μF	19p
680μF	25p
1000μF	25p
2200μF	44p

63 VOLT	
1μF	6½p
2·2μF	6½p
4·7μF	6½p
6·8μF	6½p
10μF	6½p
22μF	6½p
68μF	10p
100μF	11p
150μF	13p
220μF	19p
330μF	22p
470μF	26p
1000μF	44p

BARGAIN PACKS

Unmarked Packs

Pack of 25 1N4148 55p

Pack of 10
BC108 55p
BC107 55p
(Plastic can)

Pack of 10 Plastic BC109 55p

Pack of 10
BC169 55p
(unmarked) but tested

2N2646 (unmarked) 33p each

Pack of 10
2N2926G 55p
unbranded but tested

Unmarked but fully tested 2N3055
1–9 33p
10 plus 27p

FULLY MARKED TYPES

AD161, AD162 M/P
1–9 59p
10 plus 53p

BC107–BC108 BC109
1–9 9p
10–99 8p
100 plus 6½p

BC 182L·-3-4-212-4
1–9 9p
10 plus 8p

AC127 or AC128
1–9 13p
10 plus 12p
100 plus 11p

ZENER DIODES

400 M/W 5%
Miniature
BZY 88 Range

All voltages 3·3 – 33 Volt 9p each

1 watt 5%

All voltages 6·8 – 200 Volts 14p each

10 watt 5%

All Voltages 7·5 – 100 Volts 51p each

Transistors

AC107	16p
AC126	14p
AC127	13p
AC128	13p
AC142K	22p
AC141K	20p
AC176	15p
AC187	13p
AC187K	20p
AC188	13p
AC188K	20p
ACY17	24p
ACY18	21p
ACY19	25p
ACY20	22p
ACY21	23p
ACY22	18p
ACY39	68p
AD140	40p
AD142	44p
AD143	39p
AD149	38p
AD150	60p
AD161	29p
AD162	29p
AD M/P	50p
AF114	14p
AF115	14p
AF116	14p
AF117	14p
AF118	92p
AF124	27p
AF139	39p
AF239	41p
AL100	77p
AL102	66p
AL103	55p
ASY26	31p
ASY27	40p
AU103	99p
AU110	£1·10
AU111	77p
BC107	9p
BC108	9p
BC109	9p
BC113	15½p
BC116	16p
BC125	16p
BC126	25p
BC132	16p
BC134	16p
BC135	16p
BC137	16p

BC138	36p
BC142	33p
BC143	33p
BC144	30p
BC145	26p
BC147	9p
BC148	9p
BC149	9p
BC153	16p
BC154	17p
BC157	13p
BC158	12p
BC159	14p
BC167	13p
BC168	11p
BC169	11p
BC177	15p
BC179	15p
BC182L	9p
BC183L	9p
BC184L	9p
BC186	33p
BC212L	11p
BC213L	11p
BC214L	11p
BC258	9p
BC259	9p
BC267	14p
BC268	15p
BC300	40p
BC301	32p
BC302	30p
BC303	50p
BC304	40p
BCY70	17p
BCY71	37p
BCY72	17p
BD123	66p
BD130	50p
BD131	68p
BD132	90p
BD135	42p
BD136	50p
BD141	£1·87
BD142	50p
BF159	33p
BF173	29p
BF177	28p
BF178	29p
BF179	35p
BF194	15p
BF195	17p
BF244	27p

BF260	29p
BF329	18p
BF330	18p
BF390	37p
BFX84	28p
BFX85	35p
BFX86	22p
BFX87	28p
BFX88	26p
BFY50	21p
BFY51	17p
BFY52	17p
BFY64	39p
BFY90	72p
BSX20	19p
C407	22p
C426	33p
C428	31p
C450	17p
MP8111	35p
MP8112	42p
MP8113	35p
MP8121	33p
MP8122	44p
MP8123	50p
NKT211	28p
NKT212	28p
NKT214	25p
NKT217	55p
NKT261	23p
NKT271	20p
NKT274	20p
NKT276	25p
NKT403	71p
NKT405	83p
NKY603F	66p
NKT613G	33p
NKT674	26p
NKT677G	24p
NKT713	32p
NKT773	27p
OC19	55p
OC20	55p
OC23	33p
OC25	28p
OC28	33p
OC29	33p
OC35	38p
OC36	38p
OC41	14p

OC44	14p
OC45	14p
OC70	23p
OC71	14p
OC72	14p
OC81	14p
OC83	22p
OC84	28p
TIP29A	53p
TIP30A	64p
TIP31A	64p
TIP32A	73p
TIP33	£1·05
TIP34A	£1·54
TIP35A	£2·53
TIP36A	£3·19
TIP41A	79p
TIP42A	91p
2N706	13p
2N930	23p
2N1131	22p
2N1132	28p
2N1613	22p
2N1711	26p
2N2904	40p
2N2904A	44p
2N2905	46p
2N2924	18p
2N2926	10p
2N3053	26p
2N3054	55p
2N3055	52p
2N3405	44p
2N3663	57p
2N3702	9p
2N3703	9p
2N3704	9p
2N3705	9p
2N3706	9p
2N3707	9p
2N3708	9p
2N3709	9p
2N3710	9p
2N3711	9p
2N3794	17p
2N3819	28p
40361	50p
40362	50p
40636	50p

Diodes & Rectifiers	
1N914	8p
1N916	8p
1N4148	8p
1S44	10p
1N4007	22p
1S113	17p
1S120	17p
1S121	15p
1S130	9p
1S131	11p
1S132	13p
1S920	8p
1S922	9p
1S923	13p
1S940	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
OA5	19p
OA9	11p
OA10	24p
OA47	9p
OA70	8p
OA73	11p
OA79	8p
OA81	9p
OA85	11p
OA90	8p
OA91	8p
OA95	8p
OA200	11p

