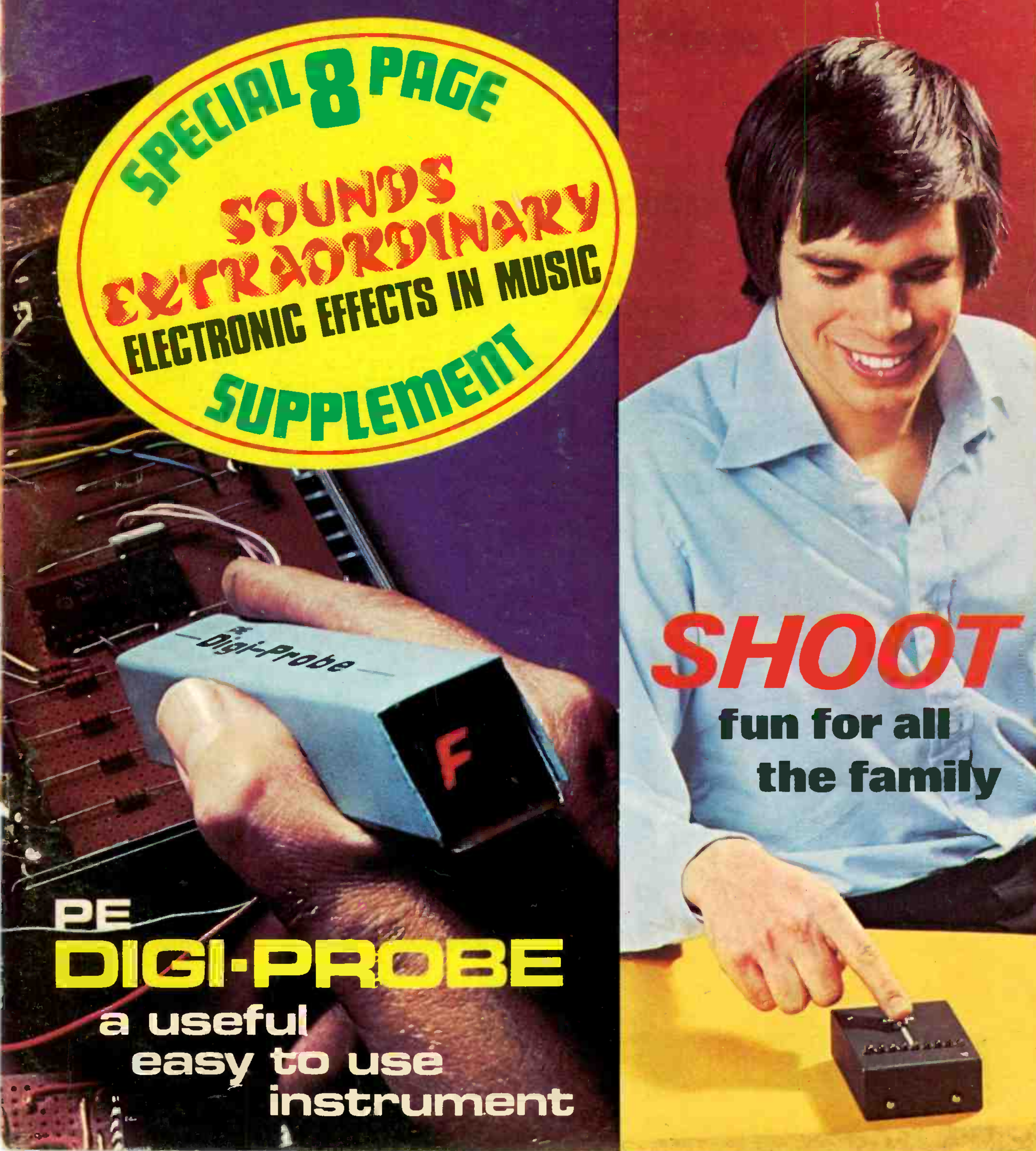
PRACTICAL

ELECTRONICS

APRIL 1976 35p



SPECIAL 8 PAGE SUPPLEMENT

SOUNDS EXTRAORDINARY

ELECTRONIC EFFECTS IN MUSIC

SHOOT

fun for all the family

PE DIGI-PROBE

a useful easy to use instrument

CHROMASONIC electronics

Dept. 2, 56, Fortis Green Road, Muswell Hill, London, N10 3HN.
telephone: 01-883 3705

C-MOS

mix prices

	1-24	25-99	100up
CD4000AE	19p *	17p *	14p *
CD4001AE	19p *	17p *	14p *
CD4002AE	19p *	17p *	14p *
CD4006AE	£1.59 *	£1.33 *	£1.06 *
CD4007AE	23p *	19p *	15p *
CD4008AE	£1.75 *	£1.46 *	£1.17 *
CD4009AE	Use	CD4049*	
CD4010AE	Use	CD4050*	
CD4011AE	19p *	17p *	14p *
CD4012AE	19p *	17p *	14p *
CD4013AE	59p *	50p *	46p *
CD4014AE	£1.75 *	£1.46 *	£1.17 *
CD4015AE	£1.75 *	£1.46 *	£1.17 *
CD4016AE	55p *	48p *	44p *
CD4017AE	£1.29 *	£1.07 *	93p *
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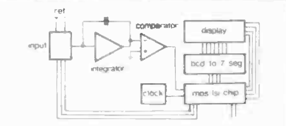
CD4020AE	£1.97 *	£1.64 *	£1.31 *
CD4021AE	£1.75 *	£1.46 *	£1.17p *
CD4023AE	19p *	17p *	14p *
CD4022AE	£1.83 *	£1.53 *	£1.22 *
CD4024AE	£1.26 *	£1.05 *	84p *
CD4025AE	19p *	17p *	14p *
CD4026AE	£2.79 *	£2.33 *	£1.86 *
CD4027AE	98p *	82p *	65p *
CD4028AE	£1.53 *	£1.28 *	£1.02 *
CD4029AE	£1.89 *	£1.56 *	£1.15 *
CD4030AE	71p *	59p *	47p *
CD4035AE	£1.75 *	£1.46 *	£1.17 *
CD4040AE	£2.01 *	£1.69 *	£1.34 *
CD4042AE	£1.49 *	£1.24 *	99p *
CD4046AE	£2.15 *	£1.79 *	£1.44 *
CD4049AE	69p *	58p *	46p *
CD4050AE	69p *	58p *	46p *
CD4051AE	£2.78 *	£2.32 *	£1.85 *
CD4052AE	£2.78 *	£2.32 *	£1.85 *
CD4056AE	£2.12 *	£1.76 *	£1.41 *
CD4060AE	£2.39 *	£1.99 *	£1.55 *
CD4066AE	£1.13 *	94p *	75p *
CD4068AE	28p *	24p *	19p *
CD4069AE	28p *	24p *	19p *
CD4070AE	28p *	24p *	19p *
CD4071AE	28p *	24p *	19p *
CD4077AE	71p *	59p *	47p *
CD4081AE	28p *	24p *	19p *
CD4082AE	28p *	24p *	19p *
CD4085AE	£1.28 *	£1.06 *	85p *
CD4086AE	£1.28 *	£1.06 *	85p *
CD4093AE	£1.56 *	£1.20 *	£1.04 *
CD4099AE	£2.95 *	£2.46 *	£1.96 *
CD4511AE	£2.36 *	£1.79 *	£1.44 *
CD4528AE	£1.30 *	£1.08 *	87p *

3½ DECADE DVM I.C.



This state-of-the-art MOS LSI chip contains all the logic necessary for a 3½ decade, dual slope integrating, automatic polarity detecting DVM. Supplied with free data and circuit booklet. AY-5-3507

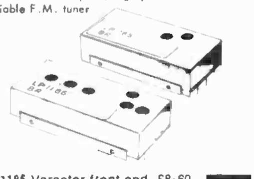
OUR PRICE ONLY £6.59.*
(Data and Circuit Booklets alone 20p.)

The AY-5-1224 tick-tock

Another marvel from G.I. A 16 pin 12-24 hr. Clock I.C. with 25 pin capability and low external parts count. Supplied with manufacturers detailed leaflet £3.95p*(inc. VAT) (Leaflet alone 20p.) Full Kit (excluding case) available towards end of 1975. Phone Clive for details.

MULLARD MODULES

Still make the simplest, highly reliable F.M. tuner



LP1186 Varactor front end	£8·60
LP1185 I.F. Strip	£6·95
LP1400 Muliplex decoder	£9·02

I.C. SOCKETS

Pin Sockets, pins in strips of 100. Just snip off what you need. 65p per strip *

Dual in line
8 pin 13p. 24 pin 26p.
14 pin 15p 28 pin 30p.
16 pin 15p 36 pin 39 p.

TO5
8 pin 31p.
10 pin 35p.

FREE CIRCUITS

Our 8 Page A4 Audio I.C. Booklet is supplied FREE with purchases of Linear I.C.'s worth £1. or more (35p. if sold alone) Contains circuits and pin connections

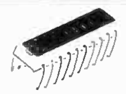
- 15 Amplifiers 250 mW to 20 watts
- 5 Audio Pre-Amplifiers
- 1 Tape Pre-Amplifier
- 1 Power Driver
- 1 Instrument Amplifier (Bifet)
- 1 General Purpose Mini Amplifier
- 1 D.C. Controlled Gain Control
- 1 Micro-mini radio (2 I.C's)

PHOTO-DARLINGTON

Vceo 25v 2N5777
Vcbo 25v
Vebo 8v
Il 250 mA
Pd 200 mW
Hfe 2500

35p.

LINE-O-LIGHT



NEW LED Linear Cursors each device contains 10 light emitting diodes in a 20 pin dual-in-line package. Ideal for solid state analogue meters or dials Type 101 RED £2.26.* Complete with leaflet.

74 TTL

mix prices

	1-24	25-99	100+
7400	14p*	12p *	10p *
7401	14p*	12p *	10p *
7402	14p*	12p *	10p *
7403	15p*	12½p*	10p *
7404	16p*	13p *	11p *
7408	16p*	13p*	11p *
7409	16p*	13p*	11p *
7410	16p*	13p*	11p *
7413	29p*	24p*	20p *
7417	27p*	22½p*	20p *
7420	16p*	13p*	11p *
7427	27p*	22½p*	18p *
7430	16p*	13p *	11p *
7432	27p*	22½p*	18p *
7437	27p*	22½p*	18p *
7441	75p*	62p*	50p *
7442	65p*	55p*	43p *
7445	85p*	71p*	57p *
7447	81p*	75p*	65p *
7448	75p*	62p*	50p *
7447A	95p*	83p*	67p *
7470	30p*	25p*	20p *
7472	25p*	21p*	17p *
7473	30p*	25p*	20p *
7474	32p*	26p*	21p *
7475	47p*	39p*	31p *
7476	32p*	26p*	21p *
7482	75p*	62p*	50p *
7485	£1.30 *	£1.09 *	87p *
7486	32p*	26p*	21p *
7489	£2.92 *	£2.80 *	£2.10 *
7490	49p*	40p*	32p *
7491	65p*	55p*	45p *
7492	57p*	46p*	36p *
7493	45p*	40p*	32p *
7495	67p*	55p*	45p *
74100	£1.08 *	89p*	72p *
74107	35p*	28p*	22p *
74121	34p*	28p*	23p *
74122	47p*	39p*	31p *
74141	78p*	63p*	53p *
74145	68p*	58p*	48p *
74154	£1.62 *	£1.48 *	86p *
74174	£1.00 *	83p*	67p *
74180	£1.06 *	88p*	71p *
74181	£3.20 *	£2.50 *	£1.90 *
74192	£1.35 *	£1.14 *	90p *
74193	£1.35 *	£1.14 *	90p *
74196	£1.64 *	£1.34 *	99p *

LINEAR I.C.'s

555 (8 pin dip)V	55p *
555 (TO-99)T	81p *
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709 (8 pin dip)	38p
709 (TO-99)	45p
709 (14 pin dip)	39p
710 (8 pin dip)	39p
710 (TO-99)	45p
710 (14 pin dip)	44p
711 (TO-99)	51p
711 (14 pin dip)	44p
720 (A.M. Radio)	£1·76
723 (TO-99)	£1·09
723 (14 pin dip	55p
741 (8 pin dip)	30p
741 (TO-99)	43p
741 (14 pin dip)	36p
747 (14 pin dip)	£1·04
748 (8 pin dip)	42p
748 (TO-99)	46p
748 (14 pin dip)	49p
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Regulators 100 mA

78L05WC (TO-92)	60p	*
78L12WC (TO-92)	60p	*
78L15WC (TO-92)	60p	*

Regulators 100mA

78L05AWC (TBA625A)	90p	*
78L12AWC (TBA625B)	90p	*
78L15AWC (TBA625C)	90p	*

Regulators 500mA

78M05HC	£1.35	*
78M12HC	£1.35	*
78M15HC	£1.35	*
78M18HC	£1.35	*
78M24HC	£1.35	*

Regulators 1A

7805KC (TO-3)	£2.09	*
7812KC (TO-3)	£2.09	*
7815KC (TO-3)	£2.09	*
7818KC (TO-3)	£2.09	*
7824KC (TO-3)	£2.09	*

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7815UC (TO-220)	£1.72	*
7818UC (TO-220)	£1.72	*
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BHA0002	£3.01	
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CA3045	£1.69	
CA3046	88p	
CA3053	59p	
CA3065	£1.60	
CA3075	£1.64	
CA3078	£1.26	
CA3080	59p	
CA3081	£1.86	
CA3082	£1.86	
CA3089E (TDA1200)	£2.43	
CA3097E	£1.67	*
CA3123E	£1.76	
CA3130	84p	
CA3401E (LM3900)	68p	
CA3600E	£1.44	
L005T1 (TO.3)	£1.46	*
L036T1 (TO.3)	£1.46	*
L037T1 (TO-3)	£1.46	*
L129 (SOT-32)	85p	*
L130 (SOT-32)	85p	*
L131 (SOT-32)	85p	*
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LM301S (8 pin dip)	59p	
LM301A T(TO-99)	67p	
LM301A S(8 pin dip)	59p	
LM307 T (TO-99)	59p	
LM307 S (8 pin dip)	57p	
LM308 T (TO-99)	£1.96	
LM308 S (8 pin dip)	98p	
LM308A T (TO-99)	£7.92	
LM308A S (8 pin dip)	£6.90	
LM309K	£2.34	*
LM339	£2.25	
LM370N	£2.85	
LM371	£2.08	
LM372N	£1.99	
LM373N	£2.99	
LM377N	£2.71	
LM380	£1.25	
LM381	£1.85	
LM382	£1.66	
LM703	68p	
LM1820	£1.03	

LM2111	£1·12	
LM3900	69p	
LM3909	66p	*
MC1303L	£1·94	
MC1306P	85p	
MC1310P	£2·10	
MC1312P	£2·52	
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MC1315P	£4·85	
MC1327P	£1·48	
MC1330P	89p	
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MC1350	68p	
MC1351	92p	
MC1352	92p	
MC1357	£1·60	
MC1358 (CA3065)	£1·23	
MC1375	£1·56	
MC1455 (555T)	65p	*
MC1456CG	£1·77	
MC1458CP1	89p	
MC1468G	£2·30	*
MC1495L	£4·48	
MC1496G	£1·01	
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MC3401P	81p	
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MVR15V (TO-3)	£1·45	*
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NE546A	£1·16	
NE555V	69p	*
NE556	£1·29	*
NE560B	£5·06	
NE561B	£5·06	
NE562B	£5·06	
NE563	£2·96	
NE565N	£2·63	
NE566V	£1·87	
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SD6000	£1·22	
SL414A	£2·09	
SL415A	£2·75	
SL437D	£7·05	
SL440	£2·84	*
SN75491N	88p	*
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TAA310A	£1.87	
TAA320	£1.44	
TAA350	£2.43	
TAA370	£3.45	
TAA550	75	
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TBA500Q	£3.16	
TBA520Q	£3.85	
TBA530Q	£3.27	
TBA540Q	£3.72	
TBA550Q	£5.29	
TBA560CQ	£5.29	
TBA625A	£1.03	*
TBA625B	£1.03	*
TBA625C	£1.03	*
TBA651	£1.87	
TBA720Q	£2.79	
TBA750Q	£2.79	
TBA800	£1.11	
TBA810S	£1.24	
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TCA760	£2.16	
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TCA940	£2.25	
TDA1054	£1·50	
TDA1200	£2·43	
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TDA1412	80p	*
TDA1415	80p	*
TDA2010	£3·00	
TDA2020	£3·75	
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ZN414	£1.26	

ZN414 Leaflet free with devices (10p alone)

MC1310, 2, 4 & 5 Leaflet free with devices (10p alone)

LED DISPLAYS

Litronix Double Digit Displays 0.5" Common Anode; 2 R/H Decimal Points

NEW

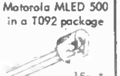
DL721 ± 1.9
DL727 0.0 to 9.9

Suitable for Clocks, Meters, Instruments, Channel Indicators

Our price £4.75 * each

C.Anode R/H Dec. pt.
C.Anode, L/H Dec. pt.
C.Anode ± 1
C.Cathode R/H Dec. Pt.

Low cost Red GaAsP Motorola MLED 500 in a TO92 package 15p.*



0.33"	Litronix DL 707 Series	✓✓✓	all £1.82* each (Red only)
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0.63	Litronix DL747 'Jumbo' Series	✓✓	all £2.42* Each (Red only)

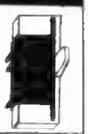
Common Cathode as Common Anode (Red only)

NOTE: MAN 4000 Series pin outs are 14 pin dil the same as MAN 50, 70 and 80 series.

DIGITAL SWITCH

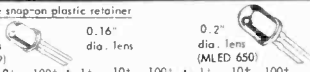
BCD encoded digital switch Reading 0 to 9. Suitable for digital clock alarm setting DVM input Scaling etc.

1 to 9. £1.49 each *



LIGHT EMITTING DIODES

Free snap-on plastic retainer



	0.125" dia. lens (TIL209) 1+	10+	100+	0.16" dia. lens 1+	10+	100+	0.2" dia. lens (MLED 650) 1+	10+	100+
Red	16p	15p	13p *	27p	24p	22p *	18p	16p	14p *
Green	27p	24p	22p *	33p	30p	27p *	30p	27p	25p *
Orange	27p	24p	22p *	33p	30p	27p *	30p	27p	25p *
Yellow	34p	31p	29p *	35p	32p	29p *	35p	33p	30p *

.......Cont'd

Our Bulk Buying Power enables a repeat of our Special Offer:
0.33" (LIT 707) 90p.* (inc. VAT)
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OPTO-ISOLATORS

ILI 4N25 or TIL116
6 pin industry standard package
2.5KV isolation £1.00.*

MAINS TRANSFORMERS

Secondaries					½A	1A	2A	4A
6-0-6V	100 mA	97p	*	0-9-17 V	-	£1.95 *	£2.27	£2.64 *
9-0-9V	100 mA	97p	*	0-12-15-20-24-30 V	-	£2.48 *	£4.15	- *
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20-0-20V	1 A	£4.55	*	0-19-25-33-40-50 V	£2.70 *	£3.40 *	£4.53	- *
24-0-24V	500 mA	£2.48	*					
28-0-28V	1 A	£6.18	*					

p.p. on transformers 10% of price min. 20p

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Items followed by a* inc. VAT at 8% all others include 25%

Overseas Customers deduct 2/27 from * items, 1/5 from others

postage & packing 20p. Orders for over £6. post free. Except transformers

Data Sheet and photocopy service available 10p. per page

Advert No. 1A of Series B

CALLERS WELCOMED

PRACTICAL
ELECTRONICS

VOLUME 12 No. 4 APRIL 1976

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

SPECIAL 8-PAGE SUPPLEMENT

Our May issue will be published on Friday, April 9, 1976
(for details of special free piece of Veroboard and other contents, see page 315)

RETURN OF POST MAIL ORDER SERVICE

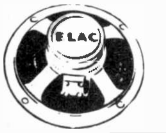
R.C.S. 10 WATT AMPLIFIER KIT

This kit is suitable for record players, tape play back, guitars, electronic instruments or small P.A. systems. Two versions are available. A mono kit or a stereo kit. The mono kit uses 13 semiconductors. The stereo kit uses 22 semiconductors with printed front panel and volume, bass and treble controls. Spec. – 10 watts output into 8 ohm, 7 watts into 15 ohms. Response 20 CPS to 30 K/CS. Input 100 M.V. high imp. Size 9½in. × 3in. × 2in.

Mono kit **£12·50** Stereo kit **£20** post 45p.

Easy to build. Full instructions supplied.

ELAC 10 inch



Dual cone plasticised roll surround. Large ceramic magnet. 50-16,000 cps. Bass resonance 55 cps. 8 ohm impedance. 10 watts **£5·50**

TEAK VENEER HI-FI SPEAKER CABINETS
Fluted Wood Fronts

MODEL "A". 20 × 13 × 12in. For 12in. dia. Baker speaker. **£12·50** Post 75p

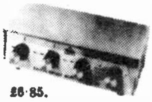
MODEL "B". 16 × 10 × 9in. For 13 × 8in. EMI speaker. **£6·95** Post 45p

LOUDSPEAKER CABINET WADDING 18in. wide, 20p ft.

BAKER RECOMMENDED 12 inch Enclosure 4 cubic ft. HI-FI CABINET £21·50. Carr. £2 each. Few only. Size 30 × 20 × 12in. Teak Finished Fluted Front.

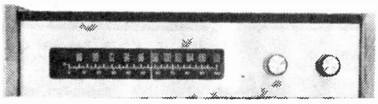
TEAKWOOD LOUDSPEAKER FRONT GRILL
Modernise your cabinets with the Grooved look.
10½" × 7½" 45p.

BARGAIN 4 CHANNEL TRANSISTOR MONO MIXER
Will mix Microphone, records, tape and tuner with separate controls into single output 9 volt battery operated. **£5·20**



STEREO VERSION OF ABOVE £6·85.

R.C.S. STEREO FM TUNER



This completely cased mains powered Hi-Fi Tuner with brushed aluminium facia is British made using the latest circuitry. Bargain **£30** Post 45p.

BARGAIN 3 WATT AMPLIFIER. 4 Transistor Push-Pull Ready built with volume, treble and bass controls. 18 volt battery operated. **£3·95**

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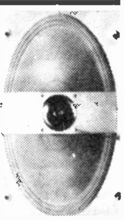

With flared tweeter cone and ceramic magnet. 10 watt. 8 ohm. Bass res. 45-60 cps. Flux 10,000 gauss. **£3·45** Post 45p

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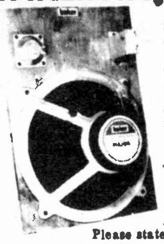

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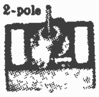

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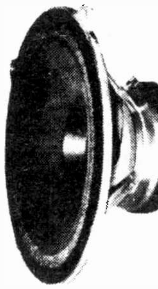

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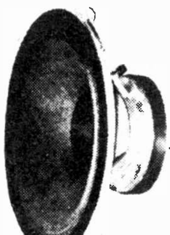

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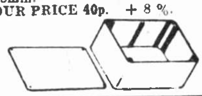

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AF181	*0·51
AF186	*0·51
AF239	*0·38
AL102	*0·68
AL103	*0·68
BC107	*0·08
BC108	*0·08
BC109	*0·08
BC113	0·10
BC114	0·16
BC115	0·16
BC116	0·16
BC117	0·19
BC118	0·10
BC119	*0·31
BC120	*0·81
BC137	0·16
BC139	*0·41
BC140	*0·31
BC141	*0·31
BC142	*0·31
BC143	*0·31
BC145	0·46
BC147	0·10
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BC161	*0·51
BC167	0·12
BC168	0·12
BC169	0·12
BC170	0·10
BC171	0·10
BC172	0·10
BC173	0·15
BC174	0·15
BC175	*0·35
BC177	*0·19
BC178	*0·19
BC179	*0·19
BC180	*0·25
BC181	0·25
BC182	0·15
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BC183	0·15
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BC184	0·20
BC184L	0·20
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BD132	*0·61
BD133	*0·67
BD135	0·41
BD136	0·41
BD137	0·46
BD138	0·51
BD139	0·56
BD140	0·61
BD155	*0·81
BD175	*0·61
BD176	*0·61
BD177	*0·67
BD178	*0·67
BD179	*0·71
BD180	*0·71
BD185	*0·67
BD186	*0·67
BD187	*0·71
BD188	*0·71
BD189	*0·77
BD190	*0·77
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BF153	0·46
BF154	0·46
BF155	*0·71
BF156	*0·49
BF157	*0·56
BF158	0·56
BF159	0·61
BF173	*0·22
BF176	0·36
BF179	*0·31
BF180	*0·31
BF181	*0·31
BF194	0·12
BF195	0·12
BF196	0·15
BF197	0·15
BF257	*0·46
BF258	*0·61
BFY53	*0·18
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2N2923	0·15
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2N2925	0·15
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2N2926Y	0·11
2N2926O	0·10
2N2926R	0·10
2N2926B	0·10
2N3053	*0·18
2N3054	*0·47
2N3055	*0·42
2N3402	*0·29
2N3403	*0·29
2N3404	*0·29
2N3405	*0·43
2N3525	*0·77
2N3614	*0·69
2N3615	*0·76
2N3616	*0·76
2N3646	0·09
2N3702	0·12
2N3703	0·12
2N3704	0·13

Type	Price
2N3705	0·12
2N3706	0·12
2N3707	0·13
2N3708	0·08
2N3709	0·09
2N3710	0·09
2N3711	0·09
2N3819	*0·29
2N3820	*0·51
2N3823	*0·29
2N3903	0·29
2N3904	0·31
2N3905	0·29
2N3906	0·28
2N4287	0·18
2N4288	0·18
2N4289	0·18
2N4290	0·18
2N4291	0·18
2N4292	0·18
2N4293	0·18
2N5172	0·12
2N5457	*0·32
2N5458	*0·32
2N5459	*0·41
40361	*0·41
40362	*0·51

VAT CHAT

Please add 8% to prices marked *. Remainder add 25%. Do not add VAT to prices marked †.

SUPER UNTESTED PAKS

Pak No.	Description	Price
U 1	120 Glass Sub-min. General purpose Germ. diodes	0·60
U 4	30 Germanium transistors like OC81, AC128	*0·60
U 5	60 200mA sub-min. silicon diodes	*0·60
U11	20 PNP Sil. planar trans. TO-5 like 2N1132, 2N2904	*0·60
U15	20 NPN Sil. planar trans. TO-5 like 2N696, 2N697	*0·60
U19	20 Silicon NPN transistors like BC108	*0·60
U26	30 Fast switching silicon diodes like IN914 Micro-Min.	0·60
U29	10 1 Amp SCR's TO-5 can. up to 600 CRS/25-600	*£1·20
U32	25 Zener diodes 400mW DO-7 case 3-36 volts mixed	0·60
U36	20 Silicon planar NPN transistors TO-5 BFY50/51/52	*0·60
U45	7 3A SCR. TO66 up to 500 PIV	*£1·20
U46	20 Unijunction transistors similar to TIS43	*0·60
U48	9 NPN Sil. power transistors like 2N3055	*£1·20

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

DIODES

Type	Price	Type	Price	Type	Price	Type	Price
BA100	*0·10	BB104	*0·15	OA10	*0·14	OA91	*0·07
BA116	*0·21	BY100	*0·16	OA47	*0·07	OA95	*0·07
BA126	*0·22	BY126	*0·15	OA70	*0·07	OA200	*0·07
BA148	*0·15	BY127	*0·16	OA79	*0·07	OA202	*0·07
BA154	*0·12	BY128	*0·16	OA81	*0·07	1N914	*0·06
BA156	*0·14	BY164	*0·51	OA85	*0·09	1N916	*0·06
BA173	*0·15	BYX38/30	*0·43	OA90	*0·07	1N4148	*0·06

THYRISTORS

PIV	0·6A TO18	0·8A TO92	1A TO5	3A TO66	5A TO66	5A TO64	7A TO48	10A TO48	16A TO48	30A TO48
10	*0·13	*0·15	—	—	—	—	—	—	—	—
20	*0·15	*0·18	—	—	—	—	—	—	—	—
30	*0·19	*0·22	—	—	—	—	—	—	—	—
50	*0·22	*0·28	*0·20	*0·25	*0·36	*0·36	*0·48	*0·51	*0·54	*1·18
100	*0·25	*0·30	*0·25	*0·25	*0·48	*0·48	*0·51	*0·57	*0·58	*1·43
150	*0·31	*0·38	—	—	—	—	—	—	—	—
200	*0·38	*0·44	*0·25	*0·30	*0·50	*0·50	*0·57	*0·62	*0·62	*1·63
400	—	—	*0·30	*0·39	*0·55	*0·57	*0·62	*0·71	*0·77	*1·79
600	—	—	*0·39	*0·48	*0·69	*0·69	*0·78	*0·99	*0·90	—
800	—	—	*0·58	*0·65	*0·81	*0·81	*0·92	*1·22	*1·39	*4·07

SILICON RECTIFIERS

PIV	300mA (DO 7)	750mA (SO 16)	1 Amp Plastic		1·5 Amp (SO 16)	3 Amp (SO 10)	10 Amp (SO 10)	30 Amp (TO 48)
50	0·05*	0·06*	IN4001	0·05*	0·07*	0·14*	0·19*	0·56*
100	0·05*	0·07*	IN4002	0·06*	0·09*	0·16*	0·21*	0·69*
200	0·06*	0·09*	IN4003	0·07*	0·12*	0·20*	0·23*	0·93*
400	0·07*	0·14*	IN4004	0·08*	0·14*	0·28*	0·35*	1·25*
600	0·08*	0·16*	IN4005	0·09*	0·16*	0·33*	0·42*	1·76*
800	0·11*	0·18*	IN4006	0·10*	0·18*	0·35*	0·51*	1·94*
1000	0·13*	0·28*	IN4007	0·11*	0·23*	0·44*	0·60*	2·31*
1200	—	0·32*			0·28*	0·54*	0·69*	2·88*

SIL. G.P. DIODES

300mW 400 PIV (min) SUB-MIN FULLY TESTED
Ideal for Organ builders
30 for *50p, 100 for *£1·50, 500 for *£5, 1,000 for *£9.

TRIACS

	Case	100V	200V	400V
2 Amp	TO5	*0·31	*0·51	*0·71
6 Amp	TO66	*0·51	*0·61	*0·77
10 Amp	TO48	*0·77	*0·92	*1·12

GP300

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

1–24	25–99	100+
*50p	*48p	*46p

GP Switching Trans

TO18 SIM. TO 2N706/8 BSY27/28/95A
All usable devices. No open and shorts. ALSO AVAILABLE IN PNP similar to 2N2906, BCY70.
20 for *50p, 50 for *£1, 100 for *£1·80, 500 for *£8, 1,000 for *£14.
When ordering please state NPN or PNP

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Rectifiers-Diodes Triacs-Thyristors-I.C.'s and Zeners.
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P&P

Postage and Packing add 25p unless otherwise shown. Add extra for airmail. £1 minimum order.

BI-PAK

P.O. BOX 6, WARE · HERTS

COMPONENTS

ALUMINIUM BOXES

No.	Length		Width		Height	Price
BA1	5¼"	×	2¼"	×	1½"	*0·45
BA2	4"	×	4"	×	1½"	*0·45
BA3	4"	×	2½"	×	1½"	*0·45
BA4	5¼"	×	4"	×	1½"	*0·54
BA5	4"	×	2½"	×	2"	*0·45
BA6	3"	×	2"	×	1"	*0·39
BA7	7"	×	5"	×	2½"	*0·79
BA8	8"	×	6"	×	3"	*£1·02
BA9	6"	×	4"	×	2"	*0·65

(Each complete with ½" deep lid and screws). PLEASE ADD 20p POSTAGE AND PACKING FOR EACH BOX.

COMPONENTS

CARBON RESISTOR PAKS

These Paks contain a range of Carbon Resistors, assorted into the following groups:

R1	50 Mixed 100Ω–820Ω ⅛W.	0·60
R2	50 Mixed 1kΩ–8·2kΩ ⅛W.	0·60
R3	50 Mixed 10kΩ–82kΩ ⅛W.	0·60
R4	50 Mixed 100kΩ–820kΩ ⅛W.	0·60
R5	30 Mixed 100Ω–820Ω ½W.	0·60
R6	30 Mixed 1kΩ–8·2kΩ ½W.	0·60
R7	30 Mixed 10kΩ–82kΩ ½W.	0·60
R8	30 Mixed 100kΩ–820kΩ ½W.	0·60

THESE ARE UNREPEATABLE PRICES

REPANCO CHOKES & COILS

RF Chokes	CH1	2·5mH	0·27
	CH3	7·5mH	0·29
	CH5	1·5mH	0·26
	CH2	5·0mH	0·28
	CH4	10mH	0·31

COILS DRXI Crystal set 0·29 DRR2 Dual range 0·42

CARBON POTENTIOMETERS

Log and Lin
4·7K, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M.

VC1	Single Less Switch	0·20
VC2	Single D.P. Switch	0·40
VC3	Tandem Less Switch	0·60
VC4	1K Less Switch	0·20
VC5	100K Log anti-Log	0·60

HORIZONTAL CARBON PRESETS

0·1 Watt 0·09 each
100, 220, 470, 1K, 2·2K, 4·7K, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M 4·7M.

REPANCO TRANSFORMERS

240V. Primary. Secondary voltages available from selected tappings 4V, 7V, 8V, 10V, 40V, 50V and 25V-0-25V.

Type	Amps	Price	P. & P.
MT/50/½	½	£1·79	0·45
MT/50/1	1	£2·24	0·48
MT/50/2	2	£3·06	0·60

COIL FORMERS & CORES

NORMAN ¼" Cores and Formers 0·07
⅜" Cores and Formers 0·09

VEROBOARDS

VBI containing approx. 50 sq.in. various sizes all 0·1 matrix *0·60
VB2 containing approx. 50 sq.in. various sizes all 0·15 matrix *0·60

CABLES

CABLES		Per Metre
CP1	Single lapped screen	*0·08
CP2	Twin Common Screen	*0·11
CP3	Stereo Screened	*0·12
CP4	Four Core Common Screen	*0·21
CP5	Four Core Individually screened	*0·28
CP6	Microphone Fully Braided. Cable	*0·11
CP7	Three Core Mains Cable	*0·11
CP8	Twin Oval Mains Cable	*0·08
CP9	Speaker Cable	*0·06
CP10	Low Loss Co-Axial	*0·14

C280 CAPACITOR PAK

Containing 75 of the C280 range of capacitors assorted in values ranging from 0·1µF to 2·2µF. Complete with identification chart.
FANTASTIC VALUE
ONLY £1·20

Add 8% VAT to all prices marked *. Remainder add 25%.

PLEASE NOTE THE ABOVE DIRECTIONS **VAT**

COMPONENT PAKS

Pak No.	Qty.	Description	Price
C1	200	Resistors, mixed values approx. count by weight	0·60
C2	150	Capacitors, mixed values approx. count by weight	0·60
C4	75	¼ width Resistors, mixed preferred values	0·60
C5	5	Pieces assorted Ferrite Rods	0·60
C7	1	Pak Wire 50 metres assorted colours	*0·60
C8	10	Reed Switches	*0·60
C9	3	Micro Switches	*0·60
C10	15	Assorted Pots and Pre-sets	0·60
C12	30	Paper Condensers preferred types, mixed values	0·60
C13	20	Electrolytics Trans. types	0·60
C14	1	Pack assorted Hardware—Nuts, Bolts, Grommets, etc.	*0·60
C16	20	Assorted Tag Strips and Panels	0·60
C19	2	Relays 6–24V Operating	0·60
C20		Sheets Copper Laminate approx. 200 sq.in.	*0·60

Please add 20p post and packing on all component packs, plus a further 10p on pack nos. C1, C2, C19 and C20.

AVDEL BOND

SOLVE THOSE STICKY PROBLEMS with

CYANOCRYLATE C2 ADHESIVE

The wonder bond which works in seconds, bond plastic, rubber, transistors, components permanently, immediately!

OUR PRICE ONLY 69p for 2gm phial

AUDIO LEADS

S221	5 pin DIN plug to 4 photo plugs length 1·5m	£1·08
S222	5 pin DIN plug to 5 pin DIN socket length 1·5m	68p
S237	5 pin DIN plug to 5 pin DIN plug mirror image length 1·5m	£1·20
S238	2 pin DIN plug to 2 pin DIN socket length 5m	68p
S270	2 pin DIN plug to 2 pin DIN socket length 10m	80p
S271	5 pin DIN plug to 2 photo plugs connected to pins 3 and 5 length 1·5m	70p
S275	5 pin DIN plug to 2 phono sockets connected to pins 3 and 5 length 23cm	68p
S318	5 pin DIN socket to 2 phono plugs connected to pins 3 and 5 length 23cm	68p
S404	Coiled stereo headphones extension cord extends to 7m	£1·40
S217	3 pin DIN plug to 3 pin DIN plug length 1·5m	80p
S219	5 pin DIN plug to 5 pin DIN plug length 1·5m	80p
S474	3·5mm Jack to 3·5mm Jack length 1·5m	68p
S600	5 pin DIN plug to 3·5mm Jack connected to pins 3 and 5 length 1·5m	80p
S700	5 pin DIN plug to 3·5 Jack connected to pins 1 and 4 length 1·5m	80p

SWITCHES

DP/DT Toggle 0·28
SP/ST Toggle 0·22

P&P

Postage and Packing add 25p unless otherwise shown. Add extra for airmail. Minimum order £1·00.

BIB ACCESSORIES

REF "D"	2 Hi-Fi Cable and Flex Tidy	*34p
REF "J"	Tape Head Cleaning Kit	72p
REF "P"	Hi-Fi Cleaner	*30p
Model 9	Wire Stripper	*£1·00
REF 23	¼" Tape Editing Kit	*£1·80
REF 24	⅛" Cassette Ed'ng Kit	*£1·84
REF 29A	Salvage Cassette	*44p
REF 32A	Stylus Balance	£1·28
REF 33	Splicing Tape	*38p
REF 36A	Record and Stylus Cleaning Kit	*32p
REF 41	8 Track Cartridge Head Cleaner	88p
Model 42	Groov-Kleen	*£1·84
REF 42/S	Roller and Brush for REF 42 and 2000	*24p
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REF 71A	Record "Dust Off" (Bubble Pack)	*70p
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REF 76	Stylus Cleaner	*36p
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TYPE B1223. 200 ohms impedance. Complete with stand, on/off switch and 2·5mm and 3·5mm plugs. Suitable for cassette tape recorders.
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ANTEX Equipment

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Model G. 18 watt	*£2·70
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BITS

102 for model CN240 3/32"	*42p
104 for model CN240 ⅛"	*42p
106 for model CN240 1/16"	*42p
1100 for model CCN240 3/64"	*42p
1101 for model CCN240 3/32"	*42p
1102 for model CCN240 ⅛"	*42p
1021 for model G240 3/32"	*42p
1021 for model G240 ⅛"	*42p
1022 for model G240 3/16"	*42p
50 for model X25 3/32"	*44p
51 for model X25 ⅛"	*44p
52 for model X25 3/16"	*44p

ELEMENTS

Model ECN240	*£1·10
Model EG240	*£1·35
Model ECCN240	*£1·55
Model EX25	*£1·20

SOLDERING IRON STAND

ST3 Suitable for all models	*£1·10
Antex heat shunt	*10p

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PLUGS		Price
PS1	DIN 2 Pin (Speaker)	0·10
PS2	DIN 3 Pin	0·10
PS3	DIN 4 Pin	0·14
PS4	DIN 5 Pin 180°	0·15
PS5	DIN 5 Pin 240°	0·15
PS6	DIN 6 Pin	0·16
PS7	DIN 7 Pin	0·17
PS8	Jack 2·5mm Screened	0·17
PS9	Jack 3·5mm Plastic	0·11
PS10	Jack 3·5mm Screened	0·17
PS11	Jack ¼" Plastic	0·14
PS12	Jack ¼" Screened	0·20
PS13	Jack Stereo Screened	0·33
PS14	Phono	0·09
PS15	Car Aerial	0·14
PS16	Co-Axial	0·14
INLINE SOCKETS		
PS21	DIN 2 Pin (Speaker)	0·13
PS22	DIN 3 Pin	0·19
PS23	DIN 5 Pin 180°	0·19
PS24	DIN 5 Pin 240°	0·19
PS25	Jack 2·5mm Plastic	0·15
PS26	Jack 3·5mm Plastic	0·15
PS27	Jack ¼" Plastic	0·28
PS28	Jack ¼" Screened	0·32
PS29	Jack Stereo Plastic	0·28
PS30	Jack Stereo Screened	0·35
PS31	Phono Screened	0·17
PS32	Car Aerial	0·20
PS33	Co-Axial	0·20
SOCKETS		
PS35	DIN 2 Pin (Speaker)	0·07
PS36	DIN 3 Pin	0·09
PS37	DIN 5 Pin 180°	0·09
PS38	DIN 5 Pin 240°	0·10
PS39	Jack 2·5mm Switched	0·11
PS40	Jack 3·5mm Switched	0·11
PS41	Jack ¼" Switched	0·19
PS42	Jack Stereo Switched	0·28
PS43	Phono Single	0·07
PS44	Phono Double	0·09
PS46	Co-Axial Surface	0·09
PS47	Co-Axial Flush	0·19

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(In 2 sections. Black Vinyl covered top and sides and bezel)

No.	Length		Width		Height	Price
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BV2	11"	×	6"	×	3"	*£1·62
BV3	6"	×	4¾"	×	1½"	0·92
BV4	9"	×	5¼"	×	2½"	£1·39

20p P. & P. Per Box.

