PRACTICAL

ELECTRONICS

MAY 1974

25p

PRACTICAL
ELECTRONICS

VOLUME 10 No. 5 MAY 1974

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18202	0·23
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2G381	0·22
2G414	0·30
2G417	0·25
2N404	0·22
2N697	0·15
2N698	0·30
2N706	0·10
2N706A	0·12
2N708	0·15
2N709	0·40
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2N2148	0·60
2N2160	1·00
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2N2219	0·25
2N2369A	0·16
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2N2646	0·50
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2N5027	0·53
2N5088	0·33
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28304	1·15
28501	0·75
28703	1·00
AA129	0·20
AAZ12	0·75
AAZ13	0·10
AC107	0·35
AC126	0·25
AC127	0·25
AC128	0·20
AC187	0·20
AC188	0·20
ACY17	0·35
ACY18	0·27
ACY19	0·27
ACY20	0·22
ACY21	0·22
ACY22	0·16
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ACY28	0·25
ACY39	0·65
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ACY44	0·32
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AD149	0·50
AD161	0·39
AD162	0·39
AF106	0·30
AF114	0·25
AF115	0·25
AF116	0·25
AF117	0·20
AF118	0·60
AF119	0·20
AF124	0·30
AF125	0·30
AF126	0·30
AF127	0·30
AF139	0·33
AF178	0·55
AF179	0·65
AF180	0·55
AF181	0·50
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AFY19	1·18

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AFZ12	2·00
ASY26	0·25
ASY27	0·30
ASY28	0·25
ASY29	0·30
ASY30	0·25
ASY50	0·20
ASY51	0·40
ASY53	0·20
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ASY62	0·25
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ASZ21	1·00
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AU101	1·60
AUY10	1·00
BC107	0·12
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BC109	0·12
BC113	0·16
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BCY71	0·20
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BD121	1·00
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BFX63	0·50
BFX84	0·25
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BFX86	0·25
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BFY11	0·50
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BFY52	0·20
BFY53	0·17
BFY64	0·45
BFY90	0·75
BSX27	0·50
BSX60	0·98
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
BTY79/400R	1·10
BY100	0·15
BY126	0·14
BY127	0·15
BY182	0·85

	£p
BY213	0·25
BYZ10	0·45
BYZ11	0·40
BYZ12	0·40
BYZ13	0·35
BYZ15	1·25
BYZ16	0·60
BYZ88C3V3	0·10
BZY88C3V3	0·10
C111	0·55
CRS1/05	0·30
CRS1/40	0·45
CS4B	1·90
CS10B	3·50
DD000	0·15
DD003	0·15
DD006	0·25
DD007	0·40
DD008	0·33
GD3	0·33
GD4	0·10
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GEX45/1	0·45
GEX941	0·45
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GJ4M	0·50
GJ5M	0·25
GJ7M	0·50
HG1005	0·50
HS100A	0·30
MAT100	0·20
MAT101	0·25
MAT120	0·20
MAT121	0·25
MJE520	0·65
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MJE3055	0·75
MPF102	0·40
MPF103	0·30
MPF104	0·35
MPF105	0·46
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NKT222	0·30
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OAZ205	0·45
OAZ206	0·45
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OC81Z	0·45
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OC470	0·30
OCP71	1·00
ORP12	0·55
ORP60	0·45
ORP61	0·43
PIC44	0·29
SX68	0·20
SX631	0·45
SX635	0·55
SX640	0·75
SX641	0·75
SX642	0·60
SX644	0·85
SX645	0·85
T1843	0·26
V15/30P	0·75
V30/201P	0·75
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XA162	0·25
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ZTX108	0·10
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7470	0·33
7472	0·33
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7482	0·87
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74107	0·51
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74170	2·88
74174	1·80
74175	1·29
74176	1·44
74190	2·30
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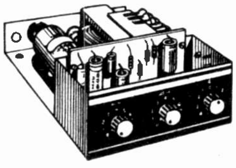

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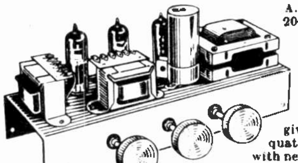

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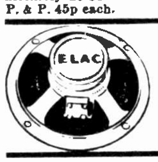

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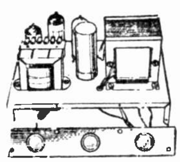
NEW FURTHER IMPROVED MODEL WITH HIGHER OUTPUT AND INCORPORATING HIGH QUALITY READY DRILLED PRINTED CIRCUIT BOARD WITH COMPONENT IDENTIFICATION CLEARLY MARKED FOR EASIER CONSTRUCTION

A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors including Silicon Transistors in the first five stages on each channel resulting in even lower noise level with improved sensitivity. Integrated pre-amp with Bass, Treble and two Volume Controls. Suitable for use with Ceramic or Crystal cartridges. (Very simple to modify to suit magnetic cartridge—instructions included). Output stage for any speakers from 5 to 15 ohms. Compact design, all parts supplied including drilled metal work, high quality ready drilled printed circuit board, smart brushed anodised aluminium front panel with matching knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief specification: Power output 14W r.m.s. per channel into 5 ohms. Frequency response ± 3dB 12–30,000Hz. Sensitivity better than 80mV into 1MΩ. Full power bandwidth ± 3dB 12–15,000Hz. Bass boost approx. to ± 12dB. Treble cut approx. to −16dB. Negative feedback 18dB over main amp. Power requirements 35V at 1·0 amp. Overall size—12" wide × 8" deep × 2½" high.
Fully detailed 7-page construction manual and parts list free with kit or send 18p plus large S.A.E.

PRICES	AMPLIFIER KIT,	£11·55	P. & P. 25p.
	(Magnetic input components 33p extra)		
	POWER PACK KIT,	£3.50	P. & P. 35p.
	CABINET,	£3·50	P. & P 35p.

(Post Free if all units purchased at same time). Full after sales service. Also available ready built and tested, £25·10. Post Free.
Note: The above amplifier is suitable for feeding two mono sources into inputs (e.g. mike, radio, twin record decks, etc.) and will then provide mixing and fading facilities for medium powered Hi-Fi Discotheque use, etc.

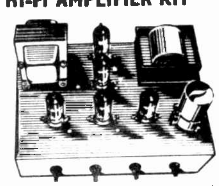
3-VALVE AUDIO AMP. HA34 MK II



Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7½in w. × 4in. d. × 4¾in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker. Separate volume control and now with improved wide range tone controls giving bass and treble lift and cut. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls. Complete with knobs, valves, etc., wired and tested for only £6·00. P. & P. 45p.

HSL "FOUR" AMPLIFIER KIT. Similar in appearance to HA34 above but employs entirely different and advanced circuitry. Complete set of parts, etc. £5·00. P. & P. 45p.

10/14 WATT HI-FI AMPLIFIER KIT



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3–15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and EZ80 rectifier. Simple instruction booklet 15p plus S.A.E. (Free with parts). All parts sold separately. ONLY £9·00. P. & P. 60p. Also available ready built and tested £13·00. P. & P. 70p.

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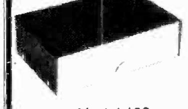

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220	8	6	3½	£2·65
221	8	6	6	£2·90
320	12	8	12	£5·75

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★ EXTREMELY ECONOMICAL PRICE. ★ Ready built, tested and fully guaranteed.
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★ S.a.e. please for full technical details.

Trade enquiries welcome.

SAJ110 7-stage frequency divider in one 14 pin DIL package. Sine or square wave input allows operation from almost any type of master oscillator including the DMO2 (when 97 notes are available). Square wave outputs may be modified to saw-tooth by the addition of a few components. SAJ110: **£2·63** each OR special price for pack of 12: **£25·00**. S.a.e. please for data sheet.

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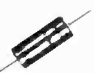
CAPACITORS

Sub-miniature
Axial lead electrolytic



Mfd	V	Price	Mfd	V	Price	Mfd	V	Price
1	63	6p	68	6·3	6p			
1·5	63	6p	68	16	6p			
2·2	63	6p	68	63	10p			
3·3	63	6p	100	4	6p			
4·7	63	6p	100	10	6p	470	6·3	6p
6·8	40	6p	100	25	8p	470	10	10p
6·8	63	6p	100	40	8p	470	25	12p
10	25	6p	100	63	12p	470	40	18p
10	63	6p	150	6·3	6p	680	6·3	10p
15	16	6p	150	16	6p	680	16	12p
15	40	6p	150	25	6p	680	25	18p
15	63	6p	150	40	10p	680	40	22p
22	10	6p	150	63	12p	1000	4	10p
22	25	6p	220	4	6p	1000	10	12p
22	63	6p	220	10	6p	1000	16	18p
33	6·3	6p	220	16	6p	1000	25	22p
33	16	6p	220	25	10p	1500	6·3	12p
33	40	6p	220	40	12p	1500	10	18p
47	4	6p	220	63	18p	1500	16	22p
47	10	6p	330	4	6p	2200	6·3	18p
47	25	6p	330	10	6p	2200	10	22p
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2 pin (1 flat) 8p
3 pin 9p
4 pin, 5 pin A (180°), 5 pin B (240°), 6 pin 10p

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PHONO
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Plug screened 12p
Chassis socket 4p

JACK
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Plastic 13p
Screened 21p

Std. ¼" stereo plug
Plastic 18p
Screened 30p
Open mono socket ¼" 10p; Moulded mono socket ¼" with 2 break contacts 14p; Moulded stereo socket ¼" with 3 break contacts 18p; 3·5mm. plug plastic 8p; screened 11p; open socket 8p.

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Lacing Cord. Strong rayon cored PVC 25m **51p.**
Panel fuse holders 20mm **20p**; 1¼in **35p.**

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Size: 46 × 31 × 38mm.
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Mains Transformer MT206AT
Pri. 200–220–240V. Sec. 0–15–20V 1A. 0–15–20V 1A **£3·08.**

Hook-up wire, 7 strand 0·2mm. PVC covered tinned copper wire for light general connexions up to 1·4A. 11 colours: black, blue, brown, green, grey, orange, pink, red, violet, white, yellow. 10 metres of any one colour **20p.** Pack of 11 (1 of each colour) 10m coils **£2·05.**

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High quality single screened 50Ω 100pF per metre, ideal for high grade audio connexions **15½p** per metre.

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Rotary miniature carbon track ¼" spindle

Single gang Lin or Log
5k, 10k, 25k, 50k, 100k, 250k, 500k, 1M, 2M (and 1k Lin) 14p

Dual gang (Stereo) without switch Log or Lin 5k to 2M as above **44p**

Single gang with DP switch 250V 2A Log or Lin 5k to 2M as above **29p**

PRESETS
Sub-miniature 0·1W Vert or Horiz
100, 250, 500, 1k, 2·5k, 5k, 10k, 25k, 50k, 100k, 250k, 500k, 1M **6p**

Wirewound 10% 1W ¼" spindle 10, 50, 100R **34p**; 250, 500, 1k, 5k **33p**; 10k, **37p**; 25k **40p**; 50k **44p**.

LINEARS

LH0042C. TO99 (TO5). FET i/p Op Amp	£4·25
LM301A. 8-pin DIL. Op Amp	50p
MC1303L. 14-pin DIL. Stereo Preamplifier	£1·39
MC1310P. 14-pin DIL. FM Stereo Decoder (no coils needed)	£3·15
MFC8010. 8-pin case. 1W Audio Power Amp	£1·20
MFC9020. 10-lead case. 2W Audio Power Amp	£1·37
NE555V. 8-pin Dil. Precision Timer	79p
NE561B. 16-pin DIL. Phase Locked Loop	£4·48
SG1495D. 14-pin DIL. Fair Quadrant Analogue Multiplier	£2·70
µA723C. TO99 (TO5). 2 to 37V Voltage Regulator	80p
µA723C. 14-pin DIL. 2 to 37V Voltage Regulator	80p
µA741C. 8-pin DIL. Op Amp	36p
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µA747C. 14-pin DIL. Dual Op Amp	£1·05
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ZN414. TO5. TRF Radio	£1·20

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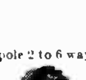
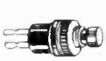
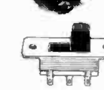
SWITCHES

Rotary with adjustable stop 1 pole 2 to 12 way; 2 pole 2 to 6 way; 3 pole 2 to 4 way; 4 pole 2 or 3 way, each **32p**
Mains rotary DPDT 250V 2A **20p.**

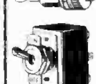




Push to make non-locking **14p**



Slide Miniature DPDT **9p**



Toggle 250V 1·5A with ON/OFF plate **25p.**

Sub-miniature toggle DPDT (12 × 12·5 × 14mm excl. toggle) 250V 3A **70p**

RESISTORS

Carbon Film ¼W 5%	1Ω to 1M; 10% 1·2M to 10M	E12		1p
Carbon Film ¼W 5%	1Ω to 10Ω; 10% 1·2M to 10M	E12		1p
Carbon Film ½W 5%	11Ω to 910k	E12 & E24		1p
Carbon Film 1W 5%	10Ω to 10M	E12		3p
Metal Oxide ½W 2%	10Ω to 1M	E12 & E24		4p
Wirewound 2½W 10%	0·22ohms to 0·47ohms	E12		10p
Wirewound 2½W 5%	1ohm to 270ohms	E12		10p

E12 values 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and decades
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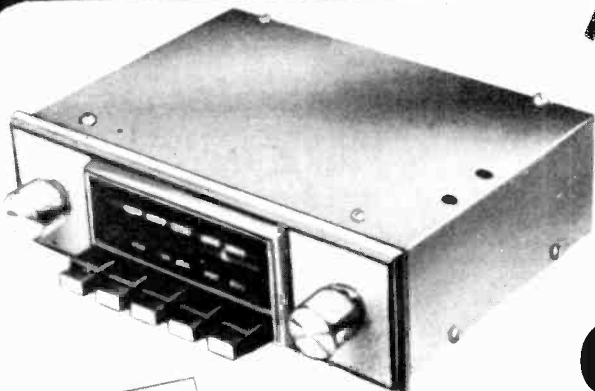

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Controls Volume, manual tuning and five push buttons for station selection, illuminated tuning scale covering full medium and long wave bands.

Size Chassis 7 ins. wide, 2 ins. high and $4\frac{5}{16}$ ins. deep approx.

NOTE: The ability to solder on a printed circuitboard is necessary to complete this kit successfully. Circuit diagram and comprehensive instructions 55p free with kit.

Car Radio Kit

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Speaker including baffle and fixing strips

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Recommended **Car Aerial** - fully retractable and locking.

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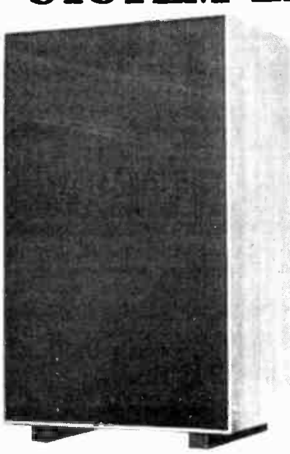

A professional standard five way speaker system with enclosure giving top quality performance.

Enclosure Dimensions
approx. (3 ft. × 2 ft. × 1 ft.).

Drive Units
Hand built – 15″ diameter bass with 3″ voice coil,
– two 5″ diameter Mid Range units,
– two $3\frac{1}{4}$″ HF. units,
plus matching crossover panel with two variable potentiometers for mid and high frequency adjustment.

Powder Handling
Continuous rating 35 W rms., Peak power rating 70 W.

Frequency Response
20 Hz 20,000 Hz.
Impedance 8 ohms

Recommended retail selling price, £86·00.

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EMI SPEAKERS

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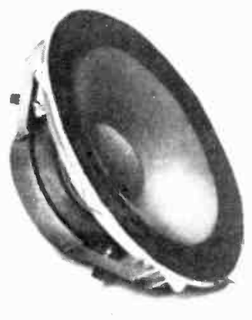

15″ 14A/780. Bass unit on a rigid diecast chassis. Superior cone material handles up to 50 watts RMS, and is treated to give a smooth frequency response. Resonance 30 Hz. flux density 360,000 Maxwells. Impedance at 1 kHz is 8 ohms. 3″ voice coil.

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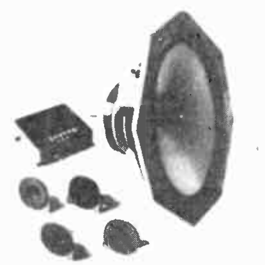
OUR PRICE £18·70 + £1·50 p & p



950 Kit – Five matched speakers and crossover unit for handling up to 45 watts, frequency response from 20 to 20,000 Hz.
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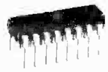

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7401	0·20	0·18	7451	0·20	0·19	74150	3·30	2·75
7402	0·20	0·18	7453	0·20	0·19	74151	1·21	1·15
7403	0·20	0·18	7454	0·20	0·18	74153	1·32	1·15
7404	0·21	0·19	7460	0·20	0·18	74154	2·20	1·87
7405	0·21	0·19	7470	0·33	0·27	74155	1·65	1·21
7406	0·54	0·49	7472	0·33	0·30	74156	1·65	1·21
7407	0·54	0·48	7473	0·46	0·42	74157	1·54	1·43
7408	0·29	0·24	7474	0·44	0·40	74160	2·18	2·05
7409	0·29	0·24	7475	0·63	0·57	74161	2·18	2·05
7410	0·20	0·18	7476	0·55	0·51	74162	4·84	4·54
7411	0·23	0·21	7480	1·10	0·99	74163	4·84	4·54
7412	0·40	0·33	7481	1·37	1·26	74164	2·73	2·63
7413	0·31	0·29	7482	1·10	0·99	74165	2·73	2·63
7416	0·49	0·47	7483	1·32	1·29	74166	4·28	3·94
7417	0·57	0·53	7484	1·32	1·21	74174	2·78	2·66
7420	0·20	0·18	7485	2·75	2·64	74175	1·94	1·81
7422	0·60	0·58	7486	0·49	0·41	74176	1·99	1·87
7423	0·60	0·58	7489	4·95	4·29	74177	2·75	2·64
7425	0·60	0·53	7490	0·82	0·71	74180	2·75	2·64
7426	0·35	0·31	7492	0·84	0·65	74181	6·49	6·05
7427	0·55	0·51	7493	0·82	0·66	74182	2·16	2·02
7428	0·85	0·79	7494	1·04	0·93	74184	2·69	2·42
7430	0·20	0·18	7495	1·14	1·03	74190	3·08	2·69
7432	0·42	0·33	7496	1·25	1·15	74191	2·30	2·24
7433	0·97	0·91	74100	2·75	2·58	74192	2·53	2·30
7437	0·77	0·74	74104	1·18	1·14	74193	2·53	2·30
7438	0·77	0·74	74105	1·18	1·14	74194	3·27	3·15
7440	0·20	0·18	74107	0·48	0·46	74195	2·42	2·30
7441	0·81	0·78	74110	0·67	0·65	74196	2·18	2·06
7442	0·81	0·78	74111	1·52	1·40	74197	2·18	2·06
7443	1·40	1·32	74118	1·10	0·80	74198	6·65	6·05
7444	1·57	1·52	74119	1·64	1·54	74199	6·65	6·05
7445	2·31	2·18	74121	0·47	0·42	74200	26·40	21·12
7446	2·31	2·18	74122	1·70	1·59			

Linear Integrated Circuits

		£
301	DIL	0·50
301	TO99	0·55
301	8 PIN DIL	0·46
301A	DIL	0·69
301A	TO99	0·69
301A	8 PIN DIL	0·66
307	DIL	0·69
307	TO99	0·69
307	8 PIN DIL	0·66
308	TO99	6·45
308A	TO99	6·40
709c	DIL	0·35
709c	TO99	0·31
723c	DIL	0·99
723c	TO99	0·95
741c	8 PIN DIL	0·38
741c	14 PIN DIL	0·39
741c	TO99	0·41
747c	DIL	0·46
748c	DIL	0·39
748c	TO99	0·41
ZN414		1·38
MC1310P		3·38

Resistors

¼ watt 5% carbon	1p
½ watt 5% carbon	1p
1 watt 10% carbon	2½p
range 10 ohms to 4·7 megohms	
¼ watt m/o 2%	4p
range 10 ohms to 1 megohms	

MINITRON DIGITAL INDICATOR TYPE 3015F

Read 0-9 and decimals. ONLY £1·65

VEROBOARD

	0·1	0·15
2½ × 3¾	24p	19p
2½ × 5	27p	23p
3¾ × 3¾	27p	23p
3¾ × 5	31p	31p
17 × 2½	82p	63p
17 × 3¾	£1·10	87p
17 × 5 (Plain)		90p
Pin insertion tool	57p	57p
Spot face cutter	46p	46p
Pk 36 Pins	20p	20p

Electrolytic Capacitors

4 VOLT

47µF	6½p
100µF	6½p
200µF	6½p
320µF	6½p
1000µF	13p
4700µF	29p

6·3 VOLT

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

10 VOLT

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

16 VOLT

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

25 VOLT

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

40 VOLT

6·8µF	6½p
15µF	6½p
33µF	6½p

40 VOLT

47µF	6½p
68µF	10p
100µF	9p
220µF	11p
470µF	19p
680µF	25p
1000µF	25p
2200µF	44p

63 VOLT

1µF	6½p
2·2µF	6½p
4·7µF	6½p
6·8µF	6½p
10µF	6½p
22µF	6½p
68µF	10p
100µF	11p
150µF	18p
220µF	19p
330µF	22p
470µF	26p
1000µF	44p

VOLUME CONTROLS
Potentiometers

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

CARBON SKELETON PRESETS

Small high quality type (linear only). All valves 100-5 meg ohms.
—1 watt 6p each
—2·5 watt 6½p each

PE RONDO KIT AVAILABLE
S.A.E. for List

SLIDE SWITCH

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

MINIATURE NEON LAMPS

240V or 110V 1–4 5p. 5 plus 4½p each.

Mullard Polyester Capacitors

C280 SERIES

250V P.C. mounting: 0·01µF, 0·015, 0·022 3½p. 0·033, 0·047, 0·068 4p. 0·1 4½p. 0·15, 0·22 5½p. 0·33 7p. 0·47 9½p. 0·68 12p. 1µF 14p. 1·5µF 22p. 2·2µF 27p.

C296 SERIES

400V: 0·001µF, 0·0015, 0·0022, 0·0033, 0·0047 3p. 0·0068, 0·01, 0·015, 0·022, 0·033 3½p. 0·047, 0·068, 0·1 4½p. 0·15 6½p. 0·22 8½p. 0·33 12p. 0·47 14½p.
160V: 0·01µF, 0·015, 0·022, 0·033, 0·047, 0·068 3½p. 0·1 4p. 0·15 4p. 0·1 4½p. 0·15, 0·22 5½p. 0·33 7p. 0·47 9½p. 0·68 12p. 1µF 14½p. 1·5µF 22p. 2·2µF 24p.

£1 BARGAIN PACKS

- £1 10 Silicon *npn* power transistors (2N3055), tested/unmarked.
- £1 30 Plastic FET'S, unmarked/untested. Similar to 2N3819.
- £1 20 TO5 transistors *npn* 2 to 5A, untested/unmarked.
- £1 20 TO18 transistors *pnp* like BC178, BC179, etc., untested/unmarked.
- £1 30 Plastic 2N3055, unmarked/untested. TO220 case.
- £1 10 General purpose, fully tested FET's.
- £1 500 Carbon resistors, ⅛, ¼, 1, 2W.
- £1 100 Electrolytic condensers.
- £1 250 Ceramic Polystyrene, silver mica, etc., condensers.
- £1 250 Polyester, Polycarbonate, paper, etc., condensers.
- £1 25 Potentiometers, assorted.
- £1 250 High Stab. 1%, 2%, 5%, resistors.
- £1 1lb Assorted nuts, bolts, washers, spacers, etc.
- £1 25 Assorted switches, rotary, lever, micro, toggle, etc.
- £1 50 Presets Potentiometers.

Any 5 Packs **£4**. P. & P. 10p for *each* pack.

★ any 5 packs £4 ★

P.P. 10p for *each* Pack.

Transformers

Primary 200-220-240V.

			£	P./P.
MT111	12V	0·5A	1·11	16p
MT111/3	24V	0·25A	1·35	20p
MT71	12V	2A	1·76	22p
MT71/B	24V	1A	1·76	22p
MT18	12V	4A	2·47	36p
MT18/8	24V	2A	2·47	36p

30V transformers

Prim. 200–220–240V. Secondary voltage, 12, 15, 20, 24, 30V or 12–0–12V or 15–0–15V.

		£	P./P.
MT112	0·5A	1·32	22p
MT79	1A	1·80	36p
MT3	2A	2·96	36p
MT20	3A	3·30	42p
MT51	5A	4·84	49p

50V transformers

Prim. 200–220–240V. Secondary voltage, 19, 25, 33, 40, 50V or 25–0–25V.

		£	P./P.
MT102	0·5A	1·76	30p
MT103	1A	2·58	38p
MT105	3A	4·84	52p
MT106	4A	6·02	22p

60V transformers

Prim. 200–220–240V. Secondary voltage, 24, 30, 40, 48, 60V or 24–0–24V or 30–0–30V.

		£	P./P.
MT124AT	0·5A	1·76	38p
MT126AT	1A	2·47	34p
MT127	2	3·90	44p

Miniature transformers

Prim. 220V

			£	P./P.
BT606	100mA	6–0–6V	0·98	15p
BT909	100mA	9–0–9V	0·98	15p
BT12012	100mA	12–0–12V	1·08	15p
BT24024	100mA	24–0–24V	1·95	15p

Semicndctrs.			
AC126	14p	OC36	50p
AC127	16p	OC44	18p
AC128	15p	OC45	10p
AC141K	26p	OC71	11p
AC142K	26p	OC81	12p
AC176	18p	2N706	14p
AC187	24p	2N1131	24p
AC188	24p	2N1132	28p
AC187K	28p	2N2904	20p
AC188K	28p	2N2926	11p
AD149	49p	2N3053	26p
AD161	38p	2N3054	55p
AD162	40p	2N3055	49p
AF114	20p	2N3702	14p
AF115	20p	2N3703	13p
AF116	20p	2N3704	14p
AF117	20p	2N3705	13p
BC107	13p	2N3706	12p
BC108	13p	2N3707	13p
BC109	13p	2N3708	11p
BC147	13p	2N3709	12p
BC148	13p	2N3710	12p
BC149	13p	2N3711	12p
BC182	13p	2N3819	35p
BC183	11p	40361	55p
BC184	14p	40362	55p
BC212	13p	40636	69p
BC213	13p	IN914	8p
BC214	13p	IN916	8p
BD131	68p	IN4001	7p
BD132	90p	IN4002	8p
BF194	16p	IN4003	10p
BF195	17p	IN4004	10p
BF244	27p	IN4006	15p
BFY50	18p	IN4148	6p
BFY51	18p	IN5400	16p
BFY52	17p	IN5401	17p
MP8111	36p	IN5402	19p
OC28	50p	IN5404	24p
		IN5406	28p

Bridge Rect.
1 amp

100V	22p
200V	24p
600V	27p

Thyristors

1 amp

50V	29p
100V	32p
200V	34p
400V	44p

3 amp

50V	39p
100V	44p
200V	48p
400V	66p

5 amp

50V	46p
100V	57p
200V	66p
400V	77p

Triacs

2 amp

100V	33p
200V	55p
400V	77p

6 amp

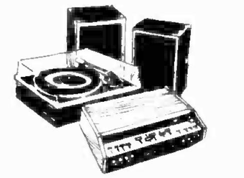
100V	66p
200V	88p
400V	99p

10 amp

100V	99p
200V	£1·32
400V	£1·43

400mW Zener Diodes
3·3 to 33V 11p each

BIG DISCOUNTS



PLUS full 12 months' guarantee and after sales service.

★ All prices INCLUDE VAT.

★ Callers welcome — listen and look at our new retail premises.

Amstrad 4000 Stereo System
Includes IC 4000 amp 12 watt RMS, Hiltone speakers, Garrard SP25 Mk. IV turntable, G800 cartridge. P and C.
R.R.P. £112
Our Price £69·80 (carr £1·50)
or £1·08 weekly for 78 weeks

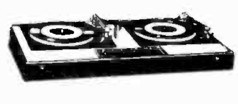
Amstrad 2000 System
Includes IC2000 amp Mk. II 20 watt RMS, Hiltone 20 + 20 speakers, Garrard SP25 Mk. IV turntable, G800 cartridge. P and C.
R.R.P £112
Our Price £84·20 (carr £1·50)
or £1·09 weekly for 104 weeks

Hiltone 10 + 10 System
Includes Hiltone 10 watt RMS amp, Hiltone speakers, Garrard 2025TC turntable complete cartridge. P and C.
R.R.P. £83
Our Price £54·80 (carr £1·50)
or £1·32 weekly for 52 weeks

Hiltone 20 + 20 System
Includes Hiltone 20 watt RMS amp, Hiltone speakers, SP25 Mk. IV turntable, G800 cartridge. P and C.
R.R.P. £104
Our Price £79·60 (carr £1·80)
or £1·03 weekly for 104 weeks

Hiltone TA100 Systems
Hiltone 10 watt tuner amp, Hiltone speakers. Garrard 2025TC turntable with cartridge and P and C.
R.R.P. £114
Our Price £84·50 (carr £1·80)
or £1·21 weekly for 52 weeks

TRANNIES DISCO UNIT



Includes

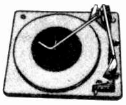
- ★ DJ 100 watt discotheque amp with full mixing and PFL facilities. **£90·75**
- ★ Stereo headphones with boom microphone. **£9·90**
- ★ Trannies Disco Console—with 2 Garrard SP25 Mk. IV turntables with G850 cartridges. **£57·50**
- ★ Pair 50 watt speakers. **£48**

or Complete System **£182·50** carr £3
★ terms £2·38 weekly over two years (total £225) ★

We stock a full range of Disco Equipment. Send for list or pay us a visit.

ALL OUR PRICES INCLUDE V.A.T.

BSR HI-FI AUTOCHANGER
STEREO & MONO

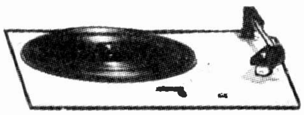


Plays 12", 10" or 7" records. Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. AC 200/250V. Size 13¾ × 11¼in. Above motor board 3⅞in. Below motor board 2½in.

with STEREO and MONO XTAL **£6·75** Post 25p.