MULLARD POLYESTER'S

MULLARD POLYESTER CAPACITORS C280 SERIES

250V P.C. mounting: 0·01μF, 0·015μF, 0·22μF, 3½p. 0·33μF, 0·047μF, 0·068μF, 4p. 0·1μF, 4½p 0·15μF, 0·22μF, 5½p. 0·33μF, 7p. 0·47μF, 9½p. 0·68μF, 12p. 1·0μF, 14p. 1·5μF, 22p. 2·2μF, 27p

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, 3½p. 0·047μF, 0·068μF, 0·1μF, 4½p. 0·15μF, 6½p. 0·22μF, 8½p. 0·33μF, 12p. 0·47μF. 14p.
160V: 0·01μF, 0·015μF, 0·22μF, 0·033μF, 0·047μF, 0·068μF, 3p. 0·1μF 3½p. 0·15μF, 4½p. 0·22μF, 5½p. 0·33μF, 6½p. 0·47μF, 8½p. 0·68μF, 12p. 1·0μF, 14½p.

VOLUME CONTROLS

Potentiometers
Carbon track 500 Ω to 2·2M Ω
Log or Linear
Single 13p. Dual gang (stereo) 44p
Single type with D.P. switch 13p extra.

SLIDE POTENTIOMETERS

58mm. TRACK
SINGLE GANGED, LOG or LIN 1k to 1M. 45p each
TWIN GANGED, LOG or LIN 1k to 500k. 66p each.

CARBON SKELETON PRESETS

Small high quality type (linear only).
All valves 100-5 meg ohms.
·1 watt 5½p each
·2·5 watt 6½p each

VEROBOARD

	0·15 Matrix	0·1 Matrix
2½in × 3¾in	19p	26p
2½in × 5in	28p	28p
3¾in × 3¾in	28p	28p
3¾in × 5in	33p	32p
5in × 17in (plain)	94p	—

Vero Pins (bag of 36), 22p
Vero cutter, 50p; Pin insertion Tools (0·1 and 0·15 matrix) at 61p.

SLIDE SWITCH

SPST 11p each. D.P.D.T. 13p each.

MINIATURE NEON LAMPS

240V or 110V 1–4 5p, 5 plus 4½p each.

MINITRON DIGITAL INDICATOR TYPE 3015F

Reads 0–9 and decimals
(Data Sheet on request)
ONLY £1·50
16 DIL Socket 33p
Driven by 7447 £1·05

RECTIFIERS

P.I.V.	1 AMP	1·5 AMP
50	IN4001 4½p	PL4001 8p
100	IN4002 4½p	PL4002 9p
200	IN4003 5½p	PL4003 10p
400	IN4004 6½p	PL4004 10p
600	IN4005 8p	PL4005 13p
800	IN4006 9p	PL4006 15p
1000	IN4007 10p	PL4007 20p

BRIDGE RECTIFIERS

P.I.V.	1 AMP	2 AMP	5 AMP	10 AMP
50	33p	53p	£1·76p	£2·20p
100	35p	57p	—	—
200	37p	60p	£1·98p	£2·31p
400	40p	64p	£2·15p	£2·42p
600	44p	66p	£2·42p	£2·75p
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

Build yourself a TRANSISTOR RADIO

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ROAMER 10 WITH VHF INCLUDING AIRCRAFT

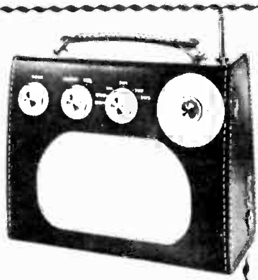
10 TRANSISTORS. 9 TUNABLE WAVEBANDS, MW1, MW2, LW, SW1, SW2, SW3, TRAWLER BAND, VHF AND LOCAL STATIONS ALSO AIRCRAFT BAND.
Built-in ferrite rod aerial for MW/LW. Retractable, chrome plated 7 section telescopic aerial, can be angled and rotated for peak short wave and VHF listening. Push-pull output using 600mW transistors. Car Aerial and tape record sockets. 10 transistors plus 3 diodes. Fine tone moving coil speaker. Ganged tuning condenser with VHF section. Separate coil for Aircraft Band. Volume/on/off, wave change and tone controls. Attractive case in black with silver blocking. Size 9in × 7in × 4in.

Easy to follow instructions and diagrams. Parts price list and easy build plans 30p (FREE with parts).

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

ROAMER EIGHT Mk. I

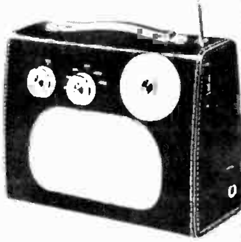
NOW WITH VARIABLE TONE CONTROL



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 easy build plans 25p (FREE with parts).

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

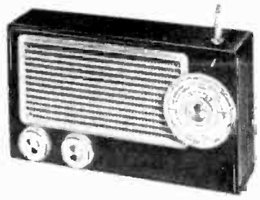
ROAMER SEVEN Mk. IV



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 easy build plans 25p (FREE with parts).

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

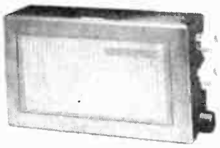
ROAMER SIX



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. Easy build plans and parts price list 25p (FREE with parts).