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7" E.P 10½ × 7" × 8" (50 records) *£2·48
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Holds 15. 10" × 3½" × 5". Lock and handle *£1·50

8-Track CARTRIDGE CASES

Holds 14. 13" × 5" × 6". Lock and handle *£2·20
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BI-PAK

P.O. BOX 6, WARE · HERTS

TUAC

TRANSISTOR UNIVERSAL AMPLIFICATION CO.LTD
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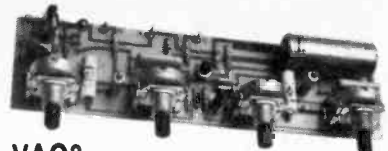
PRE AMPLIFIERS



VAO8

Designed for use with TUAC power amplifier modules. Extensive research has gone into various wide range tone control circuits to produce superb sound quality. Thousands are already in use in high quality professional amplification systems.

VAO8 Vol. Treb, Mid and Bass controls. HI. IMP. FET. I/P suitable Mid. Guitar, Radio, Crystal/Ceramic P.U. Sensitivity 4mV. Treble +35dB at 16kHz. Mid +20 −15dB at 1kHz Bass ×20 −10dB at 40Hz. **£6·50**

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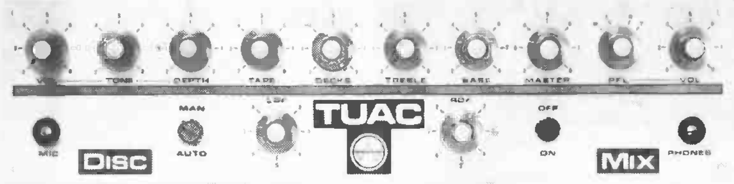
SVAO8 STEREO PRE AMP Vol, Treb, Mid and Bass controls, I/P suitable, Guitar, Radio, Crystal/Ceramic P.U. Sensitivity 4mV. Treble +35dB at 16kHz. Mid +20 −15dB at 4kHz. Bass +20 −10dB at 40Hz Plus Full Balance Control. Full I/C operation supply voltage ±15VDC. **£12·50**

MONO DISCO MIXER WITH AUTO FADE

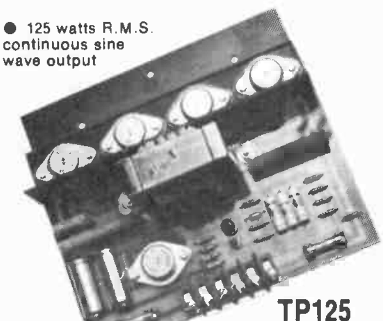


Designed for the discerning D.J. of professional standard. Offering a vast variety of functions. Controls: Mic Vol; Tone, over-ride depth, auto/Manual Sw; Tape Vol; L & R Deck Faders; Deck Volume; Treble and Bass; H. Phon Vol Selector; Master Vol On/Off Sw. Max output 1V RMS.
Specification: Deck Inputs—50mV into 1MΩ; Deck Tone Controls—treble +20 −10dB at 12kHz, Bass +22 −15dB at 40Hz; Mic Input—200 ohms upwards, 2mV into 10kΩ; Mic Tone Control—Total Variation Treble 15dB, Total Variation Bass 10dB; Tape Input—30mV into 47kΩ; Power Requirements—30–50 volts at 50mA.

£31·50
PANEL SIZE
18 × 4½in
DEPTH 3in

★ TUAC AMPLIFIER MODULES ★ POWER AND QUALITY ★

- 125 watts R.M.S. continuous sine wave output



TP125

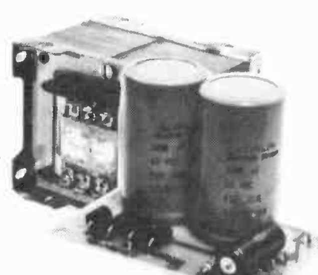
7 × 6½ × 3in

£19·50

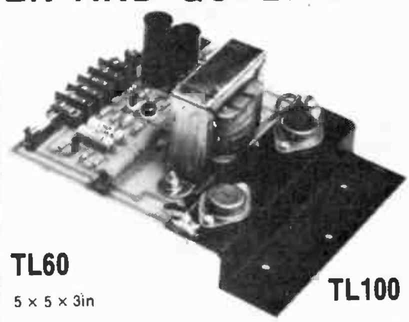
- 4 R.C.A. 150 watt 15 amp output transistors

- Rugged layer wound driver transformer
- Short—Open—and Thermal overload protection
- Only 6 connections

Power supplies vacuum impregnated. Transformers with supply board incorporating pre-amp supply.



PS 250 for supplying 2 TP125s	£22·00
PS 60/60 for supplying 2 TL60s	£19·50
PS 125 ± 45 volts for TP125	£13·75
PS 100 ± 43 volts for TL100	£12·00
PS 60 ± 38 volts for TL60	£11·50
PS 30 ± 25 volts for TL30	£7·50
PSU 2 for supplying disco mixer	£5·50



TL60

5 × 5 × 3in

- 60 watts R.M.S. continuous sine wave output
- 2 R.C.A. 110 watt 15 amp transistors

£13·50

TL100

5 × 5 × 3in

- 100 watts R.M.S. continuous sine wave output
- 2 R.C.A. 150 watt 15 amp transistors

£16·25

Specification on all power modules: All output power ratings ±0·5dB; Output impedance 8–15 ohms; THD at full power 2% typically 1%; Input sensitivity 60mV into 10kΩ; Frequency response 20Hz–20kHz ±2dB; Hum and noise better than −70dB.

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Damon Electronics, 99 Carrington Street (Tel. Nottingham 53880)
Electra Centre, 58 Lancaster Road (Tel. Preston 58488)
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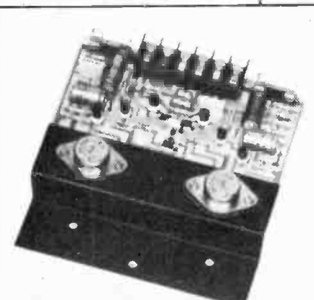

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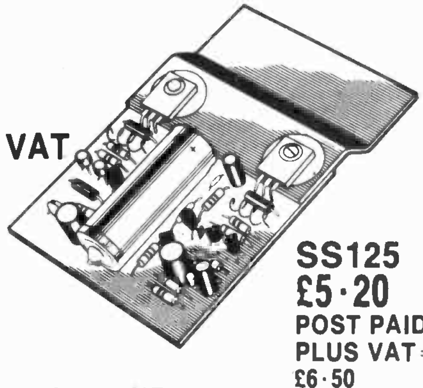

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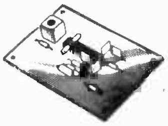

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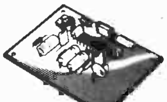

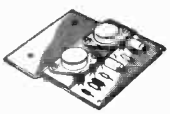

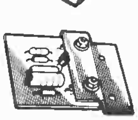

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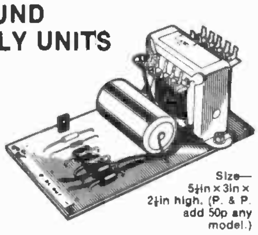

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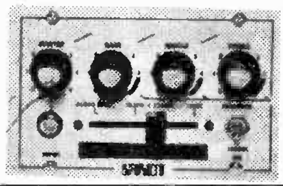

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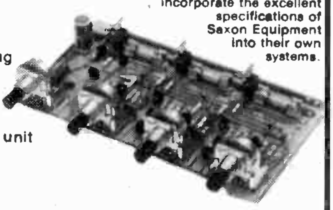

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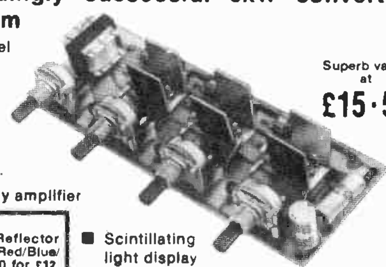

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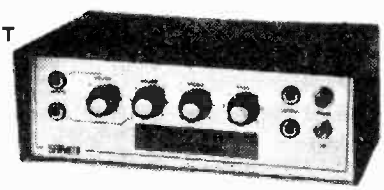

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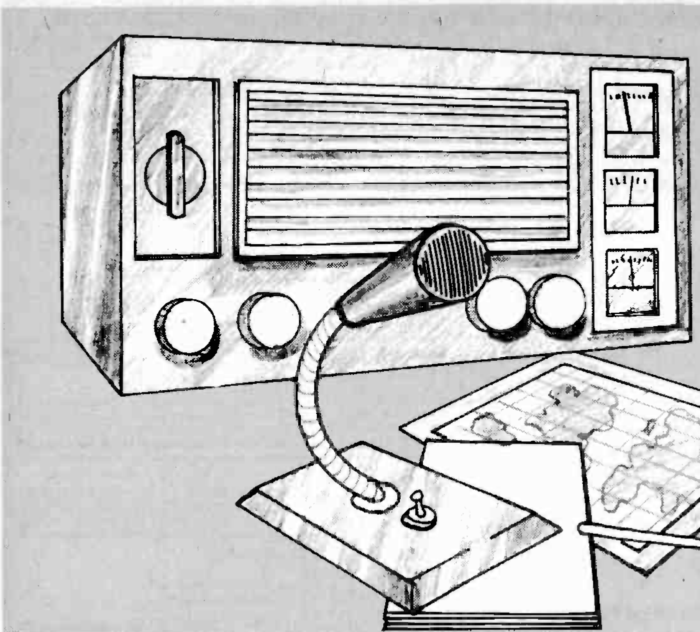

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7437	25	74105	60	74196	1-00
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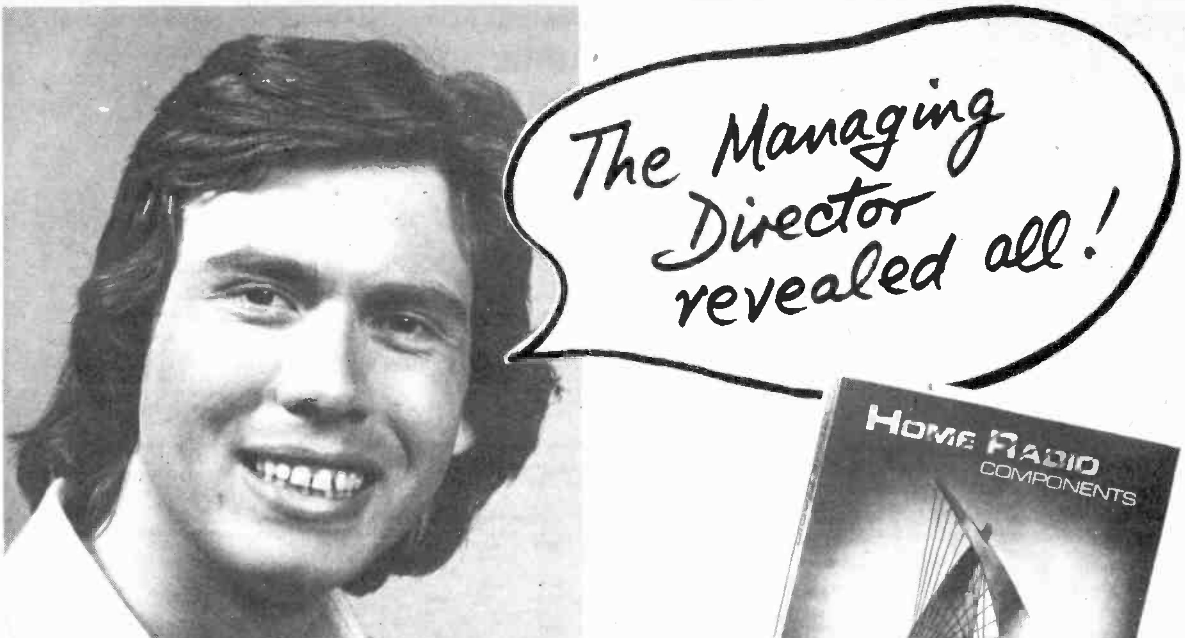

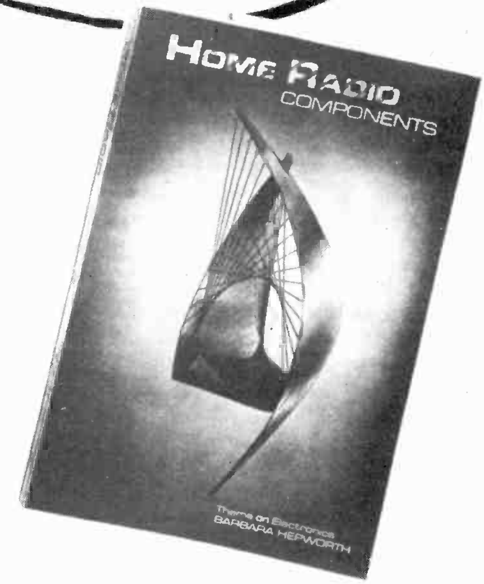

Sometimes I order my bits and pieces from Home Radio Components by post, but often I pop in to their Mitcham shop and buy over the counter. Over the years I've got quite pally with their Managing Director (nice bloke he is too) and the other day we got chatting about the mechanics of producing their catalogue. I was amazed at the amount of work that has gone into it. In fact, you could say that it has taken 20 years to produce, because the present 240-page edition de luxe has gradually evolved from the duplicated effort they turned out in 1956.

The Managing Director says that all through the years he has worked "up to a standard; not down to a price" in producing the catalogue. That principle is evident in every aspect of the catalogue—the illustrations, the indexing, the layout, the method of listing, the quality of printing and so on. It's not surprising that today it is in use all round the world, and is recognised as the finest components catalogue money can buy. Talking of money, the catalogue costs £1·30 (85p plus 45p post and packing) but every copy contains 14 vouchers, each worth 5p against orders, so there's 70p you soon get back. So the catalogue is quite inexpensive after all! And when you consider the time, care and effort that has gone into it to make it the superb production it is, it's almost a give-away! Talking of "give-aways" Home Radio Components do literally give you a new updated catalogue *free* when you have been a credit account customer for one year. Full details about the many advantages of having a credit account are given in the catalogue.

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DEPENDABILITY has become a well recognised quality where electronic equipment is concerned. Much of the reliability commonly expected or taken for granted is of course due to certain inherent characteristics of solid state devices; allied to this feature is the closely controlled manufacturing processes which ensure quality of performance to tight specifications.

The essential and important role of electronic equipment in industry and in defence has laid particular stress upon the quality of components. It was in recognition of such stringent requirements that BS9000 was drawn up by the British Standards Institution in 1967. A significant point has now been reached in the career of BS9000 with the making of this document's requirements mandatory in all military equipment sponsored by the Ministry of Defence. The national and international implications of this move are referred to in the news item in this issue.

Military equipment and industrial capital equipment may all seem very far from consumer products and the piece parts used by home constructors. Yet the widespread adoption of BS9000 by component manufacturers catering for the needs of the first two categories is bound to have repercussions throughout the entire industry. Certainly many more components emerging (fortuitously though it may be) onto the amateur market will be of unquestionable quality or standard because of their aristocratic origin. More humble applications will not deprive them of these high qualities. As the piece parts generally available for the amateur include an increasing proportion of the "top spec" devices, the performance and general excellence of home constructed equipment will be capable of further improvement.

In addition to ensuring quality control, the purpose of BS9000 backing by MoD is to introduce as much standardisation among components as is possible, in the interests of economy and efficiency. Standardisation is obviously a good thing. It is especially desirable in the electronics industry where new components are being developed at a startling rate, with identical or very similar devices often launched independently by different manufacturers. But it is probably too much to expect any serious reduction in the great abundance of type numbers in circulation. Individual manufacturers are jealous of their proprietory rights and will wish to preserve their identity for commercial purposes through their own house type numbers, though qualifying components will have a common identity via the relevant BS9000 number.

Arising from the action of the Ministry of Defence it can at least be hoped that a pattern has been marked out which will help eliminate some of the clutter of type numbers in the future. Any move in this direction can only be warmly welcomed by the component user. The "numbers game" is little fun to the uninitiated amateur. To the commercial dealer or user it must be a more serious hinderance—time consuming and a charge on efficiency.

F.E.B.

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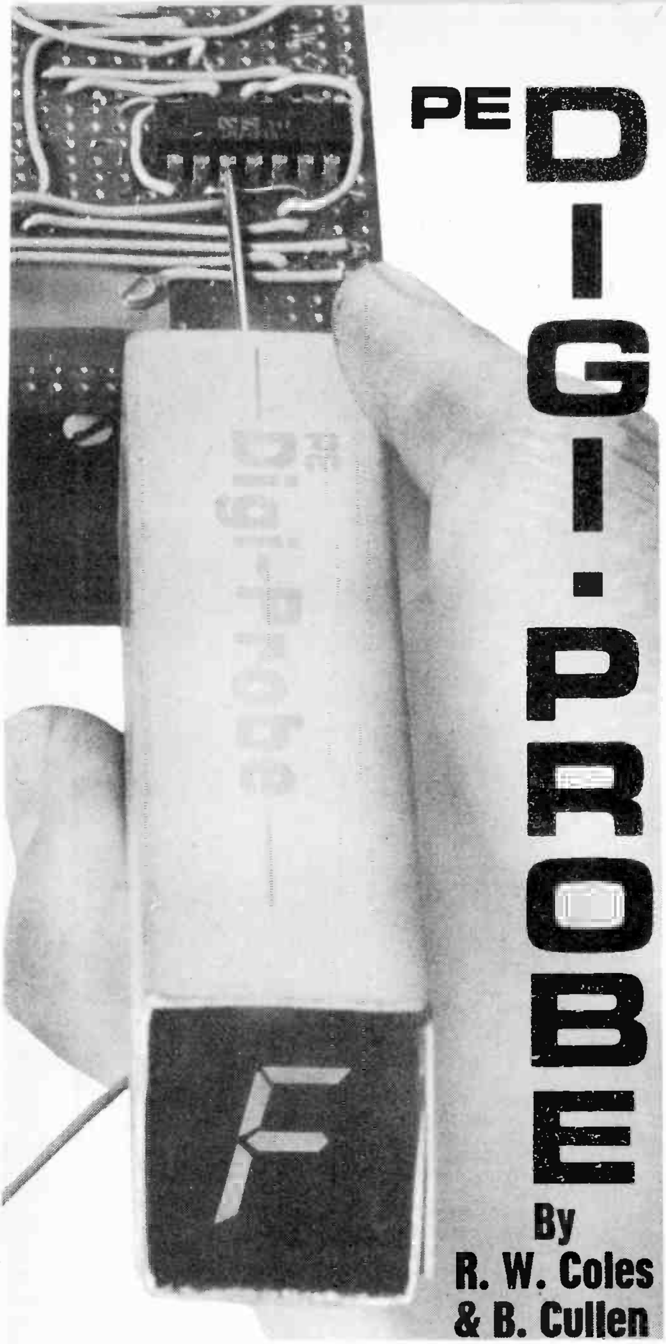
PE DIGI-PROBE



By
R. W. Coles
& B. Cullen

A LOGIC probe can be a very useful instrument for finding one's way around a logic circuit, particularly when de-bugging is in progress. During the past few years the writer has had the opportunity to try out a number of different designs, ranging from the glossy (and expensive) commercial variety, to those made to serve an immediate need. This experience left him with strongly held views on just what combination of features would make the most accurate and easy to use logic probe for general use.

You can see right away that Digi-Probe is different to its predecessors because it sports a seven-segment l.e.d. as a read-out device to give a logic state indicator which it is just about impossible to mis-interpret!

The detection circuitry recognises three input conditions as defined by the TTL data sheets and displays an unambiguous 0 for input voltages between 0 and +0·8V, a 1 for input voltages between +2·4V and +5V, and an F for the disallowed conditions of an open circuit or an input voltage between +0·8V and 2·4V.

In addition to these steady state logic outputs, Digi-Probe is designed to give a positive indication when a gate output is switching at high speed. Digi-Probe does not give an ambiguous blur as all logic states are detected in quick succession, as, for example, could occur on connection to the output of a high speed counter, in fact all the display segments turn off and the decimal point is pulsed for 30ms. This pulse detection capability means that even isolated, short pulses are stretched and made visible.

POWER SUPPLY

Digi-Probe is designed to be powered by the 5V supply of the unit under test, and to ensure that the switching of the l.e.d. segments does not inadvertently introduce noise onto the V_{CC} line to which it is connected, a novel l.e.d. drive system is employed which makes the power drain substantially constant regardless of what is displayed. Incidentally, it is not absolutely essential to power the probe from the V_{CC} line of the unit under test, a separate supply can be used, providing of course that the two systems share a common earth line.

LIGHT LOAD

The input circuitry is designed so as to load the gate under test as little as possible and in fact a current of less than 500μA is drawn in both the logic one and the logic zero states, making operation possible even with low power t.t.l. circuits. This low current drain is gained at the expense of high frequency response however, and difficulty with triggering the decimal point may ocur at very high pulse repetition frequencies. This was considered to be a better compromise than an excessive loading on the circuit under test as can occur with many other designs.

CIRCUIT OPERATION

The circuit blocks which make up Digi-Probe are shown in Fig. 1. The output of the logic "one" detector gives a logic "one" out when the input is between about 2·4V to 5V. The logic "zero" detector gives a "one" out when the input is between 0V and about +0·8V. For any other possible input voltage both detectors give a logic zero out. The output of the logic "zero" detector drives a transition detector, in fact a monostable, which will give a fixed length output pulse whenever the logic "zero" detector output goes to a logic one.

From the detector circuits, then, there are four logic outputs which have been labelled: x for the logic "zero" detector output, y for the logic "one" detector output, Q and $\overline{Q}$ for the transition monostable outputs. These four logic signals are used as an input to the decoder block which produces the correct l.e.d. segment drive signals for each unique combination of input signals, so that an appropriate display will result.

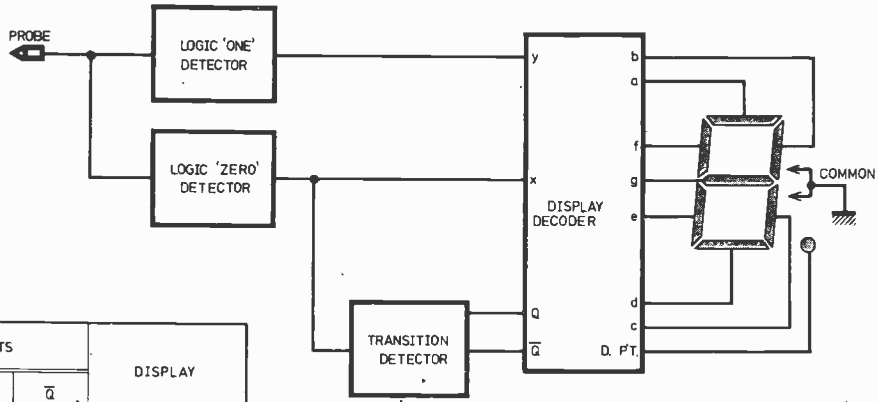


Fig. 1. Block diagram of the Digi-probe

Table 1

INPUT VOLTAGE	LOGIC OUTPUTS				DISPLAY
	x	y	Q	$\overline{Q}$	
+2·4 TO +5V	0	1	0	1	1
+0·8 TO +2·4V	0	0	0	1	F
0 TO +0·8 V	1	0	0	1	0
'1' TRANSITION '0'	'1' '0'	'1' '0'	30mS	30mS	NO SEGMENTS ON D.P. ON FOR 30mS ●

The operation of the block diagram can be best understood by reference to Table 1 which summarises the action of the circuit for various input conditions. Notice that there are redundant combinations of the three basic logic signals x, y and Q, because only four combinations can occur in practice whereas a three bit code is capable of defining up to eight unique conditions in theory. These redundancies can be used to simplfy the decoding circuitry.

DETAILED CIRCUIT OPERATION

The detailed circuit description splits logically into two parts, i.e. the detector circuits and decoder circuits, but it is important to note that although the circuitry is built on two separate circuit boards, the division of the circuit hardware does not conform to the logical "split" suggested by the circuit diagrams.

DETECTOR CIRCUITS

The input to the detector circuit comes via a "needle" probe which is connected to what are, basically, two discrete component DTL logic gates. The classic circuit of a DTL gate is shown in Fig. 2. and many readers will recognise this configuration instantly as the most important predecessor of TTL.

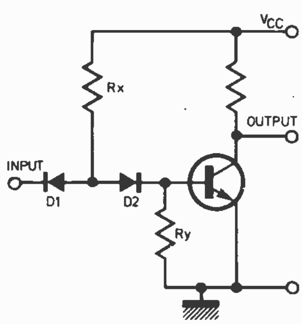
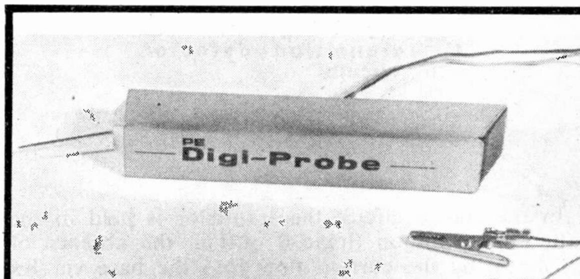


Fig. 2. A typical DTL gate arrangement



COMPONENTS . . .

Resistors

R1, R2	4.7kΩ
R3, R4	12kΩ
R5	4·7kΩ
R6, R7	2·2kΩ
R8	4·7kΩ
R9, R10	330Ω
R11	100Ω
R12, R13, R14	47Ω
R15	150Ω
R16, R17	47Ω
R18	330Ω
R19	3·9kΩ

All resistors $\frac{1}{8}$W 5% carbon

Capacitors

C1 30μF 10V elect.
C2 22μF 15V elect.

Transistors

TR1 BC107 or similar silicon npn
TR2 BC212 or similar silicon pnp
TR3 BC107 or similar silicon npn

Diodes

D1, D2, D3, D4, D5, 1N914 or similar silicon type
D6 BZY88 or similar 3·0V type

Integrated circuits

IC1 SN74121
IC2, IC3 SN7405

Miscellaneous

Display DL704 or similar common cathode l.e.d. display
0·1in matrix Veroboard, needle for probe, aluminium sheet, crocodile clips

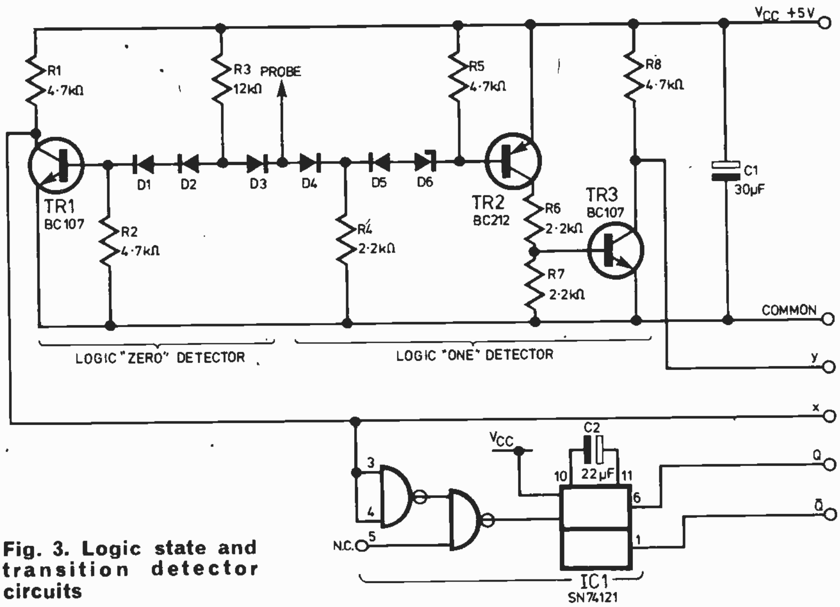


Fig. 3. Logic state and transition detector circuits

In the classic circuit the transistor is held in the saturated condition (logic 0 out) in the absence of an input, by the current flow into the base via Rx and the forward biased D2. To make the gate output go to a logic 1 condition it is necessary to take the input to 0 volts so that the transistor base current is diverted through D1 and the transistor is turned off. The basic circuit can be realised just as easily with a *pnp* transistor, providing the supply polarity and the diodes are reversed, and if required the switching thresholds of the gate can be varied by increasing the number of diodes in the D2 position.

As can be seen from Fig. 3 the input gates of Digi-Probe are based on the classic circuit, although the threshold levels have been varied by adding diodes, in one case a Zener. One of the gates is an *npn* type while the other is a *pnp* version followed by a straightforward *npn* inverter.

INPUT CONDITIONS

The easiest input condition to follow is that of an open circuit, a moments examination will show that both TR1 (*npn*) and TR2 (*pnp*) will be "on" giving a logic 0 out at the collector of TR1, and a logic 0 at the collector of TR3. These conditions will be used by the decoder to form an "F" on the display. If the probe is connected to 0 volts the base current of TR1 will be directed through D3 and the collector of TR1 will rise to a logic 1, but the output of TR2 and 3 will stay the same as before. The third test case is with the probe connected to +5V and here it is TR2 which turns off by virtue of the fact that it is starved of base current by the conduction of D4.

THRESHOLD LEVELS

The three test cases covered so far are extremes, but it is necessary for a practical probe to behave according to Table 1 where logic levels are each defined by a range of voltages. It was mentioned earlier that these threshold levels are set by the diodes, in this case D1, D2, D5 and zero diode D6. Although the diodes shown gave a very close correspondance with the table in the prototype, a certain amount of cut-and-try may be necessary to reproduce these results exactly if this is considered desirable.

For obvious reasons the possibility of adjusting the thresholds with a potentiometer was ruled out. If it is found necessary to trim the threshold voltages slightly this can be achieved by trying different types of silicon diodes, or in the case of the logic "1" detector, by changing the Zener breakdown voltage slightly, say to 2·7V or 3·3V.

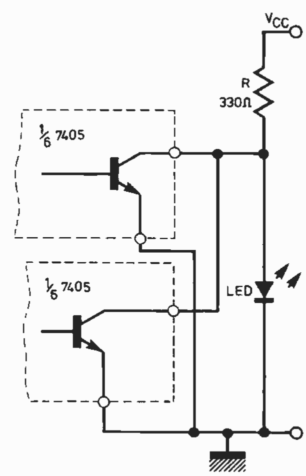
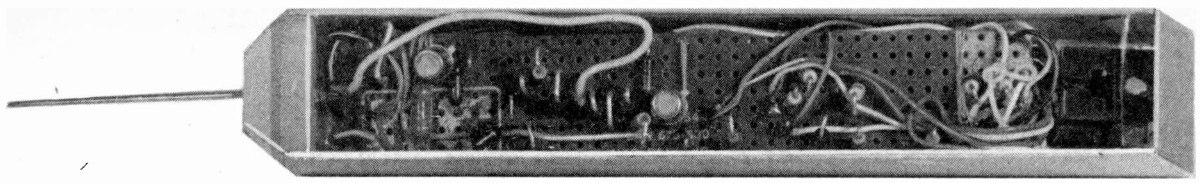
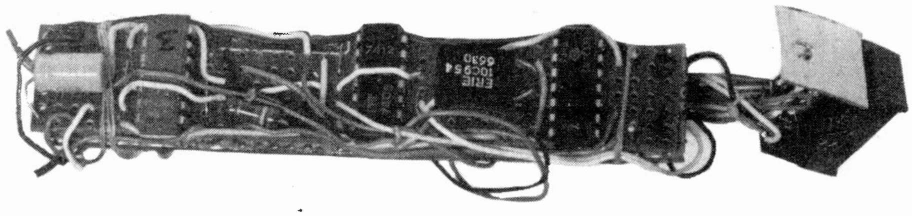


Fig. 4. WIRED-OR arrangement used for l.e.d. control





MONOSTABLE

A 74121 monostable is used as the transition detector, and in fact it is connected to the collector of TR1 so that it is triggered by a negative going transition at the probe tip. The monostable is acting as a pulse stretcher because a 1 to 0 transition will cause a 30ms pulse to be produced at the Q outputs. The pulse length is determined by the value of C2 and the internal 2kΩ resistor available in the 74121, the relationship being R × C × ln 2, i.e. 0·69 RC.

DECODER

The operation of the decoder/driver is very simple but perhaps a little unusual at first sight. The first thing to note (Fig. 5) is that no gates, as such, are used, the logic being performed by the "WIRED-OR" logic operation using open-collector inverters. The next point of interest is the fact that the l.e.d.s are operated in the normally-on mode, where the output of a gate function is used to turn the l.e.d. segment off by diverting its current supply to ground, rather than turning it on by providing a current path to

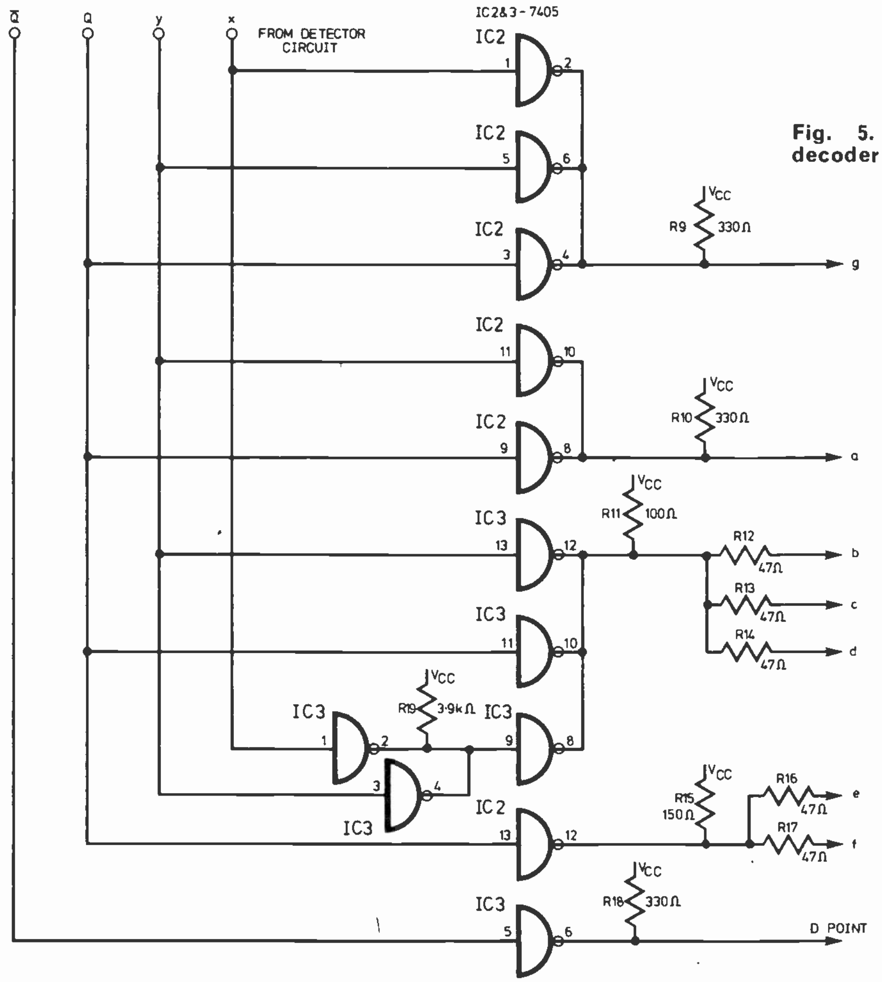


Fig. 5. Display and decoder circuitry

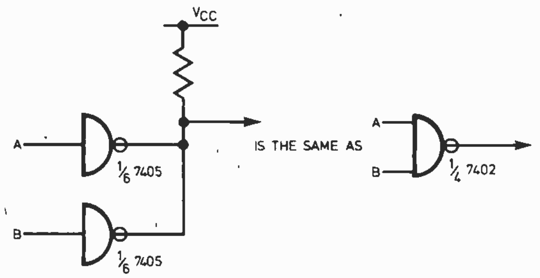


Fig. 6. Two 7405 open collector invertors used to simulate a 7402 two-input NOR gate

ground. Driving an l.e.d. in this way ensures that large current fluctuations do not occur when the segments switch on or off, the price, if you can call it that, is that current drain remains continuously high. The advantages of this approach were mentioned earlier.

WIRED-OR

The operation of the "WIRED-OR" logic is best understood with reference to Fig. 6 where two 7405 inverters are shown to be logically identical to a 7402 two-input NOR gate. Although the logic is the same, the 7405 approach has a couple of advantages for this particular application:

1. Flexibility—the logic required consists of two three-input NOR gates, two two-input NOR gates and two inverters. The 7405 inverters can be connected to form any combination required.
2. Open collector outputs—
A standard TTL totem pole output is not suitable for driving l.e.d. segments in the way necessary for Digi-Probe.

LED DRIVERS

The detailed l.e.d. driving circuit is shown in Fig. 4. R is a current limiting resistor required to set the operating point of the l.e.d. to about 10mA, and it can be seen that with both 7405 outputs in the logic 1, or non-conducting condition, the l.e.d. will be lit. If either of the 7405 outputs goes to the logic 0, or conducting, state the l.e.d. will be starved of current and will turn off.

CURRENT SHARING

Several of the l.e.d. segments are driven in parallel, and in these cases it is not sufficient to simply reduce the value of R and hope that the current will divide equally between the segments because there are often small differences between the forward voltages of otherwise similar diodes. Small variations of V_f will cause large variations in the current, and hence brightness, and are overcome in Digi-Probe by the individual 47Ω segment resistors which can be seen in Fig. 5. This arrangement works very well in practice.

CONSTRUCTION

The electronic components are arranged on two small pieces of 0·1in matrix Veroboard which lay one above the other in the case separated by a piece of acrylic sheet as an insulating spacer. No particular problems should be encountered with wiring up the circuit boards but when it comes to inter-board and l.e.d. connections, fine flexible wire should be used to prevent fatigue fractures at the soldered joints. In the prototype the l.e.d. was mounted in a 14 pin d.i.l. socket and this is certainly recommended although not of course essential.