PORTABLE PLAYER CABINET
Modern design. Black rexine covered. Silver front grille. Padded Lid. Chrome fittings. Size 17in × 15in × 7in. Few only in red rexine. Motor board cut for BSR deck **£4·50** Post 25p

4 Transistor Mono Amplifier
Powerful 3 watt output, 15 ohm. AC mains operated with transformer. 3-Controls, volume, treble, bass and On/Off switch with knobs. Ready made on printed circuit board. Fused inputs and outputs. Famous make. Size 8in wide × 4in deep × 3in high. Suitable 7in × 4in speaker, £1. **£5·95** Post 25p



R.C.S. DISCO DECK
SINGLE RECORD PLAYER
Fitted with auto stop. Acos stereo/mono cartridge. Baseplate. Size 11in × 8½in. Turntable. Size 7in diameter. A/C mains. 200 250V motor has a separate winding 14 volt to power a small amplifier.

£5·50 Post 25p

METAL PLINTH AND PLASTIC COVER
Cut out for most Garrard or B.S.R. Most will play with cover in position. 12¼ × 14¾ × 7½in. Covered in black leatherette. **£4·95** Post 45p

ALSO AVAILABLE IN SOLID NATURAL MAHOGANY WAX POLISHED FINISH—£5·95

COMPACT PORTABLE STEREO HI-FI
Two full size loudspeakers 13¾ × 10 × 3½in. Player unit clips to loudspeakers making it extremely compact, overall size only 13¾ × 10 × 8½in., 3 watts per channel, plays all records 33 r.p.m., 45 r.p.m. Separate volume and tone controls. 240V AC Mains.

Attractive Teak finish Weight 13 lb. Bargain Price **£25** 85p Carriage

SPECIAL OFFER!
SMITH'S CLOCKWORK 15 AMP TIME SWITCH 0 TO 60 MINUTES

Single pole two-way Surface mounting with fixing screws. Will replace existing wall switch to give light for return home, garage, automatic anti-burglar lights, etc. Variable knob. Turn on or off at full or intermediate settings. Fully insulated. Makers' last list price £4·50. Brand new and fully guaranteed.

OUR PRICE **£1·65** Post 25p

BLANK ALUMINIUM CHASSIS. 18 s.w.g. 2½in sides 6 × 4in 45p; 8 × 6in 53p; 10 × 7in 65p; 12 × 8in 85p; 14 × 9in 90p; 16 × 6in 90p; 12 × 3in 50p; 16 × 10in £1.
ALUMINIUM BOXES 3 × 3 × 3in 60p; 4 × 4 × 4in 70p; 6 × 4 × 4in 80p; 9 × 4 × 4in £1; 12 × 4 × 4in £1·30.
ALUMINIUM PANELS 18 s.w.g. 6 × 4in 12p; 8 × 6 in 19p; 14 × 3in 20p; 10 × 7in 24p; 12 × 5in 25p; 12 × 8in 34p; 16 × 6in 34p; 14 × 9in 40p; 12 × 12in 47p; 16 × 10in 60p.
PAXOLIN PANEL 10 × 8in 20p.
1¼ inch DIAMETER WAVECHANGE SWITCHES, 30p ea. 2 p. 2-way, or 2 p. 6-way, or 3 p. 4-way. 1 p.1. 2-way, or 4 p. 2-way, or 4 p. 3-way.
TOGGLE SWITCHES, sp. 14p; dp. 22p; dp. dt. 25p. Sub-miniature, sp. 33p; dp. dt. 50p.

BRITISH FM/VHF TUNING HEART
88 to 108 Mc/s British made. 2 Transistors ready aligned —requires 10·7 Mc/s I.F. Complete with tuning gang. Connections supplied but some technical experience essential. Our price **£3·95** Post 20p

R.C.S. STABILISED POWER PACK KITS
All parts and instructions with Zener Diode, Printed Circuit, Bridge Rectifiers and Double Wound Mains Transformer input 200/240V a.c. Output voltages available 6 or 9 or 12 or 15 or 18 or 20V d.c. at 100mA or less. PLEASE STATE VOLTAGE REQUIRED. Details S.A.E. Size 3½ × 1½ × 1¼in. **£2·20** Post 20p

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER BRITISH MADE
Ideal for Mike, Tape, P.U., Guitar, etc. Can be used with Battery 9-12V or H.T. line 200-300V d.c. operation. Size: 1¾ x 1¼ x ¾ in. Response 25 c/s to 25 kc/s. 26 dB gain. For use with valve or transistor equipment. Full instructions supplied. Details S.A.E. **99p** Post 10p

NEW TUBULAR ELECTROLYTICS				CAN TYPES	
2/350V	14p	250/25V	14p	50+50/300V	50p
4/350V	14p	500/25V	20p	60+100/350V	85p
8/450V	18p	1000/25V	35p	32+32/250V	20p
16/450V	22p	1000/50V	47p	32+32/450V	60p
32/500V	50p	8+8/450V	22p	350+50/325V	55p
25/25V	10p	8+16/450V	25p	16+16+16/275V	45p
50/50V	10p	16+16/450V	40p	32+32+32/350V	65p
100/25V	10p	32+32/350V	40p		

LOW VOLTAGE ELECTROLYTICS. 1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V 10p. 500mF 12V 15p; 25V 20p; 50V 30p. 1000mF 12V 20p; 25V 35p; 50V 47p; 100V 70p. 2000mF 6V 25p; 25V 42p; 50V 57p. 2500mF 50V 62p; 3000mF 25V 47p; 50V 65p. 5000mF 6V 25p; 12V 42p; 25V 75p; 35V 85p; 50V 95p.
CERAMIC 1pF to 0·01mF, 4p. Silver Mica 2 to 5000pF, 4p.
PAPER 350V-0·1 4p; 0·5 13p; 1mF 15p; 2mF 150V 15p. 500V-0·001 to 0·05 4p; 0·1 5p; 0·25 8p; 0·47 25p.
SILVER MICA. Close tolerance 1%. 2·2-500pF 8p; 560-2,200pF 10p; 2,700-5,600pF 20p; 6,800pF-0·01, mfd 30p each.
TWIN GANG. "0-0" 208pF + 176pF, 65p.
Slow motion drive 365pF + 365pF with 25pF + 25pF, 50p; 500pF standard 65p; small 3-gang 500pF £1·60.
SHORT WAVE SINGLE. 10pF, 30p; 25pF, 55p; 50pF, 55p.

SHORT WAVE SINGLE GANG. Precision Silver Plated Gangable Tuning Condensers. Values up to 100pF. **50p** each. Section Couplers supplied FREE with two or more gangs.

NEON PANEL INDICATORS 250V AC/DC. Amber 20p.
RESISTORS. ¼W, ½W, 1W, 20% 1p; 2W, 5p. 10Ω to 10M.
HIGH STABILITY. ½W 2% 10 ohms to 6 meg., 10p. Ditto 5%. Preferred values 10 ohms to 10 meg., 4p.
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt, 10 ohms to 100K 10p each: 2 watt, 0·5 ohm to 8·2 ohms 10p.
TAPE OSCILLATOR COIL Valve type 35p.
FERRITE ROD 8 × ⅜in 20p; 6 × ⅜in 20p; 3 × ⅜in 10p.

MAINS TRANSFORMERS ALL POST 25p each
Eagle MT12 12-0-12V 50mA 90p
250-0-250 80 mA. 6·3V 3·5A 6·3V 1A or 5V 2A .... £2·50
350-0-350 80 mA 6·3V 3·5A, 6·3V 1A or 5V 2A .... £3·00
300-0-300V 120mA, 6·3V 4A C.T.; 6·3V 2A ...... £4·25
MINIATURE 200V 20mA, 6·3V 1A 2½ × 2½ × 2in 75p
MIDGET 220V 45mA, 6·3V 2A 2¾ × 2¼ × 2in 90p
HEATER TRANS. 6·3V ½ amp 65p, 1½ amp 75p
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs at 2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30V £3·00
1 amp, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 £3·00
2 amp, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 £4·00
5 amp, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 £9·75
3 amp, 5, 8 and 13V £1·00; Ditto 5 amp £1·20. 3 amp, 3, 5, 8, 10, 13 and 5-0-5V £1·30, Ditto 5 amp. £1·50; 6-0-6V 500mA 90p 9V 1 amp 95p 12V 300mA 75p 12V 500mA 85p 12V 750mA 95p. 40V 1 amp £1·75.
AUTO TRANSFORMERS. 115V to 230V or 230V to 115V 150W £2·80; 500W £6·25; 750W £10; 1000W £15
CHARGER TRANSFORMERS. Input 200/250V. for 6 or 12V, 1½ amp £1·50; 2 amp £1·80; 4 amp £2·50
BATTERY CHARGERS. Ready built with leads and clips 1½ amp £2; 4 amp £4; 5 amp. £4·50.
FULL WAVE BRIDGE CHARGER RECTIFIERS: 6 or 12V outputs. 1½ amp 40p; 2 amp 55p; 4 amp 85p.

MAINS ISOLATING TRANSFORMER
Primary 0-110-240V. Secondary 0-240V 3 amps 720 watts. Insulated terminals. Varnish impregnated. Fully enclosed in steel case with fixing feet. Famous make (Value £19) OUR PRICE **£10** Carr. 50p. Can be used as 800 watt auto transformers 240-110V.

SET OF 3 MOTORS FOR COLLARO STUDIO 115 VOLT TAPE DECK
£2·50 Post 50p

VOLUME CONTROLS
Long spindles. Midget Size 5 K. ohms to 2 Meg. LOG or LIN. L/S 15p. D.P. 25p. STEREO L/S 55p. D.P. 75p. Edge 5K. S.P. Transistor 25p.

80 ohm Coax 5p yd.
BRITISH AERIALITE AERAXIAL-AIR SPACED 40 yd £1·40; 60 yd £2. FRINGE LOW LOSS 10p per yd. Ideal 625 and colour.

Wire Wound controls 1¼in diam. 3 Watts. 10 ohms to 100K British Made with long spindles ¼in dia. 45p each.
HELICAL POT 10K LIN. List £3. Bargain 75p.
DUAL CONCENTRIC POT 500K LOG AND 500K LIN D.P. switch. Inner spindle 3¼in; outer spindle 2¼in 75p.

E.M.I. 13½ × 8in. SPEAKER SALE!

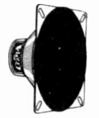
With twin tweeters. And crossover. 10 watt. State 3 or 8 or 15 ohm. As illustrated. **£4·50** Post 25p

With flared tweeter cone and ceramic magnet. 10 watt. Bass res. 45-60 c/s. Flux 10,000 gauss. State 3 or 8 or 15 ohm. **£2·75** Post 25p

Bookshelf Cabinet
16 × 10 × 9in. Teak finish **£6·60** Post 35p

E.M.I. 6½in. HI-FI WOOFER

8 ohm. 10W. Large ceramic magnet. Special Rubber cone surround. Frequency response 30-12,000 c/s. Ideal P.A. Columns. Hi-Fi Enclosure Systems, etc. **£4**
Suitable Cabinet 12 × 8 × 6 £4 Suitable Tweeter £2



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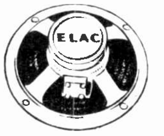

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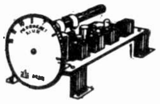

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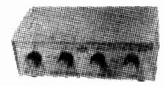

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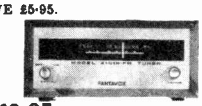

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13/16″, 7/8″	99p	Key "C" for above	13p
Key "A" for above	6p	2 5/8″	£4·50
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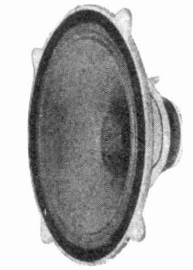

An inexpensive unit for the beginner in high fidelity and for general purposes. May be used to improve any Radio, Amplifier, Hi-Fi or Television receiver.

Bass Resonance	45cps
Flux Density	12,000 gauss
Useful response	45–13,000cps

3 or 8 or 15 ohm models.

£8·80 Post Free

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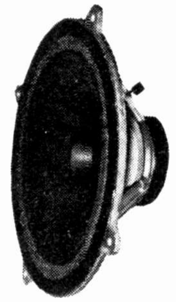
12in. 15 watts



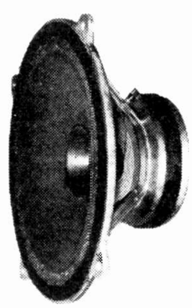
Especially designed to provide full range reproduction at an economical cost. Suitable for use with any high fidelity system. Built-in concentric tweeter cone.

Bass Resonance	30cps
Flux Density	14,000 gauss
Useful response	25–16,000cps

8 or 15 ohms models.

£11 Post Free

SUPERB
12in. 20 watts



A high quality loudspeaker, its remarkable low cone resonance ensures clear reproduction of the deepest bass. Fitted with a special copper drive and concentric tweeter cone resulting in full range reproduction with remarkable efficiency in the upper register.

Bass Resonance	25cps
Flux Density	16,500 gauss
Useful response	20–17,000cps

8 or 15 ohms models.

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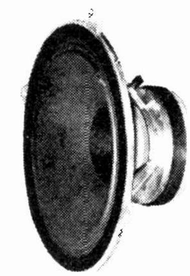
AUDITORIUM
12in. 25 watts



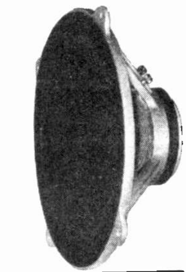
A full range reproducer for high power, Electric Guitars, public address, multi-speaker systems, electric organs, Ideal for Hi-Fi and Discotheques.

Bass Resonance	35cps
Flux Density	15,000 gauss
Useful response	25–16,000cps

8 or 15 ohms models.

£15·40 Post Free

AUDITORIUM
15in 35 watts



A high wattage loudspeaker of exceptional quality with a level response to above 8,000 cps. Ideal for Public Address, Discotheques, Electronic instruments and the home.

Bass Resonance	35cps
Flux Density	15,000 gauss
Useful response	20–14,000cps

8 or 15 ohms models.

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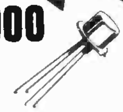

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GROWTH RATE

WHILST economic growth may hold the key to the nation's problems, there is another area of growth which is more directly our concern and perhaps the cause of a little uneasiness among some constructors. We refer to the prevalent pattern of electronic design: a trend towards expansion in circuitry, though not necessarily increased complexity in strictly constructional terms since much of current circuitry is usually accounted for by i.c.'s.

We sympathise with those who view with some apprehension this continuing circuit growth rate. Yet it has to be said that designers must, within reason, be allowed their heads, and the truly exciting progress that has been made in new and ever widening fields during the last decade or so would not have been achieved without an uninhibited approach to devices and circuits.

It also has to be said that cost-effectiveness is a vital matter so far as the majority of constructors is concerned. So we try in our contents to achieve something like a fair balance between the big and the small in constructional projects. As an example, this can be demonstrated very effectively if we take a look into a field which has undergone intensive cultivation by musically orientated designers these last few years.

One of the original roots of the now strongly flourishing creative sound branch of electronics was the pop music world, for it has rapturously seized upon every novel distortion effect the electronic designers could devise, since the earliest solid state days. So we have experienced a rash of effects units some bearing such unashamedly honest descriptive titles as fuzz and wha wha, and others of a more conventional musical character such as tremolo and vibrato.

In the meanwhile, the whole impediment of the audio laboratory has been pressed into service for rather more serious musical purposes, and to the established form of signal generators have been added new breeds of circuits, some designed specifically for the creation of artistic sounds. The synthesiser is the ultimate result of the amalgamation of an assortment of signal generating and processing circuits. So from simple pop effects units to sophisticated synthesiser. A story of electronic expansion and growth that has its parallel in other fields, of course.

Yet entry into the field of creative sound does not depend upon the possession of an expensive and complex instrument, desirable though this might be. There are easier ways to make a start. For instance the *Sound Bender* featured on this month's free Design Chart provides an admirable opportunity for anyone to commence experimenting, at no great cost. Use of this uncomplicated unit in conjunction with other simple circuits and with standard items of audio equipment will "open another window" and encourage active exploration of the fascinating possibilities of sound creation and manipulation.

F.E.B.

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Centred around a simply constructed audio modulator, SOUND BENDER is not just a single sound effects unit, but your key to a host of varied sounds

AMONG the many electronic effects featured with modern "sounds" are those obtained by modulation, such as a tremulous wavering, percussive shaping, certain rhythms, machine-like voices, and controlled fading. Modulation is the varying or shaping of one signal by another, as distinct from mixing which merely superimposes signals.

The intention with the Sound Bender described here is to offer a basic unit which can be adapted for use with electronic musical instruments and audio equipment to create a wide range of effects. The modulator will handle input signals in the range 20 to 500 millivolts r.m.s., is powered by a nine volt battery or mains unit, and has a ± 3dB frequency response of 30Hz to 20kHz.

MODULATOR ACTION

The basic unit is an audio modulator whose action is best understood by referring to the block diagram of Fig. 6. The modulator is shown as an envelope shaper, with a continuous sinewave tone on Input 1, and a control pulse on Input 2. The control pulse defines the amplitude and duration of the tone output, and hence the envelope shape.

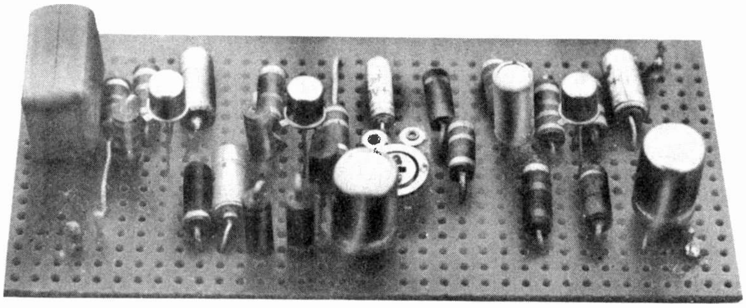
Depending on tone, frequency and waveform, and control pulse attack and decay rates, the resulting output signal can be made to sound like a guitar, double-bass, piano, tympani or bongo, to mention only a few.

With other input signal combinations, the characteristic sound output could be unique or imitative of other kinds of musical instrument.

It will be noticed in Fig. 6 that modulator output amplitude is zero when the voltage on Input 2 is zero. The audio modulator takes advantage of the principle that two signals of equal amplitude but opposite phase will cancel to give a null output when mixed.

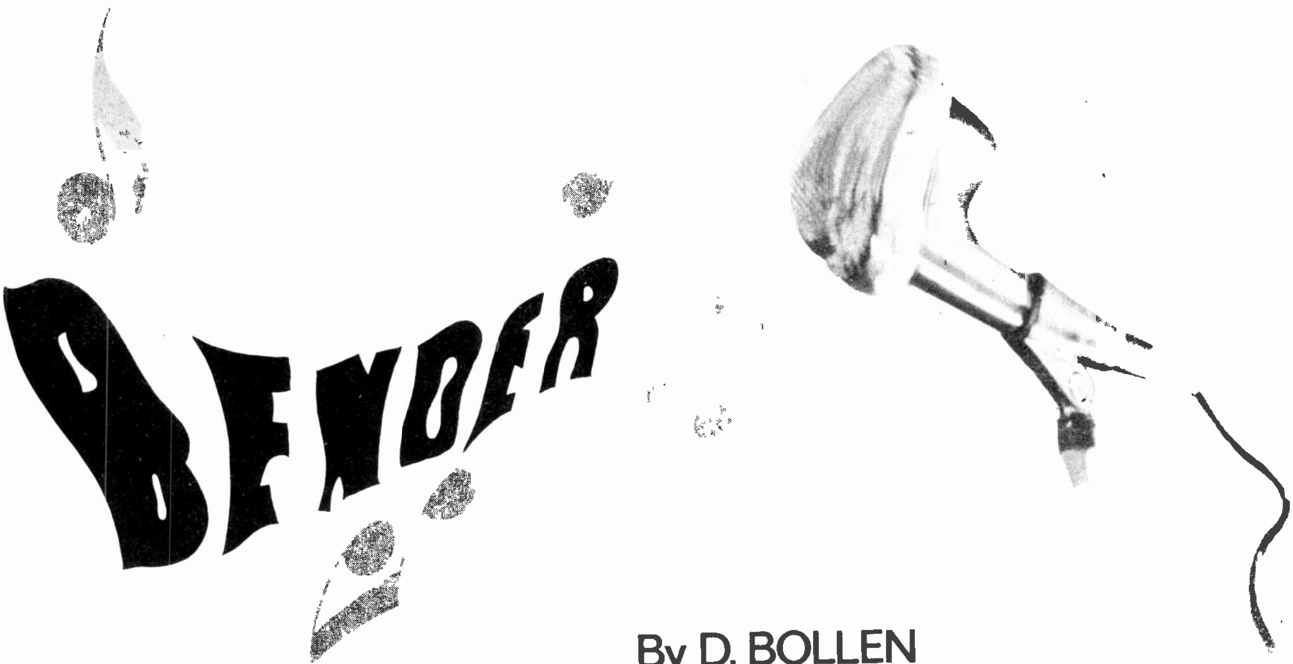
PRINCIPLE OF OPERATION

A simplified circuit of the modulator is shown in Fig. 1. The signal to be modulated (Input 1) is fed



Photograph of the completed audio modulator

ALL DIAGRAMS APPEAR ON THE SPECIAL DESIGN CHART INCLUDED WITH THIS ISSUE



By D. BOLLEN

to a phase splitter stage which gives a pair of output signals (A and B) of similar amplitude and opposite phase.

Signal A is passed straight to the mixer after undergoing a fixed attenuation by R_A, while signal B is given a similar attenuation by the potential divider formed by R_B and the source-drain resistance of a field effect transistor TRA. A voltage on the gate of TRA will vary the source-drain resistance and hence the degree of attenuation given to signal B.

If the A and B signals are of equal amplitude at the mixer input when TRA has a zero gate voltage, then any subsequent change of gate voltage, positive or negative, will give a proportional increase of output from the mixer. It is also possible to adjust the modulator for, say, half maximum output when the voltage on TRA gate is zero, then the output amplitude will be increased and decreased by positive and negative gate voltages respectively.

CIRCUIT DESCRIPTION

In the complete circuit of the modulator Fig. 2, transistors TR1 and TR2 function as a long-tailed pair phase splitter. An input signal applied to TR1 base via R1 and C1 will give rise to a pair of output signals of opposite phase at the collectors of TR1 and TR2. R7 then attenuates the signal from TR2 collector while R8 and TR3 give a variable attenuation to the signal from TR1. Both signals are mixed and amplified by TR4.

With no voltage or signal on Input 2, TR3 gate is held at earth potential by R9, and the source-drain resistance of TR3 is set by a positive bias of about 2 volts applied by way of R11 and VR1 to the source of TR3. This arrangement allows direct coupling to Input 2, and modulation by very slow waveforms, such as ramps and squarewaves of many seconds duration.

In the Fig. 2 circuit, C6 offers a low impedance path to a.c. signals across source resistor R12. Modulator input impedances are approximately 33 kilohms for Input 1 and 1 megohm for Input 2.

MODULATOR CONSTRUCTION AND TESTING

Modulator components may be assembled on a piece of 0·1in matrix Veroboard 36 holes long by 18 holes wide. Cut the Veroboard to size, break the copper strips with a spot face cutter at the locations shown in Fig. 3, and solder the six terminal pins in position.

When soldering components to the circuit board, use a small soldering iron and take care not to bridge adjacent copper strips with blobs of solder. A useful tip is to run a sharp knife along the gaps between strips to break any stray whisps of solder, and to remove surplus flux.

Check that electrolytic capacitor polarities are as shown in Fig. 3, and that transistor leads are correctly orientated.

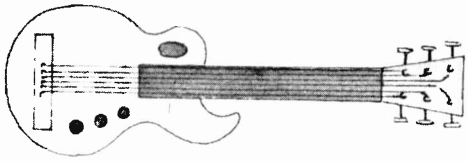
The following checks can be carried out with a testmeter when the completed modulator is connected to a nine volt battery. Approximate voltages relative to battery negative: TR1 can 5V; TR3 source with VR1 slider set mid-way 1·5V; and TR4 can 5V. Current consumption should be in the region of 17mA.

If there is a serious discrepancy in any of the above test voltages, check for incorrect component location, short circuits, or dry joints.

SOUND BENDER
DESIGN CHART FEATURE

Now test the modulator with a music or tone signal of about 200mV r.m.s. applied to Input 1, and the modulator output connected to the tape or tuner input of an audio amplifier. The signal should be heard loud and clear with VR1 set to mid-track.

Rotate VR1 slider clockwise and trim carefully for a null in sound output. In practice, the modulator will not completely suppress the audio signal at null point and a faint sound will still be heard. Having obtained a null, it should now be possible to bring up the sound output to full strength by applying approximately +0·5V d.c. to Input 2; derived from a 1·5V battery with a 2·2 megohm resistor in series with the positive battery terminal.



TREMOLO UNIT

Tremolo is a smooth and regular variation of sound amplitude produced by a very low frequency modulation, often heard with individual musical instruments, but also capable of being applied overall to the total sound output of a group or orchestra. In addition, voices can be made to sound interestingly "nervous" by the judicous application of tremolo. The musical term "rate" is used to denote tremolo modulation frequency, and "depth" the level of modulation applied.

Block diagram Fig. 4 shows a typical tremolo set-up, where a signal is modulated by the output from a very low frequency sinewave oscillator, before being fed to a power amplifier and loudspeaker. The signal source in Fig. 4 could be a guitar pick-up, a microphone pre-amplifier, or a tape recorder.

The design of a variable rate low frequency tremolo oscillator is not as straightforward as it might seem. Conventional methods of controlling oscillator amplitude (i.e. thermistor or filament lamp) tend to cause serious amplitude "bounce" at low frequencies, and this can take several seconds to die down.

A bounce-free performance can be achieved, however, at the expense of some waveform distortion, by applying "soft" diode limiting to the oscillator. Fortunately, distortion is of secondary importance with tremolo modulation, and something approximating to a sinewave shape will suffice.

TREMOLO OSCILLATOR

A suggested circuit for a tremolo oscillator is shown in Fig. 5, which employs a Wein network (C1, C2, VR1, R1 and R2) with diode amplitude limiting introduced between C2 and VR1a.

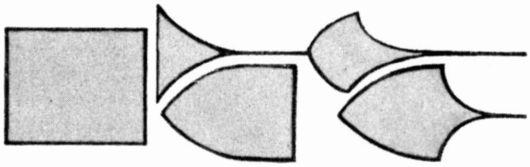
With the combined gain of TR1 and TR2 held down to about five by the ratio of R4 and R5 values, positive feedback is applied from the collector of TR2 to the gate of TR1 via one arm of the Wein network.

There is sufficient loop gain to ensure reliable oscillation over the full frequency range without excessive waveform distortion.

Ganged potentiometer VR1a and b in Fig. 5 gives an approximate frequency coverage of 1 to 20Hz, and maximum oscillator output is in the region of 400mV r.m.s. VR2 should be adjusted for six volts between the can of TR2 and the common rail. Capacitors C1 and C2 can be of moulded polyester type.

When setting up the tremolo oscillator and modulator, with a signal on modulator Input 1, VR1 in the modulator is first adjusted for an output null with oscillator depth control VR3 at minimum output, then modulator VR1 is rotated clockwise with VR3 at maximum for an undistorted signal with full depth tremolo.

Thereafter, no further adjustments to the modulator will be necessary. Various signals can now be applied to modulator Input 1 and the result of varying rate and depth controls noted.



ENVELOPE SHAPING

Envelope shaping is a very fruitful source of sound effects, and this has been touched upon briefly in connection with Fig. 6. A music or voice signal applied to modulator Input 1 can be chopped and shaped to create interesting percussive rhythms and notes which seem to be unrelated to the original sound. Alternatively, musical instruments can be imitated electronically with an envelope shaper by careful choice of control pulse shape and tone waveform.

Obviously, the need here is for a simple and flexible control pulse generator which can be coupled to the modulator to achieve a variety of envelope shaping requirements.

CONTROL PULSE GENERATOR

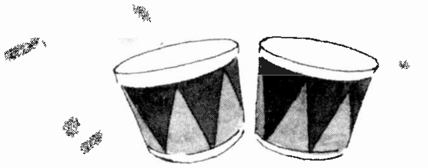
The suggested control pulse generator circuit of Fig. 7 will offer variable attack and decay of pulses of 20 milliseconds to one second duration at repetition rates of 1 to 25Hz.

With S2 in the REPEAT position, C2 charges through VR1 and R2, and discharges through VR2 and R3 when the unijunction TR1 conducts. The cycle then repeats. TR2 is switched off during capacitor discharge.

In the MANUAL mode, single-shot operation can be initiated by pressing the key switch (or one of several keyboard switches wired in parallel) and a tone on Input 1 of the modulator will then be sustained for as long as the key remains closed and will decay after the key is released.

If the pulse generator is to be used only for MANUAL operation, R1, TR1, and VR1 may be omitted from circuit, with R2 wired straight to the positive supply rail.

The basic envelope shapes given by the control pulse generator and modulator are listed A to E in Fig. 7. Other shapes can be generated by adjusting the modulator preset VR1.

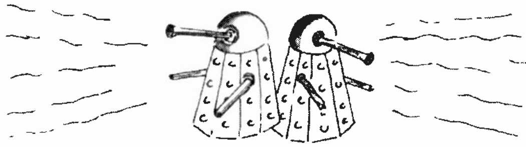


RHYTHM GENERATOR

A novel rhythm generator can be made by combining the tremolo and envelope shaper units as shown in Fig. 8. Unlike standard "dance" rhythm generators based on switching circuits, which provide pre-determined beat patterns, the principle here is to allow two independent modulating frequencies to interact and give a slowly changing relationship of amplitudes and intervals. The result can be "jungle drum" rhythms of great subtlety and variety.

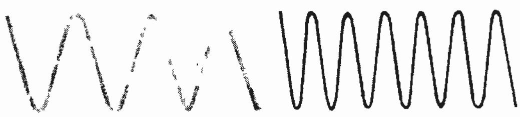
Looking at Fig. 8, a steady tone input applied to the tremolo stage is modulated by the sinewave output from the tremolo oscillator; this yields a tone of varying amplitude which is then applied to the input of the shaper stage.

The control pulse generator "chops" the tone and imparts to it a percussive envelope shape (A in Fig. 7). Tone frequency and waveform will determine the pitch and character of the drum sound, while the relative frequencies of tremolo oscillator and pulse generator will establish the rhythm.