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

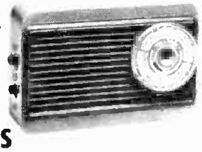
POCKET FIVE



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. Easy build plans and parts price list 10p (FREE with parts).

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

TRANSONA FIVE

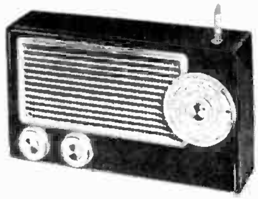


5 TRANSISTORS AND 2 DIODES

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. Easy build plans and parts price list 10p (FREE with parts).

TOTAL BUILDING COSTS **£2·75** P. P. & INS. 25p (OVERSEAS P. & P. 65p)

TRANS EIGHT



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 easy build plans 25p (FREE with parts).

TOTAL BUILDING COSTS **£4·95** P. P. & INS. 33p (OVERSEAS P. & P. £1·05)

NEW! "EDU-KIT"

BUILD RADIOS, AMPLIFIERS, ETC., FROM EASY STAGE DIAGRAMS. FIVE UNITS INCLUDING MASTER UNIT TO CONSTRUCT. Components include: Tuning Condenser: 2 Volume Controls: 2 Slider Switches: Fine tone moving coil Speaker: Terminal Strip: Ferrite Rod Aerial: 2 Plugs and Sockets: Battery Clips: 4 Tag Boards Balanced Armature Unit: 10 Transistors: 4 Diodes: Resistors: Capacitors: Three ½in Knobs. Units once constructed are detachable from Master Unit, enabling them to be stored for future use. Ideal for Schools, Educational Authorities and all those interested in radio construction. Parts price list and easy build plans 25p (FREE with parts).

ALL PARTS INCLUDING CASE AND PLANS **£6·05** P. P. & INS. 33p (OVERSEAS P.&P. £1·05)

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ROAMER EIGHT	☐	TRANS EIGHT	☐
TRANSONA FIVE	☐	ROAMER SIX	☐
POCKET FIVE	☐	EDU-KIT	☐

Parts price list and plans for ....

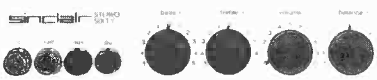
Name ....

Address ....

P.E. 54

the world's most advanced high fidelity modules

Stereo 60 Pre-amp/control unit



Designed specifically for use on Project 60 systems, the Stereo 60 is equally suitable for use with any high quality power amplifier. Since silicon epitaxial planar transistors are used throughout, a really high signal-to-noise ratio and excellent tracking between channels is achieved. Input selection is by means of press buttons, with accurate equalisation on all input channels. The Stereo 60 is particularly easy to mount.

SPECIFICATIONS—Input sensitivities: Radio – up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A. curve ±1dB 20 to 25,000 Hz. Ceramic p.u. – up to 3mV. Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE +12 to —12dB at 10KHz. BASS +12 to —12dB at 100Hz. **Front panel:** brushed aluminium with black knobs and controls. **Size:** 66 x 40 x 207mm.

Built, tested and guaranteed. **£9.98**

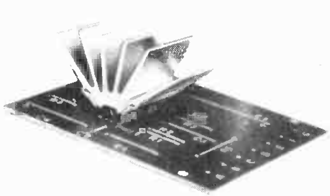
Project 60 Stereo F.M. Tuner

The phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio. Now, Sinclair have applied the principle to an F.M. tuner with fantastically good results. Other advanced features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stero decoder and switchable squelch circuit for silent tuning between stations. In terms of high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with most other high fidelity systems.

SPECIFICATIONS—Number of transistors: 16 plus 20 in I.C. **Tuning range:** 87.5 to 108MHz. **Sensitivity:** 7µV for lock-in over full deviation. **Squelch level:** Typically 20µV. **Signal to noise ratio:** >65dB. **Audio frequency response:** 10Hz – 15KHz (±1dB). **Total harmonic distortion:** 0.15% for 30% modulation. **Stereo decoder operating level:** 2µV. **Cross talk:** 40dB. **Output voltage:** 2 x 150mV R.M.S. maximum. **Operating voltage:** 25–30VDC. **Indicators:** Stereo on ; tuning. **Size:** 93 x 40 x 207mm.

Built and tested. Post free. **£25**

Super IC.12 Integrated circuit high fidelity amplifier



Having introduced Integrated Circuits to hi-fi constructors with the IC.10, the first time an IC had ever been made available for such purposes, we have followed it with an even more efficient version, the Super IC.12, a most exciting advance over our original unit. This needs very few external resistors and capacitors to make an astonishingly good high fidelity amplifier for use with pick-up, F.M. radio or small P.A. set up, etc. The free 40 page manual supplied, details many other applications which this remarkable IC. make possible. It is the equivalent of a 22 transistor circuit contained within a 16 lead DIL package, and the finned heat sink is sufficient for all requirements. The Super IC.12 is compatible with Project 60 modules which would be used with the Z.50 and Z.30 amplifiers. Complete with free manual and printed circuit board.

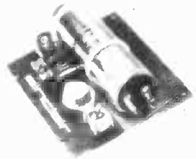
SPECIFICATIONS

Output power: 6 watts RMS continuous (12 watts peak). 6–8Ω. **Frequency Response:** 5Hz to 100KHz ±1dB. **Total Harmonic Distortion:** Less than 1%. (Typical 0·1%) at all output powers and frequencies in the audio band (28V). **Load Impedance:** 3 to 15 ohms. **Input Impedance:** 250 Kohms nominal. **Power Gain:** 90dB (1,000,000,000 times) after feedback. **Supply Voltage:** 6 to 28V. **Quiescent current:** 8mA at 28V. **Size:** 22×45×28mm including pins and heat sink..