CASE

The case was cut and bent from 22 s.w.g. aluminium sheet resulting in a neat and lightweight probe which is very handy to use. A couple of coats of aerosol cellulose paint were applied to the finished probe, and this adhered very well to the aluminium to give a smart and durable appearance.

The nose of the probe was shaped from a piece of plastic scrap and cemented in place with contact adhesive. The probe itself was made from a large sewing needle—the type without a sharp point called a bodkin. It proved a simple matter to solder to the end of this probe. The l.e.d. socket is cemented, with Araldite, to a small aluminium plate which is then bolted to the case. ★

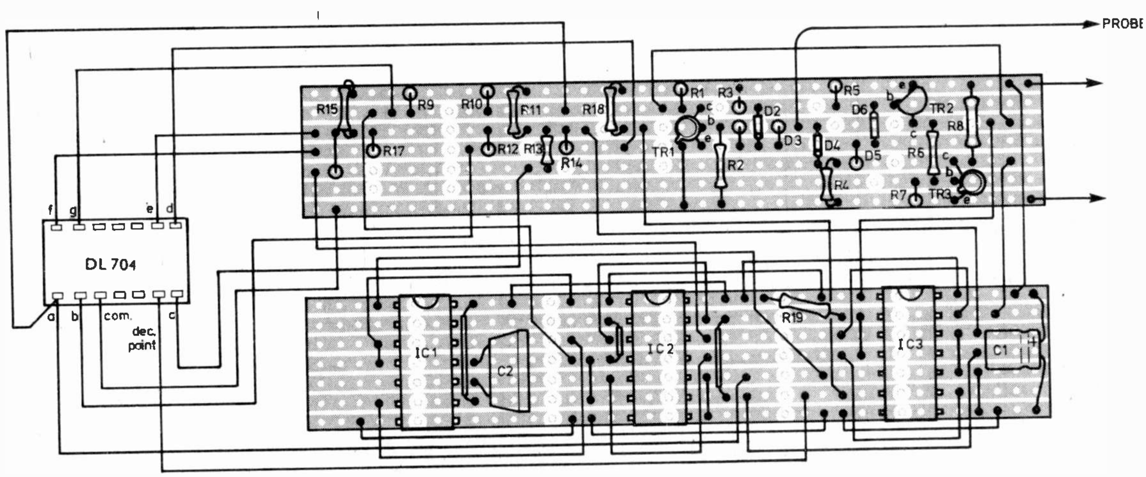


Fig. 7. Veroboard details and interwiring between the two boards of the Digi-probe

THE unit described here has been designed to fulfil the need for a more acurate synthesis of the amplitude envelope of musical instruments, particularly stringed, when used in conjunction with a music synthesiser and a keyboard.

The circuit achieves this in a very simple manner and the use of linear integrated circuits makes construction easy and keeps the cost low. In fact, this unit costs little more to build than a standard envelope shaper.

PRINCIPLE OF OPERATION

Most envelope shapers have two variables: attack time and decay time, as shown in Fig. 1a. Fig. 1b, however, shows that stringed instruments in particular have a much more complex amplitude envelope. Fig. 1c shows that a more accurate synthesis is obtained by splitting the decay slope of Fig. 1a into two parts and introducing a sustain level, the duration of which is governed by the point at which the effective key is released. Four variables are thus required: Attack time, Decay time, Sustain level and Release time (release time being the second half of the decay slope). Hence the abbreviation A.D.S.R.

THE CIRCUIT

The complete circuit diagram of the envelope shaper is shown in Fig. 2. When the keyboard contacts are closed by the depression of a key, the positive-going voltage is differentiated by C1 and applied to the base of TR2 which along with TR1 forms a bistable.

TR1 is turned off and its positive-going collector voltage causes C2 to charge via D6, R13 and VR2 (ATTACK) until the voltage set at the potential divider, R16/R17 is reached—in this case, about five volts.

At this point, the output of the comparator, IC1 will go very rapidly positive, causing the bistable to reset via C3, when TR1 again conducts.

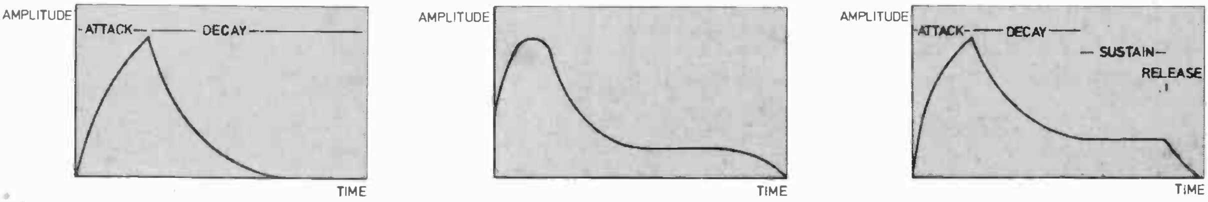


Fig. 1. Amplitude envelopes of (a) a standard envelope shaper, (b) a typical stringed instrument and (c) an A.S.D.R. envelope shaper

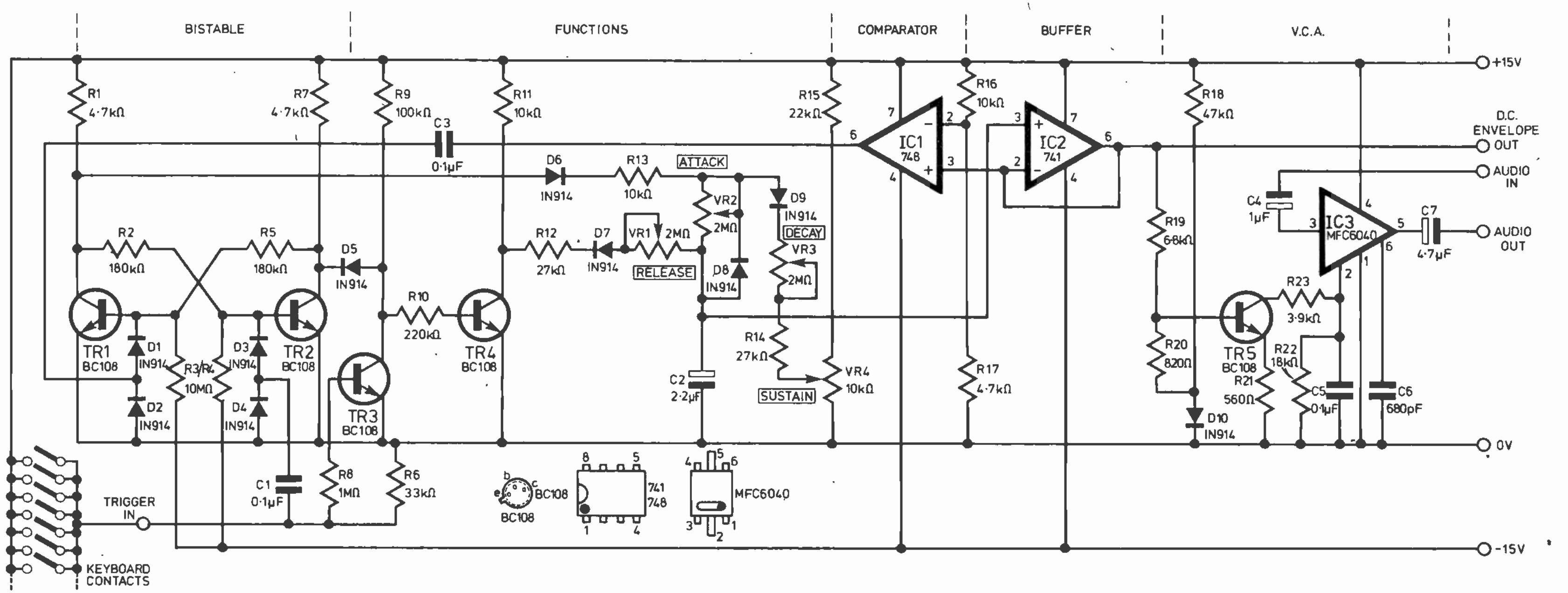


Fig. 2. Complete circuit diagram of the Envelope Shaper

COMPONENTS . . .

Resistors

R1	4·7kΩ
R2	180kΩ
R3	10MΩ
R4	10MΩ
R5	180kΩ
R6	33kΩ
R7	4·7kΩ
R8	1MΩ
R9	100kΩ
R10	220kΩ
R11	10kΩ
R12	27kΩ
R13	10kΩ
R14	27kΩ
R15	22kΩ
R16	10kΩ
R17	4·7kΩ
R18	47kΩ } see text
R19	6·8kΩ } see text
R20	820Ω
R21	560Ω
R22	18kΩ
R23	3·9kΩ

All ±5% ¼W carbon

Potentiometers

VR1–VR3	2MΩ linear (3 off)
VR4	10kΩ logarithmic

Capacitors

C1	0·1µF polyester
C2	2·2µF 16V elect.
C3	0·1µF polyester
C4	1µF 16V elect.
C5	0·1µF polyester
C6	680pF polystyrene
C7	4·7µF 16V elect.

Semiconductors

TR1–TR5	BC108 (5 off)
D1–D10	1N914 (10 off)
IC1	Type 748
IC2	Type 741
IC3	MFC6040

Miscellaneous

0·1in matrix Veroboard 102 × 64mm (4in × 2½in)

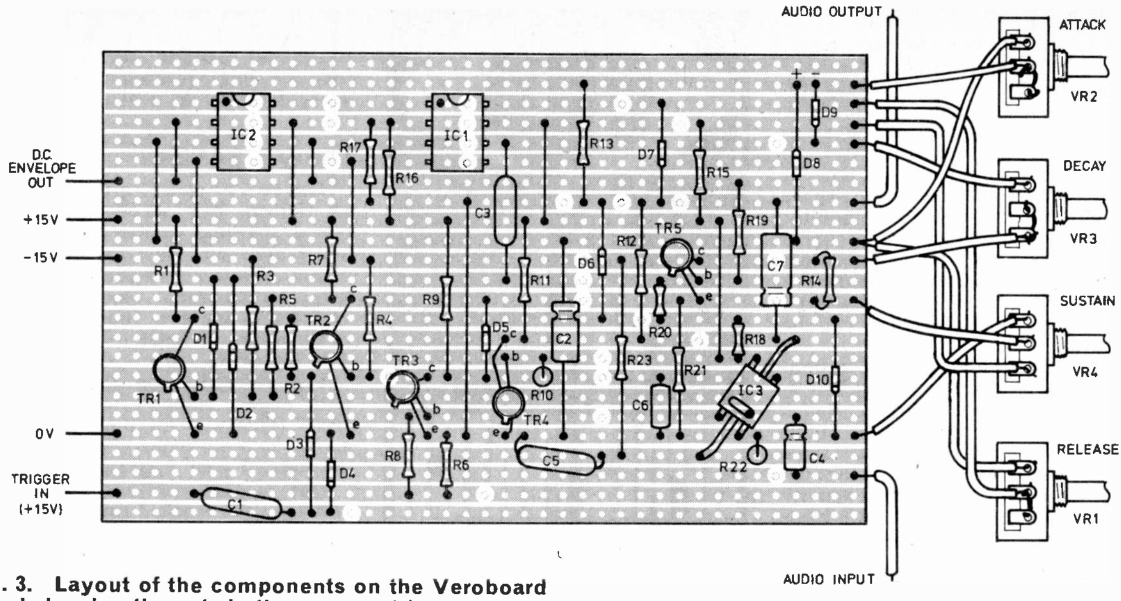


Fig. 3. Layout of the components on the Veroboard panel showing the cuts in the copper strips

Since there is no potential to charge C2, it discharges to the potential set at the wiper of VR4 (SUSTAIN). While this sequence is in progress, TR3 is biased on by the positive voltage from the keyboard contacts via R8 and will remain so until the key is released, when TR3 switches off, switching TR4 on. C2 is then discharged completely via D7 and VR1 (RELEASE), completing the A.D.S.R. sequence.

Diode D8 ensures that the full attack period is completed even if the key is released during attack. It does this by holding TR4 off while the bistable is "set", i.e. during attack.

The voltage on the positive plate of C2 is followed and buffered by IC2 to give 0 to 5 volts positive at the d.c. envelope output. This voltage is fed to TR5 which drives the voltage-controlled attenuator, IC3.

Because of the possible gain spread of TR5, the value of R19 and/or R18 may need adjusting so that the voltage at pin 2 of IC3 varies between 3·5 volts and 5·6 volts as measured with a high impedance voltmeter. This will give an attenuation range of 65dB, which was found to be adequate in the prototype. This range could be increased to about 80dB by increasing the value of R22 to 33kΩ but propagation delay might then be experienced due to the time taken to charge C2 to a voltage where the note has reached an amplitude that is audible.

CONSTRUCTION

The prototype was constructed on a small piece of 0·1in Veroboard prepared as shown in Fig. 3. Miniature resistors were used to make the unit neat and compact, but if standard resistors are used, R2 and R6 should be mounted vertically. Diode and capacitor orientation should be checked with Fig. 3.

The leads of TR1, 2 and 4 span a distance of half an inch or so and it should be checked that they do not short to the cases of the transistors. IC1 and 2 were soldered directly into the board since i.c. sockets were considered an unnecessary expense using today's robust integrated circuits and a little care. The two longest pins of IC3 should be bent halfway along their length 10 degrees to the left, as viewed from their respective ends. This will ease insertion into the board. Thin insulated wire should be used for the nine inter-track links.

The four potentiometers are connected to the board by five wires which could be quite long allowing the circuit board to be located remote from the control panel if necessary. R14, D8 and D9 are mounted on these potentiometers.

USING THE CIRCUIT

The trigger input should be connected to one of the keyboard busbars so that when any key is depressed, 15 volts will be applied.

The audio input need not be screened unless spikes are found to be induced, when it can be screened to the 0V line. The input voltage should not exceed 500mV r.m.s. if distortion is to be avoided. The maximum gain of the electronic attenuator is 13dB; hence the output voltage could reach 2·2V r.m.s.

The d.c. envelope output could be used to control a voltage-controlled filter or even another voltage-controlled attenuator to provide a separate channel for stereo effects.

It will be found by experimentation the settings of the controls required to give an accurate synthesis of a particular instrument, but as a guide, strings, for example, have a very rapid attack followed by a fairly long decay and a low sustain level. The release time varies from instrument to instrument. For example, it will be short for a piano but long for a guitar.

Special effects can also be generated. An example of this is given by adjusting all controls to minimum. The resultant sound will be a short "pop" of the note every time a key is depressed. If the DECAY control is advanced slightly, the "pop" will become a "blip". ★

BY FRANK W. HYDE

HELIOS 2

The second German spacecraft *Helios 2* for solar studies was successfully launched on January 15. This was nearly one month later than originally proposed due to problems at the launch site.

There was a limit to the time of the launch since the deep space network which is needed to monitor this mission will be fully occupied with the *Viking* mission to Mars later on. The final date would have been February 7. All is now well and the required coverage can be made.

Both structurally and operationally *Helios 2* is similar to *Helios 1*, carrying similar experiments. *Helios 1* was launched at the time of minimum solar activity. But since *Helios 2* was launched at the beginning of the high solar activity period it should have added advantages. It will therefore be of great value for collecting data as the Sun reaches its peak of high activity. Thus it will be possible to have a continuous record of the Solar events, which added to the *Skylab* data will bring a new viewpoint to the studies.

The flight trajectory will bring the spacecraft rather nearer to the Sun than for *Helios 1*. It will, in fact, have a perihelion point with reference to the Sun of about 30 million miles. In spite of the closer approach it was not necessary to make more stringent thermal protection than for *Helios 1*, whose performance was well within requirements.

The mission is expected to last 18 months and will form an agreed part of the American-German cooperation for the examination of space within Mercury's orbit. Though the mission for *Helios 1* was for the period of 18 months, it still continues to be operational. *Helios 2* will no doubt follow the same pattern, continuously adding to the value of the mission.

Spacecraft *Helios 2* was also built by the consortium of Messerschmitt-Bölkow-Blohm for the Federal Ministry of Research and Technology.

THE MOON

In the dust collected by *Apollo 16* there were 400 metallic objects in a cluster. These have been found to contain 92·5 per cent iron, 6·25 per cent nickel, which agrees with the general composition of iron meteorites.

THE SUN

A new dimension has been added to the Sun. It now seems that it pulsates at a regular rate of some 2 hours 40 minutes. This is an exciting confirmation of suggestions made by Dr Henry Hill of Santa Catalina Laboratory for Experimental Relativity by Astrometry, Arizona.

Resulting from more than 10 years' work, his suggestions for a "shivering period" of about 50 minutes, thought to be of seismic origin, led two independent teams of observers to investigate this phenomena. The two teams, one Russian with A. B. Severny, V. A. Kotov and T. T. Tsap of the Crimean Astrophysical Observatory and the other consisting of J. R. Brookes, G. R. Isaak and H. B. van der Raav at the University of Birmingham.

The two teams were working on entirely independent experiments. The Russian team were using a solar magnetograph. This instrument is employed to record the magnetic field of the Sun by the Zeeman effect (splitting of the spectral lines) but modified in this particular experiment to measure the velocities in line of sight by doppler shift.

It was found that the Sun was pulsing in a regular period of 2 hours and 40 minutes. It was calculated that the amplitude of these oscillations was about 10 kilometres. This was based on more than a 100 hours of observation time during 1974 and early 1975.

The Birmingham team had set up an experiment to compare the Fraunhofer lines of absorption for sodium and potassium in the Sun with those generated in the laboratory to detect any possible doppler shift. Their apparatus was set up on the Pic du Midi mountain top in the Pyrenees.

The primary object of the Birmingham experiment was to determine gravitational shift in the red region of the spectrum. In making their assessment and given that the effects of solar rotation and the differences of motion between the Earth and the Sun were accounted for, the final residual was within one second of the Russian result.

TARGET SATURN

The second spacecraft on its way to Saturn has successfully completed the mid course adjustments and is now on target for the ringed planet. *Pioneer 11*, the second of the successful reconnaissance vehicles to make a Jupiter fly-past, is expected to make its rendezvous with Saturn in 1979.

The correction on this occasion also added some 67mph to the speed. This was for the purpose of giving two optional trajectories at the time of near approach.

One of these options was to fly between the inner ring and the planet itself. The other is that it might be decided to approach on an upward path to pass outside the ring system. The choice no doubt will depend on what is decided for *Pioneer 10* which precedes it.

There is a fixed aerial on *Pioneer 11* and when orienting the course correction thrusters the aerial had to be disengaged from the Earth "lock". This necessitated a programme sequence which took it out of lock, made the reorientation and then once more come into lock with the Earth. At this point the vehicle was 287 million miles from Earth and out of communication for several hours.

This is the first time such a manœuvre has been carried out where everything depended on the pre-planned programme aboard the craft itself. There will be a number of new corrections to be made before the planet is reached. If problems develop or if the narrow beam aerial is more than 25 degrees out of line then failure could result.

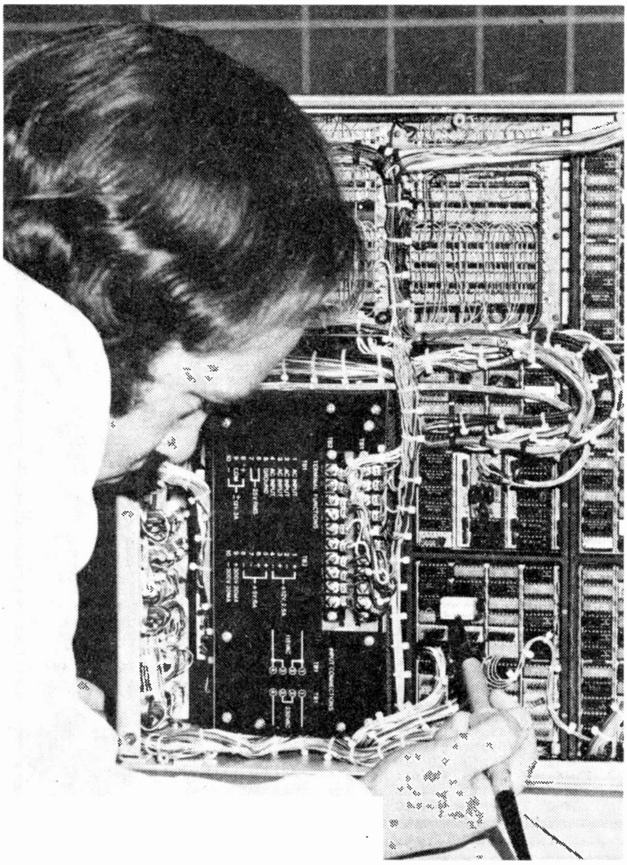
If the vehicle continues to function the first close-up pictures will be available in about three years' time. At the moment tests indicate that the cameras are working normally.

CHINA

It would seem that China is considering a manned flight in space. So far China has launched five unmanned spacecraft and have given little data to the media.

Some remarks in a newspaper relating to the return of spacecraft to Earth indicates that the manned possibility is being actively considered. It has been claimed that the fourth satellite launched was safely recovered.

Such data that has been released relating to orbit parameters suggests that the recovered capsule was a prototype suitable for manned operation.



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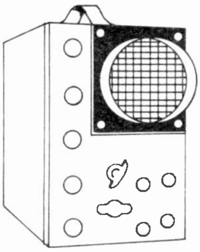

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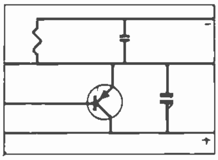

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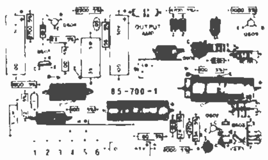

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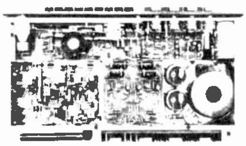

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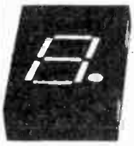

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'HOW INVENTIVE ARE YOU' COMPETITION

HOW INVENTIVE WERE YOU?

INITIAL REPORT FROM THE JUDGES...

IT may seem quite a while since last September/October when Practical Electronics and Plessey issued the challenge *HOW INVENTIVE ARE YOU?* but during that time quite a lot of discussion, investigation and head scratching has taken place. Our deliberations are now nearing completion and we thought at this juncture it would be of interest to readers to know what goes on behind the scenes in a competition of this type. Well, this is what we've been up to.

There was a very gratifying response, and the majority of entries were of a very high standard. Many entrants had gone to considerable lengths to describe their ideas, to draw up the circuit, mechanical design and styling of the product and in some instances had obviously made working prototypes to confirm their feasibility.

The panel of judges comprised of the undermentioned:

Mr. F. Bennett	—Editor of Practical Electronics.
Mr. G. Godbold	—Technical Editor of Practical Electronics.
Mr. S. E. Gent	—Technical Executive of Plessey Windings.
Mr. E. A. Quincey	—New Products Manager of Plessey Windings.

considered five main criteria.

a. Originality	—was the idea novel to the judges.
b. Technical merit	—was the design and circuitry based on sound engineering principles.
c. Practicability	—would the device work in the form envisaged and be easy to use.
d. Economic viability	—would the benefits which arose from the device warrant its cost.
e. Market potential	—what would the gross market be for the product.

Initially the ideas were all grouped under headings dependent on the suggested application. The groups included:

Flashing Lights (both neon novelties and emergency beacons)

Welding Products (arc initiators)

Insulation Testers (both for automotive applications and safety testers)

Fencers and Cattle Goads

Insect Killers

Gas Sensors

Physics Laboratory Products

Automobile Ignition Aids

Plus Miscellaneous Ideas which, as one might expect, included many of the most novel suggestions.

From each of these groups we selected the best ideas for further evaluation.

Novelty was confirmed by conducting searches at the Patents Office in London. This is where all U.K. patents are on file. Practicability was a little more difficult. Although there was a wide spread of experience amongst the panel for some ideas it was necessary to seek an expert specialist opinion of their merit. Some of the questions stretched our credibility. "Can you electrocute dandelions?"—we asked various authorities in matters botanical.

Others like "What electrical energy is required to stimulate the muscles of the body" required very careful consideration.

Assessing technical merit was not too great a problem as most of the devices were based on standard circuitry, however, a number of ideas incorporated elegant design solutions.

In a few cases circuits were proved or disproved by building prototype models and in one instance it was necessary for a judge to travel to a farm in Oxfordshire to confirm that the energy generated by a Cattle Goad was in fact sufficient to goad cattle.

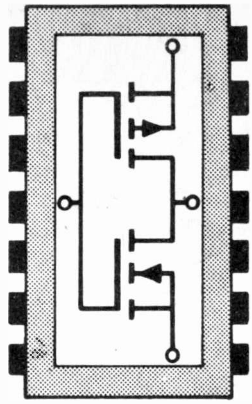
To establish economic viability it was necessary to estimate the costs of products. As in the main 80 per cent of the circuitry was common to the portable ignitor again this procedure did not present many problems.

Gross market was taken as a measure of market potential. For example, a fly killer could be used in any home. In the U.K. there are some 18 million homes and thus the market potential for a product of this type would be very good. However, the requirement for a vacuum leak tester would be limited to laboratories and alike.

So from the total of ideas submitted to a short list of some fifty. From this list we have now selected those ideas which are Winners in the "How Inventive Are You" competition.

We hope to publish the full results in our May issue and in subsequent issues we will be describing some of the ideas and circuits that were entered. We also hope to keep you up to date with the progress of any of these ideas towards manufacture and launch on the market as commercial products.

Using CMOS digital I.Cs



By D.B. JOHNSON-DAVIES & A.M. MARSHALL B.A.

PART 4

THIS month we will give linear applications of CMOS. Two bonus circuits included are a tachometer and an oscilloscope trace doubler.

LINEAR USE OF CMOS

Although most applications of CMOS are digital, it comes as a real bonus that many linear circuits can be constructed from CMOS devices, taking advantage of their extremely high input impedance, low power consumption and low cost. The next sections show how simple high-impedance linear amplifiers, and wide-range oscillators and monostables, can be constructed with very few external components. Any type of gate may be used in most of these circuits; however most B-series devices are unsuitable due to the two additional inverters at the output. Very often the gate used will be one left from the rest of the circuit.

The switching characteristics of the inverter has a substantially linear section where both the *p*- and *n*-channel devices are on simultaneously. The inverter can be deliberately biased into this region, when it will act as a small signal high-gain amplifier. The slope of the curve at the bias point gives the a.c. gain, typically 20dB or 100 times. Ideally the bias point should be at $V_{OUT} = V_{DD}/2$, but as the transfer characteristic is only guaranteed to lie within the limits shown in Fig. 4.1 for any particular device, the biasing circuit shown in Fig. 4.2 is usually used. This constrains the bias point to the line $V_{IN} = V_{OUT}$ and will give good results without needing tailoring to the particular device used.

The bias point can be trimmed to any particular value if required by the addition of a variable resistor from the input of the inverter to one or the other supply rail. The value of the feedback resistor will give the input impedance, and so it should be as large as is practical. High current buffer inverters such as the 4049 should not be used in such applications as they can dissipate excessive power if held in the linear region of their characteristic.

PRACTICAL AMPLIFIERS

The CMOS inverter may be used as a high impedance d.c. amplifier without any bias resistor provided that the mean d.c. level at the input biases it to the correct point on the characteristic. However, CMOS inverters are most usually used as a.c. amplifiers, as in Fig. 4.2. A good low frequency response can be obtained even with small values of coupling capacitor due to the 10 Megohm input impedance; with the values given the low-frequency cut-off is below 1Hz. To obtain more gain it is possible to cascade a number of inverters. As the transfer voltage of each inverter is only guaranteed within fairly wide limits, it is not usually possible to cascade inverters directly as one stage could be biased completely off by the preceding one. These difficulties are avoided by a.c. coupling the stages as in

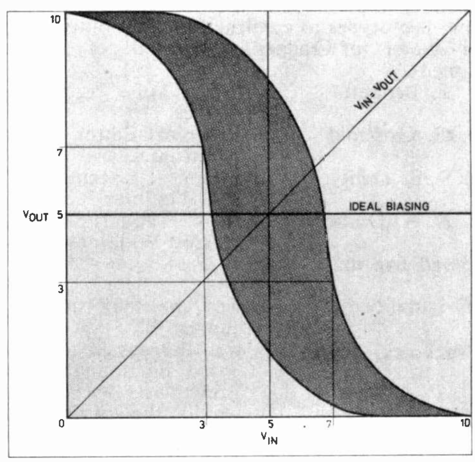


Fig. 4.1. Transfer curves of CMOS devices are guaranteed by the manufacturers to lie within the shaded region, for a 10V supply. Thus V_T, the transfer voltage, can lie between 30 and 70 per cent of the supply voltage

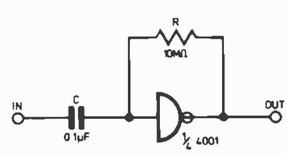


Fig. 4.2. Simple a.c. amplifier using a CMOS gate biased into the linear region. The value of R is not critical, and determines the input impedance

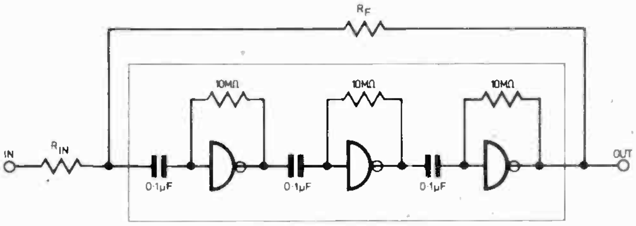


Fig. 4.3. Three-stage a.c. amplifier with gain stabilisation by negative feedback. The gain is approximately R_F/R_{IN}

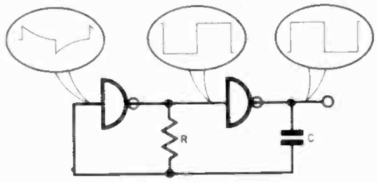


Fig. 4.4. Simple oscillator. The frequency is dependent on the supply voltage and the transfer voltages of the gates and is about 1/1·7RC

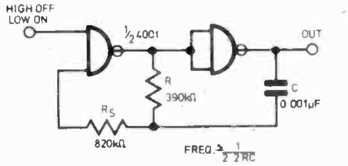
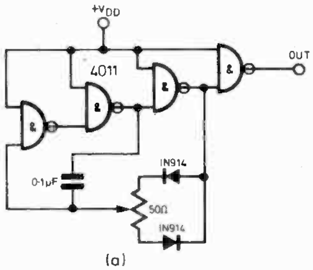
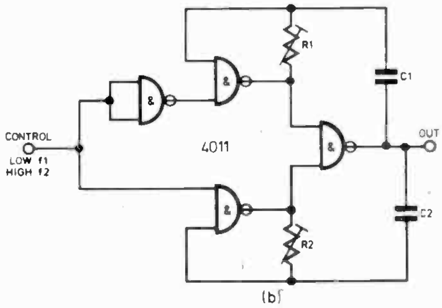


Fig. 4.5. Compensated oscillator circuit which is less sensitive to variations in supply voltage or temperature. It can be gated by the spare input of the first gate. The values shown give a frequency of 1kHz





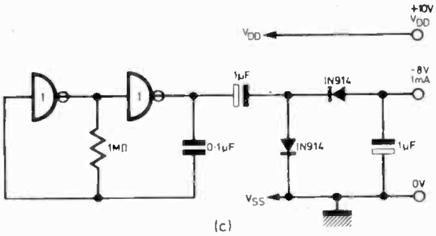
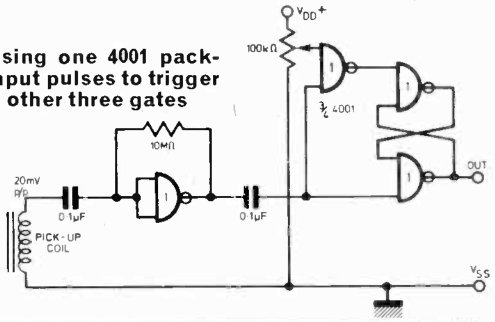
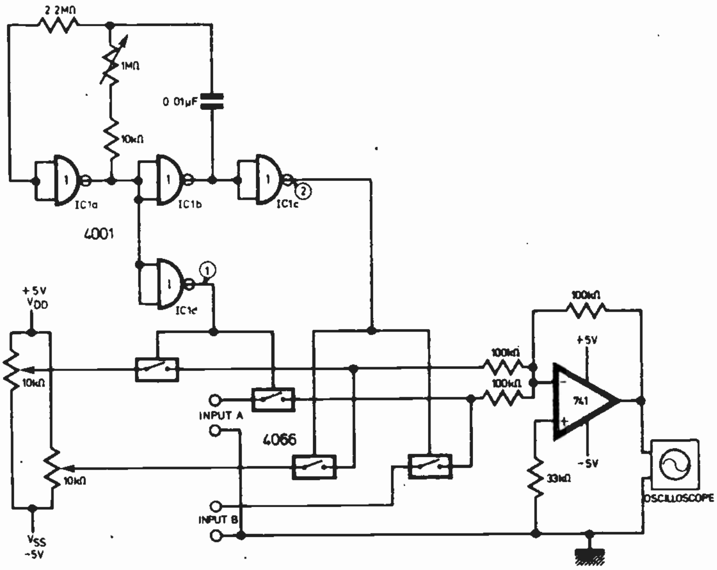


Fig. 4.6. Special purpose oscillator circuits. (a) Variable pulse-width oscillator, with mark/space ratio variable from 3 to 97 per cent. (b) Inter-gated oscillator. The two oscillators share the same output gate, giving a choice of two frequencies by the logic level at the control input. (c) Negative voltage supply. A standard CMOS oscillator feeds into a voltage doubler network to provide an additional supply of about −8V at up to 1mA

Fig. 4.7. Tachometer front-end using one 4001 package. The first gate amplifies the input pulses to trigger the Schmitt trigger formed by the other three gates





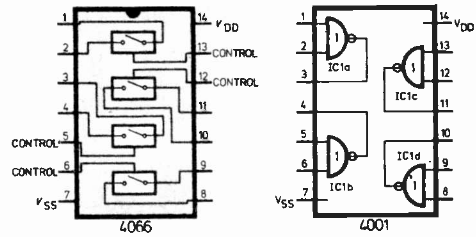


Fig. 4.8. Oscilloscope trace doubler using only two CMOS packages; the 4066 (or 4016) quad bilateral switch and the 4001 quad NOR gate. The potentiometers vary the positions of each trace on the screen. The circuit will display two signals of the same frequency simultaneously on any oscilloscope with an external trigger facility.

Fig. 4.3. The three cascaded amplifiers can be regarded as a single high-gain block, with the overall gain defined as R_F/R_{IN}. Noise becomes a problem as more stages are cascaded, and three will usually be the practical limit.

OSCILLATORS

With two gates from one CMOS package and just two external components, it is possible to construct the strikingly simple oscillator of Fig. 4.4. The circuit will oscillate from below 1Hz to about 10MHz, with values of R from 15MΩ down to 10kΩ, and values of C from 1μF down to a few pF.

The capacitor is charged in opposite directions on each half of the cycle, and so should not be an electrolytic type. The frequency of this circuit depends somewhat on the supply voltage, being in the range 1·4RC to 2RC for supplies of 3 to 15 volts, but can be made virtually independent of the voltage by the addition of R_S as in Fig. 4.5 This circuit suffers at worst a 5 per cent shift in frequency for a 10 volt change. The ratio of R_S to R should be at least 2, and preferably 10 for maximum stability.

In Fig. 4.5 a 2-input gate is used instead of the first inverter, the second input gating the oscillator. This circuit can be used as a pulse modulator, the signal to be modulated being fed to this input.

APPLICATIONS

Three circuits incorporating the basic CMOS oscillator are shown in Fig. 4.6. Circuit (a) has a fixed frequency, but the mark/space ratio can be varied from 3 to 97 per cent. The simple oscillator of Fig. 4.4 has a mark/space ratio of about 50 per cent depending on the thresholds of the two inverters. By connecting diodes in parallel with a portion of the timing resistor R it is possible to vary the charging and discharging currents of the capacitor independently, and so control the mark/space ratio. Circuit (b) shows how two oscillators can be combined to share the same output gate, so that one of the two frequencies can be selected by the logic level at the control input. The circuit in (c) will provide a negative supply of about 8 volts at up to 1mA when only a positive one is available. Negative-going pulses from the oscillator charge up the output capacitor through the conventional voltage doubler network formed by the capacitors and the two diodes. For higher output currents a buffer may be added at the output of the oscillator.

The front-end of a simple tachometer circuit using only one CMOS package is shown in Fig. 4.7. Pulses of about 20mV p/p induced in the pick-up coil by the rotating magnet are amplified by a one stage gain-block (Fig. 4.2) and then squared up by the variable trigger level Schmitt. The squared output pulses would then feed into the measuring stages which depend on the application.

TRACE DOUBLER

The trace doubler circuit (Fig. 4.8) switches rapidly between the two input signals, presenting each to the oscilloscope input for half the time together with a d.c. offset to separate the two traces on the screen. The oscillator provides out of phase pulses at X and Y, these being used to switch between the two pairs of bilateral switches. One switch of each pair admits the input signal which should have an amplitude of less than 10V p/p, and the other sets the d.c. level varied by the potentiometers. These are both fed to a unity-gain summing amplifier made from a 741 op-amp. The frequency of the oscillator should be adjustable as the unit will not display a correct trace if it is an exact multiple of the frequency of the input signals. The oscilloscope is triggered from one of the input signals. Supply connections to the CMOS packages are, as usual, not shown and are at 5V above and below earth. The 4066 quad bilateral switch will transmit signals from d.c. to 40MHz, but the upper frequency response of the circuit is limited to 1MHz by the 741.

Next month: Basic oscillators and practical examples.

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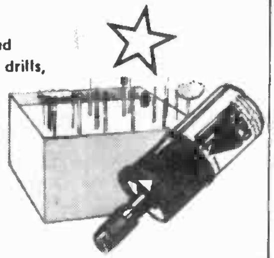

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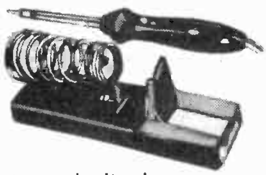

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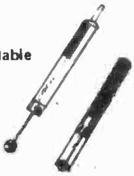

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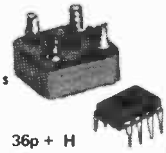

IN 4001	- 8p ea.)	
IN 4002	- 9p ea.)	+ s
IN 4003	- 9p ea.)	