AUDIO RING MODULATOR

The audio modulator can be converted into a ring modulator quite simply by nulling a music or voice signal on Input 1, and applying a tone signal from an audio oscillator to Input 2, see Fig. 9. Depending on the frequency of the tone, voices are made to sound like "Daleks" or are unintelligibly scrambled, while music is invested with a bell like or warbling quality. For best results, the signals on both modulator inputs should be kept below 100mV.

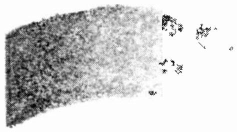


FREQUENCY DOUBLER

Fig. 10 shows the audio modulator employed as a frequency doubler. The modulator is first adjusted for a null output, then Input 2 is connected to Input 1 in series with a 0·1μF capacitor.

Frequency doubling is of limited usefulness with complex audio signals because the ear interprets a strong second harmonic signal as severe distortion, but a small amount of frequency doubled signal could be mixed back in to achieve a deliberate discordancy.

The case is somewhat different, however, with tone signals lacking in character. For example, if the doubler is added to a simple electronic organ, and adjusted for a partial null, the sound output could be made more interesting. Guitar notes might also benefit from the addition of some second harmonic content.



AUTOMATIC FADER

A smooth fade up or down, without clicks or scratching noises, gives a professional touch to amateur recordings and home disco sessions. With a few extra components, the audio modulator can be converted into a switch operated fader, with fade up times of 0 to 15 seconds, and fade down times of 0 to 30 seconds, see Fig. 11.

The modulator is adjusted for a null output with S1 held in the FADE DOWN position. When S1 is switched to FADE UP, C1 slowly charges to nine volts via VR1, and a proportion of the capacitor voltage, appearing at the junction of R1 and R2, is applied to Input 2 to increase the output level from the modulator.

For FADE DOWN, C1 slowly discharges through VR2 and returns the modulator output to its original null level.

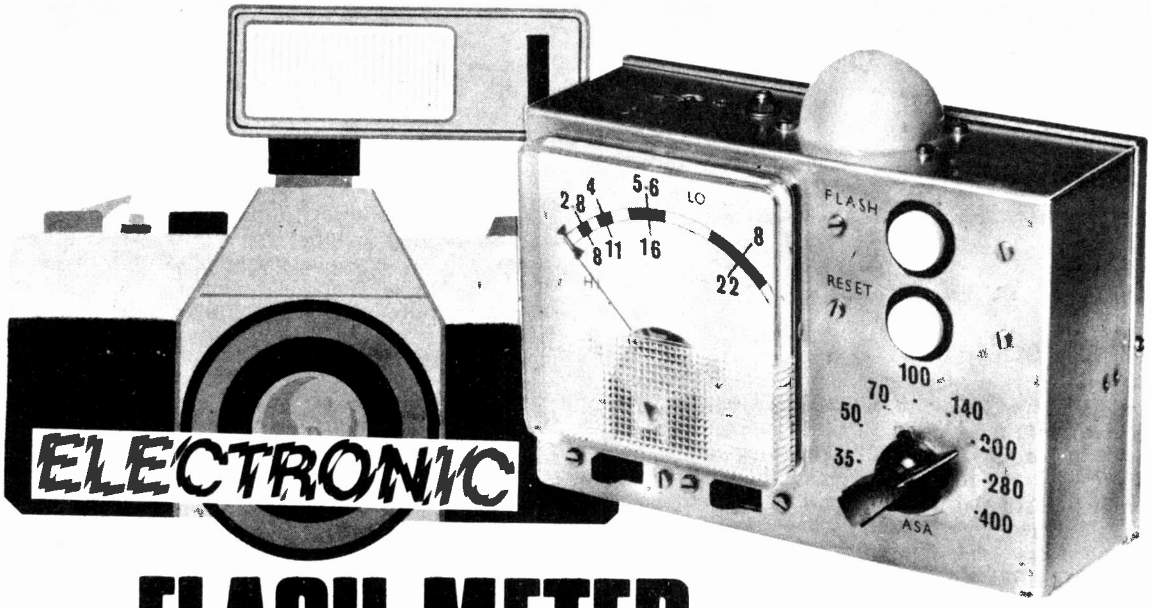
VOICE OPERATED FADER

Voice operated faders are often used by radio disc jockeys to suppress the music signal while talking, this leaves the hands free for cueing discs, and allows bursts of music to punctuate the voice during awkward pauses.

In the circuit of the voice operated fader Fig. 12, the capacitor C2 controlling the voltage on modulator Input 2 is quickly discharged by TR1 at the commencement of a voice signal, thus "killing" the music signal. When the voice ceases, C2 is allowed to charge through R1 and fades up the music in about 1·5 seconds.

TR1 is switched hard on by an intermittent d.c. bias obtained by rectification of the a.c. signal voltage from the microphone pre-amplifier. The fluctuations of base bias are smoothed out by C2. To adjust the fader, VR1 in the modulator is adjusted for a null whilst blowing into the microphone. ★

ELECTRONIC FLASH METER



By J. TUBBY

ELECTRONIC flash equipment is now available to one and all at quite reasonable prices and can be used with almost all types of camera. However, the only information normally available to a user about exposure details is in the form of so-called "guide numbers" which relate the flash unit to particular film speeds and camera-subject distances.

This can provide quite usable black-and-white pictures when using direct flash where the flash and camera both point in the same direction, but is not really ideal for use with colour film, which is much more sensitive to exposure conditions, or with "bounce" flash.

What is needed here is a meter which will measure the value of light produced by the flash under any circumstances and indicate to the user the aperture required for a given film speed.

Commercially available flash or "strobe" meters fulfil this function. However their prices tend to be somewhat high, some simpler ones starting at near £40 and the more sophisticated running into hundreds of pounds.

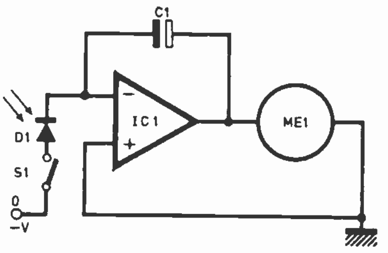


Fig. 1. The basic circuit concept of the flash meter

The present design evolved from a critical need for something to fulfill the strobe meter function as reasonably as possible. There are probably ways in which the circuit could be made more sophisticated but when calibrated the present equipment, can be accurate to within less than half a stop in measuring incident light. This is more than satisfactory for use with colour reversal film. The component cost should be in the region of £14-£16.

PRINCIPLE OF OPERATION

The circuit use three 741 operational amplifiers as main active components. These amplifiers were developed for use in analogue computers and the meter is in fact just such a computer. Fig. 1 shows, in block form, the heart of the unit.

Capacitor C1 is connected to the operational amplifier IC1 to form an operational integrator. In such an arrangement current flowing from the inverting (-) pin of the amplifier induces a voltage across the capacitor that is proportional to the total current flow in relation to time. When the flow of current is stopped the capacitor will retain its charge, and hence the voltage across it, for some considerable time.

The output of the integrator will now be a positive voltage which provokes a steady current to flow through the meter ME1. The reading on the face of this meter will be an analogue integral of the current flow from the inverting terminal of the amplifier for the duration of that flow.

Diode D1 is a silicon photodiode (reverse biased) that allows a reverse current to flow through it in proportion to the level of light falling upon its sensitive junction area at any instant in time. Being a silicon diode its normal reverse leakage is infinitesimal and can be ignored.

Switch S1 is included in the circuit since we are only interested in a pulse of current flowing as a result of a flash discharge acting on D1. S1 is

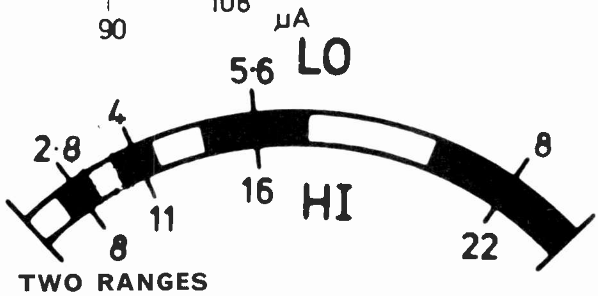


Fig. 3. A linear (above) and a curved (right) scale for the display meter. The lower figures are the actual scale values in microamps on a 100μA meter

normally open, closes at the commencement of, or slightly before, the flash discharge and re-opens again soon afterwards thereby isolating the integrator from any current flow produced as a result of ambient light striking D1.

CIRCUIT DETAILS

Fig. 2 shows the full circuit in block form. Here the integrator is formed by amplifier IC3 and the isolating switch (S1 of Fig. 1) is a transistor, TR1, that is normally biased off. TR1 conducts for a brief period dictated by the monostable. The monostable is fired by closing S3 and as well as switching TR1 it also triggers the thyristor, CSR1 which is connected into the trigger circuit of an external flash unit by means of a long synchronising lead. This provides the necessary synchronism with the flash for exposure determination.

The inclusion of amplifiers IC1 and IC2 considerably increases the usefulness and flexibility of the unit. Both operate strictly as amplifiers in this case.

Thus a useful range of apertures in photograhy could be considered to be those from f2·8 down to f22. Each f-stop is equivalent to a change in light level by a factor of two and in the range just mentioned there are six such steps. In practical terms this means that a scene requiring a lens aperture setting of f2·8 is in fact 1/64th as bright as a scene requiring an aperture of f22 for correct exposure of the film. If one tried to display all this range on one scale one would arrive at a very cramped bottom end on a meter display face, a reading of only 1·5% of full scale representing f2·8 and 6% f.s.d. representing f5·6.

TWO RANGES

Amplifier IC1 overcomes this problem by providing two switched gains. The meter face is altered to display two ranges, a high range from f22 down to f8 and a low range from f8 down to f2·8. When the flash pulse is sufficient to use the high range S1 is switched to VR1 but if the light level registered on the meter falls below f8 then S1 is switched to VR2, which is set to increase the gain of the amplifier. This allows the lower light level (obviously of a repeated identical flash) to be displayed well up the scale.

Thus the lowest marking on the scale is as much as 12% of f.s.d. and the half stop divisions are easy to see.

A brief inspection of Fig. 3, which shows two specimens for the face markings, will make the whole thing clear. Resistors VR1 and VR2 are made variable and are adjusted in practice such that a pulse of light producing a reading of f8 on the Low range, i.e. at the top of the scale, will produce, when repeated, a reading of f8 at the bottom of the High range. In this way continuity is assured.

FILM SPEED VARIATION

The flexibility of the instrument is further increased by the inclusion in circuit of amplifier IC2. This has an input resistor R1 and a parallel arrangement of nine switched feed-back resistors, R2 to R10, which control the gain of the amplifier.

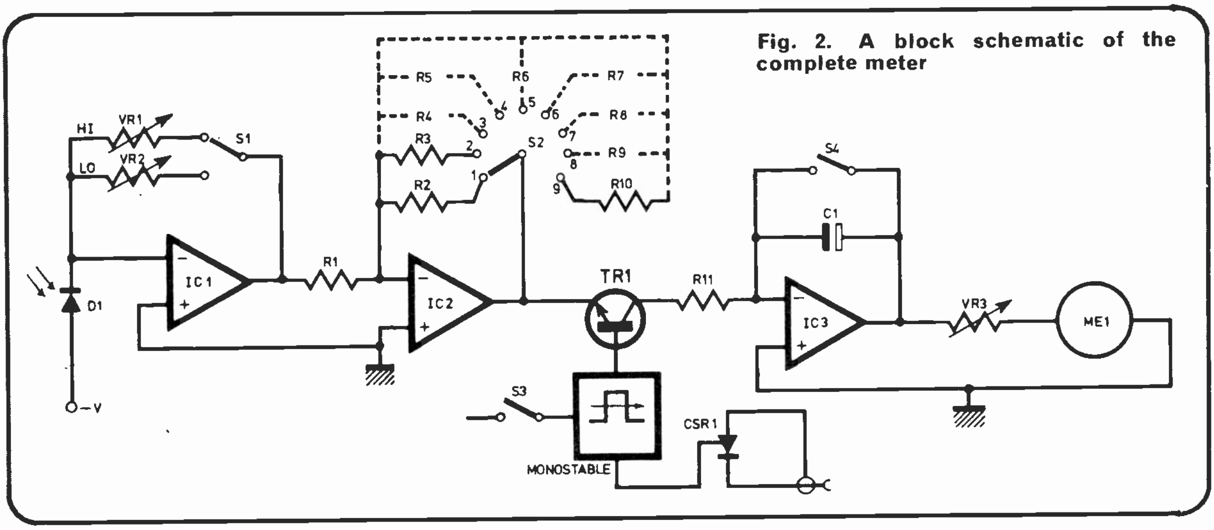


Fig. 2. A block schematic of the complete meter

Any one of these resistors can be selected by the nine-way single-pole rotary switch S2. The function of this amplifier is to process the signal passing from IC1 to the integrator IC3 in such a way that the final analogue display of the aperture required for correct exposure is a function of the sensitivity to light of the particular film in use.

Put more simply, one can set the meter for a particular ASA film-speed and the display will be suitably adjusted.

The relationship of the feed-back resistor values to the input resistor R1 is of course important. If one assumes that R2 = 25 ASA and let it have a value equal to R1 then R10 = 400 ASA and has a value of R1 × 16. So we have a table of relative values as follows:—

R2 : 25 ASA : R1 × 1
R3 : 35 ASA : R1 × 1·4
R4 : 50 ASA : R1 × 2
R5 : 70 ASA : R1 × 2·8
R6 : 100 ASA : R1 × 4
R7 : 140 ASA : R1 × 5·6
R8 : 200 ASA : R1 × 8
R9 : 280 ASA : R1 × 11
R10 : 400 ASA : R1 × 16

This might appear confusing but a short explanation should clear the matter.

Assume, for arguments sake, that you wish to photograph a scene in colour and black and white. In one camera you have Kodachrome (25 ASA) and in another you have Tri-X (400 ASA). Setting the meter for 25 ASA (R2) sets amplifier IC2 in the unity-gain mode. Tripping the flash gives you (let us say) a reading on the low scale of f5·6. If you now set the meter to 400 ASA (R10) amplifier IC2 will be operating with a gain of sixteen (R10 divided by R1 equals 16), and will amplify the through signal from another flash discharge by this amount to give a displayed reading on the high scale of f22. In both cases the correct exposure is indicated for the relevant film.

In Fig. 2, switch S4 acts as a reset control which shorts out any charge on capacitor C1 after a reading has been taken, leaving the circuit ready for a further reading to be made. Variable resistor VR3 allows the scale of meter ME1 to be suitably set during calibration.

THE PRACTICAL CIRCUIT

Fig. 4 shows the full practical circuit. TR1 and TR2 constitute the monostable, the pulse width of which is about 1/60th second determined by C2 and R5. In its quiescent phase the junction of R2, R3 and TR6 base are at positive rail potential and hence TR6 is biased off.

The junction of R6, C2 and TR3 base via R8 are at ground potential so TR3 is also biased off. The monostable is triggered by closing S2 thus raising TR1 base to the positive potential on C1 and thereby turning TR1 off.

The system now changes state. TR6 base goes to ground allowing it to pass current via R24 to the base of TR5, to bias TR5 on for the duration of the pulse. TR5 acts as the isolating switch for IC3

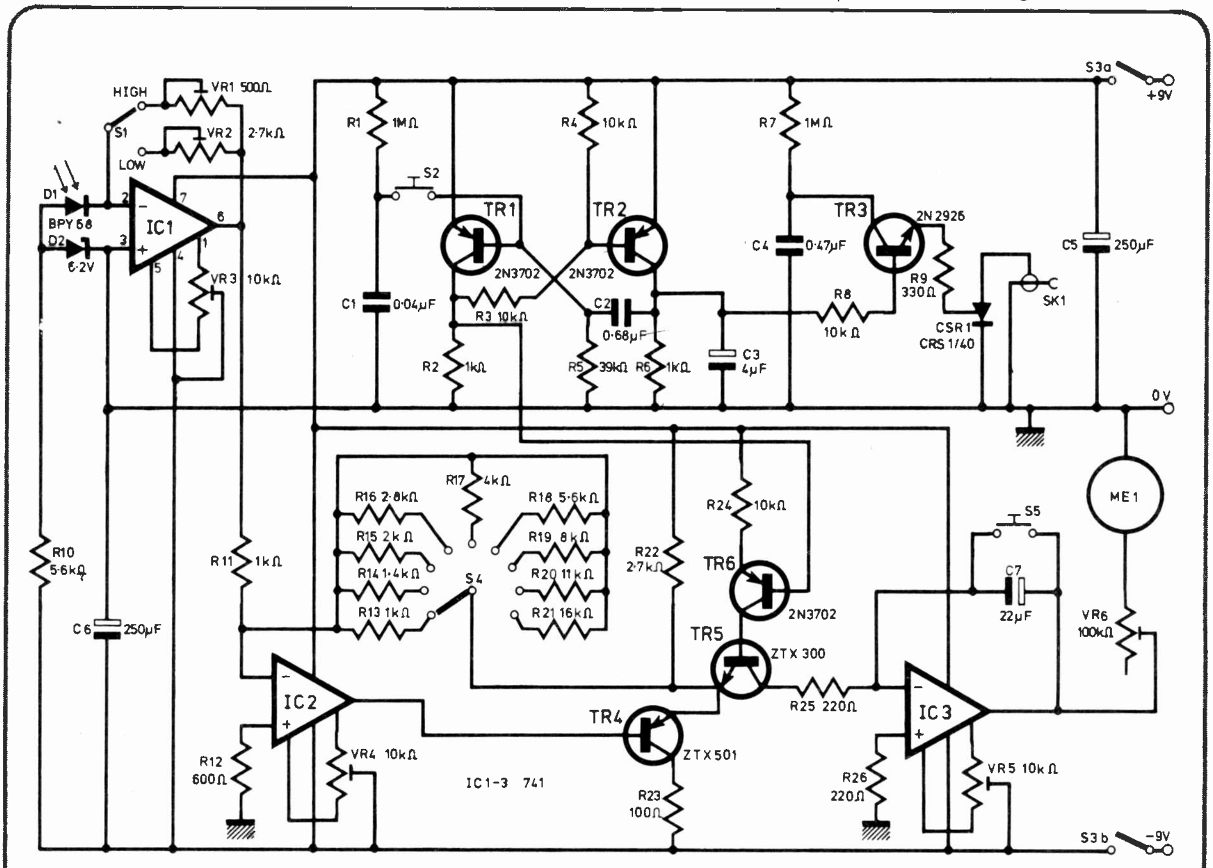


Fig. 4. Full circuit diagram of the flash meter

and allows it to "see" the light sensing circuit for this short time.

Also during this active phase the potential at the junction of R6 and C2 rises to the positive rail. This has the effect of throwing TR3 into a state of conduction and allowing C4 to discharge rapidly through R9 and the thyristor CSR1. This pulse of current triggers the thyristor into conduction which in its turn completes the flash-unit trigger-circuit and the flash discharges immediately.

COMPONENTS . . .

Resistors

R1	1MΩ	R14	1·4kΩ* (1kΩ | 390Ω)
R2	1kΩ	R15	2kΩ*
R3	10kΩ	R16	2·8kΩ*
R4	10kΩ	R17	4kΩ* (3·9kΩ selected)
R5	39kΩ	R18	5·6kΩ*
R6	1kΩ	R19	8kΩ* (2 3·9kΩ selected)
R7	1MΩ	R20	11kΩ* (2 5·6kΩ selected)
R8	10kΩ	R21	16kΩ* (2 8·2kΩ selected)
R9	330Ω	R22	2·7kΩ
R10	5·6kΩ	R23	100Ω $\frac{1}{2}$W
R11	1kΩ*	R24	10kΩ
R12	600Ω	R25	220Ω
R13	1kΩ*	R26	220Ω

All $\frac{1}{8}$W, 10% except where marked * which are 5%

Potentiometers

VR1 500Ω skeleton preset
VR2 2·7kΩ skeleton preset
VR3 10kΩ skeleton preset
VR4 10kΩ helical precision pot
VR5 10kΩ skeleton preset
VR6 100kΩ skeleton preset

Capacitors

C1 0·04μF
C2 0·68μF, 20V
C3 4μF, 10V electrolytic
C4 0·47μF
C5 250μF, 10V electrolytic
C6 250μF, 10V electrolytic
C7 22μF Tantalum, 16V

Diodes

D1 BPY68 Photodiode (A. Marshall)
D2 6·2V Zener, $\frac{1}{4}$W

Transistors

TR1, 2 and 6 2N3702 (3 off)
TR3 2N2926
TR4 ZTX501
TR5 ZTX300

Integrated Circuits

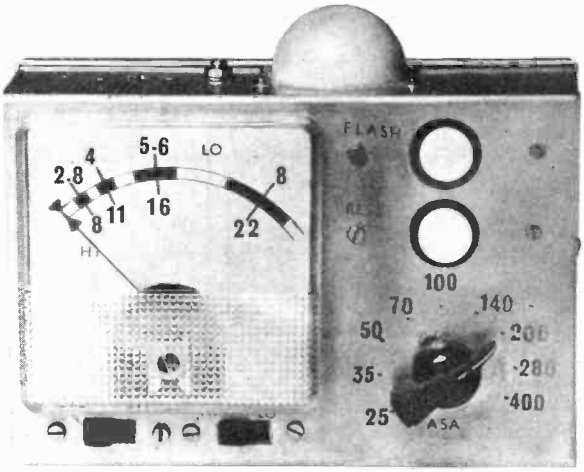
IC1, 2 & 3 741 operational amplifiers (3 off) and 3 i.c. sockets (8-pin)

Switches

S1 SPDT slide
S2 Friedland bell push (modified)
S3 DPST slide
S4 SP 9-way rotary
S5 Friedland bell push (modified)

Miscellaneous

Veroboard, battery connectors (2), batteries, meter (100μA $3\frac{3}{4}$in face), case (aluminium 2in 4in 6in), nuts and bolts, glue, resin, table-tennis ball, camera flash sync socket.



Photograph showing the completed flash meter

The remainder of the circuit is fairly straightforward. D1 is a BPY68 photodiode and has a Zener (D2) stabilised negative voltage across it of 6·2V nominal. The High and Low ranges are selected by switch S1 which is in circuit with the feed-back resistors VR1 and VR2. R11 is the input resistor to IC2 and S4 is the nine-way switch in circuit with the ASA feed-back resistors R13–R21.

TR4 and R22 constitute an emitter-follower connected into the feed-back loop of IC2. The purpose of this is to avoid possible loading of IC2 output and consequent distortion of the through-signal. R23 is a current-limiting resistor in the event of a possible short-circuit of the output to ground.

R25 is the input resistor for IC3. C7 is the integrator charge-storage capacitor which can be discharged by switch S5 thus annulling any meter reading. VR6 is a skeleton preset which limits the current output from the integrator to the 100μA meter. VR3, VR4, VR5 are preset resistors to balance current off-sets in the 741's. C5 and C6 are large electrolytic smoothing capacitors.

C3 is a stabilising capacitor for the monostable. Some electronic flash units produce quite violent voltage irregularities during charging and if the resulting spikes get to the meter circuit this can cause triggering of the monostable. This of course would fire the flash which would be triggered by each following spike in a never-ending cycle. C4 thus acts as an anti-"hiccup" device.

Switch S3 is of the double-pole variety and is inserted in the positive and negative supply rails as at a and b. Power is supplied by two PP3 batteries in series and centre-tapped. They will have virtually shelf-life since the unit in use is usually not kept switched on for more than a half-minute or so at a time.

CONSTRUCTION

Circuit construction is straightforward. A piece of 0·1in matrix Veroboard $3\frac{3}{4}$in × $2\frac{1}{2}$in is used with the copper strips running the length of the board. The practical layout is shown in Fig. 5.

The breaks in the strips should be made first, the i.c. sockets soldered in place, and then the wire links attached. The other components can then be assembled and soldered in as their positioning is more easily determined if this order is adhered to.

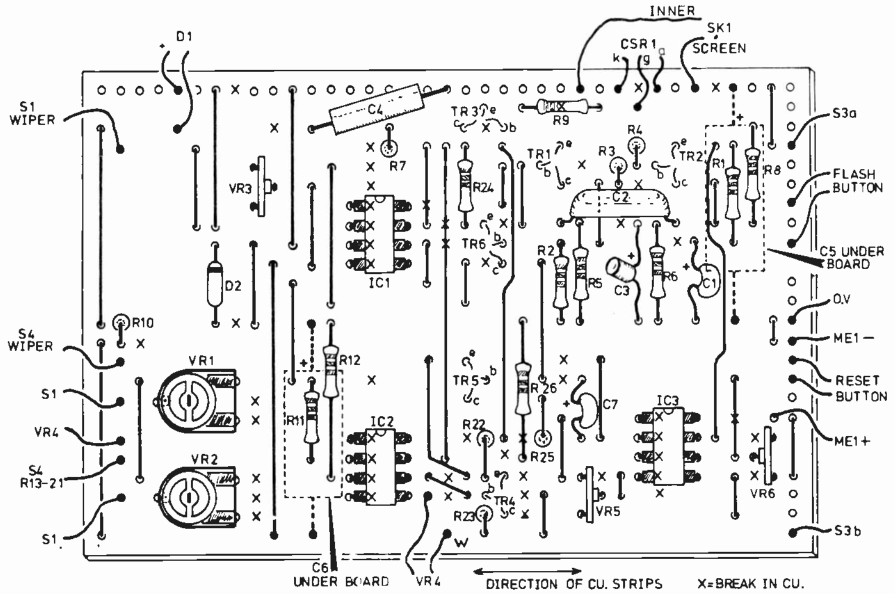


Fig. 5. Veroboard component layout complete with lead details

Solder in C5 and C6 last of all as these lie over other components. D1 should be left on longish leads (⅜in to ½in) to allow it to be angled horizontally above the board in final assembly. This component is a reversible diode so there are no polarity checks to be made before soldering in place. Keep all flying leads of a good length, say 3 inches, pending final assembly.

Resistors R13 to 21 are mounted on the back of swich S4. VR4 is a 10kΩ precision helical preset potentiometer which is mounted on the instrument case so that final calibration adjustments can be made after assembly.

In practice VR1 and VR2 might have to be components of slightly different value. The values quoted are those used in the prototype and were found to give sufficient range of adjustment with the actual diode D1 and light-diffusing dome employed. Similarly a value of 22μF was used for C7 but this is not critical. A capacitor of (say) 4·7μF would be equally suitable: the only difference it would have on circuit characteristics is that it would tend to charge to a correspondingly higher voltage but even so is still unlikely to "saturate" under operating conditions, i.e. ramp as far as supply potential limits.

The prototype unit was housed in an aluminium box measuring 2in deep, with the lid retained by two screws. On the front ("bottom" of the box) were mounted the display meter (a 3¼in square-faced 100μA meter was used for large-scale ease of legibility), the On/Off switch S3, the High/Low switch S1, the Flash and Reset buttons S2 and S5, and the nine-way rotary ASA selection switch S4. The illustrations show the general arrangement and Letraset markings—the latter varnished after application for protection. On the "top", that is the face towards the target area, of the case are mounted the flash co-axial socket, the helical preset potentiometer VR4 and a light-collecting diffusion dome behind which is situated the BPY68 (D1).

The size of case selected is dictated mainly by the size of meter used. Equally, if a smaller meter is used then the size and location of the switches becomes critical. As can be seen from the illustrations, the prototype layout follows current commercial practice with all the controls and the meter on an "upper" face and the light sensitive zone facing away from the operator using the instrument. Of course, a constructor can vary this arrangement to suit his needs and parts availability.

COMPONENT MOUNTING

The mounting of most of the items is straightforward. The co-axial socket SK1 can be taken from a flash extension synchronising lead which can be bought at photographic shops. Use the "male" end and glue it into a wooden or plastic collar about 1in long that has sufficient surplus at either end for mounting bolts to pass through. In the prototype the collar was of plywood and mounted on spacing columns so that the socket terminated just flush with the surface of the case. The socket was inserted into a tight-fit hole through the collar and made fast with Bostik quick-setting epoxy resin. Screened (co-axial) cable was used to connect it to the thyristor CSR1.

The prototype flash and reset buttons were adapted from Friedland bell-pushes. These have a fairly deep "box" moulded onto their bases which were carefully sawn off with a hacksaw so that only a thin platform of plastic (which holds the actual make/break assembly) remained. The sawn-off portion of each switch, that is the parts that normally sleeve the mounting screws, can be saved. These serve as spacing pillars on the front of the switches and allow them to be mounted with bolts so that they lie flush with the surface of the case. The effect is neat. Again, other push or toggle switches may be used if desired.

LIGHT RECEPTOR

An important item that has to be specially adapted for the instrument is a light-collecting diffusion hemisphere. For this the prototype used half a table-tennis ball. This in itself is fragile but it can be strengthened.

Cut a table-tennis ball not quite into halves with a hot knife. Ensure that the larger to be used portion is clean and free from any printed matter. Mix about a teaspoonful of clear epoxy resin with hardener and accelerator (resin such as is used for embedding objects or else the clear resin to be found in fibre-glass repair kits is suitable), and pour this into the ball half.

Roll it around so that it coats the whole of the inside surface of the ball and continue to move it thus as it sets so that it is distributed in an even layer.

Repeat this two or three times so that the resin is built up to a thickness of about ⅛in. Moderate warmth such as is provided by a fan heater will speed setting.

Now take a piece of coarse wet and dry abrasive paper, wet it and place it face-up on a flat surface and press the cut edge of the table-tennis ball gently on the abrasive surface. Steady, circular movements with moderate pressure will soon wear away the resin and the ball itself.

Cease grinding when you have a hemisphere, and the abraded surface is clean and flat. Dry off the hemisphere, varnish the outside surface with a clear varnish and glue it firmly with Bostik over the aperture in the case through which the BPY68 "looks".

The aperture itself should be about 1in diameter. On the inside surface of the case fix one or two layers of translucent diffusing material. This should preferably be plastic and have similar diffusing properties to grease-proof paper. Unfortunately grease-proof or tracing papers are not suitable as they might "yellow" in time and their light-transmitting properties change. The BPY68 should be positioned about ¼in behind this translucent screen and facing towards its centre.