Manual available separately 15p post free.

With FREE printed circuit board and 40 page manual.
£2.98 Post free

Power Supply Units The new PZ.8 Mk.3



The most reliable power supply unit ever made available to constructors. Brilliant circuitry makes failure from over load and even direct shorting of the output impossible. This is due to an ingenious re-entrant current limiting principle which, as far as we know has never before been available in any comparable unit outside the most expensive laboratory equipment. Ripple and residual noise have been reduced to the point of almost total elimination. This is, of course, the perfect unit for Project 60 assemblies, particularly where the new Z.50 MK.2 amplifiers are used. Nominal working voltage – 45.

PZ.8 Mk.3—£7.98
(Mains transformer, if required) £5.98
PZ.5 30v. unstabilised
(not suitable for Project 60 tuner) £4.98
PZ.6 35v. stabilised
(not suitable for IC. 12) £7.98

Project 605

the easy way to buy and build Project 60 without soldering

Project 605 in one pack contains: one PZ.5, two Z.30's, one Stereo 60 and one Masterlink, which has input sockets and output components grouped on a single module and all necessary leads cut to length and fitted with clips to plug straight on to the modules thus eliminating all soldering.

Complete with comprehensive manual, post free **£29.95**
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FINNED ALUMINIUM HEATSINK. 9in × 1¾in. Ready drilled. **20p**, p.p. 7p.

SUB-MIN. CROC. CLIPS. Red or Black, insulated **4p**. Min. quantity, 6, p.p. 3p.

GARRARD MAG. TAPE DECKS: 1⅞i.p.s., 50V, solenoid operated brakes, etc. Mains voltage motors **£7·50** each, p.p. £1·23.

4½in PLANNAIR FANS. Complete, capacitor, ex equip. 2,800 r.p.m. **£3·50**, p.p. 40p.

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- ¼ h.p., 1,440 r.p.m., **£3·75**, p.p. £1.
- ½ h.p., 1,425 r.p.m. or 2,800 r.p.m., **£6·75**, p.p. £1·25.
- ⅛ h.p., 1,440 r.p.m., **£2·25**, p.p. 75p.

AUDIO CONNECTORS

3 pin Din Plug	**13p** each.
5 pin Din Plug A type, B type	**13p** ,,
2 pin Din Speaker Plug/Socket	**10p** ,,
3 pin Din Line Socket	**13p** ,,
3·5mm Jack Plug Screened	**10p** ,,
Standard Jack Plug	**10p** ,,
Screened Standard Jack Plugs	**15p** ,,
Stereo Jack Plug	**18p** ,,
Screened Stereo Jack Plug	**18p**

Phono Plugs: Red or Black **3p** each.
P.p. on above items 3p.

MAINS NEONS
Red or Green. Size: ⅜in × ⅜in × 1¼in. **15p**, p.p. 3½p.

LEVER ACTION P.O.1000 TYPE SWITCHES
Lock 4-pole changeover, **15p**, p.p. 4p. Ex equip.
Lock 2-pole changeover, **10p**, p.p. 4p. Ex equip.

AUDIO LEADS
Screened Phono Leads 46in long, **15p**.
3·5mm JACK/3·5mm JACK 7ft 6in long, **40p**.
5-Pin Din A Type, 5-PIN A TYPE. Approx. 5ft long, **70p**.
P.p. on above items 5p.

MULLARD & MALLORY SCREW TERMINAL CAPACITORS 4,500µF 64V/7,100µF 40V. **50p** each. 20,000 30V, 25,000 25V, 35,000 15V, **30p** each, p.p. 16p.

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6-48V, 15 amp. **75p**, p.p. 10p.

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RUBBER 3 PIN 5 AMP NON-REVERSIBLE CABLE CONNECTORS, 20p, p.p. 5p.

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SOLENOIDS MAINS 240V A.C. pull action. 2¼in × 1½in × 1¼in, **50p**, p.p. 8p.

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SIEMENS MINIATURE RELAY. Four pole changeover dust cover/base 48V, 2500, **50p**, p.p. 5p new.

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GARDNER'S POTTED TRANSFORMER, 0-250V. Input: 18V 500m/n, 50V 150m/a, 6V 250m/a output. Size: 3in × 2¼in × 2¼in, **£1**, p.p. 20p. Ex equip. tested.

RIPLEY TRANSFORMERS. Primary 115 and 250V, sec. 12·5-0-12·5 at 750 m/A. 7V-0-7V at 1 amp. 2¼in × 2¼in × 2in. Price **£1**, p.p. 21p.

TELESCOPIC AERIALS
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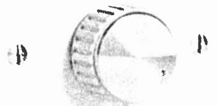

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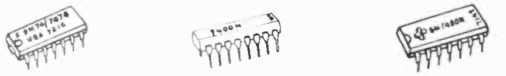

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SN7403	0·20	0·18	0·16	SN7454	0·20	0·18	0·16	SN74153	1·35	1·27	1·20
SN7404	0·20	0·18	0·16	SN7460	0·20	0·18	0·16	SN74154	2·00	1·75	1·55
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SN7406	0·30	0·27	0·25	SN7472	0·30	0·27	0·25	SN74156	1·55	1·47	1·35
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SN7412	0·42	0·40	0·35	SN7481	1·25	1·15	1·10	SN74164	2·75	2·30	2·10
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SN7425	0·48	0·40	0·35	SN7492	0·75	0·70	0·65	SN74176	1·60	1·35	1·20
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SN7447	1·75	1·60	1·45	SN74122	1·35	1·25	1·10	SN74197	1·50	1·40	1·30
SN7448	1·75	1·60	1·45	SN74123	2·70	2·55	2·47	SN74198	4·60	3·70	3·35
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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
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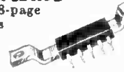