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1·6A "	(200V)	- 48p + H
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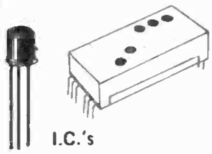

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BC 109	18p s
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BFY 51	- 24p s
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BC 238C	- 12p H
BC 239C	- 14p H
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ZTX 109	- 13p H
ZTX 300	- 15p H
ZTX 500	- 16p H
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TIP 32A	- 40p H
2N 3819	- 32p H
3N 141	- 65p s
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TBA 820	- £1.20 H
ZN 414	- £1.30 H
ZN 424	- £1.25 H
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747 Op-amp (Dual 741)	- 95p s
748 Op-amp	- 48p s
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556 (dual 555)	- £1.44 s
HA 1156 (similar to MC1310P)	- £1.60 H
ORP12	- 72p s
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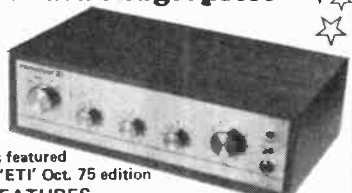

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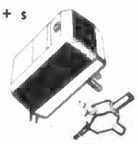

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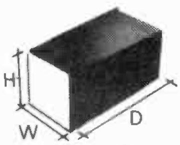

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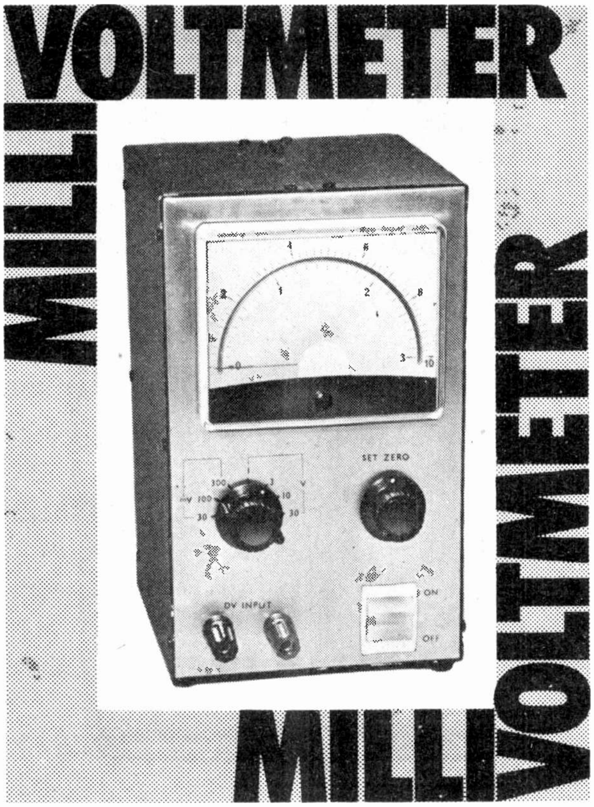


By H.T. KITCHEN

THE test meter to be described was designed and built to enable work to be carried out on transistor equipment involving low currents and medium to high impedances. Under these conditions, the loading effect of the old faithful Avo 8 at 50 micro-amps f.s.d. (20kΩ/volt) was too great, causing doubts to be cast on the validity of the readings so obtained. A test meter with a much higher input resistance was required, and in order to save money it was decided to build one. The requirements were plain from the onset; it had to be quick and easy to build, accurate, with good long term stability (an impedance transformer or meter amplifier was clearly necessary) and it had to be reasonably inexpensive. Since the meter movement was already to hand, the project turned out to be surprisingly inexpensive, particularly in view of its specification.

CIRCUIT DETAILS

The instrument uses a 741 operational amplifier, the overall gain of the circuit being set by means of two resistors. In the circuit of Fig. 1 these two resistors R12 and R14, the actual voltage gain being given by $\frac{R12 + R14}{R12}$. The meter movement used had an f.s.d. of 100 microamps, and since it had been decided to aim for an overall sensitivity of 1 microamp (1 Meg ohm/volt) it was necessary for the amplifier to provide a current gain of 100 times. This is well within its capability, and, due to the negative feedback the linearity is excellent. The voltage gain required was 260 times, given by the meter resistance of 2,600 ohms, and current consumption of 100 microamps. The actual voltage gain was 270 times or 270k + 1k/1k allowing a small margin for component tolerances.

SPECIFICATION

Ranges
30mV : 100mV : 300mV : 1V : 3V : 30V : @ 1MΩ/V
A divide by ten switch decreases the sensitivity of each of the above ranges by a factor of ten allowing measurement up to 300V. The sensitivity with the divide by ten facility in reduces to 100kΩ/V

Accuracy
Dependent on components (meter and multiplier resistors)

Drift
At 60°F 300μV max. in 5 mins. (one third scale division)

SET ZERO

Setting of the meter pointer to zero is accomplished by means of VR1. Since voltage change required for zero setting also has to be applied to the inverting input (along with the negative feedback) it is necessary to isolate the inverting input from any low impedance source, and the 470kΩ resistor R10 serves this purpose. R9 and R11 limit the swing obtained by VR1, so providing a finer zero adjustment. Even so, the resolution obtained is small, and a multi-turn potentiometer is highly recommended. Failing one of these, a low value

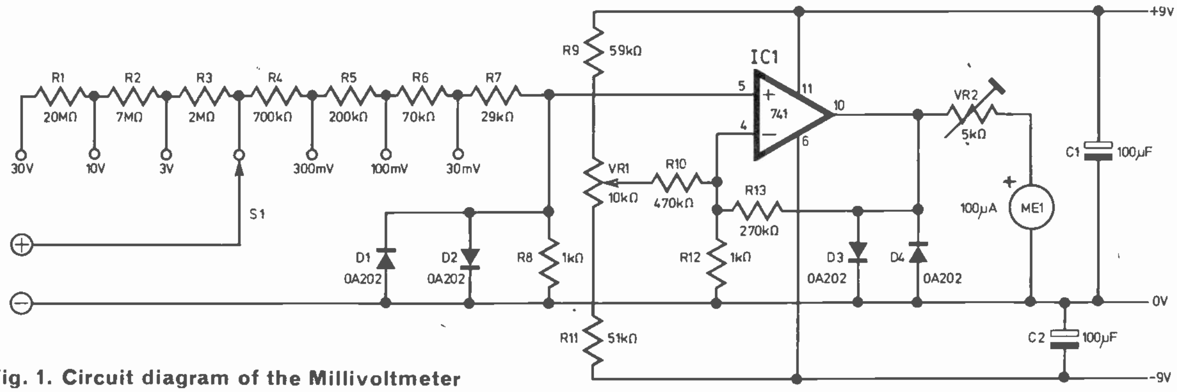


Fig. 1. Circuit diagram of the Millivoltmeter

variable resistor can be connected in series with, say, R9, this then serving as a fine zero adjust; initial, or coarse, zero being set by VR1.

PROTECTION

Although the 741 is a relatively sturdy device, it will not withstand the large overloads to its input circuitry that may result from an incorrect range setting. The diodes D1 and D2 have therefore been incorporated to restrict the maximum input voltage to about 650mV. Voltages less than this will pass through to the amplifier unaffected whilst under overload conditions the diodes will conduct excessive current to earth, thus protecting the 741. The maximum voltage swing at the output can be almost as much as plus or minus the supply voltage. This means that there is a very real danger of the meter movement being damaged by excessive voltage swings. Diodes D3 and D4 serve to limit the voltage swing at the output, starting to conduct, as do the input diodes, at around 600 to 700mV. Since the meter requires 260mV for f.s.d., the maximum overload cannot exceed some 200%, a figure well within the limits of any good meter movement. The 741 has a maximum output current limited to 20mA, hence no damage will result when the diodes are forced into conduction.

COMPONENTS . . .

Resistors

R1	20MΩ 1% (two in 10MΩ in series)	
R2	7MΩ 1%	
R3	2MΩ 1%	
R4	700kΩ 1%	
R5	200kΩ 1%	
R6	70kΩ 1%	
R7	29kΩ 1%	
R8	1kΩ 1%	All resistors ¼W
R9	59kΩ 5%	
R10	470kΩ 5%	
R11	51kΩ 5%	
R12	1kΩ 2%	
R13	270kΩ 5%	
R14	27kΩ 5%	

Potentiometers

VR1 10kΩ
VR2 5kΩ
VR3 5kΩ
All 10 turn helical

Capacitors

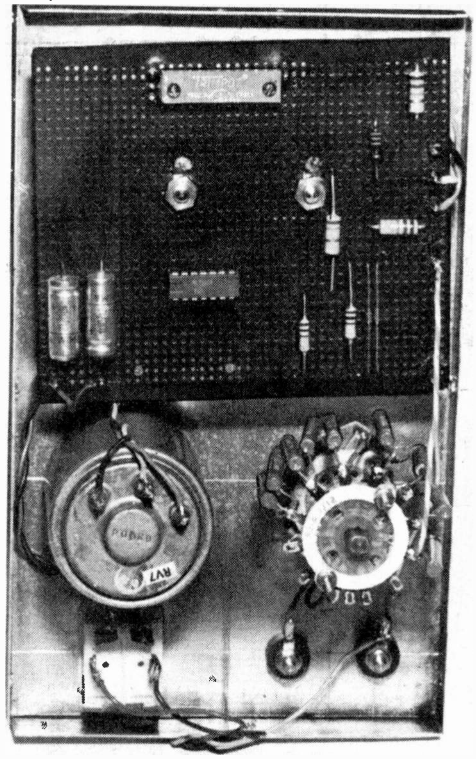
C1 100μF 12V elect.
C2 100μF 12V elect.

Semiconductors

IC1 741
D1–D4 OA202 (or similar low leakage silicon types)

Miscellaneous

S1 Two single pole 12-way wafers plus shaft ("Makaswitch") RS Components (access through Doram)
S2 Two pole on/off
M1 100μA 2,600Ω internal resistance BPL type S30V or any 100μA meter movement of good accuracy



RANGES

For the purposes for which the test meter was built, an overall voltage range of 30mV to 30V was adequate, the steps being in the 1-3-10 sequence. Resistors R1 to R7, inclusive, are the series range resistors. Although the minimum range is 30mV, the meter scale permits reading very much less than f.s.d. to be taken in confidence.

The maximum voltage the instrument can read is 30V. However, this can be easily increased to 300V (see "Modifications").

COMPONENTS

The meter movement used on the prototype was a BPL type S30V, with an internal resistance of 2,600 ohms, and an f.s.d. of 100 microamps. Clearly, other meter movements can be used, but if these differ appreciably from the one used on the prototype, then it is desirable to alter R13 to keep the gain just above the minimum required. This way, the negative feedback is always as high as possible. The voltage required for f.s.d. can be calculated from a knowledge of the meter current rating and internal resistance, and as the input sensitivity of the amplifier is 1mV (1 microamp across 1,000 ohms) this will be the gain the amplifier must provide. R13 can then be calculated as outlined earlier, and for this purpose the formula can be simplified to R13/R12.

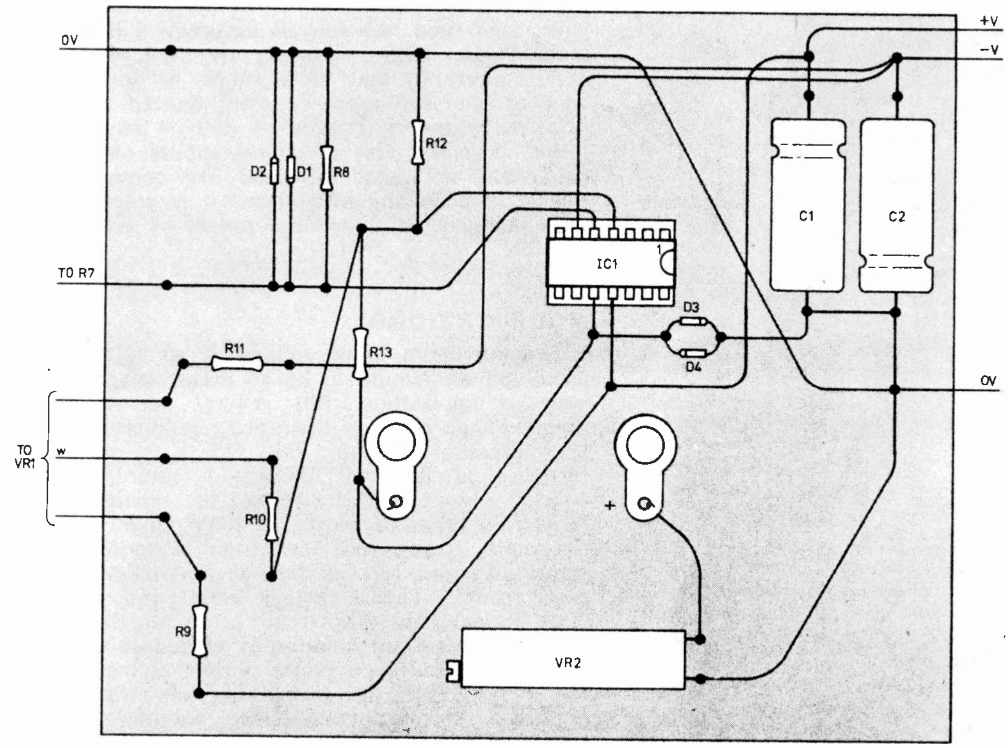


Fig. 2. Wiring arrangement used in the author's prototype. The components are mounted on perforated board and the wiring is carried out on the underside

Resistors R1 to R7 inclusive, must have a tolerance in the region of 1% if the test meter is to have any pretensions to accuracy. The tolerance can be relaxed to 2% or even 5% with a corresponding degradation in overall accuracy. In the absence of 1% resistors, it is possible to use 5% resistors in a series/parallel arrangement especially if an accurate voltmeter is available for checking the calibration.

The set zero control on the prototype was a ten turn potentiometer purchased ex-equipment, and it is recommended that the advertisements columns of the various electronics magazines be searched for such a control. The resolution that such a control is capable of is such that no one who has used one would ever willingly return to the "ordinary pot".

Diodes D1 to D4 must be low leakage silicon types so as not to affect the normal operation of the instrument.

The current consumption of the complete amplifier is very low, and with intermittent use a pair of PP9 batteries should last a long time.

CONSTRUCTION

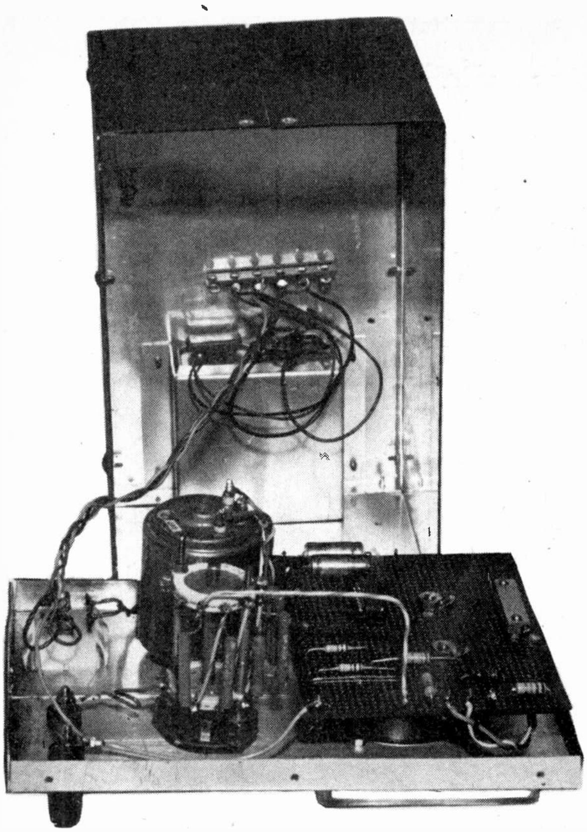
The complete instrument was built into a case as shown in photos. Any suitable case can be used; the author's was made of 22 s.w.g. aluminium, the panels being held together with small self tapping screws. The dimensions may require altering if components other than those specified are used.

The case was sprayed crackle finish black, the front panel being "brushed" aluminium. This is quite an easy finish to achieve, as well as being aesthetically pleasing. It also takes letter transfers well.

The "brushed" effect is obtained by rubbing the panel with very fine steel wool dipped in fine oil. The panel must be free from dents or marks. The steel wool is repeatedly drawn across the panel in as straight a line as possible until the desired effect is obtained. The panel is then thoroughly cleaned, dried, and then the transfers are put on. Finally, several thin coats of protective varnish are sprayed on. Carefully done, the effect is very pleasing, and rivals commercial panels.

The i.c. in the prototype was mounted in a socket, and this was fitted, along with the other amplifier components, on a piece of 0.1" wiring board. The layout is not critical. This is then secured directly onto the back of the meter movement, using the meter's terminal nuts, see Fig. 2.

The range resistors were mounted directly onto the range switch. This is a R.S. Components "Maka-switch", two wafers, single pole twelve way, being used. The wafer nearest the front panel does the range switching, the rear wafer being used as a slave, the range resistors being slung between the two wafers. This switch must have good insulation properties, as the maximum resistance on the 30 volt range is 30MΩ.



CALIBRATION

Calibrating the completed test meter is simple, provided an accurate voltmeter is available. Both meters are connected across a stable direct voltage, the range switches being appropriately set. VR2 is then adjusted to give the same reading as the calibrating voltmeter. If 1% resistors have been used for the range resistors, then it should suffice to set the test meter to read at one point only. If 2% resistors have been used, the overall accuracy will be that much worse. If 5% resistors are used, then it is highly desirable that each range be individually checked, and the range resistor adjusted as necessary, by means of other series and/or parallel connected resistors. This of course applies only if the calibrating voltmeter will read low enough. Since this is a measuring instrument, it is worth taking time and trouble to get the ranges as accurate as possible.

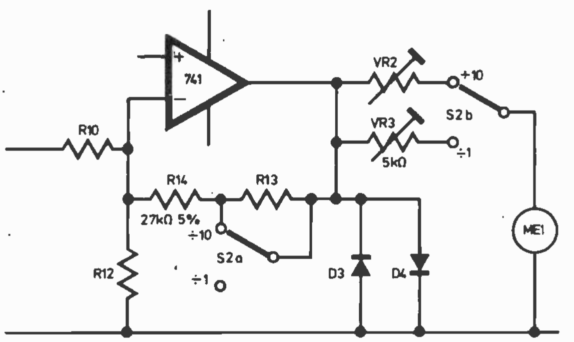


Fig. 3. The modifications required to add a ÷10 switch to the millivoltmeter

MODIFICATIONS

The maximum input voltage of 30 volts of the prototype was found to be no disadvantage for its intended application. For general use, a higher input voltage range is desirable, and there are two possibilities of obtaining this. One is by means of further input resistors; this would require a 70MΩ resistor added on to the end of the existing 20MΩ resistor in order to provide a 100V range. Difficult to obtain, (seven 10MΩ resistors in series is one possibility) and leakage resistances would possibly cause trouble. Then a further 200MΩ resistor for a 300V range. This is not really a viable solution. A much more elegant solution is to reduce the gain of the amplifier by a factor of ten, giving a 300V top range. Since the range resistors would stay unaltered, the input resistance would go down to 100kΩ/volt, i.e. the input current would go up to 10 microamps. This would not be any serious disadvantage since most circuits operating at 300V can "afford" the 10 microamps the test meter would draw.

Fig. 3 shows how the test meter should be modified. The feedback resistors should be wired as shown to prevent feedback being lost during range switching. When the range is changed, another calibration resistor is switched in (VR3) which will allow the gain in the ÷10 range to be set exactly one tenth that of the normal range. ★

SOUNDS EXTRAORDINARY

The purpose of this supplement is to list the various forms of electronic effects units popularly used in the production of modern music, and to give some idea of their principles of operation. Block diagrams and circuits are given to illustrate typical techniques used and some commercially available units are shown.

CONTENTS

FUZZ

Probably the first electronic effect to be used with guitars was fuzz. In its simplest form fuzz merely adds distortion to the original guitar signal, and in doing so provides an output which is rich in harmonics which can either be used on its own, or to enhance other effects such as waa-waa, sustain, etc.

The popular way of achieving the effect is with the use of non-linear devices (diodes, etc.) either directly in the signal path as shown in Fig. 1 or in the feedback loop of an amplifier. Either method results in a squaring or clipping of the incoming signal. A side effect from this type of process is that the output level will tend to remain much the same even though the signal from the guitar is naturally decaying. This in fact forms the basis of another effect (see SUSTAIN).

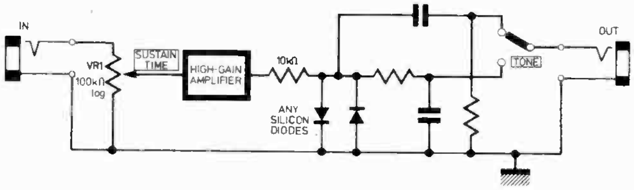


Fig. 1. A typical method used to obtain the Fuzz effect

In Fig. 1 the amount of fuzz is controlled by the setting of VR1 which sets the input level required to cause the diodes to conduct and thus square off the signal. Other fuzz circuits exist which provide distortion which does not depend on signal level. In general, these are more complex electronically and it is a debatable point whether or not the increase in cost is worthwile.

Some units couple the fuzz effect with some form of tone control, for example, the "Tone Bender" from Coloursound. This allows treble or bass boosting which mellows or sharpens the original fuzz sound.

WAA-WAA

One of the most popular effects used with guitars is that termed the Waa-Waa effect. This essentially consists of a band-pass filter whose centre frequency is varied up and down a portion of the audio spectrum (approx. 200Hz–3kHz).

In fact this simulates the operation of the mouth when pronouncing the sound waa-waa. The mouth cavity forms a resonator whose centre frequency is controlled by the actual volume of the cavity, and this in turn is controlled by the position of the lips and gums. Electronically, this is performed by a band-pass filter whose resonant frequency is controlled by a potentiometer usually mechanically linked to some form of pedal assembly. The filter usually takes the form of a band stop network (twin-tee, etc.) in the feedback loop of an amplifier. This produces the band pass function required to achieve the waa-waa. Such an arrangement is shown in Fig. 2 where a variable resistor is inserted between A and B.

The effect can be automated (then becoming known as auto-wah) where the sweeping is controlled by an internal oscillator. A typical circuit for this is shown in Fig. 3. In this case the transistor replaces the variable resistor,

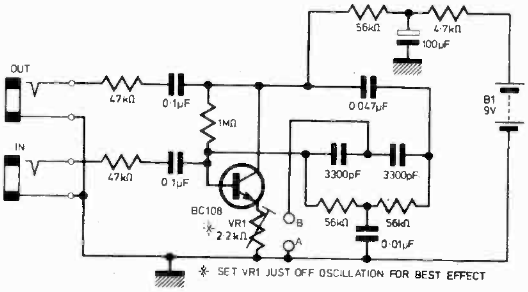


Fig. 2. For Waa-Waa (foot operated) insert a 100kΩ potentiometer between points AB. For Auto-Waa insert circuitry in Fig. 3

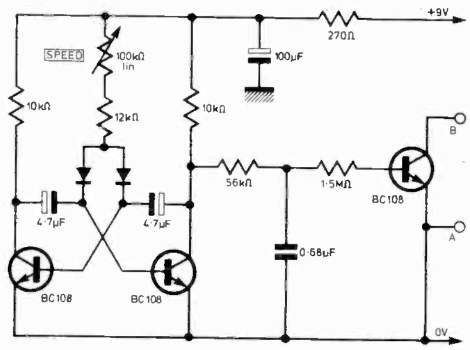


Fig. 3. Additional circuitry for Auto-Waa effect

and although a fair amount of non-linearity will occur with the transistor used in this mode, in practice the harmonics generated will tend to add to the general waa-waa sound.

By selectively boosting some harmonics and attenuating others, it is possible to change the harmonic structure of the signal and hence the actual sound by a considerable amount. As a filter can only boost what is already present in the signal, waa-waa's are often combined with fuzz or treble boost before the filter to obtain more harmonics for it to act on.

Popular commercial combinations are fuzz-waa, or wah-fuzz-swell, fuzz-phaser.

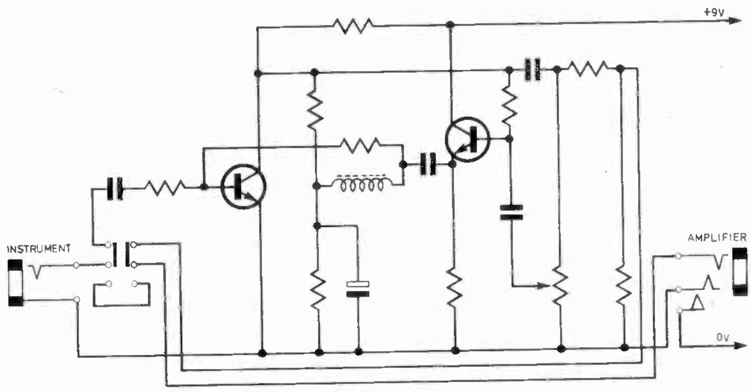


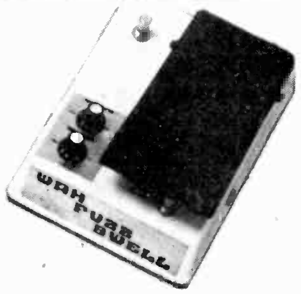
Fig. 4. A commercial Wah-Wah circuit (Colorsound). We regret that we cannot supply component values

Wah-Wah pedal **(Colorsound)**

SWELL

Swell is simply a foot-operated volume control. However, despite its simplicity, it may be used to alter the envelope of the guitar signal for "violining", cutting off the guitar's sharp attack to give a smooth attack and decay, or any other envelope modification that may be desired. The so-called "violin" effect is obtained with a swell pedal and a guitar, by keeping the level well down when the string is plucked, and then as the guitar envelope decays away, the pedal is "opened" to maintain the output at a reasonably constant level, thus simulating a violin type envelope.

Swell in commercial pedals tends to be included with other effects as an extra, and can increase the versatility of a waa-waa with negligible expense.



Wah-Fuzz-Swell **(Colorsound)**

ENVELOPE SHAPER

The envelope shaper is best known in synthesiser applications where some form of envelope control is required to shape the various waveform or noise generators which are normally continuously running. Although the output from a guitar has its own envelope, if additional shaping is added, a new range of interesting effects can be obtained.

The shaper has in common with the swell pedal the ability to alter the volume of the signal passing through it; the essential difference being that the envelope shaper performs the operation automatically. After sensing the beginning of a note, from that point in time it allows independent control of

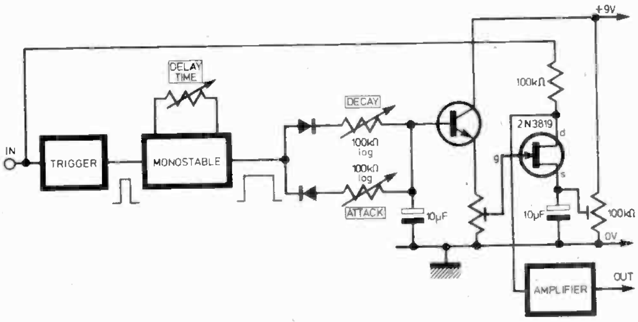


Fig. 5. Envelope Shaper block diagram

the attack, decay, sustain and release times in sophisticated envelope shapers, or just the attack and decay times in standard ones.

Although the term envelope shaper implies that the signal is processed by the shaper itself, in fact it merely provides a suitable control voltage for a VCA (voltage controlled amplifier) which is the device actually responsible for gain control. In the more simple attack—decay envelope shaper, the attack control determines the time taken for the VCA to reach minimum attenuation (i.e. fully "opened") and the decay control the time taken to reduce to minimum gain (fully "closed").

On some versions, another control is added which allows the decay mode to be delayed by a variable sustain time control.

ADSR ENVELOPE SHAPER

The more complex shaper almost exclusively found in synthesisers is termed an ADSR envelope shaper (a typical circuit appears in this issue). ADSR (attack-decay-sustain-release) provides two additional facilities to those of the attack-decay type: namely sustain and release. The ADSR attack control corresponds to the same control on the simpler shaper, and the release control to the decay. The ADSR decay control, however, determines the time taken for the VCA level to drop to a sustain level set by the sustain control. The sustain mode is only entered into when the key on the synthesiser keyboard is held down. If the key is raised prematurely the shaper will go directly into the release mode and the note will decay away at the release rate.

SHAPING

The guitar envelope has a very sharp attack, and if this is rounded off by an envelope shaper, it can be made to perform a similar type of operation to that performed by the swell pedal and provide, for instance, the violin effect. Likewise, a bass guitar can be made to sound like a cello. Also, by using a shaper to artificially remove the ends of the notes, it is possible to obtain sounds similar to pizzicato strings, or banjo. The two controls, attack and decay, can be exploited to produce an endless variety of envelopes and therefore effects.

A point in passing: when playing through an envelope shaper, it is worth mentioning that it is important to leave slight pauses between the notes to ensure correct triggering on each successive new note.

SUSTAIN

Another treatment in which gain change is involved is Sustain. As the level from the guitar decays away, the sustain circuitry increases the gain in the channel to maintain the output at a constant level.

A compromise has to be reached when deciding the range of gain change possible, as with too little gain variation the sustain effect will not be noticeable, whilst too much will result in excessive hum and noise pick-up when the strings are still.

The circuit functions by monitoring the output level and deriving a feedback signal which controls a VCA such that the output level is held constant.

In this application, the VCA must reduce its gain for higher control voltages and vice-versa. The voltage at the output of the follower (some form of rectification/integrator stage) is proportional to the output signal level and it is arranged that a small change in this voltage will cause a large gain change in the VCA which will result in a substantially constant output level until the VCA gain reaches its maximum value.

OTHER SUSTAINS

The effect referred to above is sometimes known as sustain-without-fuzz since, in theory, signal distortion is not introduced. However, popular sustain effects units use similar circuitry to that of fuzz units to achieve constant output level with respect to input level. In this case, as in fuzz circuitry, the output of a high gain amplifier is fed into a squaring or limiting circuit (often two diodes back to back) and this has the desired effect of maintaining a constant output level but also, of course, adds a large amount of distortion. In order to mask this distortion, a fair amount of h.f. feedback is incorporated which, although making the sound less bright, tends to create a less distorted sound, tending to be more like the original input.

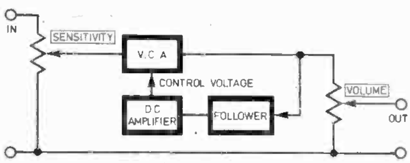


Fig. 6. Typical arrangement used in Sustain circuitry

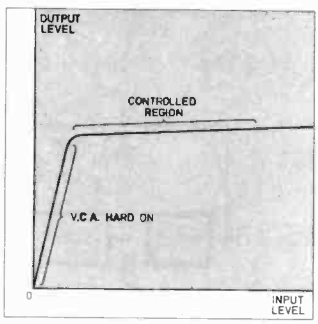


Fig. 7. The Sustain principle shown graphically

Maestro Sustainer (Henri Selmer & Co.)

TREBLE BOOST

Treble Boost, as the name implies, boosts the treble content of the input. The harmonics then overpower the fundamental of the signal and the sound is given a shriller quality. The effect combined with sustain and reverberation forms the basis of the "Floyd"-type sound.

The actual electronics involved in producing the effect are fairly simple. A high pass filter whose output rolls of at extreme h.f. (in terms of guitar frequencies) is formed around an op-amp (see Fig. 8). The input is first attenuated by R1 and R2. The amplifier has a maximum gain at around 3.5kHz, below this it decreases at 6dB per octave (C2R3) and at about 4kHz the response flattens out as C3 becomes effective. Finally at higher frequencies the gain falls off to unity as the effect of C3 becomes more and more predominant. This results in a response with a rounded peak occurring in the region of 3–4kHz and it is this that is responsible for the boost effect. Higher frequencies are rolled off since they are beyond the range required to contain the guitar passband.

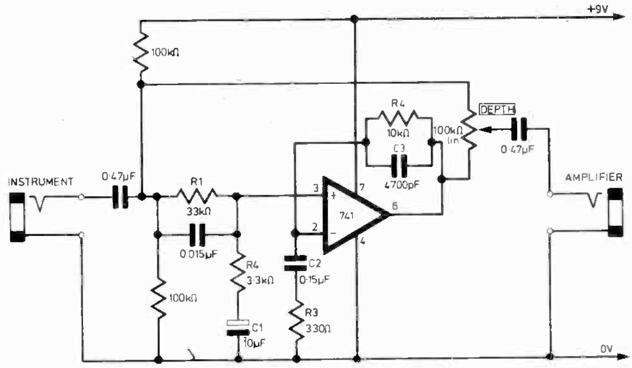


Fig. 8. Typical Treble-Boost circuitry

A depth control is also included which merely allows adjustment of the ratio of treble boosted signal to unprocessed signal.

PRESENCE

On some amplifiers a presence control is included as well as an h.f. or treble control. This can have a similar sort of effect to treble boost. The presence control boosts or cuts mid-band frequencies (1·5–3kHz) and has the effect of brightening the sound or giving the impression of bringing it forward.

TREMOLO

The Tremolo effect is generated by a repeating volume change at a rate usually between 1 and 10Hz. The volume change is accomplished by some form of VCA, which in turn is controlled by a low frequency sine or triangle wave generator.

There are two controls associated with tremolo: depth and rate. The depth control adjusts the amplitude of the modulating waveform fed to the VCA, and the rate control its frequency.

When tremolo was first introduced it was intended as an electronic substitute for vibrato, which is frequency modulation rather than amplitude modulation of the signal. The two are often confused, but there is a considerable difference. Tremolo is far simpler to achieve electronically than pitch modulation. Fig. 9 shows a typical arrangement that may be used to generate the effect.

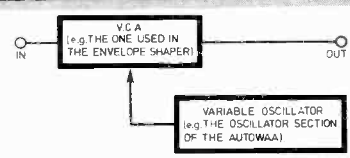


Fig. 9. Principle of the Tremolo effect

VIBRATO

The vibrato effect is achieved by altering the pitch of a note up and down around the actual note being played. This can be performed relatively simply on organs, synthesisers, etc. by modulating the frequency of the oscillators.

The effect is also easily obtained manually on most musical instruments using normal vibrato techniques. However, it is possible to generate the effect electronically using the principle that a rate of change of phase with time constitutes a frequency shift. Circuits exist which allow phase change without amplitude change, and if many of these are cascaded, considerable phase change can be made possible at any frequency. If the phase change is made voltage controllable, then with the help of a low frequency function generator, the vibrato effect can be produced automatically even though the input signal is at a constant frequency.

The Coloursound "Dopplatone" achieves a spectacular sounding effect based on the frequency bending capabilities of so-called multi-segment phase shifting circuitry as outlined above.

It is interesting to note that electronic vibrato is not a new effect, however. In order to provide a vibrato effect for one of the organs in the Hammond range in the thirties, a valve circuit was added onto the output of the organ to create vibrato.

OCTAVE DIVISION

A note which is an octave below another is at half the frequency. This lower note is called a sub-octave, and can be generated electronically by squaring off the note to be divided and then passing it through a binary divider. The output from this will be at half the frequency of the incoming signal but it will contain a large amount of high frequency harmonics due to its being a square wave. These harmonics can be filtered out, however, to provide a deep bass sound.

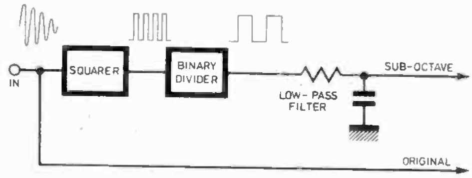


Fig. 10. The Octave Divider principle

The process can be continued further to provide other frequencies of 2 or 3 octaves down from the fundamental, and then if mixing controls are also incorporated, independent control of the levels of the various frequency sub-divisions, can be made.

The octave divider principle is shown in Fig. 10.

RING MODULATION

Ring modulation is an effect which produces complex signals from two inputs by multiplying them together. For two inputs at frequencies f_1 and f_2 the ring modulator produces two new frequencies $f_1 - f_2$ and $f_1 + f_2$. As these output frequencies are only harmonically related under certain conditions, the sound produced is often discordant.

A ring modulator needs two inputs to function. An internal oscillator is often incorporated in the same unit to act as one of these inputs, whilst the other input will be derived from a guitar. In this case one note on the guitar will produce two notes from the ring modulator and the separation of the two notes in terms of frequency is determined by the frequency of the oscillator.

Alternatively, the same signal may be fed into both inputs, in which case a frequency doubling effect will occur. This happens because the $f_1 - f_2$ component of the output is zero, and the $f_1 + f_2$ provides an output of twice the input frequency. The arrangement will produce the characteristic ring modulation when a chord is played, and intermodulation effects are produced.

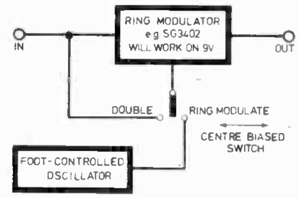


Fig. 11. The Ring Modulation effect

A typical ring modulator arrangement is shown in Fig. 11 where an i.c. is used to perform the multiplication function.

PHASING

Phasing or skyriding was first produced by simultaneously playing the same material on two different tape recorders, but slightly delaying one with respect to the other. The actual phasing sound occurs as the delay sweeps from zero to about 50ms. One method whereby this can be accomplished very effectively is with two tape recorders which should in all aspects be identical, except that one must be equipped with a "varispeed" facility.

The input signal to be phased is fed into the record inputs of both tape recorders and the "after tape" outputs of the tape recorders are mixed 1:1. If the varispeed recorder speed is set exactly at the other speed, then in theory, total signal cancellation should occur. As the varispeed control is varied either way, all frequencies whose half-cycle periods divide into the delay time an odd number of times, will be cancelled out. This effect in fact forms a comb filter (so called due to the cyclic cancellations in the frequency response thus produced) and is responsible for the familiar phase sound when swept up and down the relevant part of the audio spectrum. The sweeping is performed by varying the delay, which in turn is done by altering the speed of the varispeed machine.

A full phase cycle can be achieved in this fashion by commencing with the vari-speed machine adjusted to be running just faster than the other machine, and then by reducing the speed slowly

Phase 45 phasing unit from MXR **(Rose-Morris)**

(during which time the phasing effect will occur) until it is running just slower than the fixed speed machine.

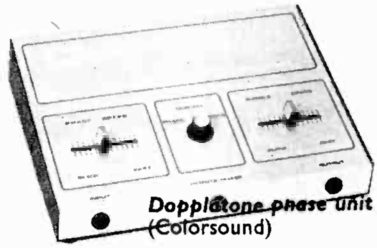
Although producing a very deep phase effect, this method is really only suitable for studio work, since the delay caused by the tape recorders is not acceptable in live performances.

PURELY ELECTRONIC PHASING

All electronic phasers are now very much in vogue and there are several types available on the market. These are all based on the "phase shift without amplitude change" circuitry mentioned in the vibrato section.

In the sales literature associated with phasers, the word "segment" is often mentioned. A segment is a phase shifting element and, in theory, the more segments a phaser has the deeper will be the phase sound. This is the case in practice to a certain extent, but the greater amount of circuitry and general complexity of multi-segment types is considered by some to be unnecessary, as the sound produced by those using only a few segments is "deep" enough. In fact, the difference between the two is that multi-segment phasers provide a better approximation to tape phase due to their having a greater number of cyclic dips in their frequency response, than those with fewer segments. As an extra bonus also, the far greater phase shifting ability can be exploited to generate other effects (vibrato, etc).

As with the waa-waa effect, phasers can only subtract from the original sound, so the best effect is obtained when there are plenty of harmonics available. Hence the reason that a phaser is often coupled to some form of fuzz unit. White noise is particularly effective when phased, or other sounds with large harmonic content.



Dopplatone phase unit (Colorsound)

It is possible to simulate the Chorale or Leslie effect with a phasing unit controlled by a sine or triangle wave oscillator (as most of the commercial units are). When added to an organ or electronic piano, a good similarity to the sound produced by a Leslie speaker is obtained and when used as such can greatly improve the sound produced by cheaper organs and pianos.

REVERBERATION

Sound takes a finite time to travel through air. In an enclosed space, with hard walls (which will reflect sound), there are an infinite number of paths a sound can take from source to listener. As some energy is absorbed at each reflection, the reverberated sound gets progressively quieter. The reverberation time of a room is the time it takes for the sound to fall to one millionth of its original intensity.

This effect can be imitated electronically or electromechanically by a number of means. The cheapest is the spring line. There are two transducers coupled by a spring. One puts vibration into the spring, and these travel to the far end in a few milliseconds. Some of these vibrations are reflected back down the spring and some drive the output transducer. The vibrations are thus reflected back and forth along the spring eventually dying away.

Spring lines need a fair power to drive them, and the response is improved if driven by a constant current. The treble response is never very good, but a bit of treble boost after the second transducer cures this tendency. The depth control crossfades from dry to fully reverberated by shorting out what is not needed.