FINAL ASSEMBLY AND SETTING-UP

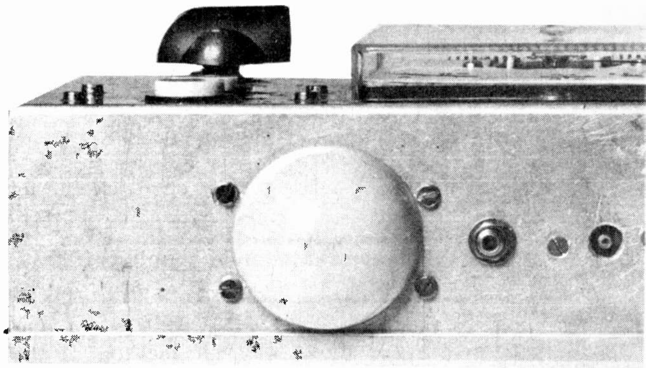
When the circuit has been built and checked and the case completed, the two can be connected together. Take especial care that the flying leads are connected up correctly, that the meter polarity is observed and that the power switch (S3) is off. Connect up the two PP3 batteries and switch on.

Set VR1 to approximately its mid position and select the High range with S1. Working in a low level of light, measure the voltage at the output (pin 6) of IC1. Adjust VR3 until the output is zero with respect to 0V.

Press the Reset button S5 and observe the 100μA meter that serves as the display. The pointer should come to rest at zero but may start to drift up or down the scale. Adjust VR5 until the drift over a period of 10 to 15 seconds is negligible.

Place the back on the case temporarily, press the Reset button in order to zero the pointer again, select 400 ASA with S4 and give the Flash button S2 a jab, do not hold it down. The pointer will probably jump up or down the scale and hold a new position. Reset, adjust VR4 and repeat.

Continue this procedure until pressing the Flash button causes the pointer to move not more than 1 or 2 micro-amp divisions in either direction—ideally it should not move at all. This completes the preliminary setting up of the equipment and the time has come to calibrate it.



Photograph showing light-collecting diffusion dome

THE METER-FACE

First the meter-face must be adapted. Remove the front cover and *carefully* move the upper scale and stop wire across to the right so that if the pointer were to swing across against the stop it would be indicating about 115μA. Next undo and remove the small bolts that hold the meter face in position and carefully slide it up and away.

Do not lift it until it is well clear of the pointer as otherwise the meter bearings might be damaged if the pointer is snagged. A new set of characters can now be drawn on a sheet of white paper, using a tracing of the original meter face as a guide and glued accurately in position on the meter face-plate. This is now slid back into position, secured with its bolts and the meter cover replaced.

It must be emphasised that care should be taken in this in fact comparatively simple but rather delicate operation.

The actual calibration of the meter might seem somewhat hit-and-miss, relying initially on the guide number system (the very system we are trying to supersede); however it is quite satisfactory to start with and small adjustments can be made later.

CALIBRATION

Set up an electronic flash unit and position the flash meter, with the hemisphere pointing towards the flash, at such a distance (computed from the guide number) that an exposure of f8 using 400 ASA film will be correct. Set VR6 to roughly mid-position. Set the ASA to 400 and connect up the meter to the flash-gun via a long trailing extension sync-lead.

Switch on and press the flash button. If the flash-gun does not fire reverse the polarity of the sync-lead (the thyristor is polarity conscious). The easiest way is by using a two-pin connector in the sync lead line.

Reset, switch to the Low scale and press the Flash button again. Adjust VR2 until the pointer comes to rest at f8 on the top end of the scale, the adjustments being made between flashes.

If, regardless of high VR2 settings, the pointer does not swing as high as f8 but consistently comes to rest somewhat lower on the scale then do not

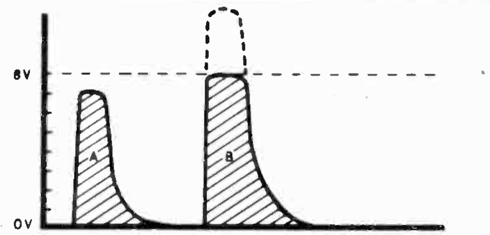


Fig. 6. Graphic representation of clipping of the pulse

reset and in fact reduce the value of VR6 so that the pointer tries to move well off the top of the scale. That is to say it is seated firmly against the end stop.

Now reset and continue flashing and adjusting VR2 as before until the pointer comes to rest centrally on f8 at the top of the scale.

CLIPPING

When this has been achieved switch to 200 ASA, reset and flash again. Check that the pointer stops at f5·6. If it does not and comes to rest higher than f5·6 it means that the signal at the output of IC2 is being clipped to the rail potential at the higher ASA settings. In Fig. 6 "A" represents the optimum pulse characteristics whereas "B" shows clipping of the signal.

If clipping does occur then first reset and reduce the effective resistance of VR6 slightly. Now switch back to 400 ASA and adjust VR2 so that once again a flash gives the correct reading of f8.

When this has been achieved again reset, switch to 200 ASA and confirm that the indicated exposure is f5.6. It might prove necessary to repeat this procedure two or three times to get the relationship correct.

CORRELATION

When it is correct move on to correlating the High scale with the Low scale. To do this, reset, switch to 400 ASA and switch to the High scale. Adjust VR1 between flashes until the pointer comes to rest on f8 at the bottom of the scale.

Finally do all the checks again: zero voltage at pin 6 of 741 (1) (adjustments on VR3), pointer drift over 10 secs (adjustments on VR5), pointer jump when Flash button depressed and flash-gun not connected in circuit (adjustment externally on VR4) and then the calibration checks should be run through as outlined. From time to time as the meter is in use carry out the pointer jumping test and make adjustments to VR4 as necessary. The adjustments should not be very great.

If, after a period of use, the meter seems to be reading slightly high or low then small adjustments should be made to VR6 to compensate. It should not be necessary to adjust VR1 or VR2 since again the correction required will probably be very small.

THE BATTERIES

The two PP3 batteries specified will adequately power the unit for several months provided the unit in use is not left switched on for any great length of time. When the batteres are replaced always fit two fresh ones together: never use one fresh and the other exhausted. ★

NEWS BRIEFS

SOLID-STATE TV CAMERA

What is claimed to be the world's most sensitive solid-state television camera has been developed by engineers at General Electric Company in the USA.

The new camera is light and compact and is capable of taking pictures by the glow of a candle.

The heart of the camera is a quarter-inch square, metal-oxide semiconductor chip. It is covered with 10,000 pairs of miniature capacitors, each pair functioning as an individual light-sensing device. As light strikes the chip each capacitor pair collects a charge proportional to the light striking it. Each pair of capacitors is then addressed by scanning circuits to release the charge into the base of the chip.

The tiny chip does the same job as the tube in a conventional camera.

Potential applications for the camera include use in surveillance systems and eventually it could find its way into consumer electronics, possibly combined with a small video recorder and television set to form a home TV studio.

BRITISH NATIONAL DATA BUOY

A contract to design and develop the Department of Trade and Industry's national data buoy has been awarded to the SEATEK group of companies which includes Hawker Siddeley and EMI Electronics.

Based on the original design by the Institute of Oceanographic Sciences, this 25ft diameter wave-riding buoy is the first large oceanographic and meteorological sensor-carrying buoy devised entirely in Britain.

The buoy will be moored off the Norfolk coast and data will be transmitted via a telemetry link to a shore station at Lowestoft.

The major function of the buoy is to provide a platform for development of advanced sensors to monitor both oceanographic and meteorological parameters. The buoy will also form Britain's contribution towards the proposed European network of data buoys.

OXFORD STREET STORE

The opening in April of a new store in London's Oxford Street marks the integration of two top names in the radio and hi-fi business G. W. Smith & Co. (Radio) Ltd. and Laskys Radio Limited who merged in 1972.

Claimed to be the first of its kind in Europe the store will cover 14,000 sq ft of selling area, have 70 specially trained staff and will be stocked with a wide range of consumer electronic products including audio, tape recorders, television receivers and associated video equipment, in-car equipment and calculators.

There will be fully equipped stereo and 4-channel demonstration rooms and accessory bars where items such as replacement styli, cartridges and record cleaning equipment may be purchased. Other departments stock d.i.y. accessories and records, pre-recorded cassettes, and 8-track cartridges.

This showpiece store is to be the forerunner of a series of hi-fi centres around Britain.

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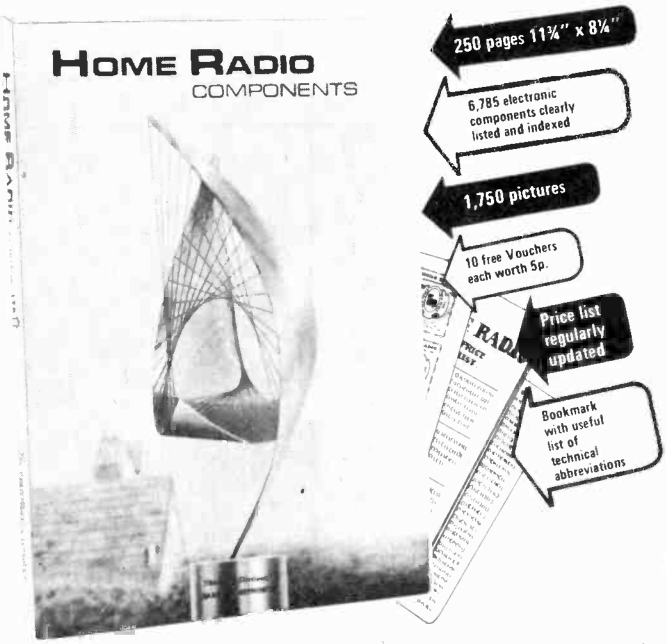

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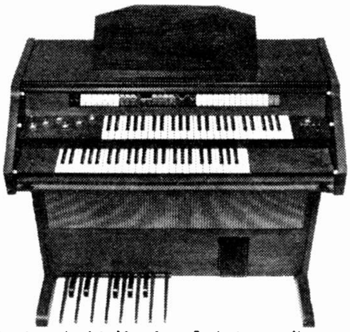

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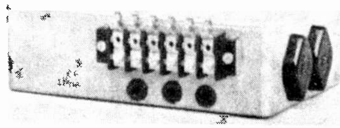

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BY FRANK W. HYDE

ENVIRONMENT AND SPACE

Nearly seventeen years have passed since the first artificial satellite went into orbit and looking back through the literature that has now accumulated it is clear that much new knowledge is now on record. Side by side with space developments there has been much speculation as to how the techniques can be turned to the benefit of the human race.

Not least of these endeavours is the attempt to assess the Earth's resources. At the same time the doom mongers prophesy dire problems of over population, shortage of food supplies while at the same time and almost in the same breath they talk of the decimation of the population from pollution and other hazards.

Since the boundaries are now not merely the Earth but the Solar system it is necessary to readjust thinking of the environment. The Earth is but a part of a composite whole which includes near space, middle space and beyond the Solar system outer space. Much has been learned of the effects of the Sun upon the Earth and the time is ripe for a good look at what technology can do.

It is inevitable that certain areas come in for most attention. These are the areas where there appears to be a lack of the necessities of life. Yet most of this is because technology is not used to the best advantage, or that an intermediate technology is more appropriate to certain situations. Since all these things are a part of a whole, some of the new thinking must revolve around the use of natural resources and the application of man's ability to readjust to a situation.

A good deal has been written on some aspects of space dangers but little of a constructive nature about adaptation. It is proposed that some of the effects of space exploration side effects should be examined. To do this, separate aspects of some of the present problems must be examined.

ENERGY FROM SPACE

One of the activities which will naturally be to the fore is the harnessing of energy. It is within the parameters of *Spacewatch* to do this and also within the electronics field. It is fitting then to start with a method of utilising the power of the Sun, which for the human race is an almost limitless source (12,000 million years anyway), of energy.

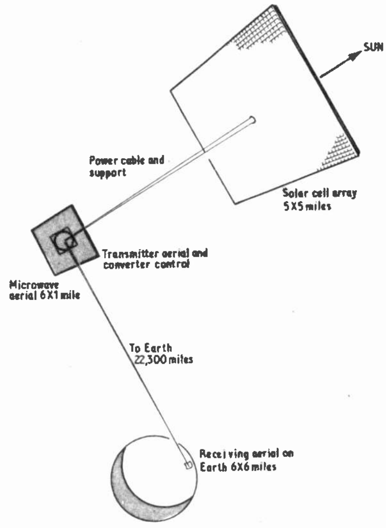
Many years ago ideas were put forward, for the setting up in space of a vast reflector of sodium which would beam the rays of the Sun down to the Earth in a concentrated ray. Speculation was rife as to how this could be used by one power or another to burn up the cities of the enemy.

The first of a similar type of reflector to beam power derived from the Sun and transmit it to Earth, for peaceful use, has already been funded, see Fig. 1.

The National Aeronautics and Space Administration of the United States have awarded nearly 200,000 dollars to a consultancy working with three American firms. These firms specialise in space platform engineering, solar cells and microwave equipment.

Experiments have already been carried out in America with the transmission of power by microwaves. A microwave beam was used to keep a model helicopter aloft by this means. The new project study is now being set up in space in a geostationary position. The basic idea is to set up a collector for the solar energy. The power would be transferred to a converter by cable where microwaves would be generated.

On the same unit would be the control system which would enable an aerial to be kept facing the Earth and the collector facing the Sun. An aerial on the Earth covering an area six by six miles would collect the microwave energy for distribution. The effective amount of energy that would be available for distribution would be 10^7 kilowatts.



Proposed space power station

This may well seem to be an extremely ambitious project but it is not beyond the present technology. The improvement in solar cell performance is enough to justify the feasibility study, and since the effects of the beam of microwave power would cause less disturbance than a direct beaming of solar energy it would seem to be a better choice.

The microwave beam, however, could raise certain difficulties. Apart from the fact that some precaution would be needed to avoid passing through the beam, space vehicles would need to avoid it (particularly space shuttles with passengers) and the fact that the ionosphere would have its temperature raised.

Some work has already been carried out from Aricebo in firing about a hundred kilowatts at one layer of the ionosphere and raising the temperature thereby. This was reported in *Spacewatch* some time ago. The effect of megawatts might well cause changes. No doubt the doom mongers will have much to work on here.

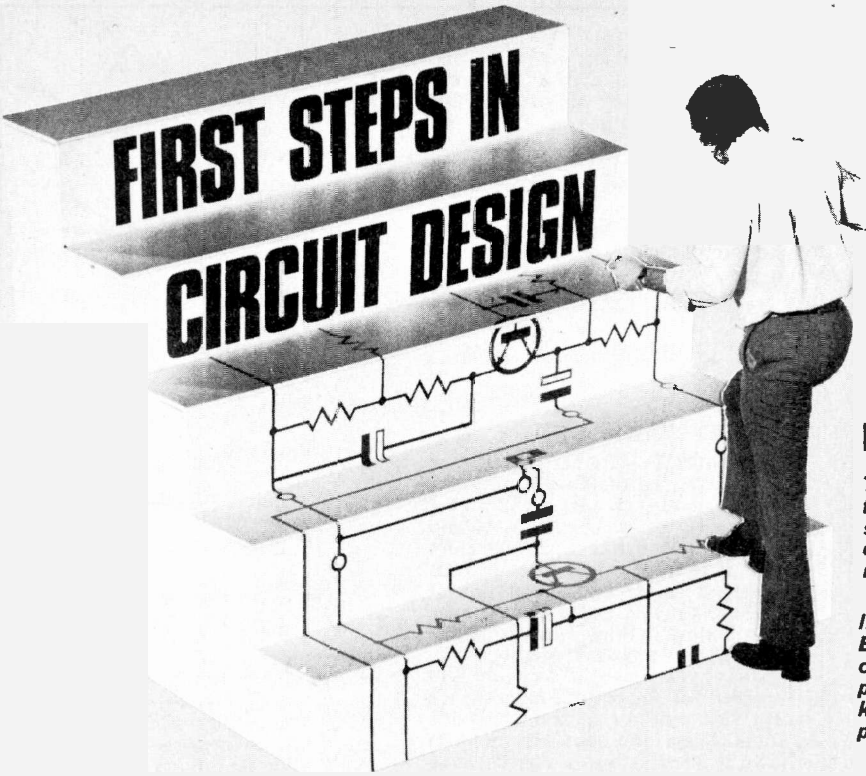
EARTH BASED SOLAR POWER STATIONS

The method of utilising natural resources just described may be the extreme end of the scale of new endeavour but is nevertheless to be considered. A more immediately possible alternative is the utilisation of solar energy at ground level.

Later *Spacewatch* articles will deal with the practical systems in use at the present time and those projected for the future.

FIRST STEPS IN CIRCUIT DESIGN

2



By A. P. Stephenson

This series, specially written for the beginner, takes you step-by-step through transistor circuit design in a simple, non-mathematical way.

Design of a small signal amplifier will be followed by a Class B amplifier and the series will conclude with a constructional project so that your theoretical knowledge can be put into practice.

LAST MONTH some of the general principles of transistor circuit design were described. This month we will look more closely at the transistor itself and examine how the characteristics of this device influence circuit design.

We shall also look at the main circuit components which influence voltage gain.

As mentioned in the previous part the principles to be discussed refer only to small signal amplifiers, power amplifiers requiring a different approach.

2.1. THE 0·6V VOLTAGE DROP $-V_{BE}$

The transistor requires the base/emitter diode to be forward biased. In the case of silicon transistors the voltage drop across the junction will appear "locked" at about 0·6V. Germanium "locks" at about 0·2V.

This voltage is an intrinsic value and is predictable from a rather involved discussion on the physics of the *pn* junction.

EFFECTS OF TEMPERATURE

The figure is almost, but not quite, a constant because at normal ambient temperature (usually specified as 25 degrees C) the variation is typically between 0·55V and 0·72V.

The effect as temperature increases is a reduction in this voltage according to the following scale:

For every degree C rise, V_{BE} falls by 2mV

For example, a transistor operating at 125 degrees C will have a V_{BE} of about 200mV less than normal, i.e. 0·4V.

For the majority of design work, however, transistors are running at the 25 degrees C norm, the only exception being the larger power stages.

V_{BE} AND CIRCUIT DESIGN

It is very important for the amateur designer to fully appreciate the significance of the 0·6V lock and to ram home this point the circuit in Fig. 2.1 may be used.

Large variations in VR1 will not have much effect on the voltage V_{BE}. However, if VR1 is reduced to too low a value, the dreaded "thermal runaway" will soon cause the death of the transistor.

In fact, if you are measuring V_{BE} with a voltmeter and you notice a reading approaching, say, 1V the transistor is either already dead or soon will be!

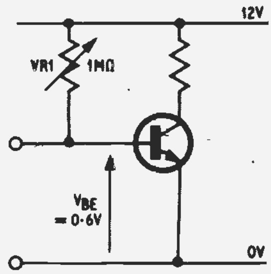


Fig. 2.1. Changes in VR1 will have little effect on the base to emitter voltage

2.2. THE COLLECTOR SATURATION VOLTAGE $-V_{CE(sat)}$

It is easier to define collector saturation voltage by reference to Fig. 2.2. As the slider of VR1 is moved towards the 10V line, I_C increases and the collector voltage falls because of the voltage drop across R_C.

At some point on the slider the output voltage stops falling, becoming locked at a certain lower limit. At this limit the collector current can rise no further, in spite of rises in the slider.

DEFINITION

The collector saturation voltage, $V_{CE(sat)}$ may be defined as follows:

The collector becomes "saturated" or "bottomed" when the collector current has reached its maximum possible value because its voltage has reached its minimum possible value.

> This minimum voltage to which the collector can fall is called the collector saturation voltage $- V_{CE(sat)}$.

A typical figure to indicate the order of magnitude would be 0·5V. The actual value for $V_{CE(sat)}$ is dependent on the value of I_C at this voltage which in turn is clearly dependent on R_C.

MANUFACTURERS' FIGURES

It is inconvenient for a transistor manufacturer to give $V_{CE(sat)}$ values in terms of R_C, because the supply voltage would also have to be quoted. Instead the $V_{CE(sat)}$ figures are quoted for a given I_C.

For example in the case of the BC108:

$V_{CE(sat)} =$ 90mV for I_C at 10mA
but $V_{CE(sat)} =$ 200mV for I_C at 200mA
measured with $I_C/I_B = 20$

Note that $V_{CE(sat)}$ rises with larger collector currents, which may be taken as a general rule. It also rises with increase in temperature.

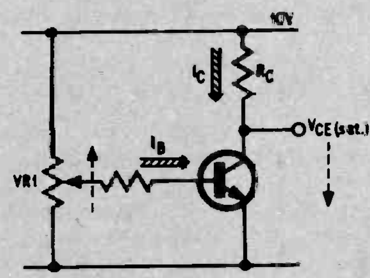


Fig. 2.2. As the slider of VR1 is moved upwards, V_{CE} falls to minimum of $V_{CE(sat)}$

2.3. THE PARAMETER JUNGLE

The academic way of explaining and measuring what goes on inside a transistor is to use a set of "network parameters" which are supplied by the manufacturer for each type of transistor. A few years ago a system called "T-network parameters" were in use.

T-NETWORK PARAMETERS

These parameters consisted of strange little resistances which were alleged to inhabit the corridors of the crystal lattice and given names such as r_e, r_b, r_c which stood for the emitter resistance, base resistance and collector resistance respectively.

In addition to these little resistances there was a ratio called "alpha" (symbol α) which was a current gain desperately trying to equal unity but never quite making it.

H-PARAMETERS

T-parameters gradually became unfashionable and gave way to a modernised set known as "h-parameters", the term "h" meaning hybrid. There were originally four in the set: h_{11}—the input resistance; h_{21}—the current gain; h_{12}—the voltage feedback ratio; and h_{22}—the output admittance. It is not difficult to see why they are called hybrid!

A breakaway group was formed causing a change in symbolism. The general symbol h_{11} became h_{ie}, h_{ib}, h_{ic} according to whether the transistor is used with grounded emitter, base or collector.

Similarly h_{21} became h_{fe}, h_{fb} or h_{fc}; h_{12} became h_{re}, h_{rb} or h_{rc}; h_{22} became h_{oe}, h_{ob} or h_{oc}.

To reassure the amateur designer, we shall try to avoid any further reference to any of them with the exception of h_{fe} which is the most generally useful of all h-parameters and r_e which is still a most useful term because it can so easily be calculated from the collector current.

The design of any circuit, within the capabilities of the amateur, can be carried out with these two alone, the rest of the tribe will be left to the academic types.

2.4. THE RATIOS h_{FE} AND h_{fe}

The ratio h_{FE} is one of the important pieces of information given in the manufacturers' literature. Its full title is "large signal forward current transfer ratio in grounded emitter configuration" which is a bit of a mouthful and is simply collector current divided by base current thus:

$$\boxed{h_{FE} = \frac{I_C}{I_B}}$$

It is useful in setting up the d.c. bias conditions because for a given collector current and h_{FE} the required base current can be found.

RANGE OF VARIATION

Unfortunately it is not a very reliable constant and should not be taken at its face value. This is not to say that manufacturers issue false information, in fact they always stress that their figures for h_{FE} are typical and often give minimum and maximum expected values. The production line spreads however are very large as can be seen from the example of the BC108 where h_{FE} = 125 to 500 which means that picking one of these at random the h_{FE} could be anything within this range.

In addition to the production line spreads there is also another variation which is an added annoyance for the designer. The mean collector current also affects h_{FE}.

This means that manufacturers always specify the mean collector current when stating h_{FE}. In the above example for the BC108 the collector current was taken as 2mA.

In general the h_{FE} increases as mean collector current increases up to a certain upper limit and then tends to fall again.

THE RATIO h_{fe}

The ratio h_{fe} is similar to h_{FE} but is strictly a small signal ratio. All the remarks above apply except for this difference. The values given for h_{fe} and h_{FE} are usually about the same anyway.

2.5. THE 25/I_C EQUATION

The base-emitter junction in a transistor must be forward biased in order to operate the device as an amplifier.

Since forward bias causes the junction to pass current it is a relevant question to ask what is the resistance across the base-emitter junction when it is conducting.

THE INTERNAL EMITTER RESISTANCE

The answer is not straightforward, because most of the emitter current ignores the base altogether and flows upwards to the collector.

It is not altogether surprising therefore to learn that the value for r_e is not a constant but depends on the collector current I_C.

In fact the formula is complex involving logs to the base e, Boltzman's constant and various other unpleasant things including the absolute temperature. Fortunately, for most practical purposes at room temperature the formula can be reduced to a very simple form:

$$\boxed{r_e = \frac{25}{I_C} \quad \text{where } I_C \text{ is in milliamps, and } r_e \text{ in ohms.}}$$

For example I_C = 1mA, r_e = 25Ω
I_C = 10mA, r_e = 2·5Ω
I_C = 0·1mA, r_e = 250Ω.

DYNAMIC RESISTANCE

Note that one should not make the mistake of thinking that r_e is a simple resistance which can be measured with multimeter set to ohms. It is a "dynamic small signal value" which only comes to life when the transistor is passing collector current.

From the designer's viewpoint, the equation is very useful because it shows how to make r_e any desired value by suitable choice of collector current.

However, it is not r_e itself which is important but the fact that it appears in equations for voltage gain and input resistance.

2.6. THE LOAD WHICH THE SIGNAL SEES

For a grounded emitter amplifier circuit the signal is applied between the base and ground (see Fig. 2.3).

The input resistance, r_{IN}, is the load which the signal sees. Superficially this would appear to be simply r_e. However, it must be remembered that only a small fraction of the total emitter current is supplied by the base, the actual fraction being $1/h_{fe}$. The apparent input resistance, as far as the signal is concerned is therefore much higher than r_e, in fact the equation is

$$\boxed{r_{IN} = h_{fe} \times r_e}$$

For example if the collector current is 1mA, r_e = 25Ω which makes $r_{IN} = h_{fe} \times 25$. If the transistor has an h_{fe} of 100, the input resistance is 2·5kΩ.

It is unusual in practice to ground the emitter directly. For stability purposes, an external emitter resistor R_E is commonly employed, see Fig. 2.4.

Since r_e and R_E are in series across the signal, the modified equation for r_{IN} is

$$\boxed{r_{IN} = h_{fe}(r_e + R_E)}$$

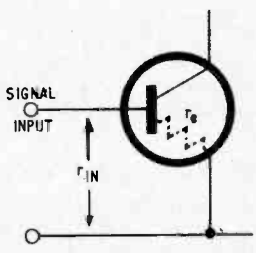


Fig. 2.3. The signal applied between base and emitter sees a load of $h_{fe} \times r_e$

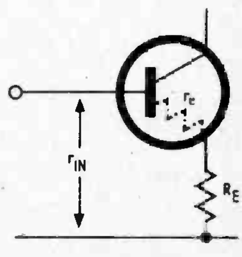


Fig. 2.4. The addition of R_E increases the load

2.7. THE STAGE INPUT RESISTANCE

Although the equation $r_{IN} = h_{fe}(r_e + R_E)$ will describe the load presented to a signal by the transistor, this is not the complete story.

Before an amplifier can amplify, the base must be supplied with forward bias, which means extra resistive networks. These extra resistors are a nuisance because they form an additional load on the signal.

For example the forward bias is often provided by a voltage divider chain R1, R2 as shown in Fig. 2.5.

The problem now is to obtain an overall equation for the total resistive load on the signal, in other words the stage input resistance R_{IN}.

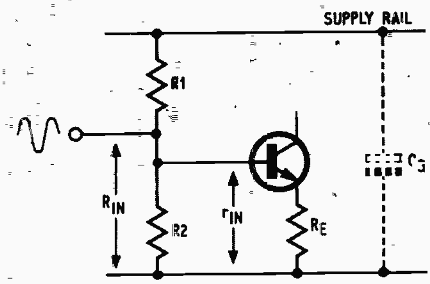


Fig. 2.5. The divider chain resistors add to the load which the signal sees

SERIES OR PARALLEL?

It appears fairly obvious that r_{IN} and R2 are in parallel but the position of R1 is not quite so easy. Is it in series with R2 or in parallel?

From the d.c. bias viewpoint there is no doubt that R1 is in series with R2.

From the signal viewpoint, however, R1 is in parallel with R2 because of the large smoothing capacitor C_S (shown dotted in the diagram because it is part of the power supply). The capacitor is a short circuit as far as varying signals are concerned, which makes the supply rail a ground line.

The input circuit which the signal finally sees is shown in Fig. 2.6. From this it is clear that

$$\boxed{R_{IN} = R_1, R_2 \text{ and } r_{IN} \text{ in parallel}}$$

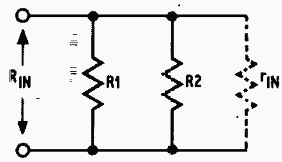


Fig. 2.6. The stage input resistance R_{IN} is effectively R_1, R_2 and r_{IN} in parallel

2.8. VOLTAGE GAIN EQUATIONS

The voltage gain of a grounded emitter stage is the ratio of the output voltage swing (measured between collector and ground) to input voltage swing (applied between base and ground).

The symbol "A" will in future be used to represent this ratio thus

$$\boxed{A = \frac{V_{out}}{V_{in}}}$$

The strictly relevant components which decide this gain are shown in the skeletal diagram of Fig. 2.7.

An equation for finding the voltage gain which has the merits of simplicity and reasonable accuracy is the following:

$$\boxed{A = \frac{R_C}{r_e + R_E}}$$

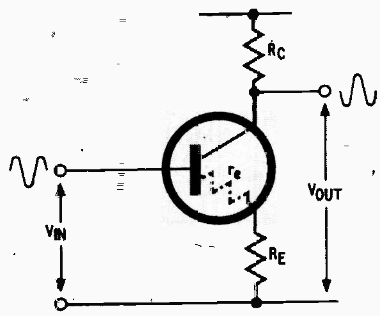


Fig. 2.7. Skeletal diagram showing components which control voltage gain

Although this equation is true as far as the amateur design is concerned there are times when an even simpler pair of equations are good enough.

If R_E is chosen to be very much larger than r_e, then the following equation is allowable:

$$\boxed{A = \frac{R_C}{R_E}}$$

If R_E is not there at all, either short circuited or by-passed the equation reduces to

$$\boxed{A = \frac{R_C}{r_e}}$$

Continued next month

INGENUITY UNLIMITED

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

UNIVERSAL FLASHER PANEL

ORIGINALLY designed for Christmas-tree illumination, the unit here described provides a method of turning each of four lamps or relays on and off in continuous sequence. But the unit has a surprising variety of other applications.

Using cheaply priced semiconductors, the circuit shown in Fig. 1 combines a clock-pulse generator; a divide-by-four counter and a decoder which drives the lamps. With the value of C1 given, the "on" time of each lamp is variable from about 0·2sec to 0·8sec but increasing the value of C1 allows this time to be extended to minutes.

The divide-by-four function is accomplished by serial connection of the two edge-triggered bistable circuits contained within the SN7474.

The outputs of the two bistables will continuously sequence through all of four possible states so long as clock pulses are applied.