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Type	Volts P.I.V.	Price 1-11
3 AMP RANGE		
SC35A	100	75p
SC35B	200	79p
SC35D	400	85p
6 AMP RANGE (TO48)		
SC40A	100	85p
SC40B	200	90p
SC40D	400	£1·00
SC40E	500	£1·20
10 AMP RANGE (TO48)		
SC45A	100	95p
SC45B	200	£1·00
SC45D	400	£1·25
SC45E	500	£1·45
15 AMP RANGE (TO48)		
SC50A	100	£1·25
SC50B	200	£1·35
SC50D	400	£1·65
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40430	(TO66)	85p
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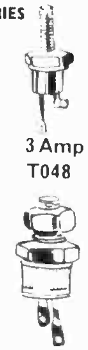

3 Amp T048

15 Amp T048

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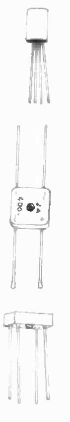
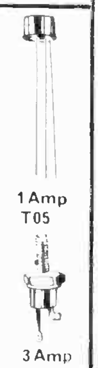
BO5/05	50	20p
BO5/10	100	25p
ONE AMP ¼ × ¾ H TUBULAR		
B1/05	50	25p
B1/10	100	25p
B1/20	200	30p
B1/60	600	35p
ONE AMP (G.I.) TUBULAR		
W005	50	30p
W01	100	35p
W02	200	40p
W06	600	45p
TWO AMPS ½ H × ½ L × 1/16		
B2/05	50	35p
B2/100	100	40p
B2/200	200	45p
B2/600	600	50p
B2/1000	1000	60p
FOUR AMPS ½H × ½L × 1/16		
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 × 1/16		
B6/100	100	70p
B6/200	200	75p
B6/400	400	90p
B6/600	600	£1·00



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

Henry's RADIO LIMITED EDGWARE ROAD, W2

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309 PA-Disco-Lighting High Power Sound 01-723 6963
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WE SUPPLY NEARLY ALL THE COMPONENTS FOR PROJECTS ADVERTISED IN THIS MAGAZINE

TRANSISTORS

2G301	0·15
2G302	0·15
2G303	0·25
2G306	0·30
2G309	0·30
2G345B	0·25
2G371	0·15
2G374	0·15
2N174	1·40
2N404	0·43
2N456	0·75
2N456A	0·75
2N457A	0·80
2N491	3·25
2N584	0·26
2N696	0·15
2N697	0·15
2N698	0·25
2N699	0·29
2N706	0·10
2N706A	0·12
2N708	0·13
2N709	0·38
2N711	0·30
2N718	0·21
2N718A	0·30
2N720	0·50
2N721	0·55
2N914	0·22
2N916	0·17
2N918	0·30
2N919	0·20
2N929	0·14
2N930	0·14
2N1090	0·23
2N1091	0·24
2N1131	0·20
2N1132	0·20
2N1302	0·16
2N1303	0·16
2N1304	0·20
2N1305	0·20
2N1306	0·22
2N1307	0·22
2N1308	0·25
2N1309	0·25
2N1483	0·90
2N1507	0·24
2N1613	0·20
2N1631	0·35
2N1637	0·30
2N1638	0·27
2N1701	1·10
2N1702	2·15
2N1711	0·17
2N1893	0·34
2N2102	0·30
2N2147	0·70
2N2148	0·60
2N2192	0·40
2N2192A	0·40
2N2193	0·40
2N2193A	0·42
2N2194	0·27
2N2194A	0·30
2N2195	0·37
2N2195A	0·18
2N2218A	0·30
2N2219	0·37
2N2219A	0·51
2N2220	0·20
2N2221	0·20
2N2221A	0·33
2N2222	0·31
2N2222A	0·41
2N2368	0·11
2N2369	0·89
2N2369A	0·17
2N2646	0·50
2N2647	1·20
2N2711	0·12
2N2712	0·12
2N2713	0·17
2N2714	0·17
2N2904	0·18
2N2904A	0·25
2N2905	0·26
2N2905A	0·23
2N2906	0·18
2N2906A	0·23
2N2907	0·18
2N2907A	0·25
2N2923	0·12
2N2924	0·12
2N2925	0·12
2N2926	
Green	0·10
Yellow	0·10
Orange	0·10
2N3053	0·31
2N3054	3·69
2N3054	0·46
2N3055	0·60
2N3390	0·20
2N3391	0·20
2N3391A	0·22
2N3392	0·13
2N3393	0·12
2N3394	0·17
2N3402	0·12