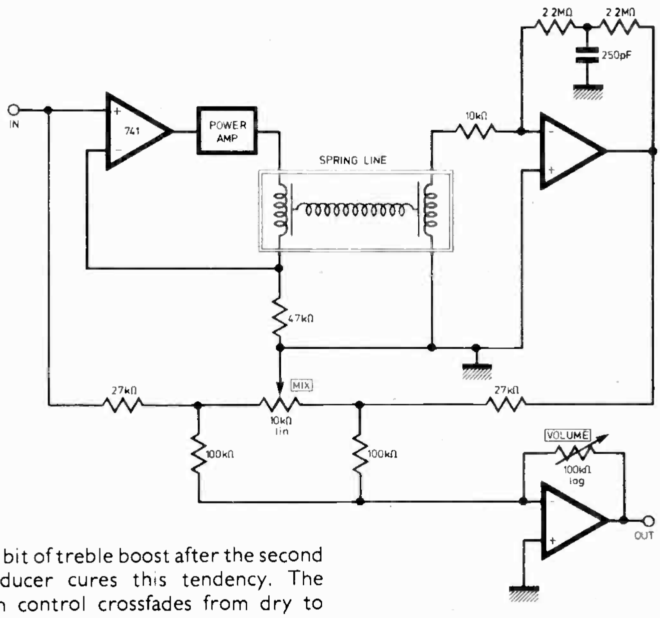


Fig. 12. Typical Reverb. circuitry

ECHO

It is also possible to produce reverb with a digital delay line. This converts the incoming signal into a binary code, and this is then clocked along a series of shift registers and reconverted to analogue form at the other end. In its basic form, it provides echo of any delay time, governed by the number of shift registers and the clocking rate used. If outputs are picked off the line at various points and fed back to the beginning, complex patterns are set up which give the effect of reverb. This is a rather expensive device, but will no doubt become cheaper as i.c. prices fall.

The more usual way of getting echo is with a tape delay. This usually consists of a tape loop with erase, record and a number of play heads. The output is any required mix of the play head outputs and the direct signal.

As the tape in a loop quickly wears out, better tape delays have an everlasting cartridge with about five minutes of tape, as this is more reliable.

Echo without reverb is a rather unreal sound, beloved of Rock and Roll vocalists.

Some interesting effects can be obtained by reducing the delay time to a tenth or a twentieth of a second. At this setting it is no longer possible to recognise the delay and it sounds more like double-tracking, i.e. the same thing played on two identical instruments at the same time.

GUITAR SYNTHESISERS

The Synthi Hi-Fli "Guitar Synthesiser" is of interest in this article as it contains most of the effects discussed already plus several others. In addition, almost all the effects on the Hi-Fli are voltage controllable allowing, where appropriate, automatic control via either low frequency oscillators of various wave shapes or by a voltage derived from envelope detecting circuitry working off the input signal.

A block diagram of the unit is given in Fig. 13. After initial amplification in the foot pedal preamplifier, the signal is sent to the main unit where the various control voltages are generated and the signal processing occurs.

Two foot pedals allow independent control of both the left and right side of the Hi-Fli. The left-hand side has a top boost section, octave-shift facilities (based on the octave divider arrangement), a ring modulator-like system which generates the octave above, and a sustain-fuzz section which creates a fuzz sound whose amplitude is proportional to the signal level but whose harmonic structure varies with it.

The right-hand section (controllable by right pedal) deals solely with the Phase Filter. The speed of the modulating oscillator and the modulation ramp time, as well as the actual modulation voltage applied to the phase shifting circuitry, are all foot-pedal controllable.

The foot pedal control voltages are inverted in the main unit to provide both increasing and decreasing voltages as the pedal is operated. On each of the various controllable functions, there are switches marked +, 0 and —, which allow complementary operation of different effects whilst the pedal is operated.

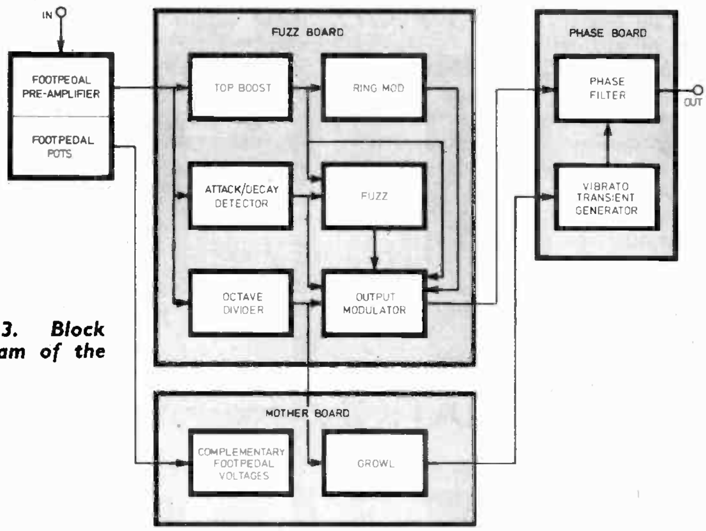


Fig. 13. Block diagram of the Hi-Fli

PHASE FILTER

This portion of the Hi-Fli is probably the most complex in the unit, but is responsible for creating the most dynamic sound effects. Phasing, frequency shifting (vibrato), waa-waa (one resonant peak), waw-waw (six resonant peaks) and meow (two sets of three resonant peaks moving in opposite directions) are all generated by the Phase Filter section.

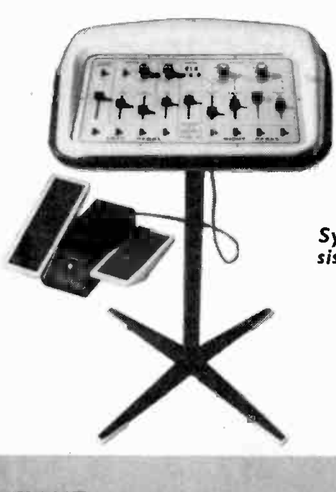
A split 12-segment phase shifting arrangement is used. The great frequency bending capability of this circuitry is very evident when the frequency shift slider is moved and, depending on the rate, the note can be shifted by as much as several semitones.

This function is performed automatically with an oscillator to provide the vibrato effect. The oscillator can either be continuous, or triggered such that after the note is played the amplitude decreases or increases with time at a predetermined rate (either manually set or foot pedal controlled).

The oscillator and decay circuitry can also be used to control the phasing mode (of which there are two) or the other effects mentioned earlier.

In order to provide effects which are triggered at the beginning of a note (for example, a vibrato which gradually increases as a note decays away), some form of trigger signal must be derived. This is not as easy as it may first appear, since the trigger must not operate on random noise produced in the handling of the guitar. On the other hand, however, it must be able to operate correctly on low level outputs in quiet passages.

The derivation of the trigger pulses is therefore a relatively complex operation and requires a fair amount of circuitry. The signal is first equalised, then logarithmically compressed and finally differentiated. This produces a pulse which as accurately as possible defines the beginning of the note. The same circuitry is used to detect rapid reductions in level (the end of a note).



Synthi Hi-Fli guitar synthesiser (Colorsound)

Another recently introduced Guitar Synthesiser from Top Gear

Time Constants

By D. MAYNARD

MOST of us are aware of the fact that capacitors and inductors behave differently when a current or voltage in a circuit is suddenly changed. We may know that an exponential growth or decay is involved, but one usually finds that, when exact values need to be determined, the text books and slide rule have to come out.

This article sets out to put together some useful formulae, and also a set of curves for quick calculation of currents and voltages.

RC CIRCUITS

Fig. 1a shows the circuit for the first set of equations and waveforms. When dealing with capacitors, it is usual to consider voltage rather than current. Let us consider what happens if the square wave of Fig. 2a is applied to the input. The maximum value is E volts and there are two changes that have to be accounted for. The first is the leading edge where we have a positive going change, and the second is the trailing, or negative going edge.

SEQUENCE OF EVENTS

The voltage across a capacitor's plates cannot change instantaneously and so when the input goes from 0 to E volts, the whole E volts appears initially across the resistor. Then, as the capacitor charges up, the voltage across it increases, and the resistor voltage decreases. At all times the sum of the resistor and capacitor voltages are equal to the input voltage. Fig. 2 shows typical voltages and currents in the circuit. The actual shape of the resistor and capacitor voltage waveforms will depend on the time constant (C × R) of the circuit.

The rising edge of the capacitor voltage is given by:

$$v_c = E\left[1 - \exp.\frac{-t}{CR}\right]$$

This is shown in detail by curve 1 of Fig. 3. The scale of the horizontal axis is in terms of the time constant CR. On the vertical axis unity is equivalent to E, so that if the square wave had an amplitude of 9 volts, all the values on the vertical scale are multiplied by 9. Using the curve we can find the actual voltage on the capacitor at any time after the initial change provided we know the time constant. For example, a $1\mu F$ capacitor and a $10k\Omega$ resistor produce a time

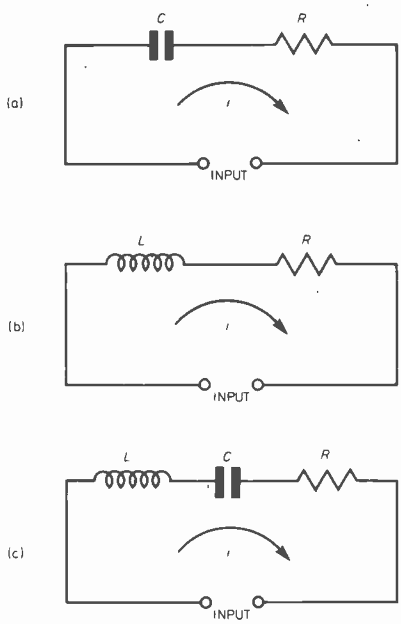


Fig. 1. (a) CR circuit, (b) LR circuit and (c) LCR circuit

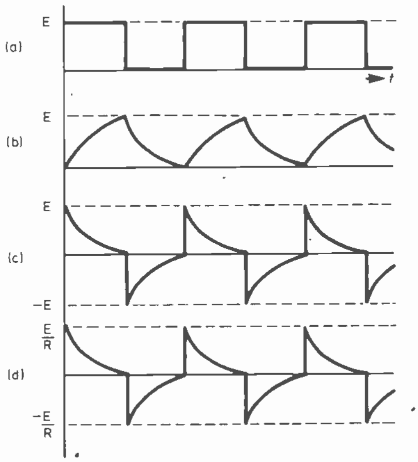


Fig. 2. Waveforms in CR circuit. (a) input voltage, (b) capacitor voltage, (c) resistor voltage, (d) current

constant of 10^{-2} seconds, or 10 milliseconds. After 5mS (one half of the time constant) the voltage is 0·39E.

On the trailing edge, the capacitor voltage equation is:

$$V_c = E \exp \frac{-t}{CR}$$

This is shown by curve 2 of Fig. 3. The scales of the horizontal and vertical axes are the same as for the leading edge. The positive and negative impulses associated with the resistor voltage waveform are defined by the following two relationships:

$$v_R = E \exp \frac{-t}{CR} \text{ for the positive impulses.}$$

and

$$v_R = -E \exp \frac{-t}{CR} \text{ for the negative impulses.}$$

In the curves of Fig. 3, the leading edge produces curve 2 while the trailing edge produces curve 3. The vertical axis is in terms of E, and the horizontal axis is again in terms of the time constant CR. To find the initial voltages we only have to remember that, with t=0:

$$\exp \frac{-t}{CR} = 1.$$

CURRENT WAVEFORM

The current waveform is obviously similar to the resistor voltage waveform. The difference is that the maximum amplitude is now $\frac{E}{R}$. The leading edge has the form:

$$i = \frac{E}{R}\left[\exp \frac{-t}{CR}\right] \text{ . . . . . curve 2, Fig. 3.}$$

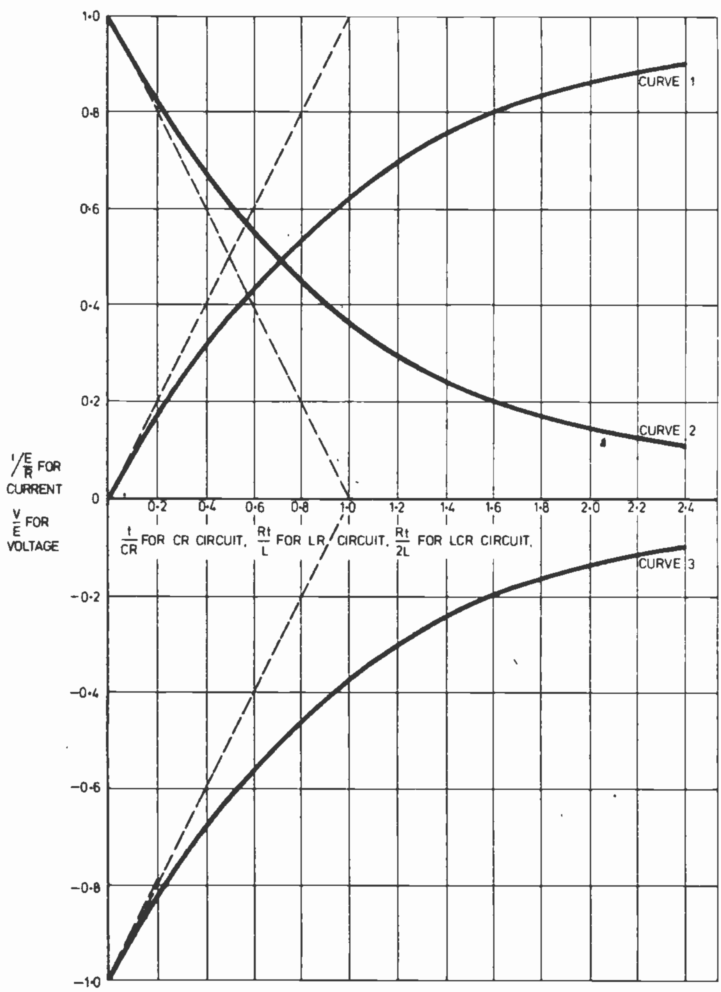


Fig. 3. Curves for calculating values of current and voltage

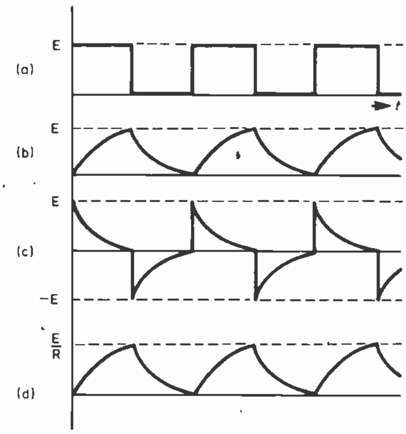


Fig. 4. Waveforms in LR circuit. (a) input voltage, (b) resistor voltage, (c) inductor voltage, (d) current waveforms

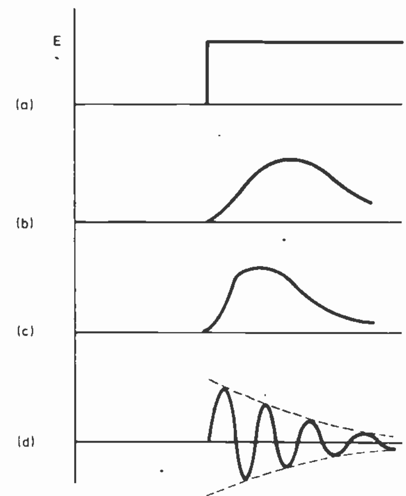


Fig. 5. Waveforms in LCR circuit. (a) input, (b) current overdamped, (c) current critically damped, (d) current underdamped

The trailing edge is a negative impulse:

$$i = -\frac{E}{R}\left[\exp\frac{-t}{CR}\right] \text{ ..... curve 3, Fig. 3.}$$

The time constant, and therefore the scale of the horizontal axis, is still equal to CR.

LR CIRCUITS

It is usual to consider current when dealing with the LR circuit, but voltages can easily be obtained from the fact that $v_L = L\frac{di}{dt}$ and $v_R = iR$. The circuit is shown in Fig. 1b, and current and voltage waveforms for a square wave input in Fig. 4. Taking the current waveform first, the leading edge is given by:

$$i = \frac{E}{R}\left[1 - \exp -\frac{Rt}{L}\right] \text{ .... curve 1, Fig. 3.}$$

The trailing edge on the other hand has the form:

$$i = \frac{E}{R}\left[\exp -\frac{Rt}{L}\right] \text{ ..... curve 2, Fig. 3.}$$

The starting point is zero for the leading edge and $\frac{E}{R}$ for the trailing edge. The time constant is now $\frac{L}{R}$.

VOLTAGE EQUATIONS

To complete the picture we can write down the voltage equations as follows:
For the rising edge,

$$v_L = E.\exp\frac{-Rt}{L} \text{ ..... curve 1, Fig. 3.}$$

$$v_R = E\left[1 - \exp\left(\frac{-Rt}{L}\right)\right] \text{ ..... curve 2, Fig. 3.}$$

For the falling edge,

$$v_L = -E\exp\frac{-Rt}{L} \text{ ..... curve 3, Fig. 3.}$$

$$v_R = E\exp\frac{-Rt}{L} \text{ ..... curve 1, Fig. 3.}$$

Table 1: Voltage and Current Equations for CR and LR Circuits

	Current		Voltage	
	Leading Edge	Trailing Edge	Leading Edge	Trailing Edge
CR Circuit	$i=\frac{E}{R}\exp\left(\frac{-t}{CR}\right)$	$i=\frac{-E}{R}\exp\left(\frac{-t}{CR}\right)$	$v_C=E\left(1-\exp\left[\frac{-t}{CR}\right]\right)$ $v_R=E\exp\left(\frac{-t}{CR}\right)$	$v_C=E\exp\left(\frac{-t}{CR}\right)$ $v_R=-E\exp\left(\frac{-t}{CR}\right)$
LR Circuit	$i=\frac{E}{R}\left[1-\exp\left(\frac{-Rt}{L}\right)\right]$	$i=\frac{E}{R}\exp\left(\frac{-Rt}{L}\right)$	$v_L=E\exp\left(\frac{-Rt}{L}\right)$ $v_R=E\left(1-\exp\left[\frac{-Rt}{L}\right]\right)$	$v_L=-E\exp\left(\frac{-Rt}{L}\right)$ $v_R=E\exp\left(\frac{-Rt}{L}\right)$

Table 2: Damping in LCR Circuit

	Overdamped	Critically damped	Under damped
	$4L<CR^2$	$4L=CR^2$	$4L>CR^2$
Current equation	$i=\frac{E\exp\left(\frac{-Rt}{2L}\right)\sinh Xt}{LX}$ $X=\sqrt{\frac{R^2}{4L^2}-\frac{1}{LC}}$	$i=\frac{E}{L}t\exp\left(\frac{-Rt}{2L}\right)$	$i=\frac{E\exp\left(\frac{-Rt}{2L}\right)\sin Yt}{LY}$ $Y=\sqrt{\frac{1}{LC}-\frac{R^2}{4L^2}}$
Frequency of Oscillation	—	—	$f=\frac{\sqrt{\frac{1}{LC}-\frac{R^2}{4L^2}}}{2\pi}$

RLC CIRCUITS

The behaviour of this circuit, shown in Fig. 1c, is dependent on the relative values of the inductor, resistor and capacitor. The three current waveforms shown in Fig. 5 correspond to three conditions known as underdamped, critically damped and overdamped.

The underdamped condition occurs when 4L is greater than CR^2, critical damping is when 4L is equal to CR^2 and the overdamped condition occurs if 4L is less than CR^2.

STEP FUNCTION INPUT

A step response is chosen as the input waveform to reduce the number of equations required. A trailing edge produces similar results but the waveforms are then negative-going. As the value of L is increased from a small value the rise and fall of the current waveform becomes more abrupt until the point of critical damping is exceeded when a decaying oscillation is produced.

For those interested in the mathematical process, we can write:

$$v = iR + L.\frac{di}{dt} + \frac{1}{C}\int i.dt.$$

Differentiating with respect to t gives:

$$L\frac{d^2i}{dt^2} + R\frac{di}{dt} + \frac{1}{C} = 0$$

The solution to this equation is of the form:

$$i = A\exp(p-q)t + B\exp(-p-q)t$$

$$\text{where } p = \frac{-R}{2L}, \text{ and } q = \sqrt{\frac{R^2}{4L^2} - \frac{1}{LC}}$$

The final solutions are obtained by assuming certain relationships between the components. It is also necessary to know the shape of the applied voltage.

Let us assume a step voltage input from 0 to E volts.

(a) When $4L < CR^2$

$$i = \frac{E}{L\sqrt{\frac{R^2}{4L^2} - \frac{1}{LC}}}.\exp\left(\frac{-Rt}{2L}\right).\sinh\sqrt{\frac{R^2}{4L^2} - \frac{1}{LC}}.t$$

This is the overdamped case shown in Figure 5b. The precise shape will depend on the relative values of R, L and C together with the value of E.

(b) When $4L = CR^2$

$$i = \frac{Et}{L}\exp\frac{-Rt}{2L}$$

The critically damped case is very similar in shape to the overdamped and is the point where oscillation just fails to occur.

(c) When $4L > CR^2$

$$i = \frac{E}{L\sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}}.\exp\left(\frac{-Rt}{2L}\right).\sin\sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}.t$$

From this, the frequency of oscillation is:

$$f = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$$

The underdamped waveform produced by the above expression is shown in Fig. 5d.

For quick reference the equations for the CR and LR circuits are laid out in Table 1. Table 2 does the same for the LCR circuit. ★

MAIL BAG

The on-going increase in postal and telephone charges does not seem to have made any difference to our post bag or our telephone bell. Enquiries continue to flood in.

We find that there are two points we are constantly mentioning. In the first place we just cannot afford to reply to any *readers' letters*, particularly those not associated with projects we have pubished, unless they are accompanied by a *stamped addressed envelope*. Were we to undertake to do so our post bill would become astronomic.

We cannot deal with *technical enquiries by telephone*. Readers should write in, giving details of symptoms and perhaps some test point readings, when requesting technical help so that we can at least give the relevant author some idea of the problems involved.

Finally, whilst we normally supply details as to source of components in each project we do assume that the constructor refers to advertisements and has an awareness of general sources. Thus, where goods are generally available we do not specify a source. You could save the cost of a letter by reading the advertisement pages first.

SEMICONDUCTOR UPDATE... By R.W. COLES

7150
MC8505P
SD600
Z10L, Z15L, Z21L

THERE can be little doubt that microprocessors are the most exciting new development to hit the electronic headlines in recent years, promising, as they do, the power of a computer for use in everyday applications. Until recently though, exciting promises are really all we have seen, and the predicted microprocessor car control chip and other down to earth ideas have never materialised as practical hardware.

I must confess to being a great fan of the microprocessor philosophy, but I am sure there are some readers who feel that computers in any shape or form, are more of a threat, than a promise.

NEW CHIP

Perhaps I can recruit a few more for the microprocessor bandwagon by describing a thoroughly practical new chip from ITT which provides all the programming required to control even the most sophisticated automatic washing machines, in a tiny fraction of the space required for the traditional electromechanical timers. The power of the microprocessor approach allows the **ITT7150** to do much more than just replace a conventional cam timer, improvements are possible to the fabric care wash programs, and the controllability of the machine is enhanced to make life simpler for the housewife (or should it be house person!).

ROMs

At the heart of the 7150 are two r.o.m.s (Read Only Memories) which store the control programmes to control up to ten machine functions in separate, 20 step, wash programmes. There are typically seven main wash programmes which conform to the system of fabric care labelling, but the flexibility of the microprocessor allows complete reprogramming by the manufacturers to cope with new wash requirements, or to change the nature of the chip so that it can control a dishwasher, tumble dryer, or central-heating system. The ITT 7150 crams into a single 28 pin d.i.l. no fewer than 2,000 memory bits, about 400 gates and even some analogue circuitry for good measure.

REFRESHING CHANGE

There have been a number of special digital i.c.s produced for use with large m.o.s. memory systems used in computer applications, but in general these can have little interest for amateur constructors because they are too specialised. It makes a nice change therefore, to report on one of these specialised devices which could have wider uses than the manufacturers intended. I refer to the Motorola **MC8505P** "m.o.s. Memory Address Refresh Logic circuit" which sounds a bit of a mouthfull but is in fact a very useful 6 bit binary counter with parallel outputs vià six AND-OR-INVERT gates in the form of a six bit multiplexer.

In a dynamic m.o.s. memory system this chip is used to sequentially step through the memory addresses in order that the memory contents may be refreshed before the limited data retention period expires. In between refresh cycles, the memory address is provided by the central processor so that data may be written in or read out, and this explains the need for the six bit multiplexer, which selects either the refresh counter outputs or the c.p.u. address.

The MC8505 operates from a 5V supply, comes in a 16 pin d.i.l., and is compatible with t.t.l. logic.

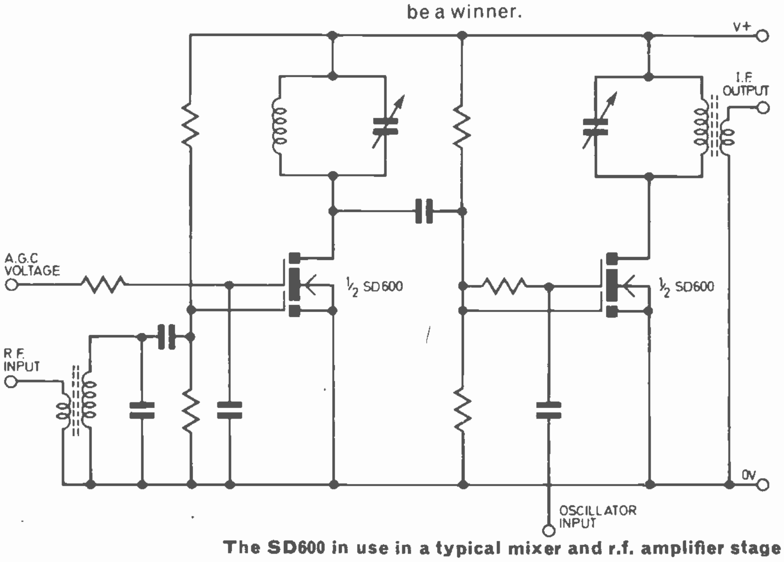
D.M.O.S

D.M.O.S. is not a new logic family but a new process for making m.o.s. transistors which makes possible much better devices for linear and r.f. applications.

The D stands for double-diffused, and d.m.o.s transistors are *N* channel devices of the enhancement mode type made by employing a new diffusion technique to achieve precisely controlled channel lengths. Because of this precise channel geometry, gain, cut-off frequency, input capacitance, and on resistance can all be optimised, and an incidental benefit is an increase in drain/source voltage breakdown rating.

A prime example of the d.m.o.s family is the **SD600** from Mullard, which is in fact two dual-gate d.m.o.s devices contained in an 8 pin mini d.i.p. package for use in the front-end of equipment operating in the range 10–200MHz.

A device of this type is ideal for use as the r.f. amplifier and mixer of a high quality f.m. tuner where all the advantages of the d.m.o.s technology give a significant improvement in performance when compared with conventional f.e.t. front-end. Add to these performance advantages the economy and ease of use of the practical minidip package, and you can see that the SD600 is sure to be a winner.



The SD600 in use in a typical mixer and r.f. amplifier stage

SURGE SUPPRESSORS

When incorporating triacs thyristors, or power transistors in high voltage circuits it is possible to allow a small safety margin in the voltage breakdown ratings to ensure that in normal circumstances there will be no catastrophic failures due to overvoltage.

Unfortunately normal circumstances do not always apply, and overvoltage conditions can occasionally occur due to lightning strikes, power grid surges and back e.m.f.s caused by the switching of inductive loads. Increasing the breakdown ratings of the semiconductors to cope with these freak occurences is unfortunately no solution, since a drastic uprating of this sort will lead to much higher prices and a likely decrease in switching performance.

The only practical protection which can be provided against transient overvoltages in high voltage equipment is the installation of surge suppressors of the voltage dependant resistor type, and an improved range of such devices has now been introduced by International-Rectifier.

The **Z10L, Z15L** and **Z21L** "Zenamic" series of devices are metal oxide varistors with a non linear current-voltage relationship so that they maintain an almost constant voltage across themselves over a very wide range of currents. That sounds a bit like a Zener, doesn't it, but the difference lies in the fact that although the average power dissipation of these transient suppressors is comparable to that of a Zener, the peak current handling capacity extends to no less than 2,000 amps for the Z21L.

WIDE RANGE

The Zenamic devices are available for a wide range of voltages between 130 and 730 volts, and are housed in a two lead disc package of 13mm diameter (Z10L) 15mm diameter (Z15L) or 24mm diameter (Z21L).

To choose a device for a particular application one simply calculates the maximum steady state voltage applicable, and selects the voltage suppressor with the identical, or slightly higher, voltage rating. To protect, say, a thyristor, the Zenamic device is simply connected in parallel with it, so that any voltage spikes are safely absorbed without causing breakdown.

NEWS BRIEFS

A New Collection of Digital Watches

SLIMMER digital watches are on the way. Fairchild Camera and Instrument Corporation has entered the UK electronic watch market with two broad ranges of slim line digital watches. Less than 3/7th of an inch in thickness the Fairchild watches incorporate the latest ideas in miniaturised circuitry and use smaller batteries. Two lines will be marketed. An "up-market" range consisting of eleven men's and eight ladies models in either gold, stainless steel or chromium finishes. They will range in price from £43.95 to £97.50 and will be sold through fine jewellery stores. A low price range includes six men's and seven ladies' models priced from £19.95 to £32.95: these will be sold through retail outlets carrying similarly priced products.

Features of all these Fairchild watches are: single-button, five-function operation for hours, minutes, month, date and seconds; scratch resistent ruby coloured lenses; an attainable accuracy to within 60 seconds a year.

This California-based company will also be entering the UK consumer market with electronic clocks and television games, it has been announced.

Ministry of Defence Backs BS9000

FROM February 1 the Ministry of Defence introduced a new contracts clause requiring electronic components used in the design of MoD sponsored equipment to be approved within the BS9000 system. This unequivocal support for British Standards should ensure that BS9000 becomes the recognised authority for component quality and performance throughout the industry.

The BS9000 series was formulated by the British Standards Institution in 1967. The decision of MoD to make its use mandatory now is based on the fact that the range of components now included in BS9000 is sufficient to make the scheme practical for many requirements; plus the realisation that an accelerated expansion of the scheme is essential to keep pace with the rapid developments in electronics, and this is likely to be brought about most effectively by the full adoption of the scheme by a major and influential user of components such as the MoD. The MoD also provides financial assistance towards the cost of obtaining qualification approval of components for defence projects.

This decision has the support of the BSI, and the British Electronics Industry, also of various US component manufacturers. It must enhance the prospect of BS9000 becoming a major part in any European and, ultimately, world wide scheme for component standardisation.

Fair Deal

A BOOKLET which summarises the current laws affecting every day trade and consumer transactions has just been published by the Retail Trading Standards Association.

Entitled "Honest, Fair and Legal", the booklet covers the rights of the shopper and where the retailer stands if he resists claims under the Sale of Goods Act 1893.

It covers law about descriptions of goods and services, selling methods and safety. Also, it refers to public authorities with which retailers will be mainly concerned, and the sanctions, prosecution and penalties which may be encountered.

The booklet concludes with the Association's advice on 14 rules for retailers, which could form the minimum basis for all voluntary codes of practice agreed with the Office of Fair Trading.

The booklet "Honest, Fair and Legal", price 75p, is available from the Retail Trading Standards Association, 360/366 Oxford Street, London, W1N 0BT.

IBA Handbook

THIS annual publication appears in its 14th edition with the new title "TV & radio 1976."

All facets of broadcasting undertaken by the Independent Broadcasting Authority come within the scope of this handbook. Programme matters receive much attention and the articles are well illustrated in black and white and colour. Facts are given about all the individual programme companies, ITV and ILR. Maps indicate normal service areas for each transmitter. ERP and aerial polarisation and physical details are given. There is advice on obtaining the best reception including stereo sound, and some peeps behind the engineering scenes. But perhaps the main appeal of this very attractively produced book will be in the programmes and the well-known personalities—whose pictures adorn many of the 224 pages.

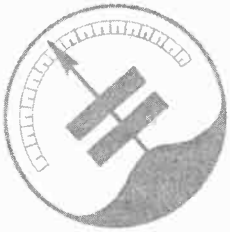
TV & radio 1976 is available from newsagents and booksellers, price £1.30.

Next Month...

FREE *with every issue!*

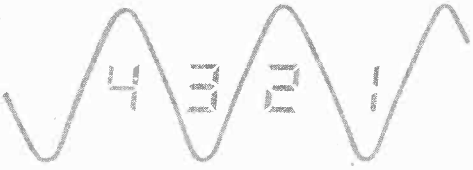
Plus these designs...

ADD-ON CAPACITANCE UNIT



Allows accurate measurement of capacitance from less than 1pF to greater than 30µF when used with any standard multimeter.

As an added bonus this project can be built on the FREE Printed Wiring Board.

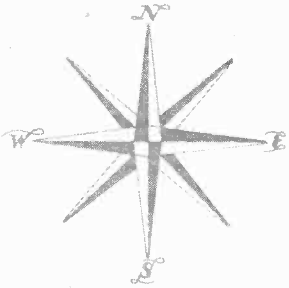


DIGITAL FREQUENCY METER

This design uses the latest integrated circuit technology to simplify construction.

Four frequency ranges covering 50kHz to 50MHz (extendable to 500MHz)—Resolution down to 10kHz at 50MHz—Variable input sensitivity—Simple calibration and maintenance.

AUDIO COMPASS



Originally developed as an aid to blind sailors, this unit can also provide an off-course alarm for use on self-steered yachts.

The Audio Compass will prove invaluable for power craft and for night sailing since it allows ears to replace eyes when steering a compass course.

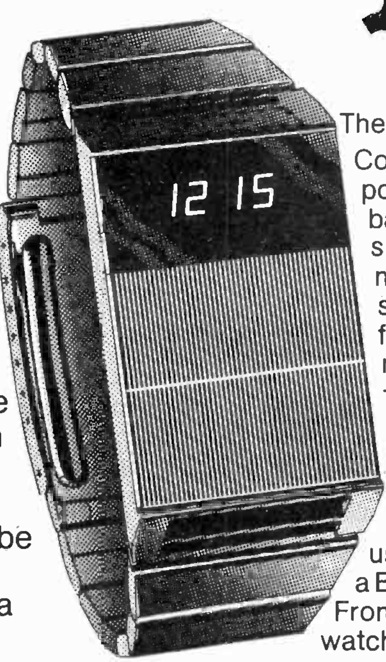
Our May issue will be published on Friday, April 9, 1976

PRACTICAL

ELECTRONICS

PLEASE NOTE:
It is in *your* interest to place a firm order with your newsagent—in advance. Back numbers are not available, so make sure of your copy now!

The Black Watch kit £14.95!



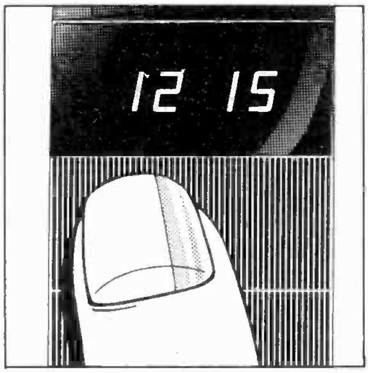
* **Practical**–easily built by anyone in an evening's straightforward assembly.
* **Complete**–right down to strap and batteries.
* **Guaranteed.** A correctly-assembled watch is guaranteed for a year. It works as soon as you put the batteries in. On a built watch we guarantee an accuracy within a second a day–but building it yourself you may be able to adjust the trimmer to achieve an accuracy within a second a week.

The Black Watch by Sinclair is unique. Controlled by a quartz crystal, and powered by two hearing aid batteries, it uses bright red LEDs to show hours and minutes, and minutes and seconds. And it's styled in the cool prestige Sinclair fashion: no knobs, no buttons, no flash.

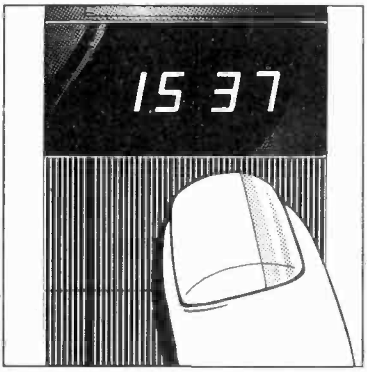
The Black Watch kit is unique, too. It's rational – Sinclair have reduced the separate components to just four–and it's simple: anybody who can use a soldering iron can assemble a Black Watch without difficulty. From opening the kit to wearing the watch is a couple of hours' work.

Touch and tell

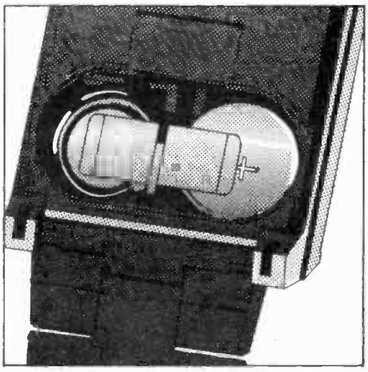
Press here for hours and minutes...



here for minutes and seconds.



Batteries easily replaced at home.



The specialist features of the Black Watch

Smooth, chunky, matt-black case, with black strap. (Black stainless-steel bracelet available as extra–see order form.)

Large, bright, red display–easily read at night. Touch-and-see case–no unprofessional buttons.

Runs on two hearing-aid batteries (supplied). Easily re-set using special button–no expensive jeweller's service.

The Black Watch–using the unique Sinclair-designed state-of-the-art IC.

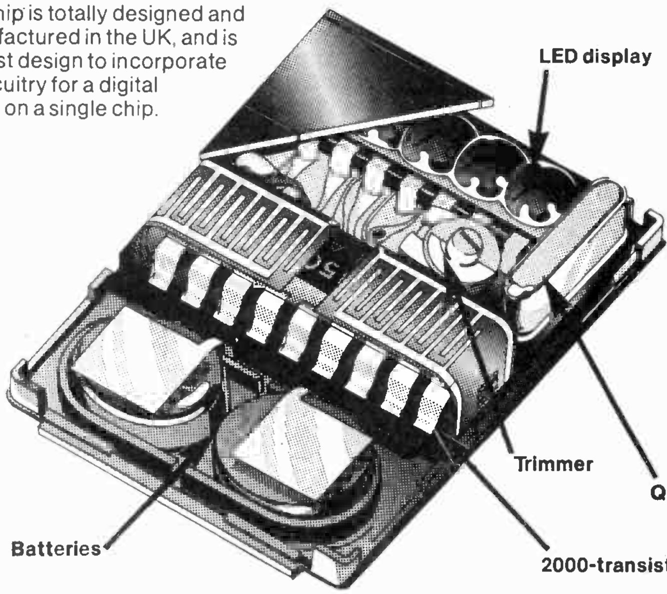
The chip...
The heart of the Black Watch is a unique IC designed by Sinclair and custom-built for them using state-of-the-art technology–integrated injection logic.

This chip of silicon measures only 3 mm x 3 mm and contains over 2000 transistors. The circuit includes

a) reference oscillator
b) divider chain
c) decoder circuits
d) display inhibit circuits
e) display driving circuits.

The chip is totally designed and manufactured in the UK, and is the first design to incorporate *all* circuitry for a digital watch on a single chip.

...and how it works
A crystal-controlled reference is used to drive a chain of 15 binary dividers which reduce the frequency from 32,768 Hz to 1 Hz. This accurate signal is then counted into units of seconds, minutes, and hours, and on request the stored information is processed by the decoders and display drivers to feed the four 7-segment LED displays. When the display is not in operation, special power-saving circuits on the chip reduce current consumption to only a few microamps.