The logic of any NAND gate in the SN7400 used for decoding, is that if both inputs are high, the output will be low. But if either one or both inputs is low, then the output will be high.

In order to interpret the bistables' four states, each pair of inputs is arranged to go high in turn so that the four outputs go from high to low and back again in sequence to give the count. Whichever output is low then produces base current through its association AC128 thereby turning on a lamp.

Fast rise time clock pulses for driving the SN7474 are generated by a type of oscillator developed by the author.

Briefly, the circuit operation is that C1 charges via R1 and the base/emitter junction of TR1 thereby turning TR1 hard on and TR2 off. But when the initially high charging current decreases, the V_{ce} of TR1 rises and begins turning on TR2.

The capacitor then begins discharging via the path TR2, VR1, R2, but in so doing, develops a positive feedback voltage across VR1, R2 which completely turns off TR1 in a rapid, cumulative action. But a negative feedback voltage developed across R4 while TR2 is conducting eventually becomes greater than the falling positive feedback and re-initiates the cycle by turning TR1 on again in another cumulative process.

VR1 controls the repetition rate and R2 is simply a value greater than the minimum necessary to sustain oscillation.

Ideally, the supply voltage should be +5V but for children's toys, battery operation is obviously desirable. The unit will operate from either a 4½V or a 6V battery but the supply is best kept below 7V.

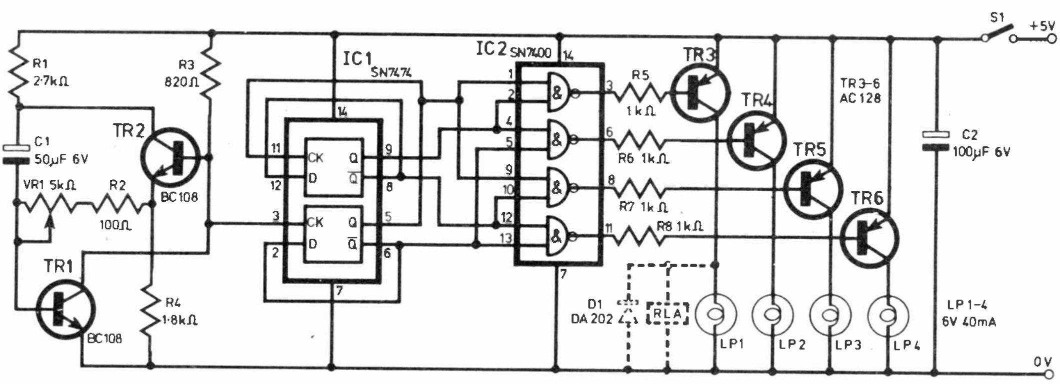


Fig. 1. Complete circuit diagram for the universal flasher unit. The arrangement for connecting relays in the circuit is shown dotted

Where long repetition times are required, VR1 may be replaced with a 25kΩ pot. This will allow smaller values of C1 electrolytics to be used at some loss of time consistency.

If relays are employed (shown dotted) an OA202 or similar diode should be connected across each relay coil.

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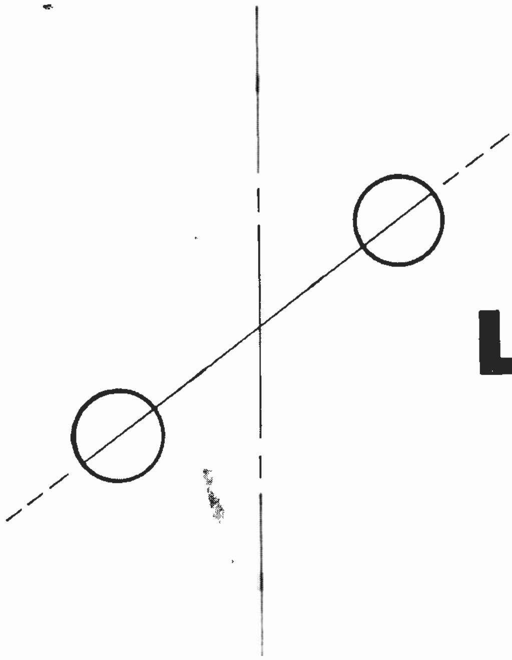


Liquid Crystals

BY G. P. STENNING*

An introduction to a new technology

LIQUID crystal materials have been known for some 80 years. However, it is only in recent years that their special property of turning a clear liquid into a milky liquid under the influence of an applied electric field has been exploited to produce information displays.

These displays are basically a sandwich of liquid crystal material between two sheets of glass. The exceptionally low power requirements of these displays gives them a considerable advantage where power is at a premium. The purpose of this article is to introduce the reader to this new and interesting technology.

WHAT ARE LIQUID CRYSTALS?

Liquid crystals are materials which over some part of their temperature range have properties intermediate between a solid and a liquid state. This special state is known as the mesophase or anisotropic liquid state.

solid phase	liquid phase	
solid crystalline state	anisotropic liquid state ("Mesophase")	isotropic liquid state
Melting Point	Clearing Point	Temperature →

Fig. 1. Showing what happens to a liquid crystal material as its temperature is increased

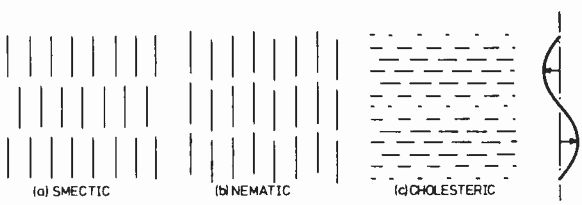


Fig. 2. Three main types of liquid crystal

Anisotropic materials have a rather peculiar property in that they exhibit different refractive indices to light which passes through them from different directions. By comparison a normal liquid is isotropic which means that it has no special optical properties. Light behaves the same no matter from what direction it passes through the liquid.

The anisotropic property of liquid crystal materials is the feature which is exploited to produce the change from a clear liquid to a milky liquid on the application of a voltage.

Fig. 1 shows diagrammatically what happens to a liquid crystal material as its temperature is increased. The material is solid at low temperatures. If the temperature is then slowly increased its melting point will be reached after which it enters the mesophase state. Further increase in temperature brings the liquid to its clearing point when it loses its special properties and behaves like an ordinary liquid.

If the temperature is now reduced the material will pass back through the same states until it is again a solid material. In other words the temperature effect is reversible.

The materials of particular interest are those which exhibit a mesophase range which covers our normal range of ambient temperatures.

LIQUID CRYSTAL MATERIALS

There are three main types of liquid crystal material. In all cases the molecules have an elongated form and can best be considered as microscopic greasy transparent sausages. Fig. 2 shows diagrammatically the three types of material.

(a) Smectic type. In this type of material the molecules exist in discrete parallel layers.
(b) Nematic type. The molecules all have their long axes parallel to each other but are free to move in any axial direction.
(c) Cholesteric type. Adjacent molecules appear to be similar to the nematic type but if the material is examined over a greater distance it will be found that a continuous twist is superimposed on the parallel arrangement.

*Siemens Ltd.

The materials in current practical use are organic compounds of the nematic type.

DESCRIPTION OF BASIC DISPLAY

Fig. 3 shows a simple cell consisting of two glass plates separated by insulating spacers which also serve to retain the liquid in the sandwich. The inside surfaces of the glass are coated with transparent conducting electrodes. The Siemens AF25250 is an example of such a simple cell.

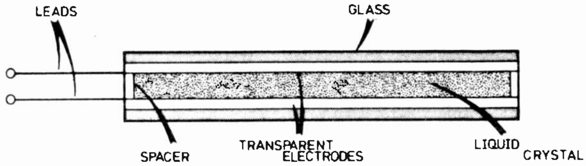


Fig. 3. Simple liquid crystal cell in section

Typical dimensions for a working cell would use glass 2 or 3mm thick with an extremely thin conducting layer on its surface. The thickness of the liquid crystal material in the sandwich between the two glass plates will be in the range of about 6 to 25μm depending upon the application.

At this stage another property of the liquid crystal molecules which make up the nematic liquid crystal material must be introduced. This is that the individual molecules in the cell also have electrical dipole axes which are at 90 degrees to the molecule axis. This is shown diagrammatically in Fig. 4.

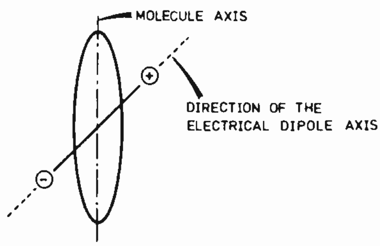
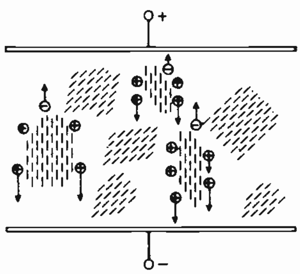


Fig. 4. Molecule and dipole axes

Fig. 5. What happens in the cell when a voltage is applied



We now have to consider what happens when a potential is applied across a cell. Fig 5 is a simplified representation of what in reality is a very complex interaction of conflicting forces in the cell.

Because the individual molecules are all individual dipoles when a potential is applied the molecules are turned at right angles to the field so that their dipoles lie in line with the field. However, things are not as simple as this and free ions present in the liquid start to migrate to the electrodes with the result that in the liquid they locally neutralise the electrical field set up by the electrodes. This then allows local groups of molecules to return to their perpendicular state.

This flow of ions and the resulting turbulence in the liquid is what gives us the practical applications of liquid crystal materials.

REFRACTION

Now it will be remembered that earlier on we referred to the property of liquid crystal materials known as the anisotropic liquid state. In this condition the liquid has different refractive indices depending on the direction in which light passes through it.

A beam of light passing through the turbulent liquid in the cell of Fig 3 encounters local differences in refractive index because of the different orientations of the different groups of molecules and hence is randomly scattered. This scattering of the light beam leads to the milky or "ground glass" appearance of the material when a potential is applied to it.

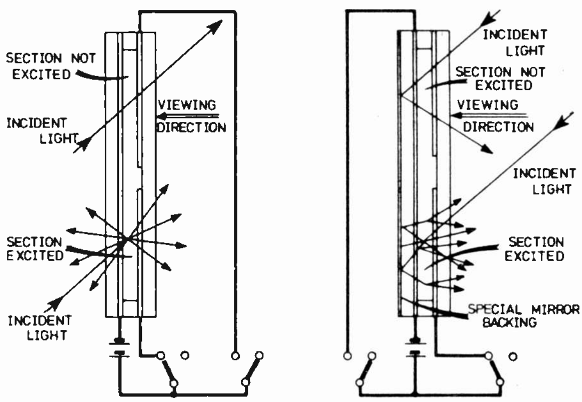


Fig. 6. Two types of display. From the left: transmissive and reflective

TYPES OF DISPLAY

There are two basic types of display. Those that operate by transmitted light and those which operate by reflected light.

Fig. 6 left shows a cell designed for use by transmitted light. It is shown with two separate conducting sections. One without voltage applied which allows the light to pass straight through it without scattering. The end of the cell which has been activated by the application of a voltage causes the light entering it to be scattered.

Similarly Fig. 6 right shows the operation of a cell designed to operate by reflected light. These cells have integral mirrors which are preferably designed so that they do not give direct reflections of objects and light sources in front of them. The reflective type of display is particularly attractive for use in battery powered equipment as no internal light source is required.

TYPICAL DISPLAYS

Fig. 7 shows a typical seven bar display which can be a single unit on a panel such as the Siemens AN1301 or a unit in a row of units on one panel such as the Siemens AN4131. A particular digit is displayed by applying a potential between the required bars on one glass plate (usually the front) and the other glass plate which will normally be a common electrode to all the bars.

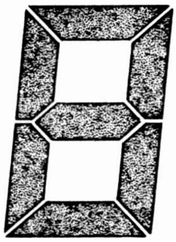


Fig. 7. Typical seven bar digit

A potential of about 0·5V per μm is required to initiate the onset of the milky effect in the liquid crystal material. The cloudiness becomes more intense and reaches a saturation level at about 5V per μm. Fig. 8 shows how the milkiness or contrast ratio increases with applied voltage for a typical display.

The electrical power consumed by typical displays is only in the order of $100\mu W/cm^2$ of character area. To quote a practical example the AN4131 display referred to above will take about $2\mu A$ per bar of the display at an operating voltage of 25 volts peak (50 volts peak to peak).

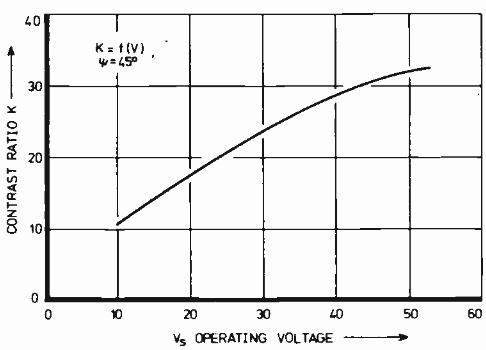


Fig. 8. Effect of voltage on contrast ratio

TYPICAL APPLICATIONS

Typical applications for liquid crystal displays are:

1. Portable equipment where low power consumption is essential.
2. For information display in situations requiring low power, intrinsically safe circuits (circuits in which voltages and currents are limited to values below which they are capable of producing an explosion initiating spark).
3. Aircraft, car and similar situations in which varying light conditions make other forms of display unsuitable. A major advantage of liquid crystal displays over other forms of display is that when using either transmissive or reflective displays an external light source however bright will not mask the display. This is because the display works by scattering light and a bright external source of light such as sunlight will automatically give a bright display.
4. Coloured displays are possible by use of coloured light sources or coloured filters.
5. Direct interface with MOS and COS/MOS integrated circuits.
6. Digital instruments, cash registers, calculators clocks.
7. Analogue displays such as thermometer strips in which successive elements are activated. These have applications in temperature instruments, speedometers and tuning dials.

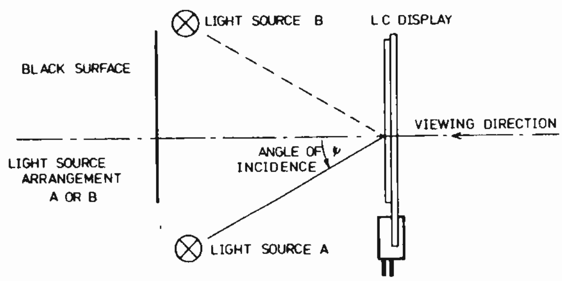


Fig. 9. A typical viewing arrangement for viewing a transmission display

A typical arrangement for viewing a transmission display is shown in Fig. 9. In this it will be noted that the light source is located outside the field of view of the user and that a matt black background is used.

METHOD OF OPERATING DISPLAYS

A brief mention must be made here about the way in which the displays are operated. In the examples given earlier d.c. circuits were implied or shown for simplicity of explanation.

In practice crystal displays of the types considered here should always be operated with a.c. as d.c. across the cells will polarise them and seriously shorten their operational lives.

To run the displays on a.c. a sinusoidal supply as such is not essential. It is only necessary for the display to "see" a.c. This is usually arranged to be a square wave a.c. as this is both easy to produce and gives the most efficient form of drive. ★

BATTERY CHARGER

BY J. N. WATT

ADVANCES in the design of battery chargers have been minimal since their introduction many years ago. Modern components have helped to reduce the size and to increase the reliability but otherwise no significant improvements have been made.

The design presented here seeks to bring the humble charger up to date.

CONVENTIONAL CHARGER

First consider the conventional battery charger of Fig. 1. A more basic circuit could not be imagined. However, there are a number of drawbacks.

For example, if the output leads should be wrongly connected to a battery to be charged, that is changed over positive for negative, a heavy short circuit current will flow. This can occur even with the charger switched off if there is no switch in the output lines as here.

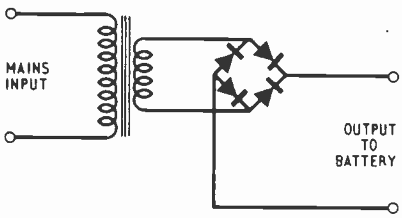


Fig. 1. A conventional battery charger circuit

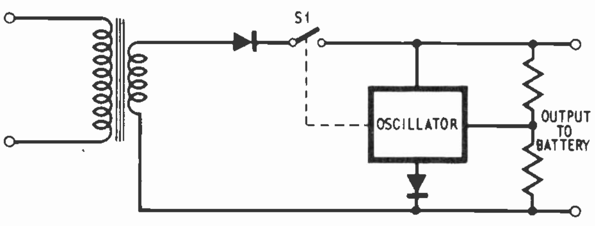


Fig. 2. Circuit of the basic concept used in the new battery charger

Although a fuse, if included, can give a measure of protection, replacement of this item is tedious and some damage can often occur due to heavy surge currents flowing before the fuse blows.

If the output leads of the charger become connected together while the unit is switched on, then once again a short circuit current will flow, and previous remarks concerning fuse protection apply here also.

Lastly, a simple charger will carry on charging after the battery is fully charged, leading to excessive gassing and perhaps battery damage.

A FRESH LOOK

The charger design presented here incorporates reverse connection and output short circuit protection, and cuts the charging rate down heavily when the battery reaches its fully charged potential.

In this way an unskilled person can connect up the charger to the battery without danger and it will not matter if, for example, the charger is inadvertently left connected all night when perhaps only a few hours charge was required.

THE SYSTEM

The block diagram of Fig. 2 shows the new charger in principle whilst Fig. 3 shows the full circuit diagram.

In Fig. 2 a switch S1 is operated in time with the output of an oscillator which is itself controlled by the voltage at the tap on a potential divider connected across the battery to be charged. Power to the oscillator is fed via a diode. The switch, when closed, connects the output of the transformer secondary, via a rectifier, to the battery under charge.

Until a battery is connected with the correct polarity to the output terminals, the oscillator will not run and the switch will remain open so that no charging takes place. Charging starts when a partially discharged battery is correctly connected to the output terminals, and stops when the correct battery voltage is reached by switching off the oscillator.

In fact, two silicon controlled rectifiers CSR1 and 2 are used for the switch, and these, together with two diodes D1 and D2 also form a bridge rectifier as in Fig. 3.

With the mains applied but no battery connected, CSR1 and 2 are unable to conduct as long as no triggering voltage is fed to their gates. Without CSR1 and 2 conducting, the remainder of the circuit is unable to provide any triggering potentials.

BATTERY CONNECTION

This apparent stalemate is circumvented by introducing a battery at the output terminals.

A partially discharged battery of correctly connected polarity is required to bring the unit to life. Whilst it might be thought that this is a drawback as a completely flat battery can apparently not be re-charged with this charger, a completely flat battery occurs very rarely indeed. Even if a vehicle's lights have been accidentally left switched on for a day or so, so that there is apparently no output from the battery, removing the load and allowing a period for the battery to recover usually results in there being sufficient output to switch the charger on in the way to be described.

In addition, a simple modification will be described which enables conventional charging to be done.

CIRCUIT OPERATION

As soon as positive battery volts appear at the supply rail, diode D6 conducts. If the battery is connected reversed then D6 does not conduct and the unit remains dormant. With D6 conducting, C3 charges through R7 and within a few milliseconds the voltage at TR3 emitter exceeds the voltage at the slider of VR1.

Both TR3 and TR4 then conduct very heavily, discharging C3 through R10 thus giving a short positive pulse at the bases of TR2 and TR1. These latter are connected as emitter-followers and so convert the pulses to a suitable low impedance for driving CSR1 and CSR2 gates. They also provide isolation between the gates.

A positive pulse at a CSR gate converts it to a conducting state. Thus, the bridge network, consisting of D1, D2, CSR1 and CSR2 becomes fully conducting and current passes to the battery for the remainder of the mains half-cycle.

As soon as C3 discharges, it starts to recharge again through R7 and soon another output pulse is generated. This has no effect whilst the CSRs are already conducting, but at the end of each mains half-cycle they revert to a blocking state as the supply voltage is passing through zero. Consequently, fresh pulses are required early in each mains half-cycle and these the unit generates at a rate of about 1·4 kHz, so keeping the CSRs conducting as required.

Eventually with rising battery voltage the voltage at TR3 emitter balances that at VR1 slider because of the action of the Zener diode D5 which limits the voltage to which C3 charges to 10 V.

Thus TR3 and TR4 do not conduct, no pulse output is generated and the two CSRs are not triggered into condition. Charging ceases at a voltage determined by the setting of VR1.

As soon as charging stops the battery voltage will momentarily fall and charging will re-start only to be stopped again by the mechanism described. This leads to the charger giving a trickle charge of less than 1A, which causes no overcharging while at the same time ensuring that the battery is maintained in a fully charged condition.

The two resistors R1 and R2 provide an external d.c. connection from CSR gate to cathode to ensure reliable triggering. Diodes D3 and D4 prevent any spurious negative pulses from being applied to the gates which could otherwise lead to device destruction.

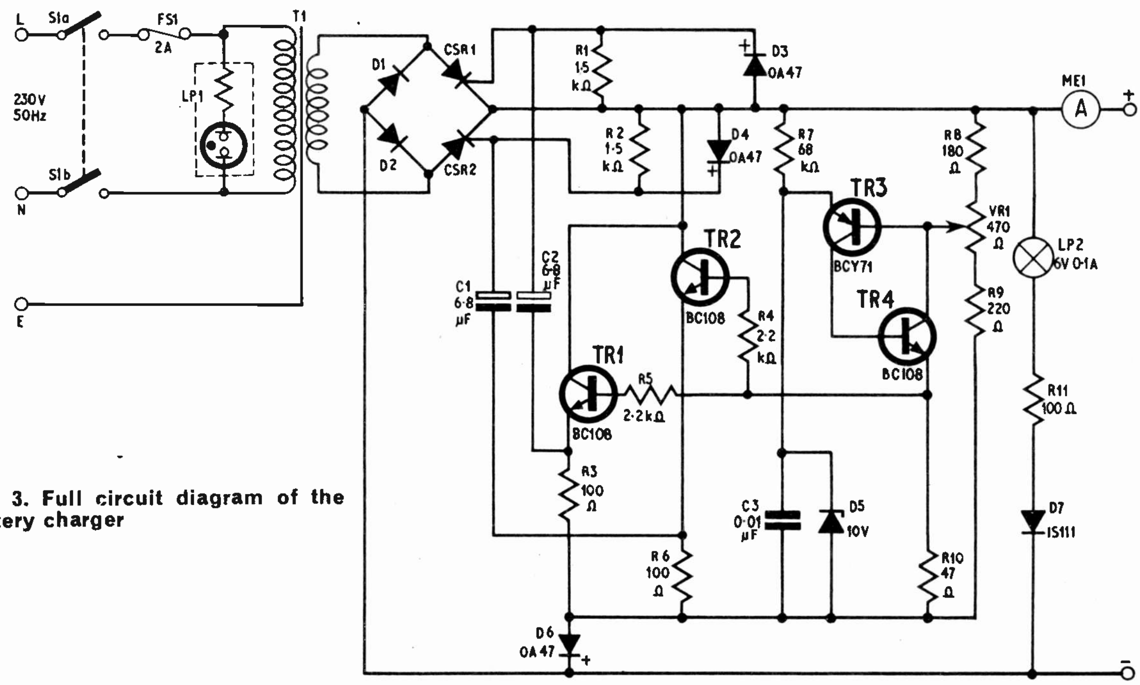
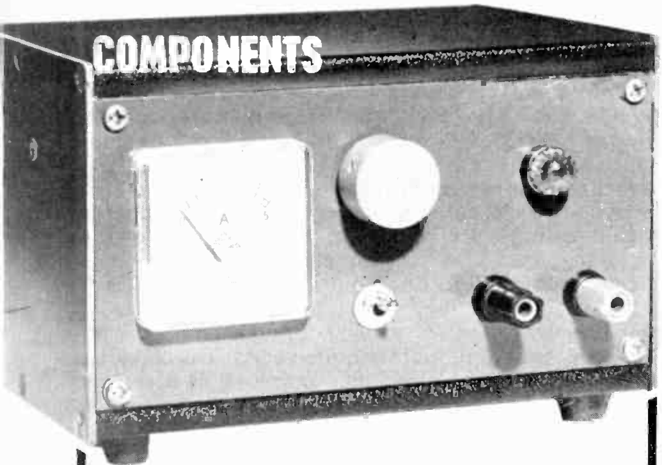


Fig. 3. Full circuit diagram of the battery charger



COMPONENTS

Resistors

R1 1·5kΩ
R2 1·5kΩ
R3 100Ω
R4 2·2kΩ
R5 2·2kΩ
R6 100Ω
R7 68kΩ
R8 180Ω
R9 220Ω
R10 47Ω
R11 100Ω 3W wirewound
R12 1kΩ
R13 1kΩ

All $\frac{1}{4}$W, 5% unless otherwise stated.

Potentiometers

VR1 470Ω

Capacitors

C1 6·8μF, 16V electrolytic
C2 6·8μF, 16V electrolytic
C3 0·01μF

Diodes

D1 50V, 3A rectifier type
D2 50V, 3A rectifier type
D3 OA47
D4 OA47
D5 10V Zener 400mW (BZY88 C10, 10V version, BZY88 C12, 12V version)
D6 OA47
D7 1S111
CSR1 50V, 3A type
CSR2 50V, 3A type

Transistors

TR1 BC108
TR2 BC108
TR3 BCY71
TR4 BC108

Switches

S1 DPST mains switch
S2 DPST on-off switch

Miscellaneous

T1 Mains transformer. 4A charger type (Douglas MT5 AT suits)
ME1 0–5A meter as available
LP1 Mains indicator with holder
LP2 6·3V, 0·1A, with holder
Case, terminals, Veroboard, 0·15 or 0·1in pitch depending on type of VR1 selected. Heatsinks to suit CSRs 1 and 2 and diodes D1 and D2. Knob, fuseholder for FS1, 5A wire and other to suit.

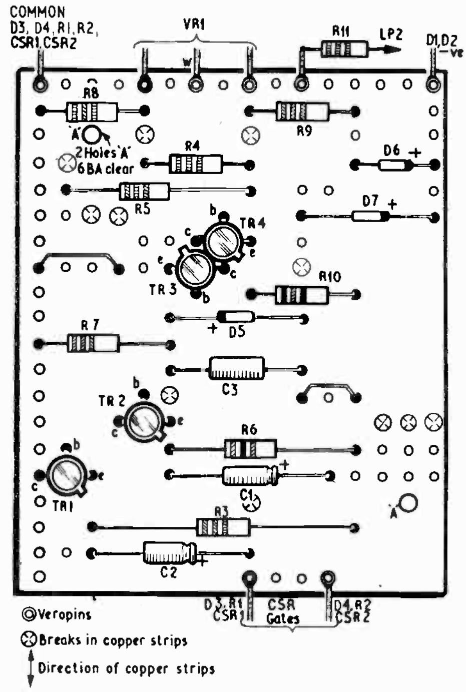


Fig. 4. Veroboard and component layout for the battery charger

The lamp LP2 lights whenever a battery is connected with correct polarity. If the battery is connected in reverse the diode D7 is reverse biased and no current flows. In the prototype, a 6V lamp of 0·1A rating was employed, together with an appropriate resistor acting as a voltage dropper. This mode of operation is preferable to the use of a 12V lamp connected directly since a nominal 12V battery on charge can reach over 14V and this could lead to shortened lamp life. Here, the value of R11 is chosen to apply no more than 6V to the lamp with a 14V supply.

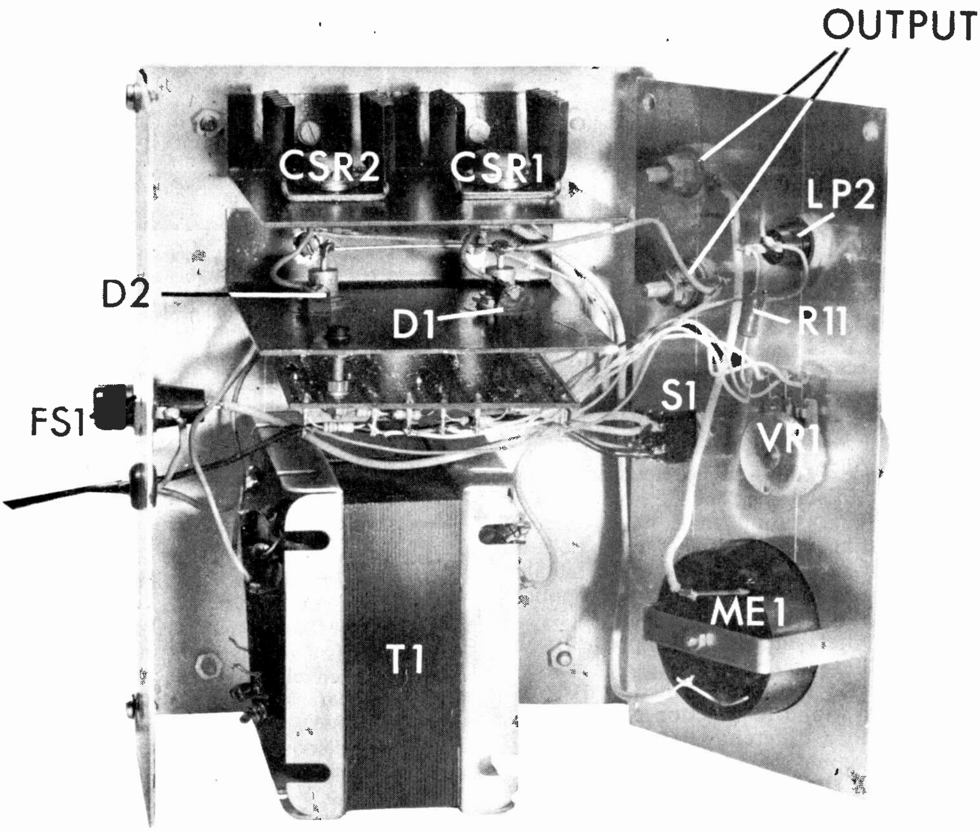
An ammeter ME1, scaled 0–5A, is connected in series with the positive output. The use of this is really optional. In the prototype, the cheapest to be found was employed for the meter is at best required only to give an approximate indication of the level of charging current, and to show that the unit really is charging.

CONSTRUCTION

Constructional details follow a conventional pattern. A suitable housing for the charger is a metal case (see parts list) measuring $6\frac{1}{2}$in. × 5in. × $4\frac{1}{2}$in. If readers prefer to employ an alternative, then it is suggested that this should be no smaller than that used here to avoid possible cramping and heating problems.

PRECAUTIONS

Make certain that all mounting holes for diodes and CSRs are free of burrs which could puncture any mica insulation used when mounting to heat sinks.