2N3403	0·19
2N3404	0·24
2N3405	0·27
2N3414	0·10
2N3415	0·10
2N3416	0·15
2N3417	0·21
2N3570	1·25
2N3571	1·12
2N3572	0·97
2N3702	0·10
2N3703	0·10
2N3704	0·14
2N3705	0·10
2N3706	0·09
2N3707	0·13
2N3708	0·07
2N3709	0·09
2N3710	0·12
2N3711	0·90
2N3712	0·95
2N3713	1·08
2N3714	1·15
2N3715	1·23
2N3716	1·30
2N3773	2·35
2N3774	3·33
2N3775	4·19
2N3776	5·95
2N3778	2·25
2N3779	3·15
2N3780	4·50
2N3781	3·67
2N3782	3·37
2N3789	1·76
2N3790	2·20
2N3794	2·06
2N3791	2·06
2N3792	2·20
2N3794	0·10
2N3819	0·37
2N3820	0·47
2N3823	0·97
2N3824	0·75
2N3826	0·23
2N3854	0·16
2N3854A	0·16
2N3855	0·16
2N3855A	0·16
2N3856	0·16
2N3856A	0·16
2N3858	0·16
2N3858A	0·16
2N3859	0·16
2N3859A	0·16
2N3860	0·16
2N3866	0·70
2N3877	0·25
2N3877A	0·26
2N3878	1·22
2N3879	1·91
2N3900	0·20
2N3900A	0·21
2N3901	0·32
2N3903	0·20
2N3904	0·17
2N3905	0·21
2N3906	0·22
2N4036	0·63
2N4037	0·42
2N4058	0·16
2N4059	0·09
2N4060	0·11
2N4061	0·11
2N4062	0·11
2N4302	0·25
2N4303	0·32
2N4913	0·80
2N4914	0·87
2N4915	0·95
2N4916	0·20
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2N4918	0·50
2N4919	0·53
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2N4923	0·60
2N4926	0·90
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2N4928	1·80
2N4929	2·23
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2N4931	2·70
2N5172	0·08
2N5174	0·22
2N5175	0·26
2N5176	0·32
2N5245	0·43
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2N5191	0·96
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2N5193	1·01
2N5194	1·10
2N5195	1·46
2N5245	0·43
2N5457	0·35
2N5458	0·33
2N5459	0·33

3N128	0·63
3N138	1·65
3N199	1·36
3N140	0·92
3N141	0·81
3N142	0·58
3N143	0·75
3N152	0·92
3N153	0·81
3N154	0·94
3N159	1·17
3N187	1·30
3N200	2·49
3N201	1·05
40050	0·78
40251	0·81
40309	0·33
40310	0·59
40313	0·92
40316	0·50
40318	0·92
40322	0·92
40360	0·46
40361	0·48
40362	0·50
43063	0·88
40389	0·46
40394	0·56
40395	0·50
40406	0·44
40407	0·33
40408	0·50
40409	0·52
40410	0·53
40411	2·25
40414	3·55
40438	1·44
40467A	0·69
40468A	0·44
40600	0·69
40601	0·67
40602	0·46
40603	0·58
40604	0·56
40636	1·10
40673	0·50
AC107	0·35
AC113	0·16
AC115	0·16
AC117	0·20
AC121	0·13
AC126	0·25
AC127	0·25
AC128	0·25
AC141K	0·30
AC142K	0·25
AC151V	0·14
AC152V	0·17
AC153	0·22
AC153K	0·25
AC154	0·20
AC176	0·18
AC187K	0·20
AC188K	0·26
ACY17	0·25
ACY18	0·15
ACY19	0·20
ACY20	0·20
ACY21	0·18
ACY22	0·13
ACY28	0·18
ACY30	0·42
ACY39	0·55
ACY40	0·17
ACY41	0·17
ACY44	0·31
AD136V	0·96
AD140	0·50
AD140	0·55
AD142	0·50
AD143	0·45
AD149V	0·66
AD149V	1·26
AD150	0·63
AD161	0·49
AD162	0·51
AD161 }	PR
AD162 }	1·15
ADZ11	1·50
ADZ12	1·75
AF106	0·27
AF109R	0·40
AF114	0·25
AF115	0·24
AF116	0·25
AF117	0·20
AF118	0·50
AF121	0·22
AF124	0·24
AF125	0·20
AF126	0·19
AF127	0·20
AF139	0·38
AF170	0·25
AF172	0·25
AF178	0·55
AF179	0·65
AF180	0·50
AF186	0·40

AF200	0·35
AF239	0·41
AF240	0·72
AF279	0·54
AF280	0·54
AFY42	0·74
AF211	0·55
AL102	0·75
AL103	0·70
ASY26	0·30
ASY27	0·36
ASY28	0·28
ASY29	0·30
ASY50	0·20
ASY55	0·35
ASZ21	0·55
AU103	1·25
BC107	0·14
BC108	0·13
BC109	0·14
BC113	0·13
BC114	0·12
BC115	0·15
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BC116A	0·18
BC117	0·21
BC118	0·11
BC119	0·27
BC121	0·23
BC123	0·29
BC125	0·15
BC126	0·20
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BC134	0·11
BC135	0·11
BC136	0·15
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BC142	0·24
BC143	0·21
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BC145	0·21
BC147	0·11
BC148	0·10
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BC160	0·37
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BC168B	0·13
BC168C	0·11
BC169B	0·13
BC169C	0·13
BC170	0·11
BC171	0·18
BC172	0·11
BC182	0·10
BC182L	0·12
BC183	0·09
BC183L	0·09
BC184	0·11
BC184L	0·11
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BC187	0·25
BC204	0·11
BC205	0·10
BC206	0·11
BC207	0·10
BC208	0·09
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BC212K	0·10
BC212L	0·16
BC214L	0·23
BC236	0·16
BC237	0·09
BC238	0·09
BC239	0·09
BC251	0·20
BC253	0·28
BC257	0·09
BC258	0·09
BC259	0·13
BC261	0·20
BC262	0·18
BC263	0·28
BC300	0·42
BC302	0·27
BC303	0·54
BC304	0·43
BC307	0·10
BC307A	0·10
BC307VI	0·10
BC308	0·09
BC308A	0·09
BC308B	0·09
BC309	0·10
BC309A	0·10
BC309B	0·10
BC313	0·30
BC327	0·24
BC328	0·22
BC337	0·19
BC338	0·19
BCY30	0·35