Complete kit £14.95!

The kit contains
1. printed circuit board
2. unique Sinclair-designed IC
3. encapsulated quartz crystal
4. trimmer
5. capacitor
6. LED display
7. 2-part case with window in position
8. batteries
9. battery-clip
10. black strap (black stainless-steel bracelet optional extra–see order form)
11. full instructions for building and use.

All the tools you need are a fine soldering iron and a pair of cutters. If you've any queries or problems in building, ring or write to Sinclair service department for help.

Take advantage of this no-risks, money-back offer today!

The Sinclair Black Watch is fully guaranteed. Return your kit in original condition within 10 days and we'll refund your money without question. All parts are tested and checked before despatch-and correctly-assembled watches are guaranteed for one year. Simply fill in the FREEPOST order form and post it-today!

Price in kit form: £14.95 (inc. black strap, VAT, p & p).
Price in built form: £24.95 (inc. black strap, VAT, p&p).

sinclair

Sinclair Radionics Ltd,
London Road, St Ives,
Huntingdon, Cambs., PE17 4HJ.
Tel: St Ives (0480) 64646.
Reg. no: 699483 England. VAT Reg. no: 213 8170 88.

To: Sinclair Radionics Ltd, FREEPOST, St Ives, Huntingdon, Cambs., PE17 4BR.

Please send me — Total £

.... (qty) Sinclair Black Watch kit(s) at £14.95 (inc. black strap, VAT, p&p). ....

.... (qty) Sinclair Black Watch(es) built at £24.95 (inc. black strap, VAT, p&p). ....

.... (qty) black stainless-steel bracelet(s) at £2.00 (inc. VAT, p&p). ....

*I enclose cheque for £.. made out to Sinclair Radionics Ltd and crossed.

*Please debit my *Barclaycard/Access/American Express account number

....

Name (please print) ______________________

Address ______________________

____

____

Signature ______________________ PE/4

FREEPOST–no stamp required. *Delete as required

SHOOT is a simple, inexpensive, electronic game of skill that tests the player's speed of reaction. Using TTL logic and a battery power supply it is small and self-contained, and an entertaining challenge to the player.

OBJECT OF THE GAME

The object of Shoot is, like a fairground rifle range, to shoot down a moving target, in this case a light moving along a row of l.e.d.s. The player "shoots" when he thinks the light is at the centre of the row. If he has "hit" the light it goes out but, unlike a rifle range, if he "misses" the light comes on and forms a second moving target, doubling the player's problem. This will happen each time he "shoots", and if the centre light is on at that instant it will go off, and if off it will turn on.

The speed at which the lights move along the row determines the degree of skill required to accurately "shoot" them down.

The player will soon find he can devise his own rules for the game and set himself problems. For example, he could progress from no lights travelling across to all nine lights full on in the minimum number of "shots". This ability for the player to determine his own rules makes Shoot an intriguing game to play.

Shoot is small and portable, simple to construct and is cheap at about £6. Operation is straightforward, consisting of only three controls. The game is quickly understood by a new player. The project also provides the chance to gain knowledge of working with TTL.

CIRCUIT DESCRIPTION

It can be seen, from the above description, that pushing the "shoot" button inverts the state of the centre l.e.d. The logic to achieve this consists of a nine-bit shift-register, its states indicated by l.e.d.s, with a conditional inverter between the fifth and sixth bits operated by the "shoot" button.

This conditional inverter is an EXCLUSIVE-OR gate. The truth table is shown below:

Inputs A	Inputs B	Output
0	0	0
0	1	1
1	0	1
1	1	0

If input B is a logic 0, then input A is the same as the output. However, if B is a logic 1, input A is inverted at the output. The conditional inverter forms the basis of Shoot.

The circuit diagram is shown in Fig. 1. IC1 and IC2 are 7496 five-bit serial-in parallel-out shift-registers. They are connected as a nine-bit shift-register, the nine l.e.d.s connected directly to the outputs via 270Ω current limiting resistors R2–10.

Between stage five and six there is an EXCLUSIVE-OR gate IC4a (a quarter of a 7486). In fact, the fifth stage l.e.d. (D5) is connected to the output of this gate. The output of the ninth bit of the shift-register is fed back into the serial input of the register so that the operation is cyclic. The other input of IC4a is connected to the "shoot" circuit.

Half a 7413 dual, four-input Schmitt NAND gate and C4, R11 and VR1 are connected in the usual Schmitt oscillator configuration, providing the clock pulses for the shift-register.

The output of IC3a is inverted by IC4b, a spare EXCLUSIVE-OR gate in the 7486 package, connected in its inverting mode by R12. IC3b, C5, C6, R12, R14, D10 and S1 form the "shoot" circuit.

CIRCUIT OPERATION

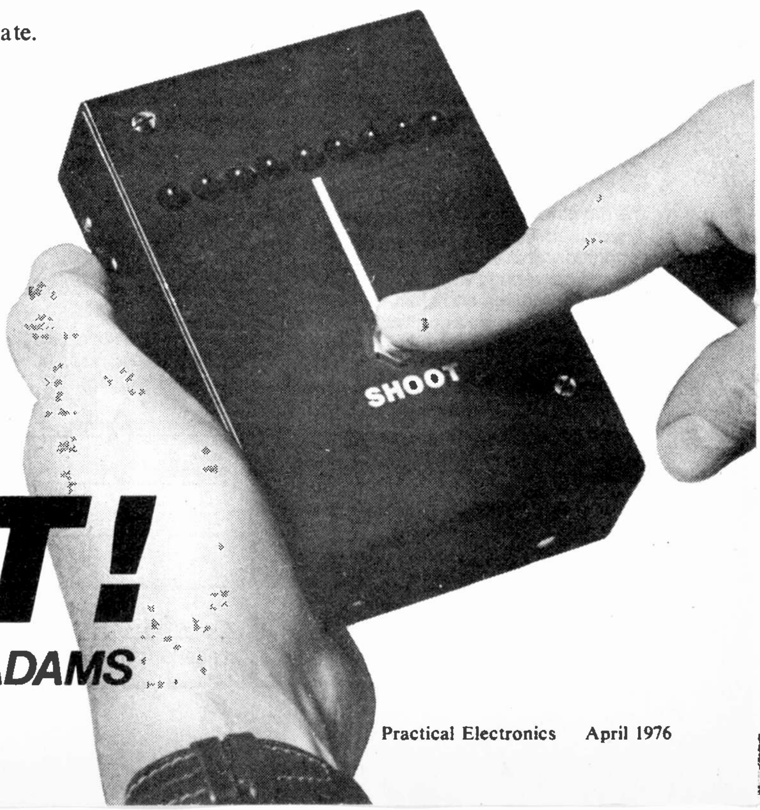
With S1 open, C5 and C6 charge via R13 and R14 to the Schmitt trigger level for the gates IC3. All other inputs are high (logic 1) so IC3a output goes low (logic 0) and starts the oscillator cycle. IC3b output then goes low. This is connected to IC4a which acts as a gated inverter and the shift-register cycles round clocked by IC3a oscillator. Light emitting diodes D1–9 give indication of states.

When S1 is closed C5 and C6 (via D10) discharge. Inputs to IC3a and IC3b go low causing their outputs to rise. IC3a can now no longer operate as an oscillator and because of the inverter IC4b, the

Fun for all the family...

SHOOT!

By P. ADAMS

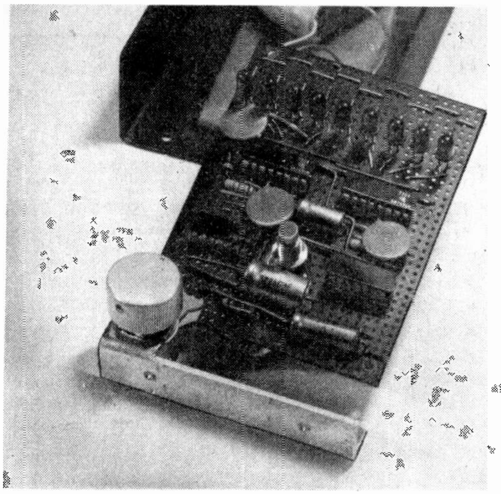


clock input to the register is held low. However, the input to IC4a is now high and it inverts the state of D5: if it was alight it goes out and vice versa. Meanwhile C4 charges to a logic 1 via R11 and VR1.

When S1 is released C5 and C6 charge. Because C6 is charged (via R14) from C5 the voltage across C6 lags that of C5. C5 reaches the Schmitt trigger level of IC3a and, all other inputs being high, its output goes low. The output of IC4b goes high and the register is stepped one state. (The 7496 changes state on the leading edge of the clock pulse.)

The inverted fifth state is thus moved to the sixth. IC3a is now again acting as an oscillator. The voltage of C6 now reaches Schmitt trigger level of IC3b whose output goes low. The conditional inverter IC4a returns to its non-inverting state before the next clock pulse and so the shift-register cycles as before until S1 is closed again.

Pushing the "shoot" button S1 stops the clock and inverts the state of the centre l.e.d. Releasing the button steps the register one state, returns the fifth l.e.d. to a non-inverted state and starts the clock. The fact that the lights stop moving when the button is depressed is very convenient to be able to study the pattern of the lights for the next "shoot".



COMPONENTS . . .

Resistors
R1 1kΩ
R2–R10 270Ω (9 off)
R11 330Ω
R12 2kΩ
R13 470Ω
R14 330Ω
R15 560Ω
All ±5% ¼W carbon

Potentiometer
VR1 470Ω (see text)

Capacitors
C1–C3 0·1µF disc ceramic (3 off)
C4 100µF 6V elect.
C5 100µF 6V elect.
C6 10µF 6V elect.

Integrated Circuits
IC1, IC2 SN7496N (2 off)
IC3 SN7413N
IC4 SN7486N

Diodes
D1–D9 TIL209 or similar
D10 1N914
D11 50 p.i.v. 250mA silicon diode

Switches
S1 Miniature push to make
S2 Miniature slide switch

Miscellaneous
B1–B4 MN1500 1·5V (4 off)
Case (see text), 0·1in matrix Veroboard 95 × 61mm (3·75 × 2·4in), battery clips, spacers, etc.

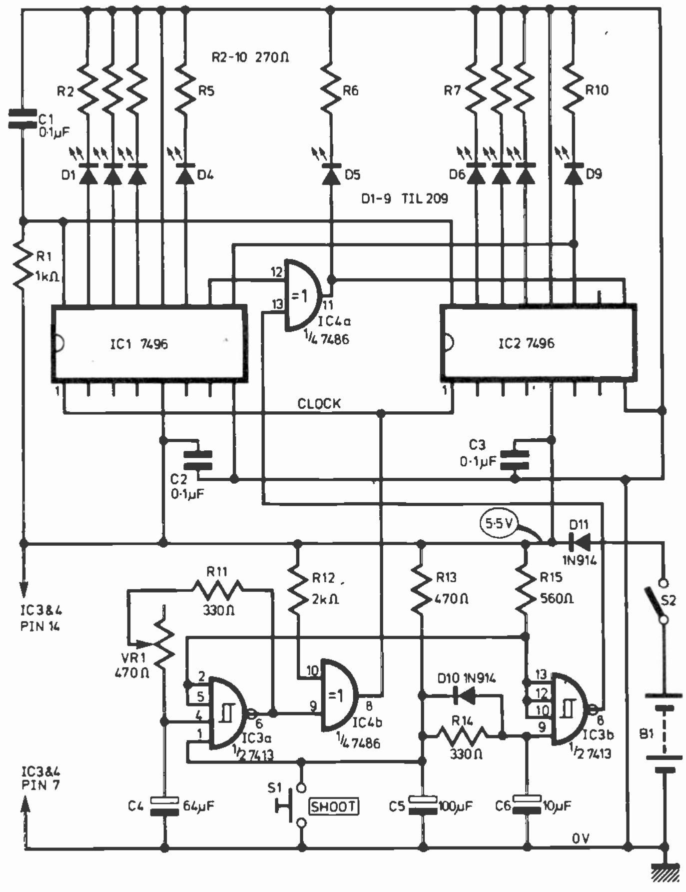


Fig. 1. Circuit diagram of the Shoot game

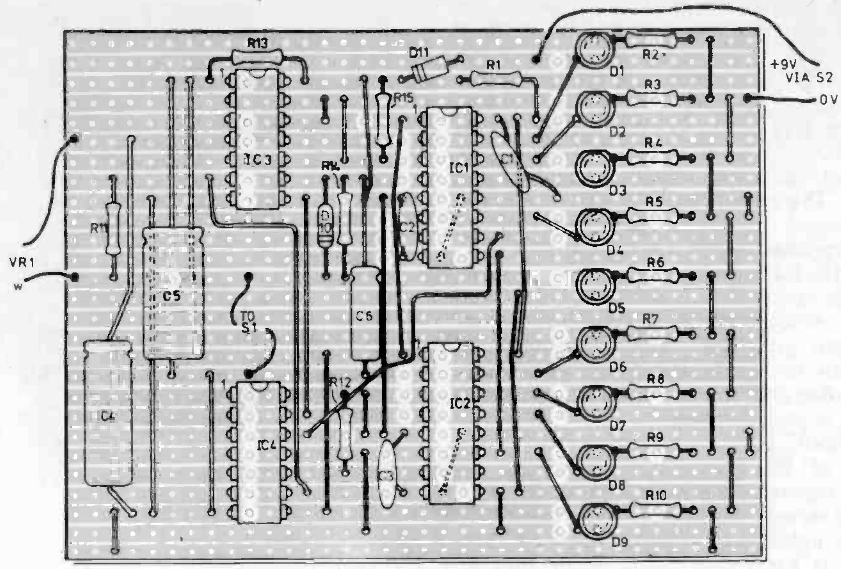
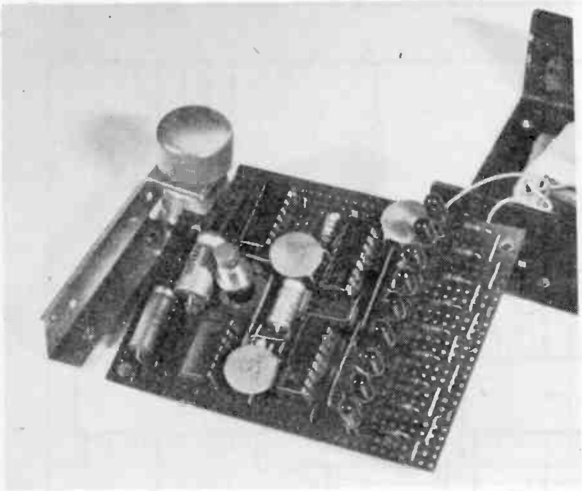


Fig. 2. Layout of the components and cuts on the Veroboard



The completed Shoot game

On switching the power on (S2), R1 and C1 clear the shift registers. This provides a useful method of returning to the "all off" state. C2 and C3 suppress switching transients on the power supply rail which could upset the operation of the logic. VR1 varies the frequency of the clock and hence the rate at which the lights appear to travel. D11 limits power supply to 5·5 volts because of the diode voltage drop. Also it ensures against wrong polarity connection.

CONSTRUCTION

The circuit is constructed on Veroboard. The layout is shown in Fig. 2.

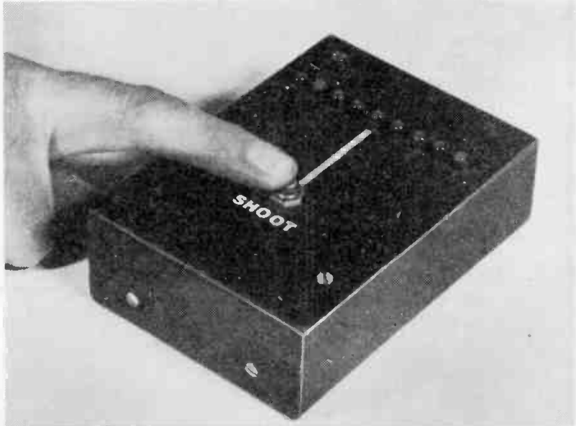
The game was housed in a plastic case 4in × 3in × $1\frac{1}{4}$in, but any instrument case will do providing it is no smaller.

To leave the front panel clear of controls except for the "shoot" button it was decided to make VR1 an edge control. This was done by gluing an edge control knob from an old transistor radio to a skeleton preset. There is no reason why an ordinary potentiometer could not be used. The batteries can either be held in holders or soldered together.

Components are not critical except C2 and C3 which must be disc ceramics. C4 gives a satisfactory range of speed for the display, but if the game proves too easy, reducing its value will increase the speed further. It was found that a switch with a heavy or long-travel action was best for S1. Alkaline Manganese batteries were used because of their higher power and longer life compared to dry batteries. However, HP7s could be used.

CONCLUSIONS

Shoot is an interesting project to construct and most compelling to play. The prototype has been in existence for some time and all who have played with it were most impressed and absorbed. Developments to the circuit such as a scoring system or firing delays, could easily be made but the added complexity would mean the game was no longer portable which was one of the major factors in the design of Shoot. ★



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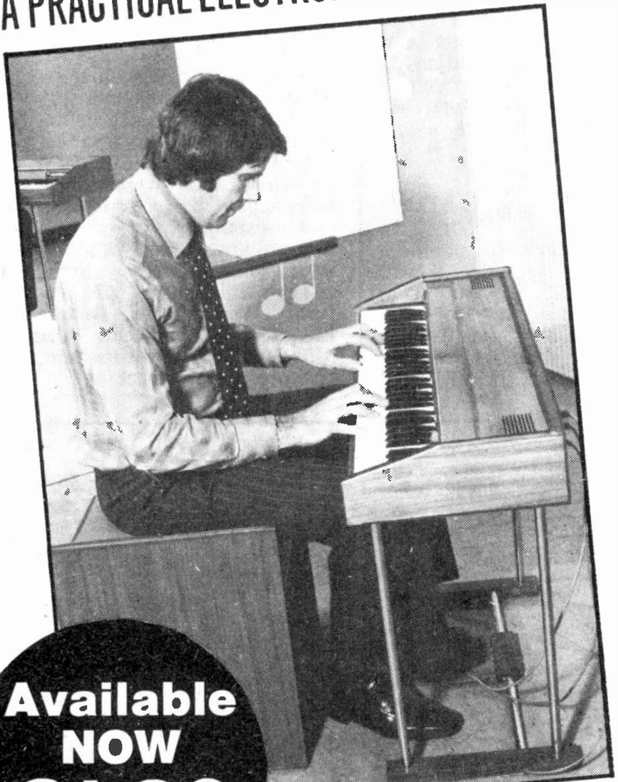

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MARKET PLACE

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

CALCULATOR

Combining the most popular functions of a handheld memory calculator and a basic slide rule calculator, **Texas Instruments** have introduced the TI-2550-II 8-function calculator.

The new calculator features the basic five functions (add, subtract, multiply, divide and percent) with an automatic constant on all five functions plus a full four-key memory: memory plus, memory minus, memory recall and clear memory. In addition, it features the widely used slide rule calculator functions of square root, square and reciprocal.

The reverse key is especially useful to divide the quantity in the memory by the quantity in the display. The square root, square and reciprocal keys operate only on the displayed quantity; they do not complete any pending operation. Thus, it can easily solve problems such as the square root of the sum of squares without using the memory.

Used for the first time in a Texas calculator is a bright green vacuum-fluorescent display with large 0·2 inch-high digits.

For maximum readability, the negative sign is always displayed immediately to the left of the first displayed digit. A ninth character on the extreme left of the display is used to indicate a quantity stored in the memory and as an error and overflow indication.

The calculator can be set to operate in full floating operation or to round off the answer to two places after the decimal point.

Weighing less than 8oz (230g), the TI-2550-II comes with the BP-2 battery pack containing two fast-charge nickel cadmium cells, the AC9900 adapter/charger and an owner/users manual. The recommended retail price for the TI-2550-II is £29·95 including VAT and accessories.

Addresses of nearest stockists can be obtained from **Texas Instruments Ltd., 165 Bath Road, Slough SL1 4AD.**

POWER AMPLIFIER

For the power enthusiasts **Bi-Pak Semiconductors** are now marketing the AL250 125W power amplifier module.

Capable of delivering 125W r.m.s. into 4 ohm loads, the module has a sensitivity of 450mV and a frequency response extending from 25Hz to 20kHz. Distortion levels are typically below 0·1 per cent and damage resulting from incorrect or short-circuit loads is prevented by a four transistor protection circuit.

Intended for use in applications such as disco units, p.a. systems and background music players, the AL250 costs £15·95 plus VAT. The module is fully guaranteed and comes complete with instructions.

Further details can be obtained from **Bi-Pak Semiconductors, 63 High Street, Ware, Herts.**

STABILISED SUPPLY

The new low voltage stabilised power supply kit from **RCS** will give up to 100mA d.c. output at various voltages.

Operated from 200 to 240V a.c. mains input the stabilised output voltages available are 6V, 7½V, 9V and 12V. The circuit is of the parallel Zener diode type, the output voltage is governed by the value of the Zener diode and the current is limited by the value of a resistor.

The kits are supplied for one output voltage and current as requested by the purchaser. All parts are available separately and a complete kit costs £2·95 including VAT; postage is 45p.

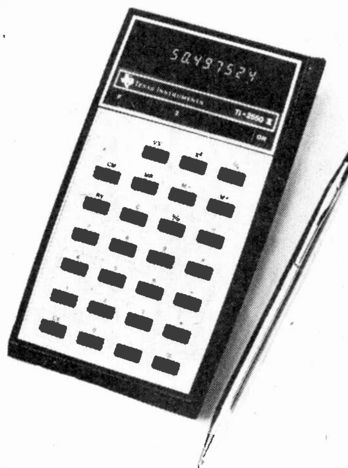
Further information and kits are available from **Radio Component Specialists, 337 Whitehorse Road, West Croydon, Surrey.**

RESISTOR CALCULATOR

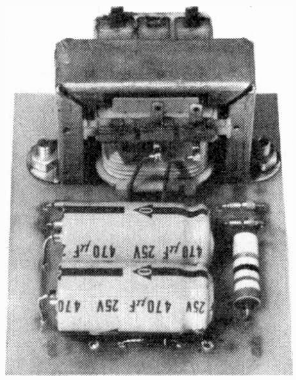
To compliment their very large range of carbon film, wirewound and vitreous wirewound resistors, **West Hyde Developments** have designed and are marketing a 5in plastic resistor calculator.

One side of the calculator has a swinging cursor which enables you to calculate power, current, voltage and resistance (any two known and two unknown). The other side contains the slide rule.

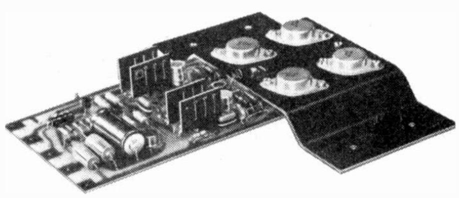
The calculators are available from **West Hyde Developments Ltd., Ryefield Crescent, Northwood, Middlesex,** price 61p including VAT and postage and packing.



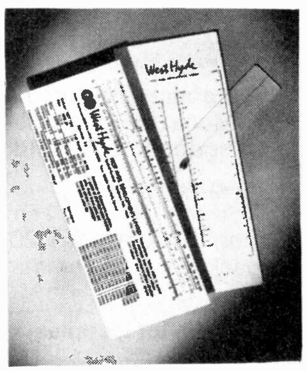
Texas TI-2550-II 8-function calculator



Stabilised supply from RCS



The 125W power amplifier module from Bi-Pak Semiconductors



Resistor/Slide Rule calculator from West Hyde

Strictly Instrumental

by K. Lenton-Smith

LATE last year, a horde of organ-building enthusiasts descended on the Hammond (U.K.) Sonorous Works at Edgware one Saturday afternoon—looking for bargains. The occasion was a sale of surplus circuit boards and spares due to certain models becoming obsolete. Keyboards, pedalboards, transistor generators and drum units were among the many items offered: as I was there (and did not come away empty-handed!), I can report that the trade was brisk.

Hammond (U.K.) have never manufactured organs as such, but have simply put together kits of parts made in America. Escalating costs are such that it is now cheaper to import complete organs from other parts of the Hammond organisation, so Bob Grant, their Sales Manager, tells me.

More expensive organs will still come from the U.S., whilst Japan will cater for the lower end of the market. Sadly, this makes economic sense.

Any Hammondphile who heard of this sale may therefore be assured that his favourite organ is still in the forefront.

SIDEMAN

Twenty years ago, the rhythm unit was not as commonplace as it is today. The Wurlitzer "Sideman" was typical then: completely valve-operated, its rhythm patterns were derived from a disc carrying concentric circles of contacts wiped by multiple pick-up brushes and motor-driven.

The voice circuits were much the same as they are today, but the whole unit was massive due to both the mechanical parts and the heavy engineering associated with valve equipment. Transistors and i.c.s subsequently reduced both size and weight, quite apart from the modern tendency to provide only a pre-amplified output.

Present prices are very different and today's version is at least portable, but there are still a few problems to contend with.

Given the choice between an electronic drummer and the real thing, most musicians would prefer the latter. His main advantage lies in the fact that he can *vary* his rhythms, he can remain tacit for a bar or two, play *ppp* or *fff* as the case may be and even react to a raised eyebrow—rapport with his colleagues perhaps?

However, even the best drummers are occasionally guilty of slowly speeding up tempo and the worst of them can get off the beat! This is the one area where the electronic version scores, the oscillator supplying the counting/logic system will give a *strictly* measured beat, ad nauseam.

Monotony is the main criticism levelled at the Rhythm Unit, so Hammond have come up with a (partial) solution.

Their latest unit features the usual rhythms but, by means of four extra buttons A, B, C and D, alternatives to each rhythm are obtained. This means that there are four variables for each rhythm, i.e. four Waltzes, four Bosa Novas, etc. In addition, the unit may be programmed to scan across these alternatives automatically, making the changes at predetermined intervals of half a bar, one, two, four, eight or 16 bars.

Short of using a recording of a live drummer as an accompaniment, this Hammond idea is about the best advance one could hope for in an electronic drum unit.

CLEAN FINGERING

The "Solovox" type of monophonic keyboard is long dead, but pianists who used these found that they had to devise a playing technique to suit its circuitry. The tone generator was an R-C multivibrator, usually a glowing 6SN7, and the playing keys effectively varied a resistive or capacitive value applied to the valve.

Though the player knew that you couldn't play a chord on a monophonic instrument, there was always a tendency to do so out of sheer habit. Normally there was no harm in this as, however many notes were keyed, only the top one affected the generator.

The same problems apply to the average Synthesiser with an added complication. We still key into a chain of resistors, but they are now used as a divider to provide *voltages* rather than a single resistive value. The forgetful pianist who inadvertently plays a "chord" will produce an odd result because a number of resistors will be shorted out of the chain, causing the VCO to produce Eastern scales and upsetting the loading of the voltage sources.

Slurs from one note to another, though feasible on organ or piano, will not work very successfully for the same reason, even the *acciaccatura* will prove difficult. A nuisance? Not really, as anything that makes for better keyboard discipline can't be bad.

Although a strong *portamento* might help to disguise the problem, many listeners will object to the "cure". Let's just say that your VCO and Hold will love you for realising that clean fingering helps them enormously!

IN TUNE

The Synthesiser is a versatile device, but this column is concerned solely with its musical capabilities. Re-recording demands accurate tuning of VCOs and, even if an oven is incorporated in the circuitry, it is usually necessary to resort to tuning-checks from time to time. A piano, or other frequency reference, may not be always available: even if it is, there is a tendency to wear a track in the carpet!

It seems to me to be a good plan to incorporate a switched oscillator in the synthesiser, tuned to 440Hz for preference, to save both patience and shoe leather. On the natural assumption that the recording apparatus runs at a constant speed, the tuning of each track laid down can be closely controlled.

This arrangement will be found invaluable where the whole keyboard can be octave-shifted for recording the extreme ends of the frequency range. A 741 op. amp. can be made to produce a good sine wave, or a Hartley oscillator could be designed round a miniature driver transformer (such as Eagle type LT44).

BOOKNOTE

Some organ-builders prefer frills to good organ tones. Two highly experienced designers who believe that musical specification comes first are my colleagues Alan Douglas and Sid Astley.

The latest edition of "Transistor Electronic Organs for the Amateur", should prove invaluable to any reader contemplating, or engaged in, building his own instrument.

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. Any idea published will be awarded payment according to its merits. Why not submit YOUR IDEA?

Please Note

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not inserted in the text.

in the off position. This is performed by TR5. Its presence is essential as it would be impractical to modify the existing direction switch to a 2-pole 3-way type which would normally be used in such a case.

When S1 is moved either way from the off position, C3 is charged via D1 and TR5 is held on via R7. This activates the astable. The time constant C3/R7 is made to be large enough to allow TR5 to be held on whilst TR4 is on. TR4 is prevented from discharging C3 by the action of D1.

As soon as S1 is moved to the off position the bulbs stop flashing and after a short while C3's charge is insufficient to hold TR5 in a conducting state resulting in the bistable being switched off.

Chow Yow Soon,
Malaysia.

ELECTRONIC FLASHER

THE circuit shown in Fig. 1 is an electronic alternative to the conventional electro-mechanical flasher found in most vehicles. Some advantages of the electronic unit are an improvement in efficiency, adjustable flashing rate, and less dependence of the flashing rate on battery voltage.

TR1 and TR2 form an astable whose oscillation rate is just over 1Hz. (This can be adjusted by altering R2 and R3.) TR3 and TR4 act as a switch which is either on or off depending on the state of TR2.

A second switch is used to turn off the supply to the flasher unit when the direction indicator S1 is

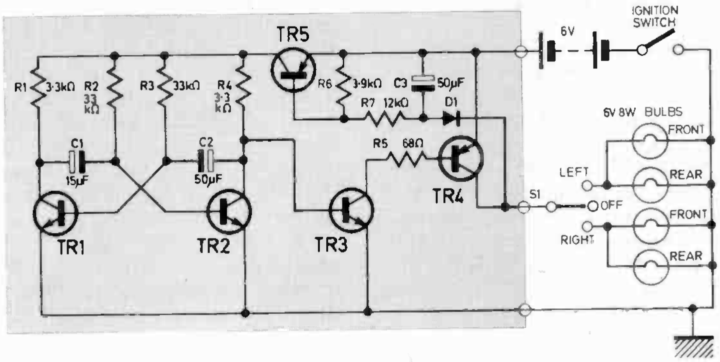


Fig. 1

ALTERNATIVE PATCH BOARD

THIS idea provides a cheap and workable alternative to a usually rather expensive piece of hardware—the patch board.

To make the patch board, pairs of Veropins are inserted into adjacent holes in a rectangular array of about 0·5in separation, on a piece of 0·1in matrix board. The pins are then wired up as in Fig. 1. Patching is then effected by clipping together the appropriate pair of pins in the array with a miniature insulated single crocodile clip. This gives a quickly changeable patching arrangement and at a fraction of the cost of commercial patch boards.

E. Swialski,
Leeds.

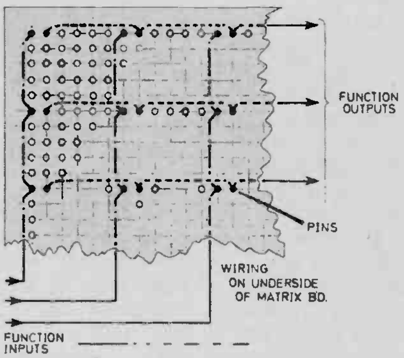


Fig. 1

TRANSISTOR TESTER

HERE is a design of a simple transistor tester which might be useful for many of your readers.

With this tester you can check transistors and see if they are in working order and measure h_{FE}.

By varying VR1 you change the current to the base from 0 to approximately 90µA. Resistor R2 limits the current to the collector to about 12mA.

If you divide the reading on ME2 by the reading on ME1 you can determine the h_{FE}.

If using a multimeter as ME2 you can also measure the leakage current if you switch it to a more sensitive range.

By switching S1 you can measure both *pnp* and *npn* transistors.

Dan Warkander,
Helsingborg,
Sweden.

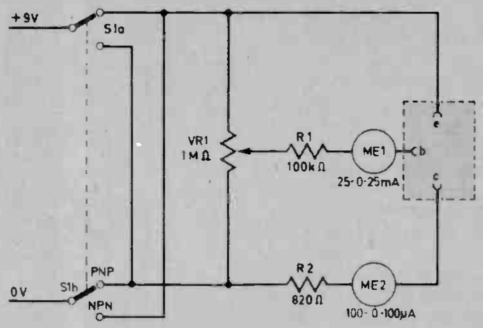


Fig. 1

CAR BATTERY CONDITION INDICATOR

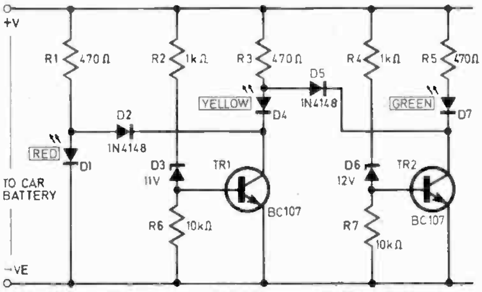


Fig. 1

THE voltage of a car battery under running conditions can tell the driver a lot about the condition of the dynamo, voltage regulator, and the battery itself. Meters to indicate battery condition are expensive but the circuit to be described performs the same function at a fraction of the cost. Typically, these meters are calibrated in sections marked "poor", "fair" and "good", and this unit utilises different coloured l.e.d.s to give the same information. This is enough to indicate a major fault, a less serious malfunction that requires checking or that the battery and electrical system are in good condition. A red l.e.d. lit denotes a battery voltage of less than 11·6V approximately, a yellow l.e.d. indicates 11·6 to 12·6V, and a green l.e.d. shows 12·6V or more.

Referring to Fig. 1, if the battery voltage is below about 11·6V, both transistors are turned off, and only the red l.e.d. is lit. If the voltage is between 11·6 and 12·6V, D3 conducts via R2, transistor T1 turns on, the yellow D4 l.e.d. is lit and diodes D2 shunts D1, turning it off. Similarly for voltages above 12·6V, D6 conducts via R4, turning on TR2 which lights the green l.e.d. Diode D5 shunts TR1 and D4 turning off D4 and thus D1.

Construction is not critical, Veroboard or printed circuit techniques can be used remembering to mount the l.e.d.s at suitable spacings first, then group the other components around them.

The only testing needed is to connect the unit to a variable power supply, or to a potentiometer across a fixed supply. As the voltage is increased from zero first the red l.e.d. will turn on then at about 11·6V the red l.e.d. extinguishes and the yellow comes on, whilst at 12·6V the yellow will go out and the green comes on.

The voltages at which the different l.e.d.s switch in and out can be easily varied for different applications by changing the values of D3 and D6. These can be "trimmed" to 0·6V limits by using an ordinary silicon diode in series with the Zener, but reversed in polarity with respect to the Zener, which will add about 0·6V to the Zener voltage.

The l.e.d.s can be increased in brightness by reducing the 470 ohm resistors to 390 or 330 ohms depending on the current capability of the l.e.d. used, not forgetting the ratings of TR1 and TR2.

The completed unit at the high voltage range consumes about 80mA, which is negligible from a car battery, but will prevent its use in battery portable equipment. The circuit has many other uses, however, where the current consumption is not critical, as a maximum detector for tuning applications, e.g. with multiple transistor stages incorporating smaller ranges at the maximum end. Also at a switch over point it is possible to have two l.e.d.s half lit, which makes it a useful voltage indicator where the expense of a meter is not justified or extreme accuracy unnecessary.

The completed board can be built into a small plastic box for mounting on the car dashboard in a suitable position (some sort of cowling may prove necessary if daylight is too strong), or with care it should be possible to insert the l.e.d.s from behind the dashboard into a composite instrument panel incorporating a cowling. The only wiring necessary is positive and negative lines, one to a switched terminal on the ignition, and the other to chassis, appropriate polarities being observed.

If the red light remains permanently on, the battery voltage regulator or dynamo or any combination of these is faulty. The yellow l.e.d. warns of a fairly low battery voltage, which warrants investigation if it has not changed to green after a few miles driving. The green light indicates that the electrical system is functioning satisfactorily.

M. J. Larner.

ELECTRONIC DICE

THE circuit uses 74 TTL logic and component values are in no way critical. It consists of a counter with a cycle length of six driving an l.e.d. display via a decoder. This is arranged so as to illuminate the l.e.d.s as they would appear on the face of a dice displaying that number.

When S1 is depressed the bistable switches over (this is included to eliminate problems caused by contact bounce) and the output of IC1a goes high, driving the JK inputs of IC3a high, allowing the clock pulses from the multivibrator to toggle through and start the counter counting. Depressing S1 also removes the bias of TR1 cutting it off and this blanks the l.e.d. display.

When S1 is released the JK inputs of IC3a go low, holding the Q output fixed, thus stopping the counter. TR1 is also switched on, allowing the l.e.d. display to come on displaying whatever is in the counter.

M. M. Malek,
Sutton, Surrey.

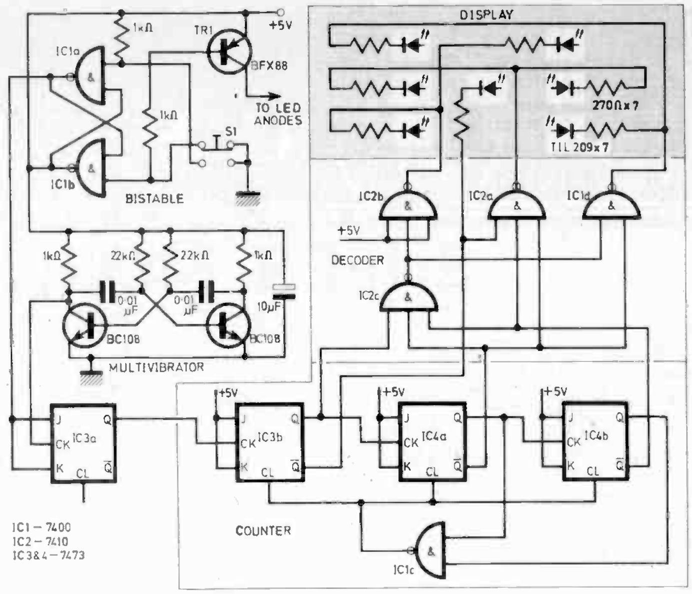


Fig. 1

FREQUENCY CHANGER FOR SYNTHESISERS

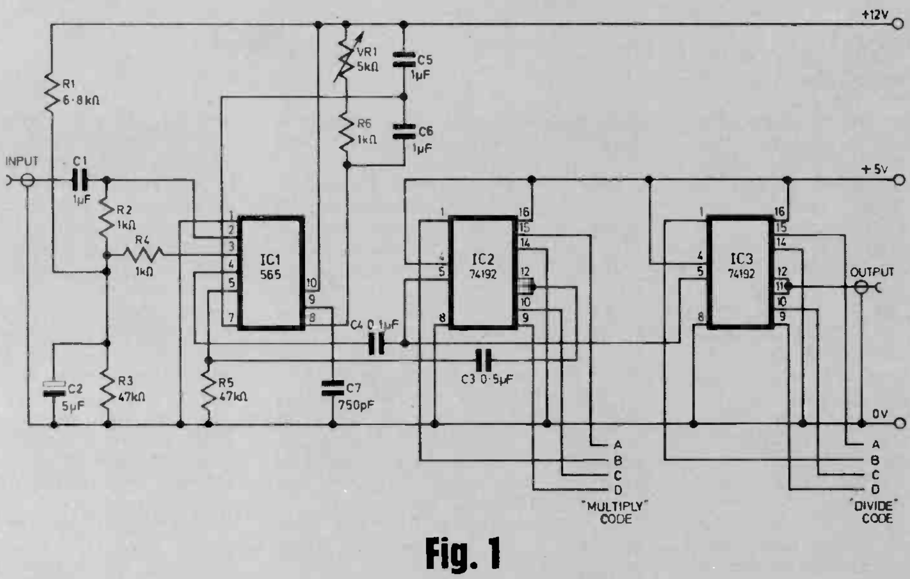


Fig. 1

THE circuit shown in Fig. 1 is a frequency changer which can be used with instruments such as synthesisers. A 565 phase-locked loop is used with a 74192 digital up-down counter which sets the multiplying value. A second 74192 then divides it to give the final output.