Photograph showing the layout of the components within the case

In the prototype the diodes were mounted using p.t.f.e. washers and two mica washers supplied, and each CSR was mounted on its own individual heat sink. These were insulated, using one mica washer and two insulating bushes on each CSR.

If available, a light smear of silicone grease should be applied to either side of each mica washer before tightening up. This ensures better thermal contact.

Before proceeding further use an ohmmeter to check that there is no electrical contact between heat sink and any part of the diodes and CSRs.

When the appropriate components have been located on the Veroboard layout of Fig. 4, this latter should be mounted on the diode heat sink and both large sinks are then fixed down to the case bottom, again using silicone grease at metal-to-metal joints for best thermal contact.

All wires that are to carry output current must be of at least 5A rating. Wires to the Veroboard and the indicator lamp can be lighter gauge if found convenient.

TESTING

When wiring up and assembly are finished, testing can be carried out. Two precautions are worth taking at this stage. An "automobile" type fuseholder fitted with a 5A fuse should be included in one of the leads to the battery to guard against accidental short circuits of the battery when the leads are disconnected from the charger. It is probably worth leaving this fuse in circuit during later use.

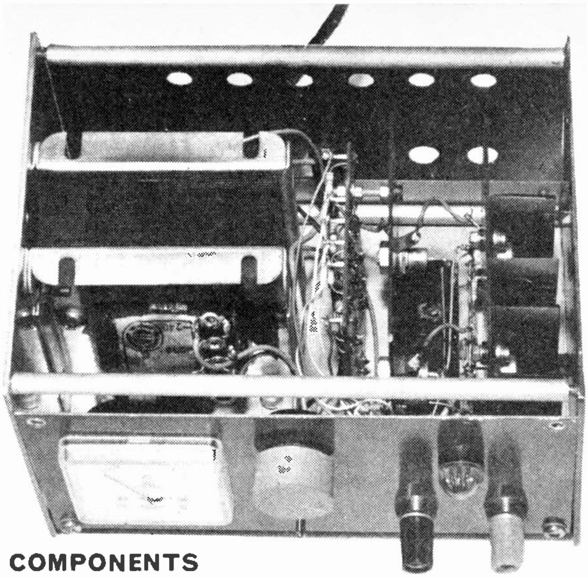
The second precaution need be included only during initial testing. Quite simply—it consists of a 12V bulb of 2A or similar rating, connected temporarily in one output lead. Thus the greatest current that can flow in any circumstances, even with faults present will be the current appropriate to the bulb selected.

Connect a 12V car battery to the charger observing polarity. The indicator lamp should light. Now switch on the mains supply to the charger and advance the setting of VR1. A charge, at a rate depending on the actual transformer employed, the state of the battery and the setting of VR1, will be indicated.

Back off the setting of VR1. The charge rate will fall, and further slight rotation will cause it to cease altogether. The actual setting of VR1 must be found by experiment. If a fully charged battery is to hand, set VR1 so that a small, trickle charge flows. Otherwise, set VR1 to give a charge in the range 2A to 4A and monitor the rate over a period of a few hours. When the battery is gassing freely, re-set VR1, again to give a trickle charge.

Some additional slight re-adjustment of VR1 setting may be called for, but experience will soon dictate this.

After some hours of supplying an output of 2A or more, the heat sinks will be warm to the touch and so too will the bottom of the case to which they are bolted. Accordingly, ensure that nothing obstructs the free flow of air through the holes in the rear panel.



INGENUITY UNLIMITED

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

COMPONENTS

The rectifier diodes and CSRs employed in the prototype were obtained as "50V, 3A" devices. Alternatives of similar rating may have different physcal characteristics, e.g. the CSRs may be stud mounting, but will probably prove to be suitable since the circuit shown is very tolerant of component variations.

It is suggested that all major components be obtained before drilling any holes.

The Zener diode D5 specified is rated at 10V but a 12V type was also found to function satisfactorily, although resulting in a different setting of VR1. It was noted that R7 could be any value from about 33kΩ to 100kΩ and that a C3 of twice the value, i.e. 0·02μF functioned adequately.

The use of such variations is left to constructors of an experimental turn of mind; others should employ the values given.

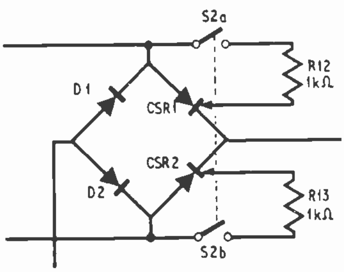


Fig. 5. Alternative wiring to compensate for a completely flat battery

THE FLAT BATTERY

The possibility of a completely flat battery being unable to activate the charger's circuitry was mentioned earlier.

Accordingly, the modification shown in Fig. 5 is suggested. The resistors R12 and R13 provide sufficient gate current to the CSRs to cause them to conduct without the presence of gating pulses. Consequently, charging takes place regardless of the state of the battery and the setting of VR1, when the switch S2 is closed.

The switch S2 should be opened to return the charger to normal operation as soon as possible.

Constructors may find that the initial charging period includes a time during which the charge-rate fluctuates fairly violently. Where this has happened it has died out after a short time and in any case appears to be a function of the state of charge of the battery and also is physical condition. ★

VOLTAGE CONTROLLED SELECTIVE AMPLIFIER

THE unit shown in Fig. 1 was constructed with the P.E. Synthesiser in mind. It provides a versatile Wha-Wha effect in conjunction with the synthesiser and keyboard.

The filter can be described as bandpass, suitably modified for voltage control. If used in conjunction with the envelope shaper some unusual effects can be obtained.

VR3, 1MΩ, is a gain (bandwidth) control and the user will discover that this provides interesting results in manipulation. VR2 is a skeleton preset and to set this up VR1 should be set to maximum whilst listening to the filter output with either headphones or an amplifier. VR2 is adjusted so that the output whistle is at its highest frequency, and then is backed off slightly.

N. Campbell,
Lee Park, Liverpool.

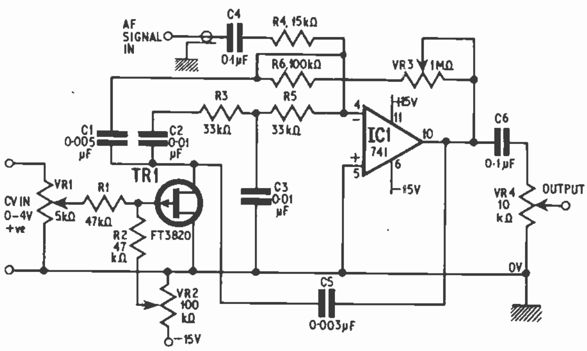
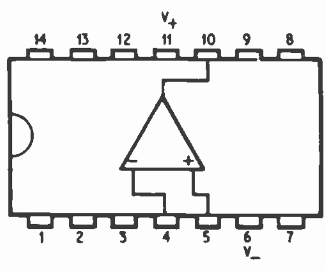


Fig. 1. Circuit diagram for the Waa Waa effects unit. The i.c. pin connections are shown on the right



INDUSTRY NOTEBOOK

By Nexus

MICROWAVES

Now when it comes to microwave technology this really is one of the black arts. All that waveguide plumbing and strip-line circuitry, the exotic vacuum glassware, the strangely named solid state devices, the newest associated developments such as surface acoustic waves, the exciting application such as satellite communications, the secretive ones such as electronic warfare, not to mention culinary ones such as microwave ovens, are now adding up to a sizeable industry though as yet fragmented. On a world scale the business in microwave parts of complete systems is running at about £1,000 million and employs some 50,000 qualified engineers.

But again there are signs of greater togetherness emerging from international conventions and exhibitions. The world's biggest ever microwave get-together is at Montreux next September and while in Switzerland recently, I had the opportunity of a long chat at the Federal Polytechnic, Lausanne, with Professor Freddy Gardiol who is Chairman of the "Microwave '74" Conference which, although the fourth in a European series, is the first one to have a full-scale commercial exhibition grafted on to it.

The new innovation has caused some controversy in academic circles but Gardiol, now an academic himself but with plenty of industrial experience in the United States (during which he got a master's degree from the famous M.I.T.) is unrepentant. He believes in the highest level of University/Industry interface and full-blooded co-operation.

As chairman of the conference he guides the programme selection committee and it is clear that "Microwave '74", while in no way neglecting the more academic aspects of the technology, will have a fine selection of down-to-earth practical applications papers plus a potent hardware exhibition where delegates can see and handle the latest developments as well as merely talking about them.

Sitting in Gardiol's office a hundred metres from the shore of Lake Geneva I could see, looking out of the window into the grounds of the Polytechnic, a beautifully constructed test track for linear motors on which the Electrical Department is conducting much research. Gardiol, as well as teaching, leads a microwave research team investigating loaded waveguides, microstrip circuits and industrial applications of microwave technology. His team of seven workers come from five different countries in three continents, an example to us all in our world of conflict. He is also a conservationist, being a member of the Swiss League for the Protection of Nature and of the World Wildlife Fund.

SET-BACK

Britain's *Skynet II* military comsat didn't get into earth orbit properly, let alone arrive at its designated position in outer space. There was a fault in the second stage firing of the *Delta* launcher from the Eastern Test Range at Cape Canaveral.

It was really tough luck for the dedicated team of Marconi men who built the satellite under a Ministry of Defence contract at Marconi Space and Defence Systems Ltd. works at Portsmouth. I have seen such satellites being built and tested. No human child has more loving care, no parents are more proud of their progeny, and no nursery is so immaculately clean as the air-filtered final assembly bay.

But there was a crumb of comfort for the designers and craftsmen involved. After six days of being "lost", a tracking station in the Pacific picked up strong telemetry signals which showed that the *Skynet* on-board systems were still functioning despite the 60G forces and overheating imposed by the faulty launch.

The satellite was now in a severely elliptical orbit, only 65 miles from earth at perigee. An attempt to fire the on-board apogee boost motor to get the satellite well clear of the earth's atmosphere failed because although the motor fired successfully the attitude of the spacecraft was wrong and it descended even lower and is presumed burnt up in the atmosphere.

The programme is now delayed some months but a second flight model is nearing completion and will be launched, one hopes with better success, later in the year. Nevertheless, the failure of the launch vehicle was a bitter blow to all concerned.

But off-setting the bad news of *Skynet II*, Marconi Space and Defence Systems has won important new contracts for radar "blindfire" trackers for the British Rapier surface-to-air missile. Rapier, produced by British Aircraft Corporation, is a huge success story with over £200 million worth of orders, half of this for export. Sharing in the bonanza for electronic sub-contracts are Decca Radar (primary radar and command link) and Cossor Electronics (IFF system).

Why big exports of weapons systems are desirable (though in many people's eyes deplorable) is the extremely high export value for a very low import content, even more important with today's high commodity values for Britain's balance of payments.

AEROSPACE STILL TOPS

Rapier, of course, is still only one product in a whole range of British aerospace projects which are doing well. Redifon has taken £9 million of orders for flight simulators from Japan, China and Singapore alone within the past twelve months.

Plessey has £7 million of orders in hand for navigation aids and has formed a completely new business for this sector under the management of Stan Kyte, an old hand in Plessey Radar who joined the company from Decca in 1965. One of Kyte's new activities in Plessey Navaids will be selling airfield electrical and electronic packages which average £4 million a shot. Nice work if you can get it!

Then there's the Multi-Role Combat Aircraft (MRCA) with nine prototypes readying for flight test. This huge multinational project with its on-board electronics complexes and ground support equipment will keep many a factory busy in the years ahead.

THAT THREE DAY WEEK

My own researches last January and February showed the electronics industry as ingenious in keeping production going as in the design and execution of its products.

I can report practically no loss of production and where some people were laid off it was shortage of components, not of power, that did the damage.

Congratulations to all these wonderful assembly workers who buckled to in difficult, sometimes uncomfortable conditions!

ESP etc

By Brian Baily...

Phantom Photos

Another off-beat subject which just fringes on ESP, in my opinion, concerns the existence of an "aura" around living things. The subject has been in dispute for centuries, and until comparatively recently only clairvoyant persons could be depended upon to detect it. Not any more, apparently.

In the 1950's some Russians claim to have discovered a way of photographing something which seems to resemble the so-called aura, or, as it might be termed, a living force-field. Claim, I say, because I am sure I have heard of earlier reports of the technique used in photography.

Ordinary film is placed on top of an insulating layer laid on a metal base plate. A volunteer's hand is then placed on another insulating layer. The bottom plate is connected to one pole of a high-voltage, high-frequency generator, and the other pole of this generator is connected to the subject's body. High-frequency energy is turned on in bursts.

All this is done in darkness, to avoid the film being exposed by any light from the room. The film is then developed in the normal way, and, if it is a negative, then prints are taken. The results are quite astounding. Details of the hand are shown up on the film, and curiously enough, the entire outline of the hand is surrounded by an over-exposed border which shows distinct "prickles" of concentrated exposure at certain points, e.g. around the finger tips. When colour film was used, the prickles appeared in different colours, depending on the temperament and mood of the subject.

Certain physicists at first thought this to be only an electrostatic concentration of electrical discharge, which might well be expected to take place around the edge of an object in such highly concentrated field conditions. Until, that is, the experiment was performed with a living leaf. Results with leaves showed all types of detail, far greater than would be seen under lighted conditions. But they also revealed a very mysterious fact. A leaf with a clipped-out portion from one edge was exposed by the "electrography" method, as it is called. The result showed the over-exposed border, but this was unbroken at the point at which the piece of leaf *should* have been, were it intact! Under colour electrography, the area displayed red blotches, almost as if the wound had bled. . .

The electrography experiments continue in Russia, where the techniqued is termed "Kirlian photography", after the discoverers. And in the United States, Dr Thelma Moss is engaged in similar researches. Strangely, her team obstinately use different voltages and frequencies from those used by the Russians. This seems strange, because in her reports, which I have read, she often uses these differences as a possible reason for her results not agreeing 100 per cent with the Russian findings.

I think both teams should be congratulated on their perseverence in a subject so frowned upon by people who, in my opinion, should know better. After all, a scientist is not supposed to know it all. His job is to find out more, and this is not achieved by a closed mind.

Psychokinesis

Research is going on into the field of paranormal phenomena in England too. One such experimenter is Benson Herbert, who is the man behind the Paraphysical Laboratory (or Paralab for short) near Downton, Wilts.

Recently, I was a close observer during a psychokinesis experiment (termed P.K.) in which a very gifted yound lady set her mind to influence the falling of soluble crystals through a glass flask of water.

Two identical glass jars, similar to those used for boiled sweets in sweet shops, were filled almost completely with clean, cold water, and allowed to settle for some hours on the table on which they were to stay, undisturbed, until and during the experiment. Two small quantities of soluble crystals of "viride nitens" were made ready on creased pieces of paper and carefully handled just prior to the experiment. Note: Crystals of viride nitens are very poisonous, but were used because of their dark blue dye-like characteristics when dissolved in water.

A hardboard screen was erected between the two bottles, so that only one bottle could be seen by the "medium", the other bottle acting as a control, with which any observed effect could be compared. The word "medium" is shown in quotation marks simply because it is not known that a spiritual medium is the only type of person who could perform the experiment satisfactory, though Miss Suzanne Padfield, who did the concentrating of mind in this instance, is well known for her abilities to heal, and perform "psychometry" (detection of facts from the past history of inanimate objects by handling them . . . to be discussed in a future article in this series).

The medium sat in a chair such that she could see only one of the bottles, and two assistants carefully shook the crystals from the creased papers into the respective bottles simultaneously. The subject was asked to influence, by thought, the falling of the crystals in the bottle she was observing. The crystals took a minute or so to become sufficiently wetted to fall slowly through the water, when they left dark blue "smoke trails".

Both sets of crystals commenced their falling at about the same time, and both bottle tops were at eye-level, to avoid breath interference. On completion of the leading crystal's fall in Miss P's bottle, the trail could be seen to be prominently "S"-shaped, as viewed from behind the medium. The first trails in the "control" bottle were quite vertical. After some dozen trails had been noted in each bottle, and in each case these were straight in the control bottle and "S"-shaped in the other bottle, we took time to chat, during which time it was noticed that further falls of crystals in *both bottles* were quite vertical.

We then asked Miss P. to concentrate on "spreading" the falls of crystals in her bottle, which, for the next few minutes, she was able to do simply by concentrating on the bottle once more. Again the control bottle traces continued to be vertical. New trails were easily identified at all times by the expansion of earlier ones, rather like vapour trails in the sky.

Accounts of this experiment, and of many others conducted at the Paralab are published in the "Journal of Paraphysics", obtainable from the Paralab, Downton, Wilts.

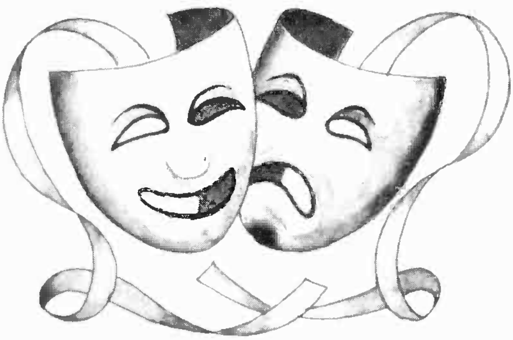
The experimenter may care to try the experiment for himself. If so, it would be wise to use less-toxic crystals, e.g. potassium permanganate, which give a purple colour when dissolved in water.

Next month: More Experiments

...NEXT MONTH

M.P.G. METER

Know just how thirsty your car really is ! Build this miles per gallon meter and keep your car fuel consumption under constant surveillance. Only suitable for cars with electric fuel pumps.

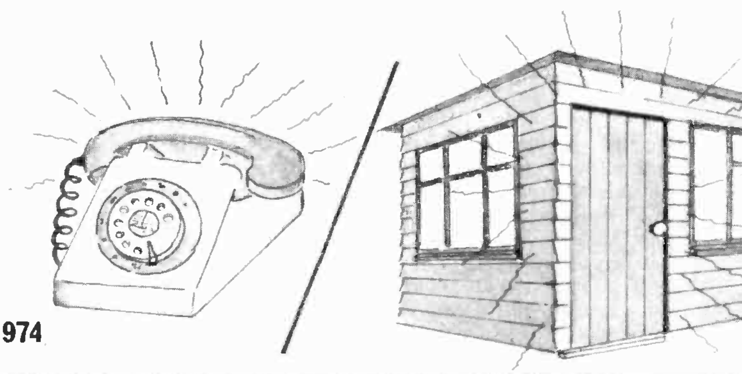


THEATRE CUEING LIGHT

We cannot guarantee actors will remember their lines, but at least they will know when to appear on stage. A very useful device for Amateur Dramatic Societies.

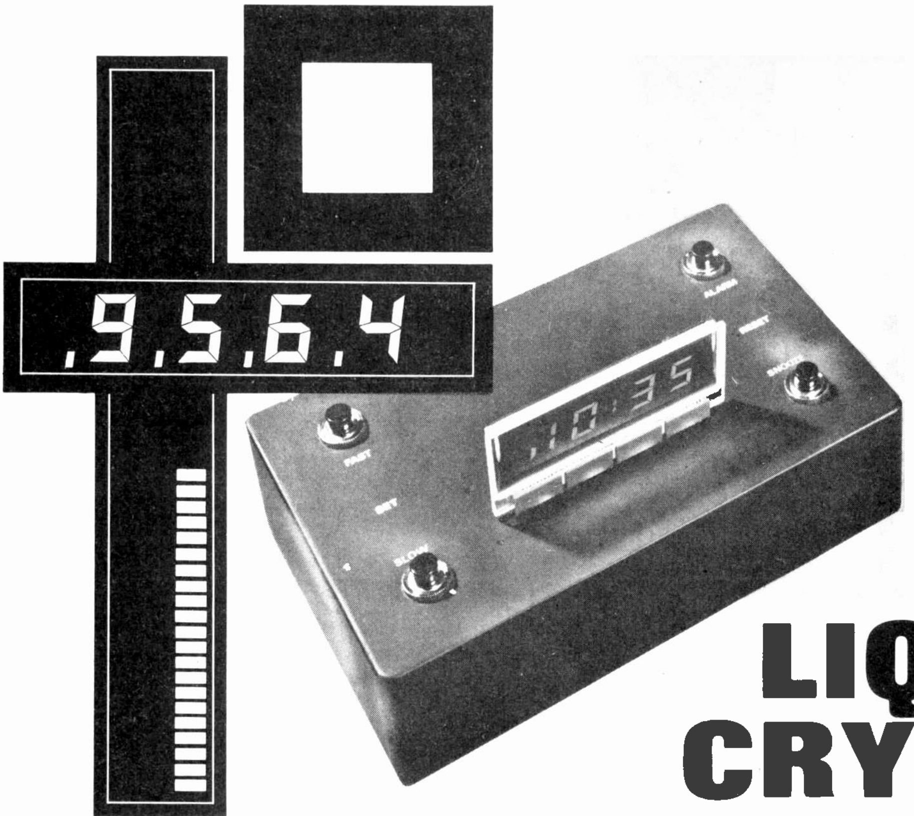
TELEBELL

A phone bell repeater—gives instant audible indication of a ringing bell anywhere you need it without wiring to a phone.



JUNE ISSUE ON SALE MAY 10, 1974

PRACTICAL
ELECTRONICS



LIQUID CRYSTAL CLOCK

BY S. GARRETT

THIS month constructional details for the Crystal Clock are given complete with instructions for final testing.

CONSTRUCTION

All the circuitry, with the exception of the control buttons and switches, is built on a 3¾in × 5in 0·1in matrix Veroboard.

The first thing to do is make all the cuts in the strips on the reverse as shown in the component layout of Fig. 4. Do this with care, and double check before going any further. In fact, if enthusiasm tempts you to hurry along at this or any other of the construction stages, remind yourself that two of the components account for just on 90 per cent of the project's total cost, and both can be remarkably sensitive to constructional errors.

The 14-pin d.i.l. socket won't cause any problems in assembly but do be quite sure it goes in the right way round. IC2 is very sensitive indeed to reversal, and getting the socket the right way round is half the battle. The 40-pin socket for the clock chip can be quite tricky to fit. The big secret is making sure all the socket pins are quite straight before starting. Any that prove reluctant to go into the Veroboard holes should be gently coaxed into position with a very small screwdriver or something similar.

Do not, under any circumstances, put either i.c. into its socket at this point. This is especially true for the clock i.c. which should be put safely to one side until much later in the construction process.

NEON, RADIO AND ALARM WIRING

First, take two 10in lengths of wire of any two differing colours, twist them together, and solder into D50 and G50, following Fig. 4. These wires will eventually carry the mains to the pair of neons mounted behind the l.c.d. Twist another two 10in lengths and solder into P19 and P36. These will eventually go to the radio jack plug JK1 on the side of the clock case.

Now, take another two differently coloured 10 inch lengths, twist together, and solder into R14 and Z17. These will go to the crystal microphone insert serving as an alarm loudspeaker.

INPUT FUNCTIONS WIRING

The next stage concerns the preliminary wiring for the various display possibilities, and control of the alarm/snooze operation.

First, take eight differently coloured 12 inch lengths of wire and solder them into the board as described below.

Solder a brown wire into EE41; a red wire into CC41; a white wire into AA41; a pink wire into Y41; a purple wire into X41; a yellow wire into W41; a green wire into V41; and a blue wire into U41.

Check that these soldered positions correspond to pins 24, 26, 28, 30, 31, 32, 33 and 34 respectively.

If this is so, then these wires have become: brown—snooze input; red—alarm off input; white—

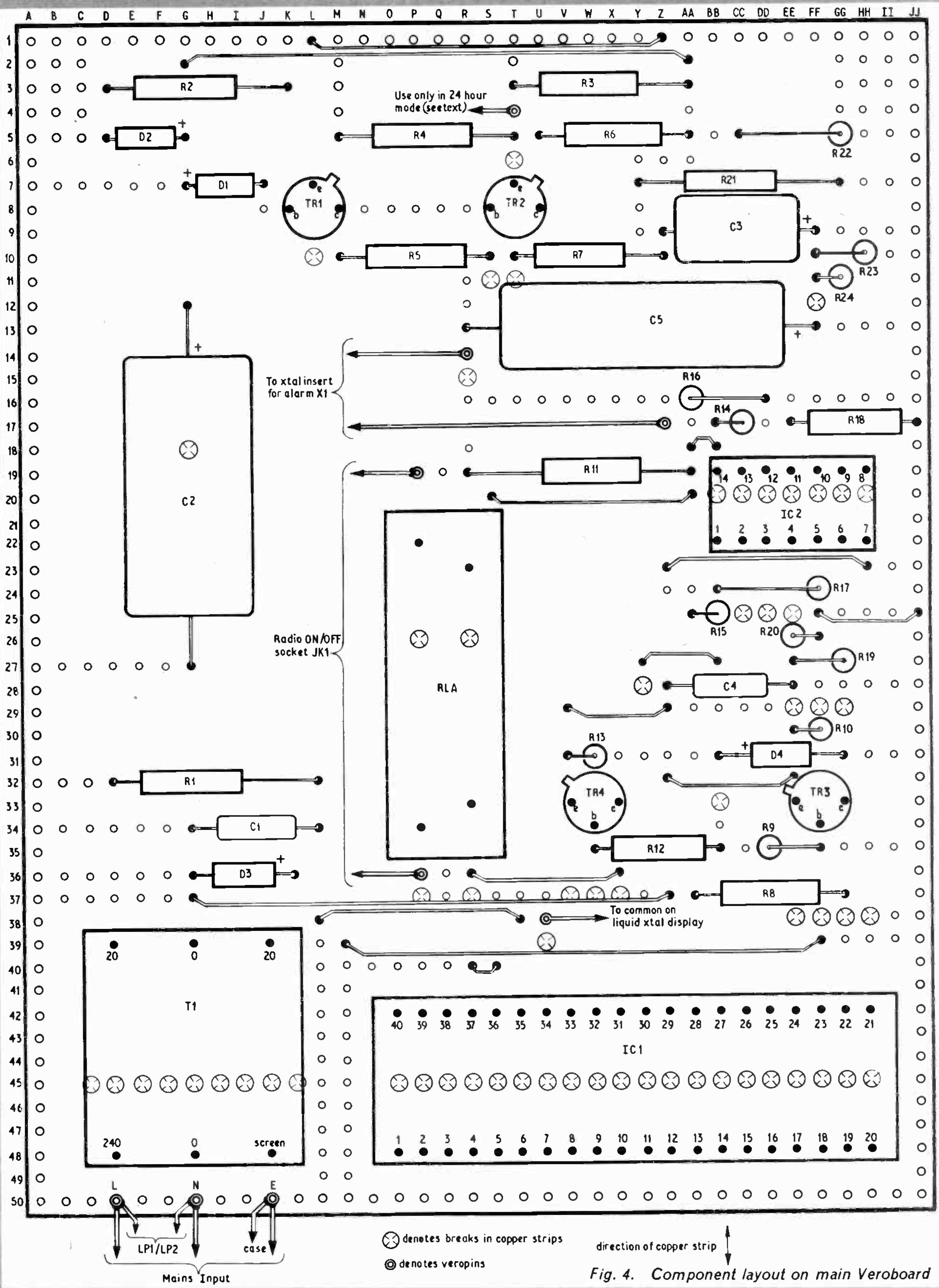


Fig. 4. Component layout on main Veroboard

V_{ss} to control the functions; pink—sleep display input; purple—alarm display input; yellow—seconds display input; green—slow set input; and blue—fast set input.

L.C.D. OUTPUT WIRING

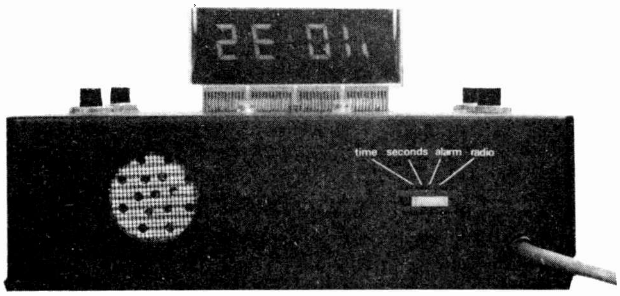
The final wiring on the Veroboard is the most extensive, and provides the outputs from the clock chip which will drive the liquid crystal display.

The following 12 inch lengths of wire will be required: four lengths yellow; four lengths pink; four lengths brown; four lengths green; three lengths white; three lengths blue; four lengths purple; one length red.

Before commencing soldering on, it is suggested that approximately ¼ inch of insulation is stripped from each wire at each end, the exposed wire twisted, and the ends tinned. This will enable the wiring process to proceed more quickly, and will also reduce the possibility of error.

The yellow wires should now be soldered into O49, Q49, X49 and DD49 a pink wire and a brown wire together into P49, with the three remaining pink wires going to T49, AA49, and GG49, and the three remaining brown wires going to U49, CC49, and GG41; the four green wires to R49, Y49, EE49 and U38 (the latter forming the l.c.d. common input); one white wire and blue wire together into Z49, with the two remaining white wires going to S49 and FF49, and the two remaining blue wires going to U49 and HH41; the purple wires to W49, BB49, HH49 and O41; the single red wire to P41.

This wiring has now provided inputs for the only two segments required for the tens of hours digit; all seven segments for the units of hours, the tens of minutes and the units of minutes; a.m. and p.m. indicators; a colon (which will pulse at a 1Hz rate) between the minutes and hours; and the l.c.d. common connection.



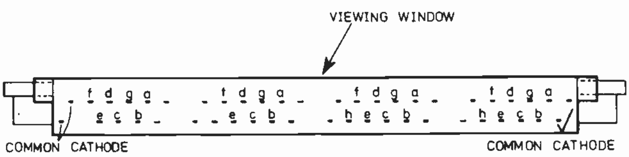
Rear of unit showing microphone insert and S1 switch positions.

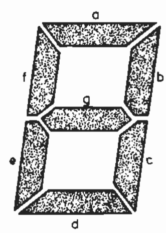
CLOCK DISPLAY CONSTRUCTION

Soldering the liquid crystal display socket into a piece of Veroboard is the first step, and is basically illustrated in Fig. 5. It will be noted that the cut in the Veroboard does not follow usual practice, and lie along the holes. It runs between them instead. This is because the l.c.d. socket pins are in two rows, each of them on 0·1 inch centres along their lengths. Unfortunately, the rows are also only 0·1 inch apart, which means the pins must go into immediately adjacent holes on the board. Thus the cut on the board to insulate the two rows of pins from each other must be done in the way shown.