BCY31	0·40
BCY32	0·60
BCY32	0·75
BCY33	0·34
BCY34	0·35
BCY38	0·40
BCY39	1·05
BCY40	0·81
BCY42	0·15
BCY43	0·15
BCY58	0·21
BCY59	0·22
BCY66	0·63
BCY67	0·94
BCY70	0·17
BCY71	0·22
BCY72	0·13
BCY87	3·47
BCY88	2·40
BCY89	0·80
BCZ10	0·35
BCZ11	0·50
BD115	0·75
BD116	0·75
BD121	0·75
BD123	0·82
BD124	0·67
BD130	0·57
BD131	0·40
BD132	0·50
BD135	0·43
BD136	0·49
BD137	0·55
BD138	0·68
BD139	0·71
BD140	0·83
BDY10	1·25
BDY11	1·50
BDY17	1·50
BDY18	1·75
BDY19	1·97
BDY20	0·92
BDY38	0·65
BDY60	0·90
BDY61	0·85
BDY62	0·75
BF115	0·23
BF117	0·43
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BF244	0·16
BF245	0·33
BF246	0·43
BF247	0·49
BF254	0·14
BF255	0·15
BF257	0·47
BF258	0·53
BF259	0·48
BF261	0·23
BF264	1·45
BF270	0·25
BF271	0·21
BF272	0·53
BF273	0·25
BF274	0·23
BF457	0·53
BF458	0·65
BF459	0·57
BF821	2·10
BF821A	2·30
BFS28	0·92
BF861	0·27
BF898	0·28
BFW10	0·61
BFW11	0·61
BFW15	0·35
BFX13	0·23

BFX29	0·25
BFX30	0·25
BFX37	0·30
BFX44	0·33
BFX63	2·48
BFX68	0·30
BFX84	0·24
BFX85	0·29
BFX86	0·24
BFX87	0·25
BFX88	0·20
BFX89	0·45
BFY10	0·35
BFY11	0·45
BFY17	0·90
BFY18	0·25
BFY19	0·25
BFY20	0·50
BFY29	0·40
BFY37	0·20
BFY41	0·43
BFY43	0·62
BFY50	0·16
BFY51	0·18
BFY52	0·16
BFY53	0·15
BFY56	0·34
BFY64	0·41
BFY75	0·40
BFY76	0·22
BFY77	0·24
BFY78	0·36
BFY90	0·60
BRY39	0·38
BSX19	0·13
BSX20	0·14
BSX21	0·20
BSX26	0·34
BSX27	0·84
BSX28	0·25
BSX29	0·47
BSX30	0·68
BSX59	0·78
BSX60	0·54
BSX61	0·42
BSX76	0·15
BSX77	0·20
ASX78	0·25
BSW70	0·28
BSY24	0·20
BSY25	0·15
BSY26	0·20
BSY27	0·15
BSY28	0·15
BSY38	0·15
BSY39	0·15
BSY51	0·25
BSY52	0·25
BSY53	0·25
BSY54	0·30
BSY56	0·79
BSY65	0·15
BSY78	0·40
BSY79	0·40
BSY790	0·45
BSY95A	0·09
BU104	1·42
BU105	2·25
C111	0·53
D40N3	0·55
GET111	0·45
GET113	0·20
GET114	0·20
GET115	0·50
GET119	0·35
GET120	0·25
GET535	0·20
GET536	0·20
GET538	0·20
GET873	0·12
GET880	0·30
GET883	0·20
GET887	0·20
GET890	0·22
GET895	0·25
TIP29A	0·49
TIP30A	0·53
TIP31A	0·62
TIP32A	0·74
TIP33A	1·01
TIP34A	1·51
TIP35A	2·90
TIP36A	3·70
TIP41A	0·79
TIP42A	0·90
TIP2955	0·98
TIP3055	0·60

RETURN OF POST SERVICE

Post and Packing 13p per order. Europe 25p. Commonwealth (Air) 65p (MIN.). Matching charge (audio transistors only) 15p extra per pair. Prices subject to stock availability.

TTL LOGIC I.C.'s

We stock the full range of the low number SN7400 series—some examples:

SN7400	0·20	SN7401	0·20	SN7402	0·20
SN7403	0·20	SN7404	0·22	SN7420	0·20
SN7447	1·30	SN7472	0·36	SN7493	0·75

We also stock the unusual numbers as follows:

SN74100	2·50	SN74153	1·53	SN74176	1·50
SN74107	0·43	SN74154	2·00	SN74180	1·55
SN74118	1·00	SN74155	1·55	SN74181	7·00
SN74119	1·92	SN74157	1·80	SN74190	1·95
SN74121	0·60	SN74160	2·60	SN74191	1·95
SN74122	1·35	SN74161	2·60	SN74192	1·90
SN74123	1·35	SN74164	2·26	SN74193	1·90
SN74141	0·90	SN74165	4·00	SN74196	1·60
SN74145	1·50	SN74167	6·25	SN74198	4·60
SN74150	3·35	SN74174	2·00	SN74199	4·00
SN74151	1·10	SN74175	1·35		

FM multiplex stereo demodulator MC1304 £3·60
dual monolithic stereo preamplifier MC1303 £2·70

SILICON RECTIFIERS

PIV	50	100	200	400	600	800	1000	1200
1A	8p	9p	10p	11p	12p	15p	20p	—
3A	15p	17p	20p	22½p	25p	27p	30p	35p
6A	—	—	25p	30p	32½p	35p	—	—
10A	30p	35p	40p	47p	58p	66p	75p	—
15A	36p	45p	48p	55p	65p	75p	87p	—
35A	70p	80p	90p	£1·00	£1·40	£1·70	£2·75	—

1 amp and 3 amp are plastic encapsulation.