The multiplication and division are set by digital codes on the respective multiply or divide inputs to the unit. These inputs are set to 10N where N is the desired frequency multiplication/division. A b.c.d. thumbwheel switch could be used here for fixed codes or a memory arrangement for controlled sequences.

B. Hatton,
Waltham Cross

RELAY OPERATION BY SHORT PULSE

FIG. 1 shows a relay RLA connected to a 12 volt power supply. When the switch S1 is momentarily closed the relay operates and locks through contact RLA1. The relay operating voltage was 8 volts and the time S1 had to be held closed for the relay to lock was 68ms. This length of time was far too long for the required application and therefore the circuit in Fig. 2 was developed to allow the relay to be triggered by a shorter pulse.

TR1 is connected as an emitter follower. In this circuit when S1 operates C1 charges through R1 and the time constant is C1R1, in this case making about 1ms. Thus the holding voltage of the relay is reached within about 2ms. Once charged the capacitor will discharge at a rate determined by the h_{FE} of the transistor TR1. The impedance C1 "sees" looking into the base of TR1 is h_{FE} × relay resistance, i.e. in this case, assuming an h_{FE} for the transistor of 28, 28kΩ. The discharge time constant will therefore be C1 × 28,000. Inclusion of the transistor has thus not only reduced the operating time of the arrangement but also the effective hold time.

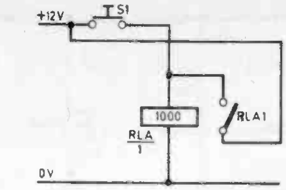


Fig. 1

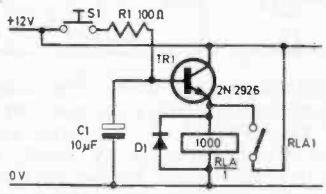


Fig. 2

R. Parfitt,
Croydon

ECONOMY DECODER FOR BCD TO 7-SEGMENT DISPLAY

FOR experimental purposes, two 7400 i.c.s can be used to decode from BCD to 7-segment display format. Whilst decoders are available in single packages they are considerably more expensive than the displays which they drive. The 7400 is the cheapest i.c. in the range and the one most commonly found on ex-computer panels.

The circuit in Fig. 1 was developed for the DL704 or MAN4 common cathode type of l.e.d. display. Pull up resistors are connected in the usual way between each segment anode and the positive rail. Current through these resistors is taken via diodes and sunk by gates which are at logic 0 thus extinguishing appropriate segments. A gate is at logic 0 when any one of the decimal numbers shown against the gate is being decoded.

The maximum sink capability of a 7400 gate output is 16mA. To allow for the heavier loading conditions at Gates 3 and 7 each segment drive is limited to 5mA by using a minimum resistor value of 820 ohms. Segment drive could be increased to 10mA by connecting the inputs and outputs of a further gate in parallel with Gate 3 and another across Gate 7. All pull up resistors could then be lowered to 390 ohms.

The diodes used without problem in the prototype were unmarked miniature silicon from a cheap pack of untested diodes but germanium diodes are preferable.

Unlike standard decoders this circuit does not decode non-decimal states and the numbers 6 and 9 are slightly more stylised with an additional top and bottom bar respectively. A further package is required when the complementary BCD outputs are not available. This problem does not arise if decade counters are built from flip-flops which are again readily available on ex-computer panels.

R. J. Shute.
Bracknell.

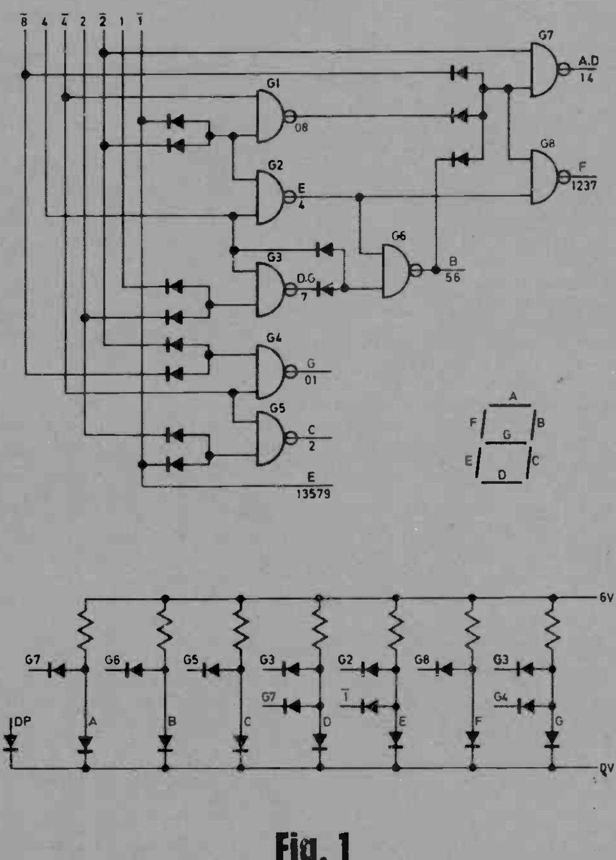


Fig. 1

ALTERNATIVE TUNING INDICATOR FOR VARICAP TUNER

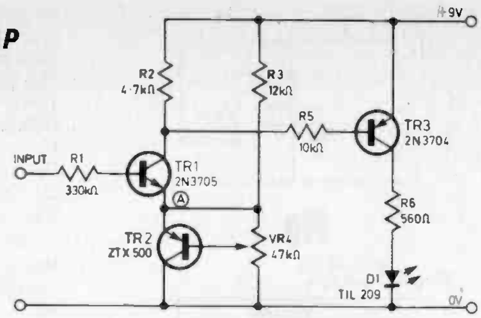


Fig. 1

IT was decided to build a tuning indicator to Mr Beeching's design (P.E. Ingenuity Unlimited, Oct. 1974) but unfortunately it proved impossible to obtain the MC1335P—Motorola having ceased production of the device early in 1973.

An alternative discrete design was therefore embarked on, the initial requirements remaining the same: (a) minimum loading on the output of the LP1185; (b) the extra current drawn from the 9V supply to be relatively small; (c) the indicator not to function on inter-station noise.

The circuit shown in Fig. 1 was eventually evolved and found to satisfy all these requirements. Without a d.c. voltage applied to the input, TR1 and TR3 are non-conducting and consequently the l.e.d. does not light. The current from the 9V rail is about 4·5mA and flows through R3, R4 and TR2 in parallel. The potentiometer VR4 and TR2 form a V_{be} multiplier allowing a low impedance variable voltage to be set at point A to meet requirement (c).

When a voltage is applied to the input in excess of that at point A plus 0·65V, TR1 conducts causing TR3 also to conduct and the l.e.d. to turn on. The loading of the output of the LP1185 is minimised by the low base current of TR1 (1·2μA) and requirement (a) is met admirably.

B. W. H. Jesse.
Orpington.

CAR THEFT ALARM

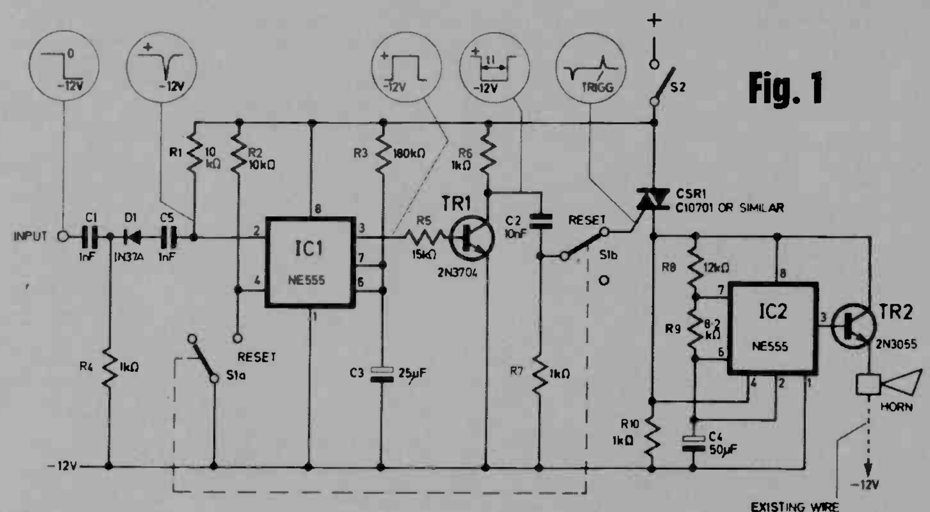


Fig. 1

THE alarm circuit shown in Fig. 1 produces an audible warning (pulsating bleeps on the car's horn) if an intruder opens one of the car doors.

The alarm uses the courtesy light switch to detect the opening of a door and this is used to trigger a delay circuit which, if the alarm is not reset, causes the horn bleeping routine to begin.

The negative going transient appearing across the bulb is differentiated and used to trigger a 555 timer in the monostable mode. The output of the 555 is inverted and differentiated once again to provide a firing pulse for the thyristor CSR1. When on this powers a further 555 operating in the astable mode, and the output of this stage is used to pulse the horn via a 2N3055.

When the circuit is initially switched on it must be reset immediately as the timer will have commenced an initial timing cycle.

An alternative, slightly simpler version may be constructed leaving out the delay timer and taking the input directly to TR1. The delay is a useful asset, however, as it allows sufficient time for one to reach the reset switch before the horn sounds.

The circuit can be used on negative cars also, but the modifications shown in Fig. 2 must first be performed. TR3 is used to invert the voltage step to the input and the horn is connected in the collector circuit of TR2.

O. Jensen,
Oslo.

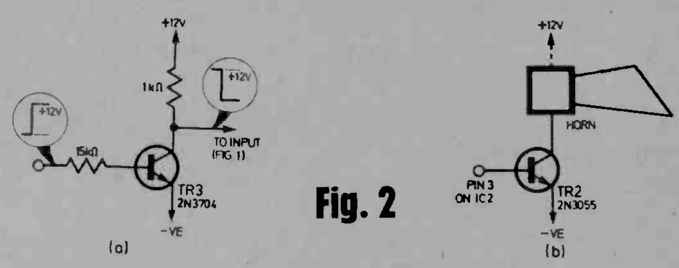


Fig. 2

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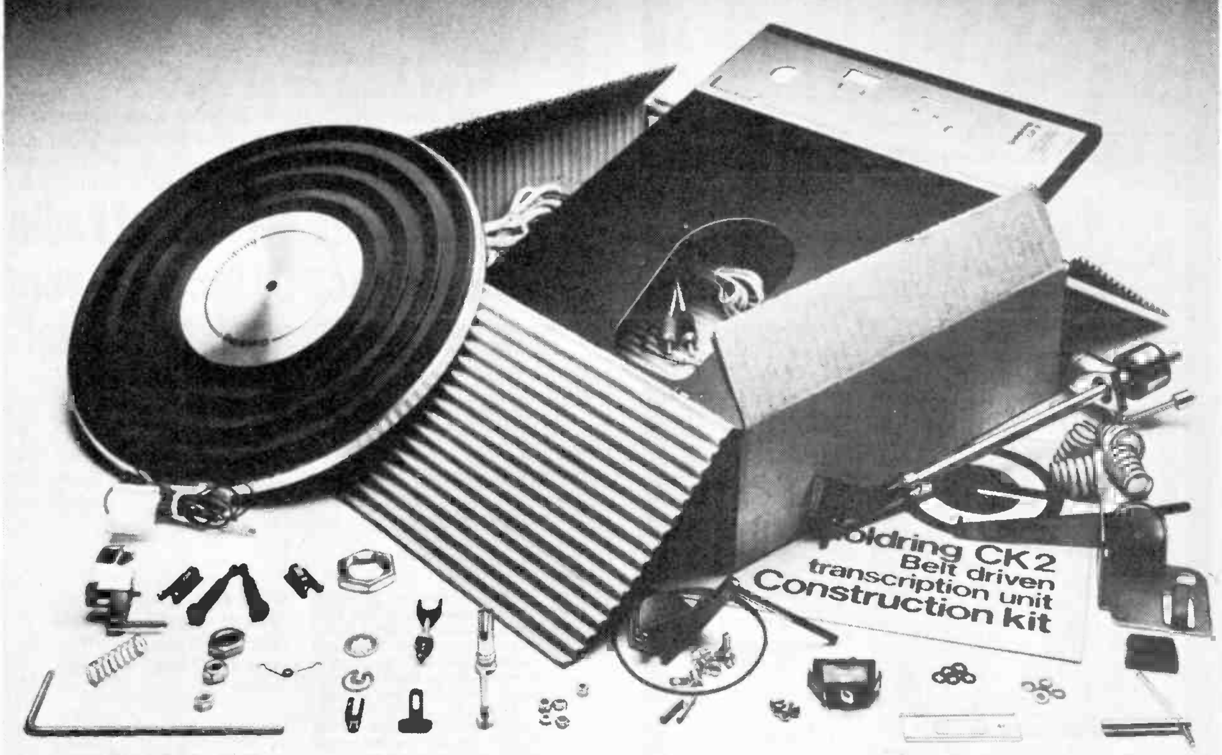

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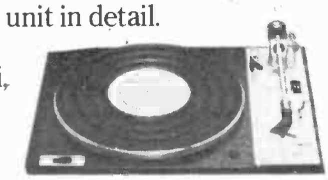

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207	500, 500	0-8-9, 0-8-9	2·02	51
208	1A, 1A	0-8-9, 0-8-9	3·07	58
236	200, 200	0-15, 0-15	1·56	25
214	300, 300	0-20, 0-20	2·03	58
221	700 (d.c.)	20-12-0-12-20	2·38	58
208	1A, 1A	0-15-20-0-15-20	3·63	72
203	500, 500	0-15-27-0-15-27	3·15	72
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108	8	4	5·09	85
72	10	5	5·50	85
116	12	6	5·80	97
17	16	8	7·48	97
115	20	10	10·91	1·61
187	30	15	14·20	1·41
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104	2·0	4·95	85
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67	500	0-115-200-220-240	9·36	1·25
84	1000	0-115-200-220-240	14·36	1·61
93	1500	0-115-200-220-240	19·02	BRS
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SOUND TO LIGHT MODULATOR

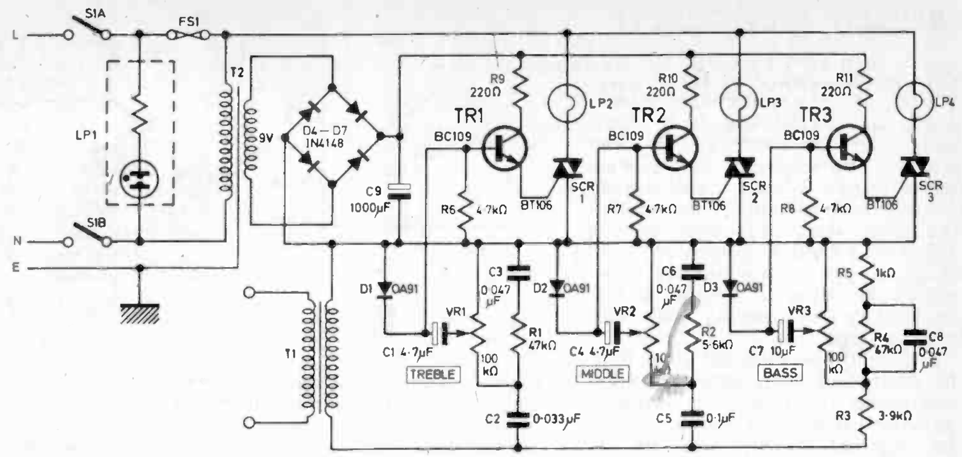


Fig. 1

This circuit (Fig. 1) uses cheap, easily obtainable components to make a simple but effective sound-to-light unit.

The input signals for the unit are derived from a 1 : 1 transformer which is wired in series with the speaker. The signal is then filtered into three channels (treble, middle and bass). The level of each channel can be adjusted by the three potentiometers VR1 to 3. A thyristor is then fired by a transistor (operating as a switch) and this in turn illuminates the display light.

It is important that the negative supply rail of the unit is connected to neutral of the mains. With the specified thyristors, 300W loads can easily be driven. A suitable transformer for T1 is an EL84 output transformer. T2 can be any 6–9V 500mA mains transformer.

By-pass switches can be fitted if desired to allow all displays to be on irrespective of sound level.

K. Coldwell, Sheffield.

SIMPLE 7-SEGMENT TO BCD ENCODER

This circuit was devised to convert the seven-segment outputs of the now widely-available l.s.i. calculator chips into a form of binary-coded decimal, for use in home-constructed calculators where BCD outputs may be required to feed into an external RAM i.c.

The basic circuit (Fig. 1) consists of a quad EXCLUSIVE OR two-input gate, type CD4030. Although more expensive than its TTL counterpart, the SN7486, this CMOS i.c. is far more versatile when one considers interfacing with other logic families.

Table 1 shows the outputs given by this circuit and, while the outputs are not pure BCD, they should be useful in most applications, and this should not prove to be a disadvantage.

For feeding these numbers from the external RAM back into the calculator input a BCD-to-decimal decoder can be used (except for the negative sign, but this cannot normally be entered directly on the keyboard, anyway).

It must then be remembered that the BCD-to-decimal decoder output would represent different decimal numbers.

If the input marked x is connected to −V instead of +V then the circuit will still produce the output shown in Table 1 if the seven-segment inputs are inverted illustrating the versatility of this circuit.

Andrew Cornish,
Teignmouth,
Devon.

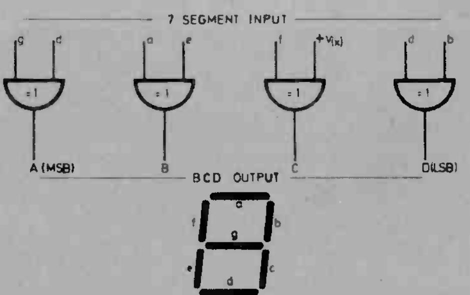


Fig. 1

Table 1.

Number	Segments on	Output A B C D
0	a b c d e f	1 0 0 0
1	b c	0 0 1 1
2	a b d e g	0 0 1 0
3	a b c d g	0 1 1 0
4	b c f g	1 0 0 1
5	a c d f g	0 1 0 1
6	a c d e f g	0 0 0 1
7	a b c	0 1 1 1
8	a b c d e f g	0 0 0 0
9	a b c d f g	0 1 0 0
Negative sign	g	1 0 1 0

AUXILIARY POWER SUPPLY

The system described below was used as an additional power source for a portable radio normally running from a PP9 9V battery. The external supply was tapped from a 9½V d.c. transformed, rectified, and smoothed a.c. supply. The latter may, of course, be installed as a battery eliminator. This design is better than merely connecting the external supply across the battery for reasons that will be given later.

The circuit is designed such that the external system generally supplies power (provided it is stronger than the battery) but should it fail, the internal battery will supply power. A socket is used to provide easy connection to the auxiliary supply. A brand new battery when first used may supply a fraction of the power, but as it ages the voltage drop across the diodes will eventually isolate the battery.

S1 is an optional switch which may be used to switch off the external supply thus switching on the battery. The diodes should be silicon and chosen so that they are capable of taking the maximum current drawn by the radio. D1 will prevent the battery from being "charged" by the external supply. D2 prevents the radio from being subjected to a reversed polarity. D3 will stop the battery from discharging if a short circuit occurs outside the radio with S1 closed.

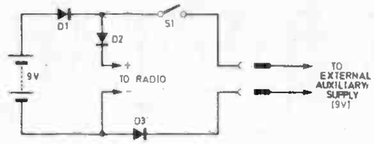


Fig. 1

When constructing the circuit cut the battery supply wires. In the positive line insert two diodes D1 and D2 in series and connect the external positive to the junction of D1 and D2. Join the two ends of the negative battery wire and connect D3 to this junction.

It is important to note that a brand new battery may have sufficient power to overcome the forward drop across D2 and will isolate the external supply. The actual p.d. of the external supply in the prototype was 9·35V which was enough to "overpower" the battery. D1 merely serves to prevent the radio being subjected to incorrect polarities. D3 is present to stop the battery being discharged should the external supply or associated components cause a short circuit to occur.

An additional component may be added namely a BZY88C10 Zener diode. This will conduct at approx. 9·4V and prevent spurious peaks from the external supply causing damage to the radio. It should be included across the external supply.

S. Bygrave,
Norwich,
Norfolk.

THYRISTOR WINDSCREEN WIPER DELAY

This wiper delay is suitable for cars with self-parking wipers. The delay can be continuously adjusted from 0 to 30 seconds (or more). I have used his device without trouble for a year in my Austin Mini.

The unit receives its power through the wiper motor. Capacitor C1 charges through VR1 and R1 until the stand-off voltage of the unijunction transistor TR1 is reached. Then C1 discharges through TR1 and R2 switching the thrysistor CSR1 on. During the wipe the contact in the wiper closes and the current through the thyristor falls allowing it to switch off. At the end of the wipe the contact in the wiper opens and the unit receives power again, through the motor, and the delay commences. With VR1 at minimum the delay is 0·01 seconds, i.e. effectively zero.

R3 is included to ensure the current through the thyristor falls enough for it to switch off when the wiper contact closes. It may be necessary to increase the value of R3 and clean the wiper contact.

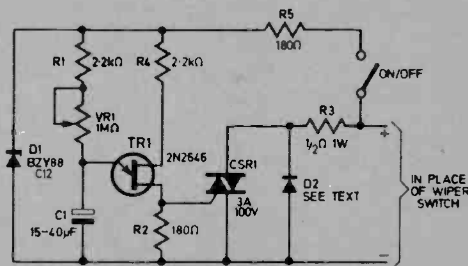


Fig. 1

When the wiper opens at the end of a wipe the back e.m.f. of the motor can break down the thyristor and switch it on again without waiting for the delay. Diode D2 has a Zener breakdown less than that of the thyristor and so prevents this happening. (The diode used was a germanium diode from a computer panel. A 1N4001 would be suitable.)

Different values of C1 may be required to give the desired range of delays because of the differing stand-off ratios of unijunctions.

Polarity must, of course, be observed, when connecting this unit to the car.

M. P. Roberts,
Oxted, Surrey.

PATENTS REVIEW...

CAR SOUND BP 1 404 316

Lecturing recently to the Institution of Chemical Engineers, Dr Robert Aries, a prolific patent and trademark filer based in France, suggested that large firms frequently filed too many patent applications. He argued that research departments frequently felt obliged to file a reasonable number of patents per year, and so justify and maintain their annual budget.

Certainly this would explain the remarkable number of patents for trivial advances which continue to be filed, despite ever increasing official fees.

Although BP 1 404 316 from the Lucas Electrical Company Limited, appears to fall into this category, it is based on an interesting idea. In a car, it is conventional to mount the radio or tape deck speakers at the left and right of the dashboard or at the left and right of the rear window.

Lucas suggest that the ideal location is with one speaker under each of the front seats. The loudspeakers point in the direction of the longitudinal axis of the car, and it is claimed that this improves bass response by achieving a longer than usual unrestricted air path for the reproduced sound.

Ideally, each loudspeaker is open at its front and back except for a protective grille.

COMMUNICATION FOR THE DEAF BP 1 400 042

In BP 1 400 042, Bruno Fracassi, of Rome, Italy, describes a fairly simple method of using the telephone to provide a morse code readout suitable for the deaf. Because the telephone is coupled only acoustically to the device described, there should be no Post Office objections to its use.

A cradle is provided, into which a telephone handset can be rested for transduction in the manner conventional for a temporary computer terminal. A morse key makes and breaks an oscillator circuit which drives a small loudspeaker coupled acoustically to the handset microphone. Paper tape from a roll is guided by a motor between an electromagnet and the writing point of an ink-reservoir pen.

Incoming sounds reproduced by the headset are received by the microphone and amplified to energise the electromagnet to move the paper tape temporarily towards the pen point. Received morse code signals therefore cause the pen to inscribe dots and dashes on the paper tape.

Morse code signals produced by the morse key will produce similarly inscribed signals on the paper tape of a matching device at the other end of the telephone line connection.

HEAT/ENERGY BP 1 404 689

In BP 1 404 689, Francis, Fergan and Christopher O'Sullivan, of Sydney, Australia, patent and apparently simple system for converting heat into electrical energy.

The fact that the Australian inventors have thought it worth while to file an application here, on the other side of the earth, and the fact also that the British Patent Office Examiners have accepted the case, suggests that although the idea is simple it may be new. Electronics enthusiasts should have no difficulty in establishing for themselves whether it works.

A liquid container made from electrically conductive material, such as aluminium, and containing an aqueous ionic solution, a 3 per cent solution of sodium chloride (salt) is instanced but it is suggested that the quantity and strength of the solution are not important.

An electrode is immersed in the liquid and another electrode is connected to the exterior of the container. The electrodes can be of any conductive material provided that it is different from the material of the container. The electrodes may, for instance, be of copper.

The claim is that if heat is applied to the container, for instance by focusing the sun's rays onto it or heating it with a natural gas flame, bubbles will appear in the liquid to produce four-phase interfaces, i.e. one electrode/bubbles (solid/gas); the container/bubbles (solid/gas); liquid/bubbles (liquid/gas); and liquid/other electrode (liquid/solid).

According to the inventors, electrical energy is available, as a result of the chemical reactions across the two electrodes.

IN BRIEF

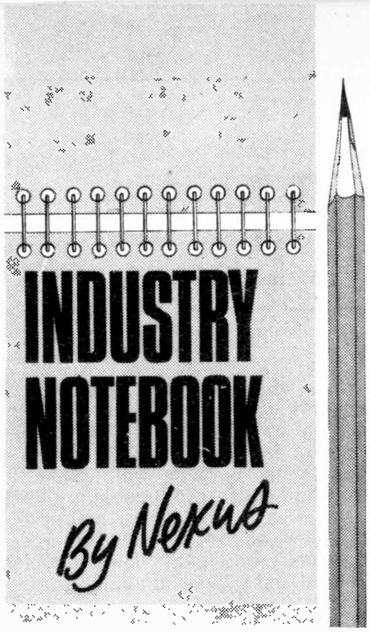
BP 1 410 380 — Elektroakusztikai Gyar: *Tone control circuit.* An amplifier having an inverting and a non-inverting input, with feedback loops provided.

BP 1 414 260—Elektromechanikai Vallalat: *Quadraphonic transmission.* The radio transmission of more than two channels of sound by multiplex techniques. This is one of numerous patents for surround sound radio, but is particularly interesting in that (like BP 1 410 380 mentioned above) it originates from Hungary, suggesting increasing interest in audio engineering from that country.

BP 1 411 994—Cooper D. H.: *Signal matrixing for directional reproduction of sound.* These two patents from Duane Cooper, of the USA, describe the BMX matrix system used in the base band of the Nippon Columbia UD-4 surround sound system. The closely related Ambisonics system developed by a British team including Professor Fellgett, Michael Gerzon and backed by the NRDC was also recently the subject of a British patent, **No. 1 369 813.**

Both systems have in common the basic concept of matrixing different signals together according to coefficients which vary in dependence upon the original sound source direction. Even more recently a very similar system was patented by the BBC in **BP 1 414 166.**

Copies of Patents can be obtained from the Patent Office Sales, St. Mary Cray, Orpington, Kent Price 75p each



MEMORIES

Anno Domini 1975 was rough and tough and perhaps best forgotten as the world now edges upwards out of recession. But figures keep trickling through suggesting that 1975, although by no means one of the great years, still had a lot going for it for those who knew what they were doing and had something first-class to sell.

SPACE AND AVIONICS

Aerospace deserves yet another mention if only because this particular industry is the cradle of technology. British exports were £800 million, the highest level ever and in this grand total airborne navigation aids achieved a gain of over 20 per cent over 1974, flight simulators up by nearly 250 per cent and instruments up by some 75 per cent. BAC's Rapier missile system topped the £400 million mark on the order book and, apart from substantial deliveries due this year, there should be some more orders in the pipeline.

On the stocks for this year are the Ferranti Blue Fox airborne radar for the naval version of the Harrier V/STOL aircraft. Blue Fox is a further development of the Ferranti Seaspray designed for the Lynx helicopter. A very large contract has been placed with Hawker Siddeley for the XJ521 air-to-air missile following successful firings late last year.

Based on the US Sparrow missile it has all-British electronic guidance by Marconi Space and Defence Systems and a new fuse by EMI Electronics. The British update version is said to be so effective operationally that the missile is virtually a new generation system which should see service through to the 1990s.

Then there is the continuing success of Marconi-Elliott's head-up display systems. A new version has a TV raster display superimposed on the ordinary flight information, coupled to low-light TV cameras or infra-red scanners enabling a pilot to see the landscape while flying at night.

Eight systems have been sold to the US Navy for evaluation and two are now being test flown in A-7E Corsairs of the US Navy. Other systems are on evaluation for the Royal Air Force at the Royal Aircraft Establishment.

The Raster HUD will keep Britain ahead. Marconi-Elliott has already built more HUD's than the rest of the world added together and most have gone for export.

Best news of all for British avionics is that the multi-role combat aircraft (MRCA) is still going ahead despite pressure from some quarters to cancel or cut the existing contracts.

CIVIL FRONT

On the civil front I will confine myself to three companies. STC took orders for £84 million for submarine cables and repeaters in 1975, all of which are for export. EMI continues the enormous success with medical brain and body scanners and although US General Electric has announced a competitive product EMI remains unconcerned.

Marconi Communications Systems working with the Post Office put North Sea Oil on the radio map with a quadruple diversity troposcatter system of unparalleled reliability in a little over a year. Further extensions will be added this year.

ENTERPRISE

It seems only yesterday that we were looking ahead to the big leap forward to the solid state 4k random access memory. Such is the rapid progress of solid state technology that samples of 16k devices are now available from several manufacturers.

Companies like TI, Intel, Mostek, Motorola and Fairchild are all in the race to supply the world with the best devices and, as volume grows, at the keenest prices. We may expect the subsequent economic war to be at its fiercest with frantic price-cutting in the now well-established tradition of the semiconductor industry.

I often think to myself what would have happened if world socialism and the doctrine of the nationalised industry had been implemented a quarter of a century ago. Would a monolithic Global Solid State Corporation with monopoly powers and overloaded with bureaucracy have achieved so much in a single generation, both in basic research and in virtuosity of production?

SHEER COMPETITION

When I glance through the advertisement columns of this journal and see dozens of types of i.c.s available at less than half the price of a packet of cigarettes and in many cases less than the cost of postage and packing to the customer, I just cannot believe that any system other than competitive private enterprise with the real-life pressure of the market place could have done so well.

Companies who couldn't stand the heat in the early days retired hurt, financially speaking. Sheer competition sorted out the men from the boys and although painful to the losers, this was to the general good. The struggle for survival has not only forced prices down but has kept technology on the move at a cracking pace, far faster than would be possible in any "planned" enterprise.

My guess is that Global Solid State, after 25 years of major effort and a few billion pounds of money milked from taxes paid by World Citizens, might today be just getting round to a simple family of TTL devices to be marketed at around £5 per one-off, just about the price of a complete pocket calculator in free-market conditions. Let us be duly thankful that Global Solid State exists purely in the imagination.

COST OF PERFECTION

Electronic timepieces are going up in accuracy and down in price. Sinclair, for example, guarantees an accuracy of one second per day for £24·95 but suggests in his advertising that even better accuracies may be expected. But if you need greater guaranteed accuracies you need to pay the price, just like buying diamonds where each succeeding level of perfection demands a ten-fold increase.

Kelvin Hughes latest electronic ship chronometer is claimed to have an accuracy of better than 0·1 seconds per day. But the recommended price is £290, available for the traditionalist shipowner in mahogany case and for the avant-garde in either rosewood or aluminium.

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7406	30p	7476	26p	74141	63p
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AC152	0·25	BF115	0·20	2N2221A	0·18
AC153	0·27	BF200	0·25	2N2222	0·17½
AC176	0·14	BF194	0·09	2N2646	0·30
AC187K	0·27	BF195	0·09	2N2904	0·18
AC188K	0·27	BF198	0·12	2N2905	0·18
AD161	0·35	BF199	0·12	2N2906	0·18
AD162	0·35	BF257	0·24	2N2907	0·18
BA102	0·10	BF258	0·24	2N2926G	0·09
BAX13	0·03	BF259	0·24	2N3053	0·20
BAX16	0·04	BFX29	0·22	2N3054	0·40
BC107	0·09	BFX30	0·22	2N3055	0·45
BC108	0·09	BFX84	0·20	2N3393	0·12
BC109	0·09	BFX85	0·27	2N3441	0·56
BC147	0·09	BFY50	0·19	2N3442	0·96
BC148	0·09	BFY51	0·19	2N3638	0·10
BC149	0·09	BFY52	0·19	2N3638A	0·10
BC167	0·10	BY126	0·11	2N3702	0·10
BC168	0·10	BY127	0·11	2N3704	0·10
BC169	0·10	OA47	0·06	2N3706	0·10
BC182	0·09	OA90	0·04	2N3708	0·10
BC183	0·09	OA91	0·04	2N3771	1·25
BC184	0·09	OA200	0·05	2N3772	1·35
BC212	0·09½	OA202	0·06	2N3773	2·00
BC213	0·09½	IN914	0·04	2N3904	0·11
BC214	0·9½	IN4004	0·05	2N3906	0·12
BC237	0·08	IN4007	0·06	2N5294	0·35
BC238	0·08	IN4148	0·03	2N5296	0·35
BC239	0·08	IS920	0·05	2N3794	0·20
BC307	0·09	2N697	0·15	2N3819	0·30
BC308	0·09	2N698	0·14	2N4036	0·55
BC309	0·09	2N706	0·10	2N4037	0·40
BC327	0·12	2N708	0·10	2N4921	0·80
BC328	0·12	2N916	0·23	2N5060	0·25
BCY70	0·13	2N1305	0·25	2N4289	0·25
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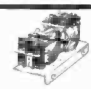

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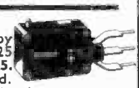

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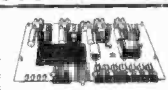

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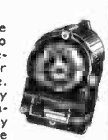

'Horstmann' Type V Mk. II Time switch. 200/250 volt A.C. Two on/two off every 24 hours, at any manually pre-set time. 30 amp contacts. 36 hour spring reserve in case of power failure. Day omitting device. Fitted in heavy high impact case, with glass observation window. Built to highest Electricity Board Spec. individually tested. Price **£7·75.** Post 50p. (Total inc. VAT **£8·91**)

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MULTI RANGE METER. A.C. volts 2·5-500, D.C. volts 2·5–500 (Sensitivity 2000Ω/V d.c. and a.c.). D.c. current 0/1/10/100 mA, Ohms range. Sturdy compact moving coil instrument with 21 ranges. Dimensions 120 × 80 × 44mm. Weight 0·32kg.
SERVICE TRADING CO. Price **£5·00.** Post 50p. (Total price inc. VAT and post **£5·94**). Incl. leads and battery.

VAT

VAT AT 8%, MUST BE ADDED TO ALL ORDERS FOR THE TOTAL VALUE OF GOODS INCLUDING POSTAGE UNLESS OTHERWISE STATED

SERVICE TRADING CO.

ROTARY VACUUM AIR PUMP AND COMPRESSOR

Carbon vane, oilless, 100/115V a.c., 1/12h.p. motor, 50/60 cycle, 2875/3450 r.p.m., 20 in vacuum, comp. 1·25 c.f.m., 10 p.s.i. (approx. figures). New unused surplus stock. Supplied with electrical connection data. FRACTION OF MAKERS' PRICE **£12.** Post £1·00. Suitable 110/240V, 150 watt auto transformer **£3·50.** Post 50p. (Both items together Post £1·25).

GEARED MOTORS

36 R.P.M.
230/240V a.c. 60lb. in. torque. Continuously rated. Size: L 235mm, W 120mm, H 125mm. Spindle dia. 13mm × 60mm long. Fitted mounted feet, M.f.g. Croydon. Brand New. **£15.** Post **£1.**
60 R.P.M.
220/240V a.c. Small, powerful, continuously rated, reversible motor. M.f.g. Berger (Germany). Size 80mm × 65mm × 65mm. Spindle dia. 6mm × 15mm long. Weight 725g. **£5·50.** Post 50p.

BODINE TYPE N.C.I.

(Type J) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. 50Hz. **(Type 2) 28 r.p.m.** torque 20 lb. in. **Reversible** 1/80th h.p. 50Hz.
The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115V A.C. Supplied complete with transformer for **230/240V A.C. input.**
Price, either type **£6·25.** Post 75p or less transformer **£3·75.** Post 65p.

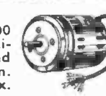
15 R.P.M.

Type SD48 80 lb. in. Input 100/200 volt A.C. Length incl. gearbox 270 mm. Height 135 mm. Width 150 mm. drive shaft 16 mm. Weight 8·5 Kilos. BRAND NEW. Price **£10.** Carr. **£1.**
Suitable transformer for use on 220/240 volt A.C. **£3·85.** Post 50p.

20 R.P.M.

230/240 volt a.c. miniature motor. Price **£1.** Post 20p.

REVERSIBLE MOTOR



General Electric, 230V a.c. 1,600 r.p.m. 0·25A. Complete with anti-vibration mounting bracket and capacitor. O/A size 110mm × 95mm. Spindle 3/16in. dia. 20mm long. Ex. equipment tested, **£3.** Post 50p.

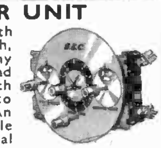
PROGRAMME TIMERS

230/240V a.c. 15 r.p.m. Motors. Each cam operates a c/o micro switch. Ideal for lighting effects, animated displays, etc. Ex equipment tested.
2 cam model. 15 r.p.m. **£2·00** post 35p.
8 cam model. 20 r.p.m. **£4·75** post 60p.

TRIAC

Raytheon Tag symmetrical Triac. Type TAG. 250/500V, 10 amp, 500 p.i.v. Glass passivated plastic triac. Swiss precision product for long term reliability **£1·00.** Post 10p. (Inclusive of Data and application sheet.) Suitable Diac **18p.**

A.C. MAINS TIMER UNIT



Based on an electric clock, with 25 amp. single pole switch, which can be preset for any period up to 12 hrs. ahead to switch on for any length of time, from 10 mins. to 6 hrs. then switch off. An additional 60 min. audible timer is also incorporated. Ideal for Tape Recorders, Lights, Electric Blankets, etc. Attractive satin copper finish. Size 135mm × 130mm × 60mm. Price **£2·25.** Post 40p. (Total incl. VAT and Post £2·87).

POWER RHEOSTATS !!!

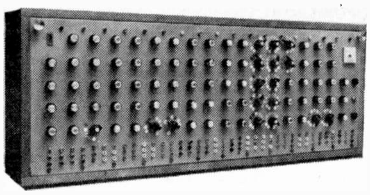
Superior Quality Precision Made
NEW POWER RHEOSTATS

New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.
25 WATT 10/25/50/100/150/250/500/1k/1·5k ohm. **£1·70.** Post 20p.
50 WATT 1/5/10/25/50/100/250/500/1k ohm. **£2·10.** Post 25p.
100 WATT 1/5/10/25/50/100/250/500/1k/1·5k/2·5k/3·5k/5k ohm **£3·30.** Post 35p.
Black Silver, Skirted knob calibrated in Nos. 1–9 1½in. dia. brass bush. Ideal for above **22p** each.