The photograph of the interior of the prototype shows the looming that was done. Basically, the wires for the various digits were grouped together by digit, and loomed like that, while the function output wires were also loomed together. The result is five separate wire looms, a neat appearance, but most important of all, ease of handling in the stages to come.

Immediately before starting to connect the wires to the l.c.d. board, make sure it is lying the right way round, as in Fig. 5. In other words, the shoulder





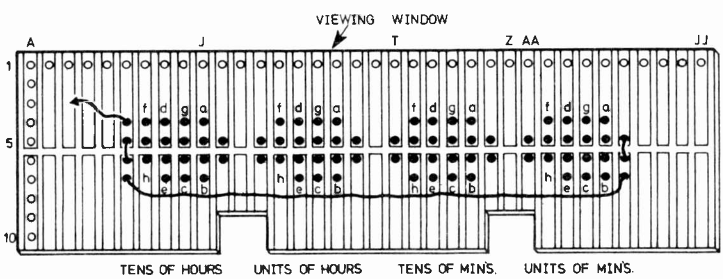


Fig. 5. Upper left shows pin diagram for l.c.d. Related digit segments are on right. To conform with the Veroboard when mounting one layer of pins should be bent by 0·05 in. Pin h connects to a colon which separates the two pairs of digits in the display.

on the socket, against which the shoulder on the l.c.d. lies, should be closest to you underneath the board.

When wiring, note that the wires go straight to the underside (copper strip side) of the l.c.d. board, and are soldered there, rather than passing down through the board from the top. The connections are as follows. The notation is for the l.c.d. Veroboard; the pins mentioned are those on the clock chip.

Solder the yellow wire from pin 1 to segment f at G4; the purple wire from pin 40 to segment e at H7; the pink wire from pin 2 to segment c at I6; the brown wire from pin 2 to segment b at J6. This completes the tens of hours digit, plus the a.m. and p.m. indicators.

Solder the yellow wire from pin 3 to segment f at N4; the blue wire from pin 7 to segment d at O4; the green wire from pin 4 to segment g at P4; the white wire from pin 5 to segment a at Q4; the purple wire from pin 9 to segment e at O7; the brown wire from pin 8 to segment c at P7; the pink wire from pin 6 to segment b at Q7. This completes the wiring for all seven segments of the units of hours digit.

Now solder the yellow wire from pin 10 to segment f at U4; the blue wire from pin 12 to segment d at V4 (leave the white wire from pin 12 for a moment); the green wire from pin 11 to segment g at W4; now take the remaining white wire from pin 12 to segment a at X4; the red wire from pin 39 to the l.c.d. colon at U7; the purple wire from pin 9 to segment e at V7; the brown wire from pin 15 to segment c at W7; the pink wire from pin 13 to segment b at X7. This completes the wiring for all seven segments of the tens of minutes digit, and also for the colon in the display.

Solder the yellow wire from pin 16 to segment f at BB4; the blue wire from pin 21 to segment d at CC4; the green wire from pin 17 to segment g at DD4; the white wire from pin 18 to segment a at EE4; the purple wire from pin 20 to segment e at CC7; the brown wire from pin 22 to segment c at DD7; the pink wire from pin 19 to segment b at EE7. This completes the wiring for all seven segments of the units of minutes digit.

Finally, make two small wire links—first, from F5 to F6; second, from FF5 to FF6. Then link F7 and FF7 with a longer wire. Lastly, connect the green wire from U38 on the clock board to F4. This has linked in the l.c.d. common connection. The wiring to the liquid crystal display board is now complete.

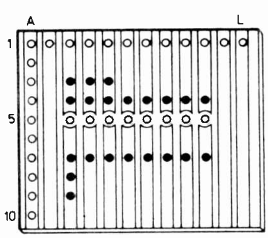


Fig. 6. Veroboard wiring detail for the d.i.l. switch S1.

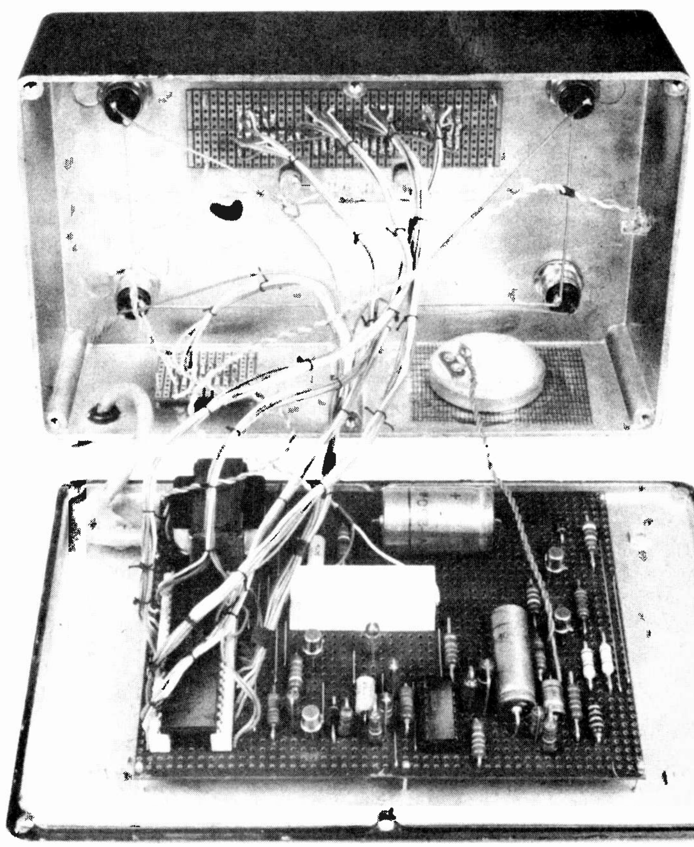
THE DISPLAY FUNCTION BOARD

The display function board contains the two-pole four-way switch used to control the display on the liquid crystal. It consists of a small piece of 0·1in matrix Veroboard as in Fig. 6. The switch is a very small two-pole four-way, built to correspond exactly to a 16 pin dual in-line package, and thus capable of being soldered directly into Veroboard or a printed circuit having holes at a ·1 inch matrix. Manufactured by ERG Industrial Corporation of Dunstable, the switch is remarkably small and remarkably neat. It comes in a number of the standard variations more often found in the much larger rotary wafer switches. The correct description for the switch used in the project is "DIL" DS16A switch—2 pole, 4 way.

The wiring of the Veroboard is very straightforward. Note that all wires go to the underside (copper strip) of the Veroboard, just as in the l.c.d. display board.

First, take the white wire from pin 28 of the clock chip to position C9 on the board. Before soldering, check that C9 corresponds to one of the poles, and not one of the "ways" of the switch. This can be easily seen by turning the board over and examining the switch. The two poles on one side, joining together two sets of four pins, are very obvious, as are the two sets of four "ways" on the other. Yet another advantage of this miniature switch.

Interior of crystal clock.



Soldering the white wire to C9 connects V_{ss} to the board, ready to control the functions.

Now connect the pink wire from pin 30 on the clock chip to C3; the purple wire from pin 31 to D3; and the yellow from pin 32 to E3. This has now completed the control wiring for sleep countdown display, alarm set time display, and minutes/seconds display. The last position on the switch is not connected, because this will correspond to normal true time display.

CLOCK OPERATION CONTROLS

The prototype uses four push buttons to control operation of the clock. They are of the simple push-to-make variety, and each one will eventually receive one of the remaining four unconnected wires from the clock chip. The push buttons will also, of course, receive V_{ss} as their other connection. However, it will prove more convenient to finally wire the buttons after the various boards are in position in the clock case, and so the various electronic assemblies can now be laid aside, so that work can begin on the case itself.

CLOCK CASE CONSTRUCTION

Construction is really a misnomer here, for the basic metal box into which the electronics go, and on which the l.c.d. is mounted. is a readily available standard size die-cast box, measuring a nominal 7¼in by 4½in by 2in. It has a lid, which will become the base in the project, held in position by six small bolts.

It seemed a shame to hide the l.c.d. away inside a box, merely letting the digits be visible, when it would then start to look like almost any other digital clock, with little novelty value. And, of course, there would also be a positive need to illuminate the digits in some way, since they generate no light of their own. It was for this reason that the display was mounted on top of the box.

It should be remembered that the four holes on the top for the push buttons must be drilled with diameter of the intended buttons in mind. No indication has been given of size because of the large number of different push buttons available. The same applies to the holes for the small neons behind the l.c.d.

In the same way, no size has been given for the much larger hole behind which the crystal microphone insert will go for the alarm tone. The type of insert used is unimportant, but again they vary in size.

The insert is held in place with an epoxy resin adhesive, so the hole should be less in diameter than the insert by at least a ¼ inch, if not a little more. It should be cut as neatly as possible—a tank cutter is ideal for the job—because this is the only hole in the case in which the edges will be clearly visible.

The dimensions given for the rectangular opening, through which the l.c.d. socket will emerge, are correct for the socket in the prototype, but it might be wise to check carefully against the socket actually obtained. Dimensions are unlikely to vary greatly, but the neatest result is obtained if the box opening fits very snugly round the socket. Modify the dimensions if necessary, therefore.

The four small holes round the l.c.d. socket, the four small holes round the d.i.l. switch opening, and the six small holes in the base are all of a size to take 12 B.A. bolts.

PAINTING AND LABELLING

After all the metalwork has been completed, the box should be very thoroughly rubbed down with wet-and-dry paper. It may be necessary first to use a coarse glass paper, or even a fine file, to remove any particularly bad rough edges. It is possible to get a singularly smooth finish finally, before painting. When the metal is completely smooth, it's a good idea to give the box a thorough wash in warm water and washing-up liquid. This will get rid of all remaining dust.

The paint used for the prototype was initially matt black. All the openings were sealed from the inside by masking tape, and the box was sprayed with the base screwed in position. Three coats were given, following the instructions on the spray can.

After allowing a three day drying period following the final coat of matt black, the various controls were labelled with Letraset. This was immediately followed with the first of three coats of matt polyurethane varnish, each coat being allowed to dry before applying the next. The aim, of course, is to give protection to the original matt black, as well as the Letraset.

When the final varnish coat is completely dry, assembly work can commence.

ASSEMBLING THE CLOCK

The first step is to mount the four feet on the underside of the base. This will keep it away from the working surface, and prevent unnecessary damage to the paint. Mount the feet in the normal way, using appropriately sized bolts and nuts.

Now the clock board can be placed on the base. First, take six 12 B.A. bolts and nuts, and mount them firmly in the six small holes in the base. Then take another six nuts and screw each one down on a bolt until it is approximately ¼ inch from the base. The Veroboard will rest on these.

Now take the main clock board and gently ease it onto the six bolts, sliding it down until it is resting on the six secondary nuts. Make any minor adjustments to the nuts to ensure the board is seated firmly without warping.

The board should now be removed from the base for a time, in order to complete the last wiring connection on it, before it is finally mounted. This is the mains input.

Normal three core mains wire should be used, with the earth connection going to the screen tag on the transformer input and case.

PRELIMINARY POWER TESTING

A point has now been reached in the construction and assembly at which it is advisable to carry out a preliminary test of the power supplies to the board, and on the board.

First, securely tape the ends of the miniature wires from the mains input side of the transformer which will eventually go to the neons. These will, of course, be live when the mains is turned on. Second, make sure the main clock board is standing on a non-conducting surface, and arrange the two sub-assemblies (l.c.d. display and display control boards) so that they are not shorting to any of the components on the main board.

Finally, remember that *neither the clock chip or the alarm noise i.c. are to be inserted at this stage.*

The mains can now be applied to the board, so that the voltage between V_{ss} and V_{dd} can be measured, in order to make sure that it is approximately the correct value, and therefore unlikely to damage either i.c. when the final tests are done later.

There are a number of convenient points on the top of the main clock board at which this measurement can be done. Probably the best is across the two wire links which run between G2/AA2 (V_{ss}) and between L1/Z1 (V_{dd}). The reading should be approximately 30 volts. Anything at all higher than 31 volts, or significantly lower than about 27 volts almost certainly indicates a fault in the power supply circuitry, which should be investigated and put right before going any further.

Assuming the voltage readings are correct, the mains can now be turned off, and the main clock board replaced on the six 12 B.A. bolts on the base. A further six 12 B.A. nuts are now screwed on to the bolts, thus holding the board firmly in position.

At this stage, the base can be laid aside, and some preliminary work done on fitting components to the main part of the case. First, put the four push buttons, the two neons, and the radio jack plug in their respective positions, and fix them securely. Next, the crystal microphone insert can be glued into place, using an epoxy resin adhesive.

Now the basic V_{ss} wiring for the push buttons can be done. This involves a ring common connection to one of the terminals on each of the push buttons. V_{ss} will eventually be connected to this ring.

FINAL ASSEMBLY AND TESTING

The three pairs of leads from the main clock board for the neons, the crystal microphone insert, and the radio jack plug should be connected to their respective components inside the main case first. Check back to Fig. 4 to make sure the right pair goes to the right place. The function control subassembly board, bearing the d.i.l. switch, should now be fitted.

The fitting of the function control board is done in exactly the same manner as the main clock board was fitted to the base. The optimum position for the d.i.l. switch is sufficiently far through the side wall of the main case to be easily operated, but not so far as to possibly short out the external tags on the side of the switch.

The next step is to wire in the other ends of the only four leads from the clock chip so far unconnected.

These are the brown wire from pin 24 (snooze input); the red wire from pin 26 (alarm off or reset input); the green wire from pin 33 (slow time set input); and the blue wire from pin 34 (fast time set input).

These wires go to the vacant terminal on each of their appropriate push buttons. Rather than attempt a complicated explanation of which button is which when viewed from underneath, the pictures of the outside and inside of the case make the push button positions quite clear.

V_{ss} must now be supplied to the common ring connection round the four push buttons, and this can be most handily obtained from the display control board, which is now in position and conveniently close to one of the buttons. V_{ss} is, as will be known, at the point where the white wire is connected to the display control board, and thus another very short lead needs to come from here to the push button common ring connection. The final assembly step comes with the mounting of the l.c.d. display board into the main case. Again, the mounting procedure is exactly the same as that for the main clock board on the base. Care should be taken, however, to make sure the board is the right way round, though this is virtually guaranteed by the small cut-outs to clear the neons.

FINAL TESTING OF THE CLOCK

The time has now come for the two i.c.s to be put in position, and a great deal of care should be taken at this stage when fitting the clock chip. To start with, it has 40 pins instead of the more familiar 14 or 16, and this makes fitting very much more difficult. Secondly, it is extremely sensitive to any small charge of static which may have built up. This is why the chip will probably have been supplied with the pins in a material to prevent this. Handle the chip cautiously therefore, and try to avoid shorting any of the pins out, either with the fingers or a component. The loomed wires each side of the clock chip socket will need to be carefully parted to allow the chip to be slid in to rest on the socket. Once this has been done, *make a last check to be sure the chip is the right way round,* and then ease the pins home into their respective holes. Once they start to go in, there will be no further problem. The chip should be pushed well down and should finally lie flat.

The smaller i.c. for the alarm noise will present no problem, but it is worth repeating that it is especially sensitive to any accidental reversal in the socket. The normal check to avoid this becomes even more essential therefore.

If the l.c.d. was tested in position earlier but then removed, it should now be replaced.

FIRST SWITCH-ON

Once both i.c.s and the display are in position, the mains can be turned on.

This should cause at least two things to happen —first, the neons should light, confirming the presence of power; second, and much more rewarding, the l.c.d. should show some form of display.

If it is showing some form of display, but this appears to be a collection of unrelated segments, then the display is slightly off-centre. Merely slide it fractionally left or right, holding it by the ends, until recognisable digits appear. If the l.c.d. started in the approximate centre of the socket, only a tiny movement will be necessary.

If, by this stage, (a) the neons have not come on or (b) the l.c.d. display is either non-existent or cannot be made recognisable or (c) the p.m. indicator is not pulsing or (d) the colon between hours and minutes is not pulsing or (e) there is a combination of any of these symptoms, then there is a fault somewhere which must be located and cured before proceeding further.

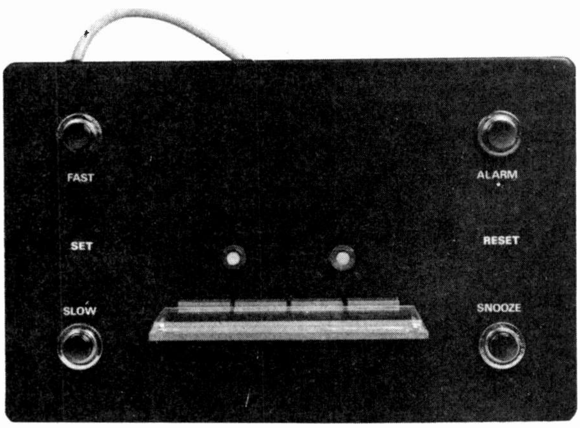
One point which should be checked without delay is the position of the function display d.i.l. switch. It should, of course, be set for normal time display.

All other fault-finding will follow the traditional path of checking soldered joints, checking for bridges between the Veroboard strips, checking the polarity and operation of components, and so on. If construction has been done carefully, however, there should be no problems at this point.

PRESS BUTTONS

Assuming that all is well therefore, the "Set fast" button can now be pressed. This should cause the time to count rapidly forward, at one hour per second, and cancel the pulsing "power interruption" indication, replacing it with a steady indication of either a.m. or p.m. time status. Releasing the button will stop the time movement and normal time counting will begin.

The "Set slow" button should now be tried, and should give exactly the same results, excepting that the time will now count up at two minutes per second.



Showing control button legends and neon placement for best contrast

The display control switch can now be moved to the "seconds" display position. This should result in the previously displayed units of minutes digit moving to the units of hours position, and the total minutes display being replaced with a steadily counting seconds display.

With the display control switch still in the "seconds" position, the "Set fast" and 'Set slow" buttons should be tried again. The former should result in the seconds count reverting to "00" and holding there, while the latter will merely hold the seconds count at whatever point it is when the button is pressed. This ability is invaluable if the clock is to be set accurately against a known time source, as will be explained shortly.

ALARM

The display control switch should now be moved to the "alarm" position. This should result in the display changing immediately to "12:00", which is the alarm set time until changed. The "Set fast" and "Set slow" buttons can now be used as they were with a normal time display, in order to set the alarm. It is suggested that the alarm be set two or three minutes ahead of whatever the time display happens to be.

When this is done, and as the normal time display reaches the alarm set time, the alarm should sound. Instead of pressing the "Reset alarm" button, press the "Reset snooze" button. The alarm noise should stop immediately, but should come on again approximately 8 minutes later. This preset time may vary slightly but not a great deal.

When the alarm sounds again, press the "Reset alarm" button, which should turn it off for a full 24 hour period.

SLEEP

Finally, move the display control d.i.l. switch to its "sleep" position. This should immediately result in the display changing to a two digit figure. There should be no colon or a.m./p.m. indicator. This display shows the time remaining in minutes before the continuous circuit available via the radio jack plug will be cut.

The "Set fast" and "Set slow" buttons will now have a reverse effect on the display, in that they will cause it to count down, rather than up, but at the normal speeds for each button. When the display reaches "00", it will recycle immediately to "59". However, in normal operation, when it reaches "00", it will latch there and not recycle.

RADIO

The device is used to control a radio very simply by connecting one side of the radio's battery power via the jack plug. Providing the sleep display shows a time in minutes, the radio will play. When "00" is reached, the radio will go off.

If every operation described in this section is achieved, the checking process is completed, as is also the entire project, and the constructor now has a fully operating liquid crystal display clock of which he can reasonably be proud!

ACCURATE SETTING OF TIME

For ease of explanation, it is assumed that a telephone is handy. The process will be identical, however, for setting the clock against the Greenwich time signal from a radio, or the clock displayed on TV from time to time. The only problem with the latter two methods is the inconvenient times at which the time signals seem to be made available!

First, set the clock to a point several minutes ahead of what the true time is believed to be. Then switch to "seconds" display and press the "Fast set" button, holding it down. This will hold the time count, and revert the seconds ingredient in the time count to zero. In other words, the clock is being held on a precisely set minute.

Then, while still holding the "Fast set" button down, use the other hand to dial the Post Office Speaking Clock. It is at this point that the final choice of switches for some functions on the clock, but buttons for others, will become abundantly clear!

The rest is obvious—as soon as the third stroke is heard for whatever precise minute is being held, the "Fast set" button is released, and the clock is set to the second. ★

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2G306	0·80	2N3402	0·18	40050	0·78	BC107	0·16	BCY89	0·97	BFY19	0·35
2G309	0·80	2N3403	0·19	40251	0·81	BC108	0·16	BCZ10	0·36	BFY20	0·50
2G345B	0·25	2N3404	0·24	40309	0·30	BC109	0·19	BCZ11	0·50	BFY29	0·40
2G371	0·15	2N3405	0·27	40310	0·50	BC113	0·13	BD115	0·75	BFY37	0·20
2G374	0·15	2N3414	0·10	40313	0·92	BC114	0·12	BD116	0·75	BFY41	0·43
2N174	1·40	2N3415	0·10	40316	0·50	BC115	0·15	BD121	0·75	BFY43	0·65
2N404	0·43	2N3416	0·15	40318	0·92	BC116	0·15	BD123	0·82	BFY50	0·22½
2N456	0·75	2N3417	0·21	40360	0·46	BC116A	0·18	BD124	0·67	BFY51	0·18½
2N456A	0·75	2N3570	1·25	40361	0·48	BC117	0·21	BD131	0·40	BFY52	0·20½
2N457A	0·80	2N3571	1·12½	40362	0·50	BC118	0·11	BD132	0·50	BFY53	0·16
2N491	3·58	2N3572	0·97	40363	0·81	BC119	0·29	BD135	0·43	BFY56	0·34
2N696	0·15	2N3702	0·11	40389	0·46	BC121	0·23	BD136	0·49	BFY64	0·41½
2N697	0·15	2N3703	0·12	40394	0·56	BC125	0·15	BD137	0·55	BFY75	0·40
2N698	0·25	2N3704	0·14	40395	0·65	BC126	0·20	BD138	0·63	BFY76	0·22
2N699	0·29	2N3705	0·12	40406	0·44	BC132	0·30	BD139	0·71	BFY77	0·24
2N706	0·16	2N3706	0·09	40407	0·33	BC134	0·11	BD140	0·87	BFY78	0·36
2N706A	0·18	2N3707	0·13	40408	0·50	BC135	0·11	BDY10	1·25	BFY90	0·60
2N708	0·14½	2N3708	0·70	40409	0·52	BC136	0·15	BDY11	1·50	BRY39	0·28
2N709	0·38	2N3709	0·11	40410	0·52	BC137	0·15	BDY17	1·50	BSX19	0·13
2N711	0·30	2N3710	0·12	40411	2·25	BC138	0·24	BDY18	1·75	BSX20	0·20½
2N718	0·21	2N3711	0·11	40414	3·55	BC140	0·34	BDY19	1·97	BSX21	0·20½
2N718A	0·49	2N3712	0·96	40467	0·69	BC141	0·29	BDY20	1·05	BSX26	0·49
2N720	0·50	2N3713	1·20	40468A	0·44	BC142	0·23½	BDY38	0·65	BSX27	0·34
2N721	0·55	2N3714	1·38	40600	0·69	BC143	0·21	BDY60	0·85	BSX28	0·25
2N914	0·22	2N3715	1·50	40601	0·67	BC144	0·24	BDY61	1·25	BSX29	0·47
2N916	0·41	2N3716	1·80	40602	0·46	BC145	0·21	BDY62	1·00	BSX60	0·54
2N918	0·47	2N3773	2·65	40603	0·58	BC147	0·12	BF115	0·25	BSX61	0·42
2N929	0·30	2N3779	3·15	40604	0·56	BC148	0·13	BF116	0·23	BSX76	0·15
2N930	0·48	2N3790	2·40	40636	1·10	BC149	0·13	BF117	0·43	BSX77	0·20
2N1090	0·30	2N3791	2·35	40673	0·70	BC153	0·18	BF119	0·58	BSX78	0·25
2N1091	0·32	2N3792	2·69	AC107	0·25	BC154	0·25	BF121	0·25	BSW70	0·28
2N1132	0·54	2N3794	0·10	AC113	0·16	BC157	0·14	BF123	0·27	BSY24	0·20
2N1302	0·18½	2N3819	0·37	AC117	0·20	BC158	0·13	BF125	0·25	BSY25	0·20
2N1303	0·18½	2N3820	0·38	AC121	0·13	BC159	0·14½	BF152	0·20	BSY26	0·20
2N1304	0·24	2N3823	1·42	AC126	0·25	BC160	0·37	BF153	0·21	BSY27	0·15
2N1305	0·24	2N3824	1·33	AC127	0·25	BC167B	0·13	BF154	0·16	BSY28	0·15
2N1306	0·31	2N3826	0·23	AC128	0·25	BC168B	0·13	BF158	0·23	BSY38	0·19½
2N1307	0·22	2N3854	0·18	AC141K	0·30	BC168C	0·11	BF159	0·27	BSY39	0·19½
2N1308	0·25	2N3854A	0·16	AC142K	0·25	BC169B	0·13	BF160	0·23	BSY51	0·25
2N1309	0·35½	2N3855	0·19	AC151V	0·14	BC169C	0·13	BF161	0·41½	BSY52	0·25
2N1483	0·90	2N3855A	0·20	AC152V	0·17	BC170	0·11	BF163	0·31½	BSY53	0·25
2N1507	0·30	2N3856	0·19	AC153	0·25	BC171	0·11	BF166	0·31½	BSY54	0·30
2N1613	0·33	2N3856A	0·20	AC153K	0·25	BC172	0·11	BF167	0·21	BSY56	0·79
2N1631	0·38	2N3858	0·16	AC154	0·20	BC182	0·12	BF173	0·24	BSY65	0·15
2N1637	0·36	2N3858A	0·19	AC176	0·18	BC182L	0·12	BF177	0·29	BSY78	0·40
2N1638	0·32	2N3859	0·14	AC176K	0·30	BC183	0·09	BF178	0·33	BSY79	0·40
2N1701	1·19	2N3859A	0·19	AC187K	0·28	BC183L	0·09	BF179	0·43	BSY790	0·45
2N1702	2·15	2N3860	0·19	AC188K	0·34	BC184	0·11	BF180	0·35	BSY95A	0·10½
2N1711	0·45	2N3866	1·09	ACY17	0·35½	BC184L	0·11	BF181	0·34	BU104	1·42
2N1893	0·81	2N3877	0·25	ACY18	0·24	BC186	0·25	BF182	0·40	BU105	2·25
2N2102	0·30	2N3877A	0·26	ACY19	0·27	BC187	0·27½	BF183	0·40	C111	0·53
2N2147	0·70	2N3900	0·21	ACY20	0·22	BC207	0·12	BF184	0·30	D40N3	0·55
2N2148	0·94	2N3900A	0·21	ACY21	0·26	BC208	0·11	BF185	0·17	GET111	0·45
2N2192	0·40	2N3901	0·32	ACY22	0·17	BC212K	0·10	BF194	0·16	GET113	0·25
2N2192A	0·40	2N3903	0·24	ACY28	0·20	BC212L	0·16	BF195	0·17	GET114	0·20
2N2913	0·40	2N3904	0·27	ACY30	0·42	BC214L	0·21	BF196	0·15	GET115	0·50
2N2193A	0·61	2N3905	0·24	ACY39	0·65½	BC237	0·09	BF197	0·15	GET119	0·35
2N2194	0·73	2N3906	0·27	ACY40	0·17	BC238	0·09	BF198	0·18	GET120	0·40
2N2194A	0·30	2N4036	0·62½	ACY41	0·17	BC239	0·09	BF199	0·28	GET535	0·20
2N2218A	0·86	2N4037	0·42	ACY44	0·31	BC251	0·20	BF200	0·40	GET536	0·20
2N2219	0·57	2N4058	0·18	AD136V	0·96	BC252	0·18	BF224J	0·14	GET538	0·20
2N2219A	0·86	2N4059	0·09	AD142	0·50	BC253	0·23	BF225J	0·19	GET873	0·12
2N2220	0·45	2N4060	0·11	AD143	0·45	BC257	0·09	BF237	0·22	GET875	0·15
2N2221	0·41	2N4061	0·11	AD149V	0·66	BC258	0·09	BF238	0·22	GET880	0·35
2N2221A	0·83	2N4062	0·11	AD150	0·63	BC259	0·13	BF244	0·16	GET883	0·20
2N2222	0·60	2N4302	0·25	AD161	0·45	BC261	0·20	BF245	0·43	GET887	0·20
2N2222A	0·91	2N4303	0·47	AD162	0·45	BC262	0·18	BF246	0·43	GET890	0·25
2N2368	0·31	2N4916	0·11	AD161 }	Pr.	BC263	0·23	BF247	0·49	GET895	0·25
2N2369	0·37	2N4917	0·17	AD162 }	1·05	BC300	2·12	BF254	0·16	TIP29A	0·49
2N2369A	0·41	2N4918	0·73	AF109R	0·40	BC301	0·34	BF255	0·17	TIP30A	0·58
2N2646	0·77	2N4919	0·84	AF114	0·25	BC302	0·29	BF257	0·47	TIP31A	0·62
2N2647	1·12	2N4920	0·99	AF115	0·24	BC303	0·54	BF258	0·59	TIP32A	0·74
2N2711	0·13	2N4921	0·73	AF116	0·25	BC307	0·10	BF259	0·55	TIP33A	1·01
2N2712	0·12	2N4922	0·84	AF117	0·20	BC307A	0·10	BF270	0·21	TIP34A	1·51
2N2713	0·17	2N4923	0·83	AF118	0·50	BC308	0·09	BF272	0·53	TIP35A	2·90
2N2714	0·18	2N5172	0·12	AF121	0·22	BC308A	0·12	BF273	0·15	TIP36A	3·70
2N2904	0·55	2N5174	0·22	AF124	0·24	BC308B	0·09	BF274	0·17	TIP41A	0·79
2N2904A	0·70	2N5175	0·26	AF125	0·20	BC309	0·10	BF457	0·53	TIP42A	0·90
2N2905	0·71	2N5176	0·32	AF126	0·19	BC309A	0·10	BF458	0·65	TIP2955	0·98
2N2905A	0·88	2N5190	0·92	AF127	0·20	BC309B	0·10	BF821A	2·30	TIP3055	0·60
2N2906	0·65	2N5191	0·95	AF139	0·38	BC327	0·21	BF828	0·92	ME0401	0·18
2N2906A	0·70	2N5192	1·24	AF170	0·25	BC328	0·19	BF861	0·27	ME0402	0·20
2N2907	0·38	2N5195	1·46	AF172	0·25	BC337	0·19	BF898	0·28	ME0404	0·18
2N2907A	0·41	2N5245	0·43	AF178	0·55	BC338	0·19	BFW11	0·61	ME0411	0·17
2N2923	0·12	2N5457	0·49	AF179	0·65	BCY30	0·43	BFX13	0·23	ME0412	0·18
2N2924	0·14	2N5458	0·45	AF180	0·50	BCY31	0·51½	BFX29	0·30	ME0413	0·14
2N2925	0·17	2N5459	0·49	AF186	0·40	BCY32	1·15	BFX30	0·25	ME1120	0·25
2N2926		3N128	0·73	AF200	0·35	BCY33	0·34	BFX37	0·33	ME4001	0·09
Green	0·12	3N138	1·65	AF239	0·51	BCY34	0·36½	BFX44	0·33	ME4002	0·11
Yellow	0·11	3N139	1·42	AF240	0·72	BCY38	0·52½	BFX63	2·48	ME4003	0·14
Orange		3N140	0·92	AF279	0·54	BCY39	1·05	BFX68	0·30	ME6101	0·10
	0·11	3N141	0·81	AF280	0·54	BCY40	0·87	BFX84	0·24	ME4102	0·11
2N3053	0·32	3N142	0·58	AFY42	0·74	BCY42	0·15	BFX85	0·30	ME4103	0·10
2N3054	0·86	3N143	0·75	AL102	0·75	BCY43	0·15	BFX86	0·25½	ME4104	0·11
2N3055	0·75	3N152	0·92	AL103	0·70	BCY58	0·21	BFX87	0·28	ME4101	0·14
2N3390	0·26	3N153	0·81	ASY26	0·30	BCY59	0·22	BFX88	0·25	ME6102	0·16
2N3391	0·28	3N154	0·84	ASY27	0·36	BCY70	0·17	BFX89	0·45	ME8002	0·17
2N3391A	0·29	3N159	1·17	ASY28	0·28	BCY71	0·22	BFY10	0·35	ME8003	0·16

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SN7403	0·20	SN7442	0·85	SN7490	0·65	SN74161	1·58
SN7404	0·24	SN7445	1·59	SN7491	1·10	SN74162	1·58
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SN7406	0·45	SN7447	1·30	SN7493	0·65	SN74165	2·01
SN7407	0·45	SN7448	1·50	SN7494	0·85	SN74167	4·10
SN7408	0·25	SN7450	0·20	SN7495	0·80	SN74174	1·80
SN7409	0·33	SN7451	0·20	SN7496	1·00	SN74175	1·29
SN7410	0·20	SN7453	0·20	SN74100	2·16	SN74176	1·44
SN7411	0·25	SN7454	0·20	SN74107	0·48	SN74180	1·44
SN7412	0·28	SN7460	0·20	SN74118	1·00	SN74181	5·18
SN7413	0·50	SN7470	0·30	SN74119	1·92	SN74190	1·95
SN7416	0·45	SN7472	0·38	SN74121	0·57	SN74191	1·95
SN7417	0·30	SN7473	0·44	SN74122	0·80	SN74192	2·05
SN7420	0·20	SN7474	0·48	SN74123	0·72	SN74193	2·30
SN7423	0·37	SN7475	0·59	SN74141	1·00	SN74196	1·58
SN7425	0·37	SN7476	0·45	SN74145	1·44	SN74197	1·58
SN7427	0·45	SN7480	0·75	SN74150	1·44	SN74198	3·16
SN7430	0·20	SN7481	1·25	SN74151	1·10	SN74199	2·88

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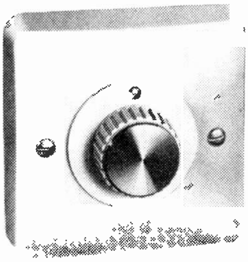
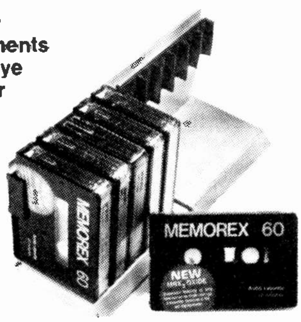


Rendar Instruments Secureye dimmer



Memorex MRX2 cassette tape

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.