NE555 TIMER I.C. 90p. AS DESCRIBED IN THIS ISSUE.

NE560 phase locked loop, **£4·48.**
SCORPIO IGNITION KIT for improved performance **£10** + 50p P. & P.

MONTHLY NEWS FEATURE

1. NEW OFFICE OPEN: 65 BATH STREET, GLASGOW. Tel. 041-332 4133.
2. NEW OFFICE OPENING BRISTOL. WATCH THIS SPACE.
3. NEW CATALOGUE AVAILABLE. PRICE 15p.
4. TAD 100+CFT-470C: NORMAL PRICE £2·80 OUR PRICE £2 ONLY

DIODES AND RECTIFIERS

IN34A	10p	AA119	7p	BAX16	12½p	FST3/4	22½p
IN914	7p	AA129	15p	BAY18	17½p	OA5	17p
IN916	7p	AAZ13	12p	BAY31	7p	OA10	20p
IN4007	20p	AAZ15	12p	BAY38	25p	OA9	10p
IS44	7p	AAZ17	10p	BY100	15p	OA47	8p
IS113	15p	BA100	15p	BY103	22p	OA70	7p
IS120	12p	BA102	25p	BY122	47½p	OA73	10p
IS121	14p	BA110	25p	BY124	15p	OA79	7p
IS130	8p	BA114	15p	BY126	15p	OA81	8p
IS131	10p	BA115	7p	BY127	17p	OA82	10p
IS132	12p	BA141	17p	BY161	57p	OA90	7p
IS920	7p	BA142	17p	BYX10	22p	OA91	7p
IS922	8p	BA144	12p	BYZ10	35p	OA93	7p
IS923	12p	BA145	17p	BYZ11	32p	OA200	7p
IS940	5p	BA154	12p	BYZ12	30p	OA202	10p
		BAX13	5p	BYZ13	25p	TIV307	50p

OPTOELECTRONICS

MINITRON 3015F 7-SEGMENT INDICATOR (16 PIN DIL) £2.
DRIVER SN7447 £1·30
SOCKETS 20p

TIL 209 LIGHT EMITTING DIODE. Made by TEXAS INST. (Red). **42p**

B9900 PHOTORESISTOR **38p**

ENCAPSULATED FULL-WAVE RECTIFIER. 1·8A 100 piv **25p** ea.

WIRE-WOUND RESISTORS

2·5 watt 5% (up to 270 ohms only), **7p.**
5 watt 5% (up to 8·2kΩ only), **9p.**
10 watt 5% (up to 26kΩ only), **10p.**

POTENTIOMETERS

Carbon:
Log. or Lin., less switch, **17½p.**
Log. or Lin., with switch, **29p.**
Wire-wound Pots (3W), **38p.**
Twin Ganged Stereo Pots, Log. or Lin., **47p.**

PRESETS (CARBON)

0·1 Watt	6p	VERTICAL
0·2 Watt	6p	OR
0·3 Watt	7½p	HORIZONTAL

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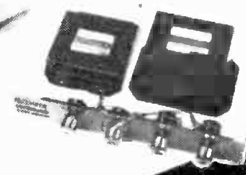

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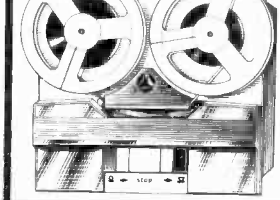

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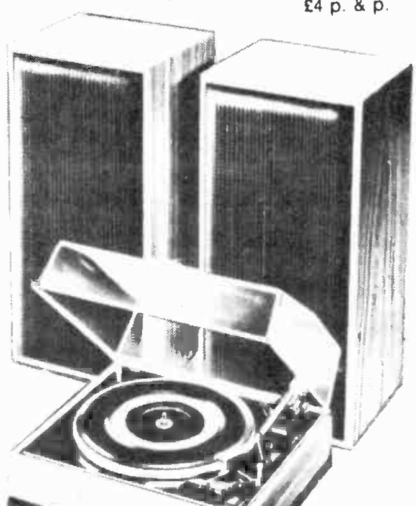

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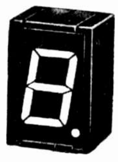

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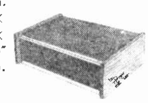

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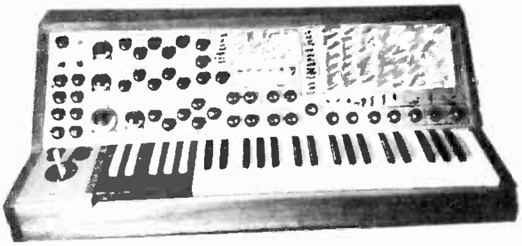

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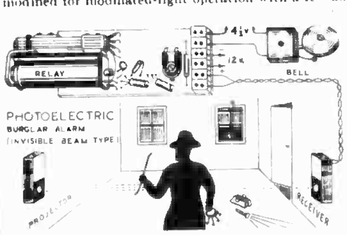

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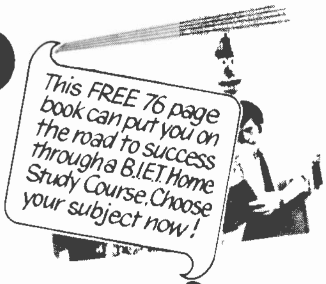

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