All Mail Orders—Callers—Ample Parking
Dept. PE4, 57 BRIDGMAN ROAD CHISWICK, LONDON W4 5BB
Phone 01-995 1560
Showroom open Mon.-Fri.

Personal callers only. Open Sat.
9 LITTLE NEWPORT STREET LONDON WC2H 7JJ
Phone 01-437 0576

SYNTHESISERS AND KEYBOARDS



P.E. SYNTHESISER

(P.E. Feb. 1973 to Feb. 1974)

The well acclaimed and highly versatile large-scale mains-operated Sound Synthesiser complete with keyboard circuits. All function circuits may be used independently, or interconnected. The greater the number of circuits, the greater the versatility. Other circuits in our lists may be used with the Synthesiser to good advantage.

THE MAIN SYNTHESISER

Stabilised Power Supply	£12·05
Two Linear Voltage Controlled Oscillators and one Inverter—all 3 circuits:	£16·38
PCB (2 are required)—each	£1·48
Two Ramp Generators and Two Input Amplifiers—all 4 circuits	£5·62
PCB (holds all 4 circuits)	£1·38
Sample-Hold and Noise Generator—	£6·64
PCB (holds both circuits)	£1·70
Tone Control, £2·43; PCB, 80p	
Reverberation Amplifier	£6·36
Sprine Line unit for Reverb Amp	£4·95
Ring Modulator	£3·75
Peak Level Meter Circuit	£1·50
100µA Panel Meter	£3·75
PCB for Rev., R-Mod. & Meter Ccts.,	£1·94
Envelope Shaper, £5·35; PCB, £1·46	
Voltage Controlled Amp. and Diff. Amp.	£6·86
PCB (holds both circuits)	£1·32

THE SYNTHESISER KEYBOARD CIRCUITS
Can be used without the Main Synthesiser to make an independent musical instrument)

2 Log. Voltage Controlled Oscillators	£14·55
PCB for both log VCO's	£2·60
Divider, 2 Hold Circuits, 2 Modulation Amplifiers, Mixer and 2 Envelope Shapers	£19·64
PCB (Holds the first 6 circuits)	£1·80
PCB for both Envelope Shapers	£1·55
Keyboard Stabilised Power Supply	£7·30
Printed Circuit Board	94p

P.E. JOANNA

(P.E. May to Aug. 1975)

The new electronic piano that has switchable alternative voicing of Piano Honky-Tonk and Harpsichord. All PCB's are "as published".

Power Supply	£7·96
Tone Generator and Top C Envelope Shaper	£9·25
PCB for above	£1·30
Envelope Shapers	
12 sets (full requirement)	£32·16
Set of 12 PCB's (full requirement)	£15·00
Voicing and Pre-Amplifier Circuits	£8·37
PCB for above circuits	£1·84
Power Amplifier	£14·50
PCB for power amp	95p

KEYBOARDS

Kimber-Allen Keyboards as required for many published circuits, including the P.E. Joanna, P.E. Minisonic and P.E. Synthesiser. The manufacturers claim that these are the finest moulded plastic keyboards made.

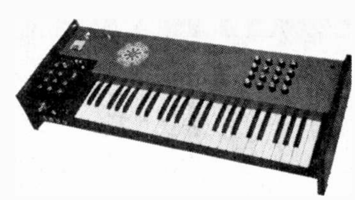
3 Octave Keyboard (37 notes C to C)	£20·50
4 Octave Keyboard (49 notes C to C)	£23·50
5 Octave Keyboard (61 notes C to C)	£27·00

Contact Assemblies for use with above keyboards: Single-pole change-over (SP) as for P.E. Joanna and P.E. Minisonic. Two-pole normally-open make-break (2P) as for P.E. Synthesiser. Special contact assembly (4PS) having 4 poles, 3 of which are normally-open make-break contacts and the fourth is a change-over contact—this special assembly enables the **same keyboard** to be used with the P.E. Synthesiser, P.E. Minisonic, and P.E. Synthesiser simultaneously thus avoiding the cost of more than one keyboard.

Contact	Each	3 Octave Set	4 Octave Set	5 Octave Set
SP	20p	£7·40	£9·80	£12·20
2P	24p	£8·88	£11·76	£14·64
4PS	48p	£17·76	£23·52	£29·28

Printed Circuit Boards for use with the above contacts and thus eliminating most of the inter-wiring required, are available—details in our lists.

PHONOSONICS



P.E. MINISONIC

(P.E. Nov. 1974 to March 1975)

A portable, battery or mains operated, miniature sound synthesiser, with keyboard circuits. Although having slightly fewer facilities than the large P.E. Synthesiser, the functions offered by this design give it great scope and versatility.

Two Voltage Controlled Oscillators	£5·22
Voltage Controlled Filter and Voltage Reference Circuit	£3·41
Two Envelope Shapers and Two Voltage Controlled Amplifiers	£7·25
Keyboard Controller and Hold Circuits	£2·66
Keyboard Divider Resistors (select type to suit keyboard used, all are 2% tolerance). 2 Octave, £1; 3 Oct., £1·48; 4 Oct., £1·96; 5 Oct., £2·44.	
H.F. Oscillator and Detector	£1·66
Ring Mod., Noise Gen. & Env. Inverter	£5·27
Two Power Amplifiers and Two Mixers	£3·55
Battery Eliminator	£5·88
Temperature Stabiliser	£1·47
PCB to hold 2 VCOs, VCF and V-Ref	£2·02
PCB to hold 2 ESs, 2 VCAs, 2 Mixers, Ring Mod, Keyboard Control and Hold	£2·20
PCB to hold 2 Power Amps, Noise Gen, Envelope-Inverter, HF Osc. and Detector	£1·45
PCB for Battery Elim. & Temp. Stab.	£1·35

FOR ADDRESS, INFORMATION REGARDING POST AND PACKING, VAT, LISTS, AND EXPORT TERMS SEE OUR OTHER ADVERTISEMENT ON OPPOSITE PAGE

Photos: 2 of our units containing some of the P.E. projects built from our kits and PCBs. (The cases were built by ourselves and are not for sale.)

4-STATION INTERCOM

£15·95
+ VAT £1·28

Solve your communication problems with this 4-Station **Transistor Intercom** system (1 **master** and **3 Subs**), in robust plastic cabinets for desk or wall mounting. Call/talk/listen from **Master** to **Subs** and **Subs** to **Master**. Ideally suitable for Business, Surgery, Schools, Hospitals, Office and Home. Operates on one 9V battery. On/off switch. Volume control. Complete with 3 connecting wires each 66ft and other accessories. P. & P. 75p.

MAINS INTERCOM NEW MODEL

No batteries—no wires. Just plug in the mains for instant two-way, **loud and clear communication. On off switch and volume control. Price £31·24 per pair. P. & P. 35p.**

NEW! AMERICAN TYPE CRADLE TELEPHONE AMPLIFIER

ONLY
£12·95
+ VAT £1·04

Latest transistorised Telephone Amplifier with detached plug-in speaker. Placing the receiver on to the cradle activates on/off switch for immediate two-way conversation without holding the handset. Many people can listen at a time. Increase efficiency in office, shop, workshop. Perfect for "conference" calls: leaves the user's hands free to make notes, consult files. No long waiting, saves time with long-distance calls. Volume. Direct tape recording model at £13·95 + VAT £1·12. P. & P. 70p. 10-day price refund guarantee.

WEST LONDON DIRECT SUPPLIES (PE4)
169 KENSINGTON HIGH STREET, LONDON, W.8

OSMABET LTD

We make transformers amongst other things

LOW VOLTAGE TRANSFORMERS
Prim. 200/240V a.c., 5V 1A **50p**; 6·3V 1·5A **£1·65**; 3A **£2·10**; 6A CT **£3·75**; 12V 1·5A **£2·10**; 3A **£3·75**; 6A CT **£5·25**; 18V 1·5A CT **£3·45**; 24V 1·5A CT **£3·75**; 3A CT **£5·25**; 5A **£8**; 8A **£11·25**; 12A **£16·50**; 40V 3A CT **£7·50**; 50V 6A CT **£18·75**; 25V 2A + 25V 2A **£7**; 12V 4A + 12V 4A **£7**.

LT TRANSFORMERS TAPPED SEC, Prim 200/240V
0–10–12–14–16–18V 2A **£4**; 4A **£5·25**. 0–12–15–20–24–30V 2A **£4·50**; 4A **£6·75**. 0–5–20–30–40–60V 1A **£4·85**; 2A **£6·75**. 0–40–50–60–80–100–110V 1A **£7**.

MIDGET RECTIFIER TRANSFORMERS
For FW rect. 200/240V a.c., 6–0–6V 1·5A or 9–0–9V 1A **£1·80** each; 12–0–12V 1A, or 20–0–20V 0·75A, or 9–0–9V 0·3A, or 12–0–12V 0·25A, or 20–0–20V 0·15A, or 6V 0·5A + 6V 0·5A, or 9V 0·35A + 9V 0·35A, or 12V 0·25A + 12V 0·25A, or 20V 0·15A + 20V 0·15A, all at **£2** each.

LOUDSPEAKERS
2¼in 8 or 75Ω, 2½in 8 or 25Ω, 3in 3, 8 or 35Ω, 3½in 8, 15 or 80Ω, **95p** each; 8 × 5in 3, 8, 15 or 25Ω, **£1·75**; Goodmans speakers, 5in full throw 8Ω 10W, **£4·25**; 6½in double cone 4Ω, **£3**; 12in 25W 4 or 15Ω, **£8**.

"INSTANT" BULK TAPE/CASSETTE ERASER
Instant erasure any diameter tape spool or cassette, demagnetises tape heads, 200/240V a.c., **£3·75**.

TAPE RECORDER MOTORS
New, blowers, fans, etc., 110V a.c., **50p** (**75p** pair).

SYNCHRONOUS GEARED MOTORS 200/240V a.c.
Brand new Smiths, built in gearbox, 2 r.p.h., **75p** each.

PAPER TUBULAR CONDENSERS
4·7mF, 160V, 30 × 20mm, **20p** (100 for **£10**).

SPEAKER MATCHING AUTO TRANSFORMER
12W, 3 to 8 or 15Ω, up or down, **£1·65**.

CABLES — CABLES — CABLES

MICROPHONE TWIN H/DUTY, BRAIDED SCREEN
Professional cable for stage, studio, outdoor. PVC covered, grey, **20p** per metre. Grey: Single cable, black, **10p** per metre.

MULTI WAY SCREENED, PVC COVERED
36 way **£1**; 25 way **75p**; 14 way **50p**; 6 way **20p**; 4 way **14p**; 2 way **10p**; 1 way **6p** per metre.

LOW LOSS CO-AXIAL CABLE 75Ω
Standard UHF **12p** and VHF **9p** per metre.

3 CORE MAINS CABLE
13A **25p**; 6A **15p**; 2·5A **8p** Per metre, 1A mini cable **£3** per 100 metres; speaker twin cable, **£2·50** per 100 metres; loudspeaker twin cable, **75p** per 20 metres.

ALL TYPES DOMESTIC AND COMMERCIAL CABLES, ALL SIZES AND COLOURS CONNECTING WIRES, MULTI SCREENED AND UNSCREENED CABLE. TRADE ENQUIRIES INVITED

Carriage and VAT extra on all orders
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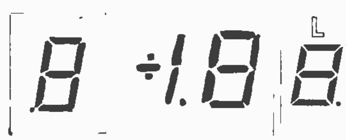
46 Kenilworth Road, Edgware, Middx. HA8 8YG
Tel. 01-958 9314

LITRONIX LED DISPLAYS



Size (in)	Full Spec.		Class 2	
0·3	DL701	£1·48	DL701E	70p
0·3	DL704	£1·48	DL704E	70p
0·3	DL707	£1·48	DL707E	70p
0·5	DL721	£3·75	DL721E	£1·80
0·5	DL727	£3·75	DL727E	£1·80
0·5	DL728	£3·75	DL728E	£1·80
0·6	DL746	£2·45	DL746E	£1·50
0·6	DL747	£2·45	DL747E	£1·50
0·6	DL749	£2·45	DL749E	£1·50
0·6	DL750	£2·45	DL750E	£1·50

0·5	5LT01 Phosphor diode	£5·80
0·5	5LT02 Phosphor diode	£5·80
0·5	5LT03 Phosphor diode	£5·80
0·5	3016F Minitron filament	£1·25
0·6	3017F Minitron filament	£2·00
2·5	RDS1 Itoka filament	£8·00
5·0	DM2C Itoka filament	£24·80

National, Mostek, Caltex clock chips. MHI clock and display kits. Case available.

NEW CLOCK CHIP, AY-5-1202. 4 digit 12/24 hour, interfaces with 5LT01, £4·76.

Terms: CWO, Access, Barclaycard (simply quote your number and sign). Credit facilities to accredited account holders.

VAT—All prices exclude VAT (8%). P. & P. 15p

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PHONOSONICS

SUPPLIERS OF QUALITY PRINTED CIRCUIT BOARDS, KITS AND COMPONENTS TO A WORLD-WIDE MARKET

SOUND-TO-LIGHT (P.E. Apr./Aug. 71)
The ever-popular AURORA—4 or 8 channels each responding to a different sound frequency and controlling its own light. Can be used with most audio systems and lamp intensities. A MUST for any Disco, and a fascinating visual display for the home.

4 channel component set (excl. thyristors)	£13·05
8 channel component set (excl. thyristors)	£22·56
Power supply component set	£4·96
PCB for 4 frequency channels	£3·32
PCB for power supply and 8 lamp drivers	£1·56
1 Amp 400V thyristors (1 per chan. requ.) each	75p
Panel meter (1μA) (optional)	£3·75

VOICE OPERATED FADER (P.E. Dec. 73)
For automatically reducing music volume during "talk-over" particularly useful for Disco work or for home-movie shows.

Component set incl. PCB £3·05

TAPE-NOISE LIMITER
Very effective circuit for reducing the hiss found in most tape recordings.

Component set (incl. PCB)	£2·60
Regulated power supply (incl. PCB)	£3·98

P.E. MINIMIX 6

DETAILS IN LIST

GUITAR EFFECTS PEDAL (P.E. July 75)
Will modify an audio signal not only from a guitar but from any audio source, producing 8 different switchable effects that can be further modified by manual controls. Possibly the most interesting of all the low-priced sound effects units in our range.

Component set with special foot operated switches	£6·25
Alternative component set with panel mounting switches	£4·60
Printed Circuit Board	£1·30

HI-FI TAPE-LINK (P.E. Mar./Apr. 73)
Designed for use with reasonable quality tape-decks, this high performance pre-amp includes record, playback and metering circuits. While stocks last.

Stereo component set (excl. panel meter)	£24·25
Mono component set (excl. panel meter)	£14·70
Power supply component set	£5·93
Stereo main PCB	£2·80
Stereo sub-assembly PCB	98p

VOLTAGE CONTROLLED FILTER (P.E. Oct. 74)
An independently designed VCF that can be used with the P.E. Synthesiser.

Component set	£3·41
Printed circuit board	£1·25

ENVELOPE SHAPER

The new ADSR Envelope Shaper published in P.E. October 1975 and having manual control of its Attack, Release and Sustain functions.

Component set incl. PCB £4·16

RHYTHM GENERATOR

(P.E. Mar./Apr. 74)

Programmable for 64,000 rhythm patterns from 8 effects circuits (high and low bongos, bass and snare drums, long and short brushes, blocks and soft cymbal), and with variable time signatures and rhythm rates. Really fascinating and useful.

Tempo, Timing and Logic circuits	£12·59
PCB for above circuits (double-sided)	£2·94
Component set for all 8 effects circuits	£10·49
Set of 4 PCB's to hold all 8 effects	£4·74
Simple mixer (no PCB available)	£2·76
Alternative mixer with external volume controls and adjustable gain (independently designed), including PCB	£9·93
Power Supply, including PCB	£6·42

SOUND BENDER (P.E. May 74)
A multi-purpose sound controller, the functions of which include envelope shaper, tremolo, voice operated fadar, automatic fader and frequency-doubler.

Component set for above functions (excl. SWs)	£6·58
Printed circuit board	£1·58

Optional extra—additional Audio Modulator, the use of which, in conjunction with the above component set, can produce "jungle-drum" rhythms.

Component set (incl. PCB) £2·55

PHASING UNIT (P.E. Sept. 73)
A simple but effective manually controlled unit for introducing the "phasing" sound into live or recorded music.

Component set (incl. PCB) £2·50

PHASING CONTROL UNIT (P.E. Oct. 74)
For use with the above Phasing Unit to automatically control the rate of phasing.

Component set (incl. PCB) £3·75

ULTRASONIC TRANSMITTER-RECEIVER
(P.E. May 1972). A highly sensitive, tight-beam, long-range, "invisible beam" detection circuit with numerous applications. While stocks last.
Component set with PCBs but excluding transducers £4·60

WIND AND RAIN UNIT
A manually controlled unit for producing the above-named sounds.

Component set incl. PCB £2·83

POWER SUPPLIES
Sophisticated low-noise highly-stabilised power supply kits complete with PCB's and detailed information are now available. Details in list.

Other PCBs (all "as published") While stocks last

Bench Power Supply (P.E. Sept. 1974)	70p
CCTV:	
Master Logic, Video Amp., Sync Mixer and Cathode Switch PCB (P.E. Oct. 1974)	£2·20
PCB for remaining Circuits (P.E. Oct. 1974)	£2·20
Digital Power Supply (P.E. Aug. 1972)	50p
Electronic Piano:	
Pre-amp PCB (P.E. Oct. 1972)	85p
Power Supply PCB (P.E. Oct. 1972)	60p
Power Slaves: Power Supply PCB (P.E. Aug. 1974)	55p
Rondo:	
Pre-Amp PCB (P.E. Oct. 1973)	60p
Tone, Balance and Volume Control PCB (P.E. Oct.)	£1·40

BIOLOGICAL AMPLIFIER (P.E. Jan./Feb. 73)
Multi-function circuits that, with the use of other external equipment, can serve as lie detector, alphaphone, cardiophone, etc.

Pre-Amplifier Module
Component set and PCB £3·71

Basic Output Circuits
Combined component set with PCBs, for alphaphone cardiophone, frequency meter and visual feed-back lamp driver circuits £5·39

Audio Amplifier Module
Type PC7 £5·50

SINE AND SQUARE WAVE GENERATOR (P.E. July 75)
Suitable for audio, digital, or general purpose. Controllable through 4 decade ranges 10Hz to 100kHz. Switched attenuation through 10 ranges from 10V to 1mV peak-to-peak.

Component set	£8·88
PCB for above components	£1·60
Power Supply	£5·70
PCB for Power Supply	96p

P.E. TUNING FORK

(P.E. NOVEMBER, 1975)

Main component set incl. PCB	£13·50
Power supply set incl. PCB	£6·57

REVERBERATION UNIT (P.W. Nov./Dec. 72)
A high quality unit having microphone and line input pre-amps, and providing full control over reverberation level.

Component set (exl. spring unit)	£7·55
Printed circuit board	£1·76
9 inch spring unit	£4·95
Panel meter (50μA) (optional)	£3·75

SEMI-CONDUCTOR TESTER (P.E. Oct. 73)
Essential test equipment for the enterprising home constructor. While stocks last.
Set of resistors, capacitors, semiconductors, potentiometers, makaswitches and PCB £8·44
Panel meter (500μA) £3·75

PHOTOPRINT PROCESS CONTROL (P.E. Jan./Feb. 72)
For colour and B & W, an indispensible dark-room unit for finding exposure, controlling enlarger timing, and stabilising mains voltage.

Component set (excl. meter)	£10·72
Printed Circuit Board	£1·74
Panel meter (1mA)	£3·75

SYNCHRONOME AND PEAK LEVEL INDICATOR

DETAILS IN LIST

PHOTOCOPIES
of P.E. texts for most of our kits are available. Prices in our lists.

Component sets include all necessary resistors, capacitors, semiconductors, potentiometers and transformers. Fuller details are in our lists.

Transistors

AC128	20p	BFY51	22p	2N3055	48p
AC176	20p	BFY52	24p	2N3702	12p
BC107	13p	BSY95A	22p	2N3703	12p
BC108	13p	MJE2955	110p	2N3704	12p
BC109	13p	OC28	60p	2N3819	35p
BC147	12p	OC71	14p	2N3823E	39p
BC148	12p	OC72	14p	2N4060	12p
BC149	12p	OC84	25p	2N4871	36p
BC157	13p	ORP12	66p	2N5245	51p
BC158	13p	ZTX107	12p	2N5777	45p
BC159	13p	ZTX108	7½p		
BC182L	12p	ZTX501	13p		
BC184	12p	ZTX503	15p		
BC187	25p	ZTX531	23p		
BC204	14p	2N706	13p		
BC209C	14p	2N914	22p		
BC212L	15p	2N1304	22p		
BC213	15p	2N2905	27p		
BC478	29p	2N2907	22p		
BCY71	22p	2N3053	18p		
BFY50	22p	2N3054	66p		

Diodes

1N914	4p
1N4001	6p
1N4002	7p
1N4004	8p
1N4006	9p
1N4007	10p
OA91	7p
OA200	8p
OA202	8p
Z5J	75p
ZS171	16p

Integrated Circuits

709 TO5	40p
709 8-pin DIL	40p
723 TO5	95p
741 8-pin DIL	32p
748 TO5	63p
748 8-pin DIL	63p
μA7805 TO220	165p
μA7815 TO220	165p
AY-1-0212	550p
AY-1-6721/6	188p
CA3046	71p
MFC4000B	73p
MFC6040	83p
SG3402N	202p
EP27/3015F	135p
STK025	595p

Zeners

3·3V 400mW	15p
3·9V 400mW	15p
4·7 1W	25p
5·1V 400mW	15p
5·1V 1W	25p
5·6V 400mW	15p
5·6V 1 3W	20p
6·2V 400mW	15p
6·8V 400mW	15p
9·1V 400mW	15p
10V 400mW	15p
11V 1W	25p
12V 400mW	15p
12V 1W	25p
15V 400mW	15p
15V 1W	25p
18V 400mW	15p
18V 1W	25p
20V 400mW	15p
20V 1W	25p
27V 400mW	15p

Electrolytic Capacitors (μF/V)

0·47/63	8p	100/40	7p	2200/40	71p
1·0/63	6p	100/63	13p	2800/100	390p
1·5/63	6p	150/16	6p	3300/63	133p
2·2/63	6p	150/63	13p	4700/16	60p
4·7/63	6p	220/10	6p	4700/25	75p
6·8/40	6p	220/16	7p	4700/40	93p
10/25	6p	220/25	15p		
10/63	6p	220/40	17p		
15/40	6p	220/63	21p		
22/10	6p	330/10	6p		
22/25	6p	470/6·3	7p		
33/6·3	6p	470/10	15p		
33/16	6p	470/25	18p		
33/40	6p	470/40	20p		
33/50	6p	680/6·3	10p		
47/10	6p	680/25	20p		
47/25	6p	1000/10	14p		
47/40	6p	1000/16	25p		
47/63	7p	1000/25	30p		
100/4	6p	1000/40	54p		
100/10	6p				
100/25	6p	2200/25	45p		

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0·15	5½p
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0·33	8p
0·47	10p
0·68	12p
1·0	15p
2·2	26p

Tantalum (μF/V)

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0·22/35	13p
0·47/35	13p
1·0/35	13p
1·5/35	13p
2·2/35	13p
4·7/35	16p
10/16	16p
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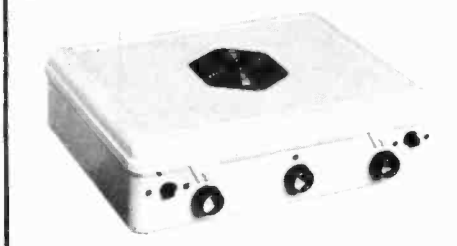

- 4 Transistor Earpiece Radio
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- Signal Injector
- Transistor Tester NPN—PNP
- 4 Transistor Push Pull Amplifier
- 5 Transistor Push Pull Amplifier
- 7 Transistor Loudspeaker Radio MW/LW.
- 5 Transistor Short Wave Radio
- Electronic Metronome
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Build this converter kit and receive the aircraft band by placing it by the side of a radio tuned to medium wave or the long wave band and operating as shown in the instructions supplied free with all parts.

Uses a retractable chrome plated telescopic aerial, gain control, V.H.F. tuning capacitor, transistor, etc.

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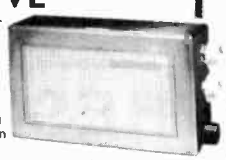
POCKET FIVE



Now with 3½in Loudspeaker 3 tunable wavebands. MW, LW and trawler band. 7 stages, 5 transistors and 2 diodes, supersensitive ferrite rod aerial, attractive black and gold case. Size 5½in × 1½in 3½ in approx.

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NEW Everyday Series

Build this exciting new series of designs.

E.V.5. 5 Transistors and 2 diodes. MW/LW. Powered by 4½V battery. Ferrite rod aerial, tuning condenser, volume control, and now with 3in. loudspeaker. Attractive case with red speaker grille. Size 9in. × 5½in. × 2¾in. approx. All parts including Case and Plans.

Total Building costs **£4·75** P. & P. + Ins. 50p

E.V.6. Case and looks as above. 6 Transistors 3 diodes. Powered by 9V battery. Ferrite rod aerial, 3in. loudspeaker, etc. MW/LW coverage. Push/Pull output.
All parts including Case and Plans.

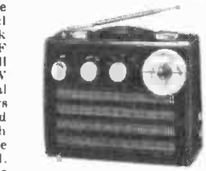
Total Building costs **£5·50** P. & P. + Ins. 55p

E.V.7. Case and looks as above. 7 Transistors and 3 diodes. Six wavebands, MW/LW, Trawler Band SW1, SW2, SW3, powered by 9V battery. Push pull output. Telescopic aerial for short waves. 3in. Loudspeaker.
All parts including Case and Plans.

Total Building Costs **£7·05** P. & P. + Ins. 55p

ROAMER TEN MARK 2

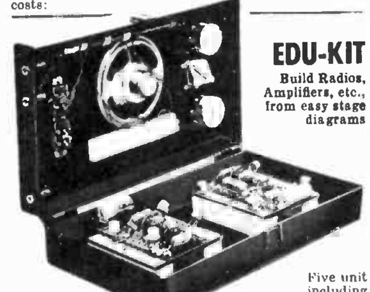
WITH VHF INCLUDING AIRCRAFT



Now with free earpiece and switched socket. 10 transistors. Latest 5" × 3" loudspeaker. 9 tuneable wavebands, MW1, MW2, LW, SW1, SW2, SW3, trawlerband, VHF and local stations, also aircraft band. Built in ferrite rod aerial for MW/LW. Chrome plated, 6 section telescope aerial, can be angled and rotated for peak short wave and VHF listening. Push pull output using 600mW transistors. Car aerial socket. 10 transistors plus 3 diodes. Ganged tuning condenser with VHF section. Separate coil for aircraft band. Volume on/off. Wave change and tone controls. Attractive Case in rich chestnut shade with gold blocking. 9in. × 7in. × 4in. Easy to follow instructions and diagrams. Total building costs: **£11·87** P.P. and Ins. 65p

EDU-KIT

Build Radios, Amplifiers, etc., from easy stage diagrams



Five unit including master unit to construct

Components include: Tuning condenser, 2 volume controls, 2 slider switches, fine tone 3in moving coil speaker, terminal strip, ferrite rod aerial, battery clips, 4 tag boards, 10 transistors, 4 diodes, resistors, capacitors, 3 ¼in 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.

All parts including case and plans. **£6·99** P.P. and Ins. 55p

ELECTRONIC CONSTRUCTION KITS

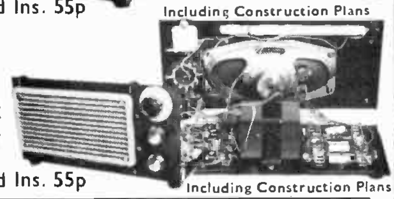
E.C.K. 2 Self Contained Multi-Band V.H.F. Receiver Kit.

8 transistors and 3 diodes. Push pull output. 3in loudspeaker, gain control, superb 9 section swivel ratchet and retractable chrome plated telescopic aerial, V.H.F. tuning capacitor, resistors, capacitors, transistors, etc. Will receive T.V. sound, public service band, aircraft, V.H.F. local stations, etc. Operates from a 9 volt P.P. 7 battery (not supplied with kit).

Complete kit of parts **£7·95** P.P. and Ins. 55p

Including Construction Plans

E.C.K. 4



7 Transistors, 6 tuneable wavebands, MW, LW, Trawler Band, 3 Short Wave Bands. Receiver Kit.
With 5in × 3in loudspeaker. Push pull output stage, gain control, and rotary switch. 7 transistors and 4 diodes. 6 section chrome-plated telescopic aerial. 8 in sensitive ready wound ferrite rod aerial, tuning capacitor, resistors, capacitors, etc. Operates from a 9 volt P.P. 7 battery (not supplied with kit).

Complete kit of parts **£7·25** P.P. and Ins. 55p

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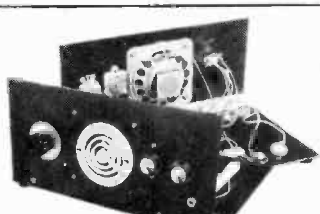
EDU-KIT JUNIOR



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All parts including loudspeaker, earpiece, MW ferrite rod aerial, capacitors, resistors, transistors, etc.

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2N709	0·40
2N1091	0·55
2N1131	0·25
2N1132	0·24
2N1302	0·18
2N1303	0·18
2N1304	0·28
2N1305	0·22
2N1306	0·28
2N1307	0·28
2N1308	0·28
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2N2148	0·60
2N2160	0·78
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2N2925	0·15
2N2926	0·12
2N3054	0·48
2N3055	0·45
2N3702	0·11
2N3703	0·15
2N3706	0·11
2N3707	0·13
2N3709	0·10
2N3710	0·11
2N3711	0·11
2N3819	0·38
2N4289	0·30
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2S301	0·59
2S304	1·15
2S501	0·75
2S703	1·00
40250	0·54
40251	0·81
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AAZ12	0·75
AAZ13	0·12
AAZ17	0·13
AC107	0·51
AC126	0·25
AC127	0·25
AC128	0·15
AC187	0·21
AC188	0·20
ACY17	0·55
ACY18	0·35
ACY19	0·35
ACY20	0·35
ACY21	0·35
ACY22	0·35
ACY27	0·25
ACY28	0·25
ACY39	0·78
ACY40	0·22
ACY41	0·22
ACY44	0·32
AD140	0·50
AD149	0·50
AD161	0·44
AD162	0·44
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AF114	0·25
AF115	0·25
AF116	0·25
AF117	0·24
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ASY51	0·40
ASY53	0·20
ASY55	0·20
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ASZ21	1·00
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AU104	1·00
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BC107	0·14
BC108	0·13
BC109	0·14
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BC115	0·20
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BC122	0·20
BC125	0·68
BC126	0·65
BC140	0·55
BC147	0·10
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BC157	0·14
BC158	0·12
BC160	0·63
BC169	0·14
BCY31	0·45
BCY32	0·85
BCY33	0·38
BCY34	0·45
BCY38	0·55
BCY39	1·50
BCY40	0·80
BCY42	0·30
BCY70	0·18
BCY71	0·22
BCZ10	0·60
BD121	1·00
BD123	1·00
BD124	0·65
BDY11	1·45
BF115	0·20
BF167	0·25
BF173	0·28
BF181	0·35
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BF194	0·10
BF195	0·13
BF196	0·15
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BFS61	0·25
BFS98	0·25
BFX12	0·20
BFX13	0·26
BFX29	0·28
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BFX63	0·50
BFX84	0·25
BFX85	0·28
BFX86	0·25
BFX87	0·25
BFX88	0·24
BFY10	0·50
BFY11	0·50
BFY17	0·40
BFY18	0·45
BFY19	0·55
BFY24	0·45
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BFY50	0·21
BFY51	0·20
BFY52	0·20
BFY53	0·17
BFY64	0·36
BFY90	0·81
BR100	0·40
BSX27	0·50
BSX60	0·93
BSX76	0·18
BSY26	0·17
BSY27	0·20
BSY51	0·50
BSY95A	0·12
BSY95	0·12
BT102/500R	0·75
BTY42	0·92
BTY79/100R	0·75
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BY127	0·12
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BYZ15	1·25
BYZ16	0·60
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CRS1/40	0·50
CS4B	1·90
CS10B	3·50
DD000	0·15
DD003	0·15
DD006	0·25
DD007	0·40
DD008	0·38
GD3	0·33
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GET114	0·30
GET115	0·90
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GET881	0·25
GET882	0·35
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MAT121	0·25
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MJE520	0·63
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MPF104	0·35
MPF105	0·36
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OA81	0·18
OA85	0·15
OA86	0·15
OA90	0·07
OA91	0·07
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OA200	0·08
OA202	0·06
OA210	0·20
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OAZ205	0·45
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OAZ244	0·25
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OC23	1·25
OC24	1·10
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OC26	0·40
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OC29	0·65
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OC42	0·40
OC43	0·70
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OC66	0·50
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OC74	0·30
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OC79	0·30
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OC81M	0·20
OC81DM	0·18
OC81Z	0·45
OC82	0·28
OC82D	0·25
OC83	0·60
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OC114	0·38
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OC140	1·14
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OC206	1·10
OC207	1·00
OC460	0·20
OC470	0·30
OCP71	1·20
ORP12	0·60
ORP60	0·55
ORP61	0·48
SX68	0·20
SX631	0·45
SX635	0·55
SX640	0·75
SX641	0·75
SX642	0·60
SX644	0·85
SX645	0·85
TIC44	0·29
V15/30P	0·75
V30/201P	0·75
V60/201	0·50
V60/201P	0·75
XA101	0·10
XA102	0·18
XA151	0·15
XA152	0·15
XA161	0·25
XA162	0·25
XB101	0·43
XB102	0·30
XB103	0·35
XB113	0·30
XB121	0·43

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ZS170	0·10
ZS271	0·18
ZT21	0·25
ZT43	0·25
ZTX107	0·12
ZTX108	0·10
ZTX300	0·13
ZTX304	0·24
ZTX500	0·13
ZTX503	0·16
ZTX531	0·25
INTEGRATED CIRCUITS	
7400	0·16
7401	0·16
7402	0·16
7403	0·16
7404	0·26
7405	0·22
7406	0·42
7407	0·42
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7411	0·25
7412	0·30
7413	0·36
7416	0·36
7417	0·36
7420	0·16
7422	0·25
7423	0·37
7425	0·37
7427	0·37
7428	0·40
7430	0·16
7432	0·37
7433	0·37
7437	0·37
7438	0·37
7440	0·22
7441AN	0·92
7442	0·79
7450	0·16
7451	0·16
7453	0·16
7454	0·16
7460	0·16
7470	0·36
7472	0·38
7473	0·41
7474	0·42
7475	0·59
7476	0·45
7480	0·60
7482	0·87
7483	1·10
7484	1·00
7486	0·47
7490	0·55
7491AN	1·00
7492	0·70
7493	0·70
7494	0·80
7495	0·80
7496	0·95
7497	3·87
74100	1·89
74107	0·45
74110	0·58
74111	0·86
74118	0·90
74119	1·68
74121	0·50
74122	0·70
74123	1·00
74141	0·90
74145	1·26
74150	1·75
74151	1·00
74154	2·00
74155	1·00
74156	1·00
74157	0·95
74170	2·52
74174	1·57
74175	1·10
74176	1·26
74190	2·00
74191	2·00
74192	2·00
74193	2·00
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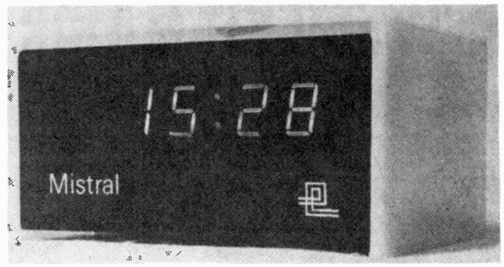

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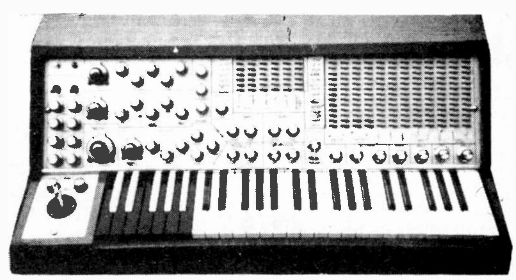

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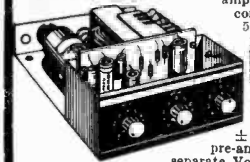

A superb solid state audio amplifier. Brand new components throughout. 5 Silicon transistors plus 2 power out-put transistors in push-pull. Full wave rectification. Output approx. 13 watts r.m.s. into 8 ohms. Frequency response 12Hz. 30KHz ± 3db. Fully integrated pre-amplifier stage with separate Volume, Bass boost and Treble cut controls. Suitable for 8-15 ohm speakers. Input for ceramic or crystal cartridge. Sensitivity approx. 40mV for full output. Supplied ready built and tested, with knobs, escutcheon panel, input and output plugs. Overall size 3" high × 6" wide × 7½" deep. AC 200/250V. PRICE £15·00. P. & P. 85p.

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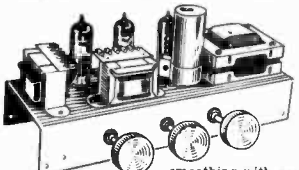

A.C. mains 200-240 v. Using heavy duty fully isolated mains transformer with full wave rectification giving adequate smoothing with negligible hum. Valve line-up:-2 × ECL86 Triode Pentodes. 1 × EZ80 as rectifier. Two dual potentiometers are provided for bass and treble control, giving bass and treble boost and cut. A dual volume control is used. Balance of the left and right hand channels can be adjusted by means of a separate 'Balance' control fitted at the rear of the chassis. Input sensitivity is approximately 300m/v for full peak output of 4 watts per channel (8 watts mono), into 3 ohm speakers. Full negative feedback in a carefully calculated circuit, allows high volume levels to be used with negligible distortion. Supplied complete with knobs, chassis size 11"w × 4"d. Overall height including valves 5". Ready built and tested to a high standard. £12·50. P. & P. 95p.

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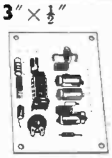

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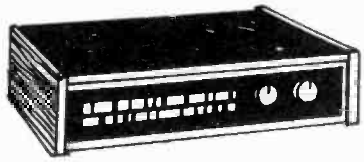

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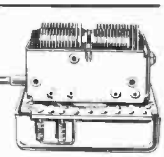

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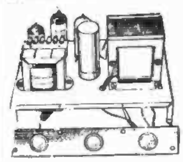

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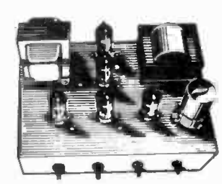

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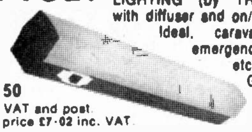

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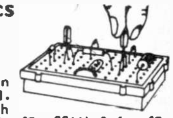

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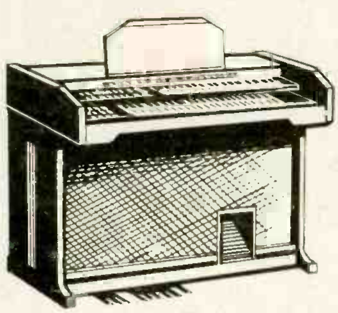

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