SECURITY LIGHT DIMMER

Apart from being able to control the amount of lighting power being used, the latest light dimmer now being marketed by **Rendar Instruments Ltd.** also acts as an intruder deterrent.

Designed as a direct replacement for the existing light switch, the Secureye embodies a manual on/off switch, dimmer and an automatic on/off switch operated by ambient light.

As light falling upon the cell is reduced, power is allowed to flow through the switch progressively until approximately half brilliance is achieved. When ambient light level is increased the control automatically operates as a dimmer until power is cut off completely.

Capable of carrying a load of up to 500W a.c., the dimmer is suitable for use with any type of incandescent lighting. The automatic action is claimed to produce surge-free switching at up to 50 per cent of normal power, thus prolonging lamp life.

The Secureye is ideally suited as a standby lighting; control of home or office lighting during absence; and maintenance of illumination level in hospitals, on stairways and in other areas where safety considerations apply.

The recommended retail price for the Secureye is £5·60 plus VAT. Addresses of nearest stockists can be obtained from Rendar Instruments Ltd., Victoria Road, Burgess Hill, Sussex.

CASSETTE TAPE

With so many different processes and differing claims for the large number of tapes now appearing on the market, it is difficult to choose one tape from another. However, we can certainly recommend the new cassette tape from **Memorex U.K. Ltd.**

By using a highly concentrated iron oxide particle method, the Memorex MRX2 cassette tape is claimed to give better frequency response and signal/noise ratio performance than most current tapes. Using a tape recorder in the £100 range, recordings on various cassette tapes, including chrome oxide types, showed that the Memorex MRX2 tapes gave better high note performance and in many cases far less tape noise.

The cassettes are available from most audio stores with playing times from 30 to 120 minutes. Prices vary from 62p for 30 minutes to £1·60 for 120 minutes, plus VAT.

EMERGENCY DESK LAMP

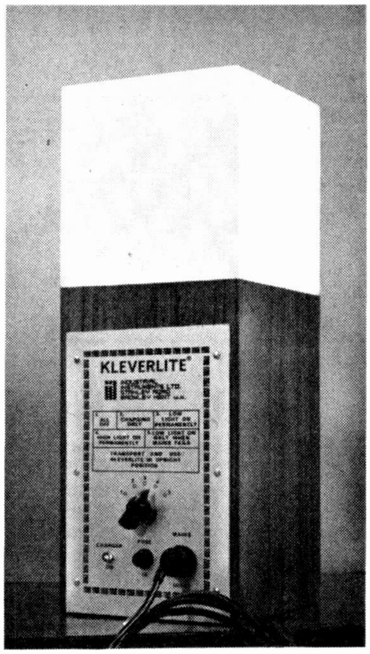
Whilst on the subject of power and lighting, readers may be interested in an ingenious desk lamp produced by **Industrial Instruments Ltd.**

Called the Kleverlite the lamp has a five position selector switch which enables the light to be used during power cuts and also charges the internal nickel cadmium battery during mains operation.

The five positions of the selector switch are as follows: 1. Unit off; 2. Charger only on; 3. Low light intensity; 4. High light intensity; 5. Low light intensity on when mains fail. Should the mains fail, the light will also continue to function if the light is in positions 3 or 4.

The low light position enables approximately four hours' operation under power cut conditions, while the high light position gives normal desk working lighting for approximately two hours.

The built-in charger is a transistor controlled, constant current type, which ensures a high current to recharge the battery as quickly as possible when the mains is restored. Once the battery is charged, the charger reverts automatically to trickle charging.



Kleverlite desk lamp from Industrial Instruments

The bulbs used in the light are 6V 6W low light and 6V 18W high light; replacements being readily available from motor accessory shops. The bulbs are deliberately under run from the 4·5V battery to ensure long life.

The Kleverlite is available from Harrods or Hastings Lighting Centre, price £49·50. Further information can be obtained from Industrial Instruments Ltd., Stanley Road, Bromley, Kent, BR2 9JF.

SOLDERING TIPS

It is generally recognised that soldering iron efficiency is largely dependent upon the design and shape of the soldering iron bit, so this year **Adcola Products Ltd.** are concentrating on producing almost 100 different soldering tip designs as standard off-the-shelf items.

The range includes both copper and iron plated long life bits in a variety of shapes; standard, taper, reduced chisel, conical, screwdriver and special printed circuit types.

In addition to soldering bits for their own tools, the range has been extended to cover other manufacturers' soldering irons.

Further details of the complete range of tips can be obtained from Adcola Products Ltd. Adcola House, Gauden Road, London, SW4 6LH.

NOTE

With regards to the **Radio & TV Components** Stereo 21 System announcement on page 218 of the March issue. The postage and packing should be £1·60 not 16p as stated. We apologise for this printing error.

PATENTS REVIEW...

PRINTED CIRCUITS

BP 1 329 770

Printed circuits conventionally take the form of a network of electrically conducting lines on a non-conductive substrate. Often the substrate is a resin or ceramic material and the conductors are of silver or a precious metal such as platinum, palladium or gold. Application is by painting, stamping or screen printing. The outstanding disadvantage is of course the cost of the precious metal.

In BP 1 329 770 NL Industries Inc. of New Jersey, USA, suggests an inexpensive alternative approach. Conducting lines or paths, the inventors say, can be formed from liquid compositions which consist of the reaction product of aluminium powder with a liquid vehicle which contains a phosphate-chromate reaction product.

The base plate or substrate is of conventional type and in one specific example given, a substrate of high density, sintered alumina is taken and a circuit of lines painted on one face.

A composition containing 80 parts of fine aluminium powder mixed with an aqueous slurry containing 32·3 parts H_3PO_4, 9·1 parts CrO_3 and 7·1 parts MgO in water is used for painting, the water being in sufficient quantity to permit reaction of the ingredients and allow easy application of the mix to the substrate. After application the substrate with applied composition is fired to 705°C in air and then cooled. It is claimed that this gives a workable printed circuit with good adherence of the lines to the substrate and low electrical resistance. But it is admitted that it is very difficult to solder connections to such lines.

The answer proposed to the soldering problem is that small amounts of conventional silver electrical paste be applied to those points on the conductive lines at which it is desired to solder up connections. The bod is then refired in an oxidisin atmosphere (air will apparently do) at a temperature of about 650°C It is found that soldered connections can now be easily made at the points where the silver paste has been applied.

If the various claims are justified, the resultant printed circuit board should be relatively cheap to produce.

LIGHT-OPERATED LAMPS

Lamps which turn themselves on and off according to the strength of ambient illumination are fairly well known. These, of course, rely on light sensitive switching, but a problem is the confusion which can arise from the lamp light falling on the photosensitive switch. Elaborate shielding is possible but this may cause overheating which causes switch degradation.

In BP 1 325 810 Kabushiki Kaisha Sankosha of Tokyo describes one way of overcoming these problems. Although the patent claim is obviously directed to a fairly simple elaboration over what is known, the description taken as a whole contains useful information.

In Fig. 1 a lamp is screwed into an adaptor with a screw fitting intended to screw into the mains socket. Obviously UK style bayonet connections could be used instead.

A heat sensitive switch S1 is located inside the hollow body of the adaptor and a light sensitive element is mounted in a torch-like head remote from the adaptor and connected to the adaptor by a fairly long flexible 2-core cable. The photosensitive head is placed in any convenient position so that its photosensitive surface is screened from receiving direct light from the lamp.

As shown in Fig. 2 the make and break contacts of the heat sensitive switch S1 are in series with the power supply to the lamp and its heater element is permanently connected across the mains supply in series with the Light Dependent Resistor (LDR). This element is of the cadmium sulphide, cadmium selenide or similar type of which the resistance varies with incident light.

While the photosensitive surface of PCC1 is bathed in ambient light, its resistance will be low and a substantial amount of current will pass through the heater element. The switch contacts S1 are open in this condition. When the amount of light falling on the LDR reduces, the electrical resistance of the element increases and the current flow through the heater drops. The switch contacts close and the lamp lights.

Provided that the light sensor has been properly positioned and is sufficiently directional in its characteristics, it will not receive sufficient light from the lamp to re-open the switch.

BP 1 325 810

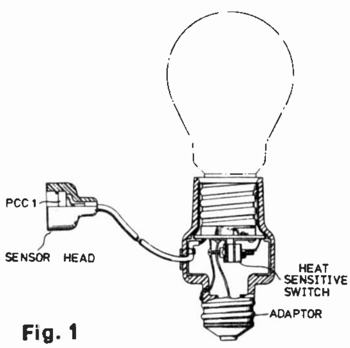


Fig. 1

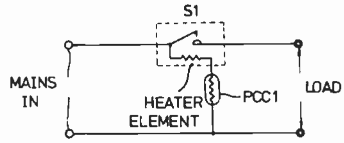


Fig. 2

Copies of Patents can be obtained from the Patent Office Sales, St. Mary Cray, Orpington, Kent. Price 25p each

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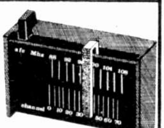

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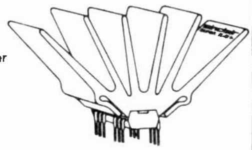

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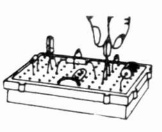

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Readout—
A SELECTION FROM OUR POSTBAG

P.E. RONDO

Sir—Forgetting the price increase and maybe putting the E.S.P. article to some use, perhaps you could tell me what happened to the "RONDO" series. I started this unit at a slow steady pace—looking forward to each article as it appeared, only to find it comes to an abrupt end with no further mention of it. After searching the February and March issues to see if there is a temporary postponement of the series, I came up with nothing.

Can you tell me the solution; will it be concluded in later articles?

G. E. Heslop,
Carlisle.

In view of the current power crisis it was decided to insert items such as the "100W Power Inverter", lamp inverter and the like, rather than continue the Rondo series which had, in any case, reached the completion of the audio stages.

This series will be resumed next month.

What-phonic ?

Sir—Is it not a little odd that we have "progressed" from stereophony to quadraphony when the former is superior to the latter? Should we perhaps consider the possibility that engineers, who have devised words and used them without regard to their meaning, might have betrayed confusion of mind?

A. D. Blumlein, who is generally regarded as having "invented" stereophony, didn't use the word in his famous patent. He did describe how several loudspeakers might be fed from two channels to restore a measure of three-dimensional reproduction—suggesting that four loudspeakers might be sufficient. Good engineers are precise, Blumlein was both. He said (in effect)—that two loudspeakers could restore a measure of binaural effect—insofar that azimuth separation, instrument from instrument or instrument from reverberation, could be restored to a certain extent; this is not stereophony because "stereo" means:—"Solid in the sense of three dimensional." As far as I am aware, stereophony has yet to be invented.

A lot depends upon whether the "phony" (meaning voices!) relates to the number of loudspeakers or to the voices being reproduced; if the latter is intended then monophonic reproduction will become rather boring. If the former is intended, stereophony has been known for years: it has recently been revived and demonstrated by the Sennheiser dummy-head disk which is able to provide binaural headphone listening. What the fuss is all about is how the binaural signals should be presented through loudspeakers.

With the exception of Blumlein's patent, the remaining technical literature reveals little sign of coherent theory or rigorous experimentation. Quadraphony does have a genuine objective: it is to create a better stereophonic effect. It would hardly be fair to say that the consumer is being "conned" although he is most certainly participating in a mass-experiment to determine which particular system will "win". The effects of advertising and muddled explanations could hardly be seen as beneficial towards ensuring that the experiment is a fair one.

It would be a pity if those of use who are less sensitive to the defects of a particular quadraphonic system should "vote it in" as acceptable, denying others, and ultimately themselves, the benefit of further development because a low-grade commercially acceptable system has been found to provide sufficient turnover without the need for further research or investment. By all means say to the recording companies, "your quad isn't yet good enough for me to buy it" or—"it is so good that I can't tell I'm not in the concert-hall". Some of the uninformed all-black/all-white insensitivities in "Readout" remind me of a bar-room brawl. There are those who swear that beer makes a piano sound better—it doesn't have the same effect in an organ.

A last word: Eric Partridge, in "Usage and Abusage" gives: Quadra-; Quadri-; Quadru-. The first is always wrong . . .

Peter J. Unwin
Rochdale.

Charger/Regulator

Sir—After reading the article on the "Auto-Charger Regulator", (Feb. 1974), I decided to investigate the material presented.

1. Every mechanical regulator irrespective of manufacture (e.g. Lucas, CAV, Bosch, Hitachi, etc.) has current regulation incorporated.
2. Use of a solid state voltage regulator without the current regulator will burn out the dynamo. On test with the battery voltage down to 10V a C40 dynamo produces 40 amps at the regulation voltage. Max. safe current for C40 is 22A.
3. Voltage regulation figures vary from 13·8V to 16·5V, not about 15 volts.
4. Current output at a safe level for dynamos fitted to very ordinary cars varies from 22A to 34A according to type. Only one is quoted at the 20A average mentioned.
5. All cable has been supplied in metric sizes for a considerable time.
6. Spade terminals are readily available so there is no need to knock them out of bits of plumbers' copper.
7. The method illustrated is definitely not the way to solder Lucas terminals to cable.
8. No car ever had a connector in the dynamo leads as standard equipment.
9. Positive earth went out with the Ark so why give it as a first choice?
10. A current sensing resistor is available from CAV or any scrap yard.
11. No protection is provided on the unit against voltage surges produced by the vehicle equipment or a worn dynamo.

It would appear, therefore, that whilst the project will work to a limited extent, the application on cars could have been more thoroughly researched. This comment is also applicable to other car projects and I would suggest some form of pre-publication critique to avoid serious mistakes.

May I stress that I welcome car orientated projects and hope that you will include many more as I know from my involvement with the motor trade that these arouse a very great interest.

H. D. Briggs,
Telford.

The answers to the points raised are as follows:

1. The article clearly states that if a vehicle having a current and voltage regulator is to be fitted with the solid state unit, then the current/voltage solid state unit should be used.
2. Current limits given for dynamos are continuous rating. Intermittent, or short term rating is considerably higher.

Any battery which cannot be raised from 10V to regulation voltage within the allowed time before generator heating occurs must be faulty, and probably would not start the engine. Remember that the generator would be starting from cold in this case, and so would have greater thermal capacity. Your reader forgets that with a conventional regulator the output of say 20A is created by a far from constant pulsed current whose peak value is probably well over 30A.

3. The article quite clearly refers the constructor to the maker's manual to set the voltage accurately.
4. The current rating I quoted was that for my own vehicle. I did not dispute that other capacity generators exist but I imagine that any reader who knew enough about the vehicle to fit my circuit to it would be aware of the fact, and would soon find out if—as I suggested—the manual was consulted to find the voltage setting; the current capacity would probably be found on the same page.
5. Cable has been available in metric sizes for some time, this does not mean that all "Imperial" stocks were destroyed at the day of changeover. I still have quite a lot of "old" wire. The size 14/0076 was quoted only for robustness, as it actually carries 1 milliamp the application is hardly critical. The main current carrying cable was quoted as "50A" which is neither metric nor Imperial.
6. I was unable to purchase ⅜in. spade terminals from Southampton's main Lucas agent. In my design, construction is simplified by making the spades part of the diode bracket so I see no sense in the comment at all. As for "knocking them out of plumbers' copper", surely that is all the commercial article is! Why not do it yourself and save money?
7. I did not draw the illustration, but, as an engineer, I find that any method which achieves a satisfactory result will not cause me as much indignation as it does to your reader. I would be interested to know what the British Standard way of soldering a Lucas connector is.
8. The only answer to this is "Mine has!" In the age of mass production, when an engine descends into a vehicle, all of the relevant electrics, including the generator cable, are connected up with one multi-pole plug, to save time. This is the case with mine.
9. I expected the average reader to understand that either polarity version could be built. If your reader is so scornful of the positive earth system then he is under no compulsion to build it. It occurs to me that most of the techniques used in modern cars went out with the Ark, but are still used for economic reasons.
10. So what! Why buy one when the cable can be used? The cable-voltage-drop technique has been used commercially with alternators. (Incidentally my circuit will also work with alternators, simply by omitting the cutout diode. I intend to do this quite soon).
11. My circuit does not allow a worn dynamo to create voltage surges sufficient to cause damage. A 2μF capacitor is incorporated to suppress transients, so I hardly consider that there is "no" protection. In my vehicle, the voltage waveform produced is so smooth that the CD inverter spillback masks any other irregularities.

I am pleased that your reader admits, despite its shortcomings, that my unit will work. Mine has been working for 18 months now and has covered about 15,000 miles. I consider that to be adequate research.

I think I have answered any technical queries raised. I feel, however, that I must make a reply also to the tone of the letter, which was, in my opinion, rather provocative. I do not see any valid scientific purpose served by "having a go" in this manner, as to my mind, criticism couched in these terms loses some of its credibility. I assure you that my article is based on sound principles, and I avidly await the publication of an article by Mr. Briggs!

J. R. Watkinson, B.Sc., M.Sc.

Inverter/Charger

Sir—I am writing in connection with Mr Verrill's article (100W Inverter/Charger) in February P.E. There seems to be some error under the section entitled "Transformer Calculations" regarding average and peak values of rectified sinewaves. The first two paragraphs do not make sense.

More serious though is the implication that a transformer designed for mains to low voltage and not vice versa, may be used freely in this or any other inverter circuit. The fact is that unless a transformer has been specifically designed for such an application it is possible for the inductance of the "new" primary (LT side) to be so low as to allow a large magnetising current to flow. This means that an inverter may take several amps when unloaded, only being reasonably efficient on full load.

Another point regarding the published circuit is the use of 2N3055 transistors which have a high $V_{ce(sat)}$ when handling high collector currents. Silicon may well be "à la mode" but germanium would save precious watts, thanks to their low on resistance.

Both these points lead me to ask either the magazine or the author to clarify the following points.

1. How many amps does the inverter take when no load is connected?

2. How many hard-earned watts are lost when the inverter is drawing, say 10 amps, in each 2N3055 transistor?

3. How many amps are drawn from the battery to illuminate 80 watts of filament lamps *to full brilliance?*

In conclusion I should like to point out that these are meant to be constructive criticisms intended to enable constructors to eke the last amount of useful energy out of their batteries in the most efficient manner possible. As such I hope those concerned will reply to these points fully.

L. Cook,
Prescot, Lancs.

LOW PRIMARY INDUCTANCE

Contrary to Mr. Cook's statement, a low primary inductance is an advantage since a transformer designed with a higher inductance to give lower magnetising current would need more turns of wire and hence would have a higher resistance giving greater losses to load current. This is made clear by the following example:

12V winding resistance $= 0{\cdot}1\Omega$
Magnetising current $= 2A$
Load current $= 10A$
Total current $\simeq \sqrt{2^2 + 10^2} = 10{\cdot}2A$
$\therefore I^2R$ *loss* $= 10{\cdot}4W$

If the number of turns is now doubled the inductance is multiplied by 4 and the resistance is also multiplied by 4 since for a given volume of wire, twice the length at half the thickness is required.

$\therefore$ *12V winding resistance* $= 0{\cdot}4\Omega$
Magnetising current $= 0{\cdot}5A$
Load current $= 10A$
Total current $\simeq \sqrt{0{\cdot}5^2 + 10^2} = 10{\cdot}012$
$\therefore I^2R$ *loss* $= 40W$

To this must be added the increased loss due to the doubled number of secondary turns.

The foregoing calculations refer to the untuned square wave version. It is correct to take the square root of the sum of the squares of the two components of current, since the

magnetising current lags 90 degrees behind the load current. The fact that the input is a square wave of voltage does not alter this rule, since the 90 degree lag also applies to the harmonics of the square wave.

Note that the 12V battery does not supply 12V × 2A = 24W of power due to magnetising current since this power is effectively an oscillating component which flows in and out of the battery with only a very small nett loss due to the increased copper loss.

In the tuned version the magnetising current is supplied in the secondary (240V) winding by the tuning capacitor C7. The foregoing arguments on increased power loss if the number of turns is increased still apply, but here there is an added advantage in having a high magnetising current since this increases the Q of the tuned circuit giving a better sine wave. It is equivalent to the experiment mentioned in the article, where extra inductance and capacitance was added in parallel with the output.

USE OF SILICON TRANSISTORS

It is true that Germanium transistors saturate better than Silicon but a 2N3055 carrying 10A with 1A base drive saturates to less than 0·5V, typically, giving less than 5W power loss from this cause. The 2 watts or so improvement obtained by using Germanium could well be lost by increased leakage current.

The major power losses are I^2R losses in the transformer and inductor and approximately 12W in the base drive circuitry. In this type of circuit where the power transistors are driven by a separate oscillator transformer iron loss is very small.

Some commercially available inverters use a saturating core type of free running oscillator; in these circuits the transformer is driven hard into saturation in alternate directions giving in many cases a low efficiency due to the high hysteresis loss. Such circuits are notoriously difficult to start under load and have a tendency for both transistors to latch on in the output in some cases causing them to burn out.

R. Verrill

INCREASING THE POWER

Sir—May I congratulate you on the timely and very helpful constructional article on the above. I am building this as an urgent project and would ask you if there is a simple way to increase the output wattage.

I have a fairly massive 200 watt mains transformer which I would like to press into service and while leaving the earlier stages as they are could I fairly easily use additional 2N3055's in place of TR6 and 7? You mention the direct coupling method without using R15 and R17 and would prefer this if possible.

Also is it feasible to double the battery voltage to the output stage only i.e. to 24 volts while leaving the earlier stages as they are on 12 volts, if this would simplify a 200 watt output?

I would be most grateful for a little guidance on the above and any comment if it would then be suitable for running a domestic television set.

John S. Aston,
Dorchester, Dorset.

I have had a report from one person who simply connected two 2N3055's in parallel and was able to run a 140W colour television with some reduction in performance. For optimum results it is necessary to duplicate the drive circuitry, i.e. everything from the collectors of TR3 and TR4 onwards to the bases of a second pair of 2N3055's with parallel collectors and emitters.

If you wish to go to 24V input it is not necessary to leave the earlier stages at 12V; simply increase R15 and R17 to 22 ohm at 12 watts. If you have a few 2N3055's to spare you could probably risk using them but there is a danger of them breaking down with the increased voltage. A higher voltage type which is suitable is the 2N3442 (RCA or Ferranti) but this is considerably more expensive. *R.V.*

NOTES

With reference to the first and third queries raised by Mr. Cook, the no-load current of the inverter appears to vary with the quality of the driver and switching transistors and the nature of the "tuning" selected for a particular application. We have measured values between 1·0A and 3·0A.

As to current drawn under load, we have not measured this with 80W of filament load alone since an 80W bulb is not standard. However, using a 100W bulb as load again gives varying conditions dependent apparently on the condition of the components and the tuning but it should be emphasised that full brilliance (measured by eye in the absence of an accurate photometer) has been obtained with a load current under 10A.

In the section dealing with transformer calculations on page 135 of the February issue a line was printed twice in error. Thus the line "winding is 12V because of the equal number of" should be replaced with "winding of T1 is a rectified sine wave and since". Additionally, the reference to 12V in the next paragraph should, of course, be to 2Vm.

From information received and our own experiments it seems that one or two basic precautions are needed. For example, peak voltages as high as 1,200V have been measured at the output in the inverter mode with the circuit not tuned but using the choke. Thus clearly it is not to advantage to try switching the a.c. output as arc formation can occur at the switch with consequent further spike generation and the risk of component damage.

In fact there seem to be several sources of "spike" and it is suggested that the driver transistors and switching transistors might benefit from protection diodes and the 12V d.c. rail from the use of a 1W Zener of around 18V rating. One constructor who has met with switching problems has solved no-load switching by using a 100W 12V projector lamp in the d.c. line during switching on and then subsequently shorting it with a switch after all is running smoothly.

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January 1971
Mr. A. J. Fellouzis, 16 Cyclades Street, Kipseli, Athens, Greece.

January to June 1968, June-July 1970, September 1971, July 1972
Mr. F. J. Pycroft, 140 Old Road, Crayford, Kent

September 1973
Mr. R. Ridges, 25 Broomfield Grescent, Leeds L56 3DD.

January to September 1973
Mr. J. R. Dow, 73 Marchburn Drive, Northfield, Aberdeen, AB2 7PP.

October 1973
Mr. M. J. Clements, "Pendennis", Knowles Road, Brighouse, Yorks HD6 3RN.

August-September 1972
Mr. W. D. Gorst, Hannover Telecommunications, BAOR, B.F.P.O. 33.

Any issues previous to January 1971
Mr. P. Nelson, 17 Porlock Road, Flixton, Urmston Manchester, Lancs.

February to October 1973
Mr. B. Regan, 354 Sandon Road, Meir Heath, Stoke-on-Trent, Staffordshire, ST3 7EB.

Any issues prior to October 1969, June, August and September 1970, January, March, May, July, August, September and October 1971, April, June, and November 1972
Mr. J. H. Rapley, 9 Whitehouse Park, Wick, Caithness, KW1 4NX.

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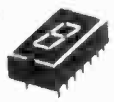

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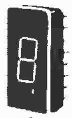
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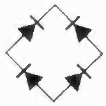

P.I.V.	1 amp	R.M.S.	2 amp
100V	20p	50V	35p
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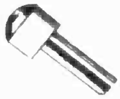

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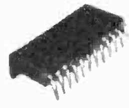

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½ watt	Metal Oxide Film	±2%	E12 Series	10Ω to 1MΩ	4½p
½ watt	Cermet Thick Film	±2%	E12 Series	56Ω to 150KΩ	8p
½ watt	Carbon Film	±5%	E24 Series	10Ω to 10MΩ	1½p
½ watt	Carbon Composition	±0·5Ω	{2·2Ω} 2·7Ω 3·3Ω	3·9Ω 4·7Ω	4½p
1 watt	Carbon Composition	±10%	{5·6Ω} 6·8Ω 8·2Ω		5½p
1 watt	Carbon Film	±5%	E12 Series	10Ω to 10MΩ	3p
2 watt	Carbon Film	±5%	E12 Series	10Ω to 10MΩ	6p
2½ watt	Wire Wound	±10%	E12 Series	0·22Ω to 0·47Ω	10p
2½ watt	Wire Wound	±5%	E12 Series	1Ω to 270Ω	10p
5 watt	Wire Wound	±5%	~ E12 Series	0·5Ω to 8·2KΩ	10p
10 watt	Wire Wound			0·5Ω to 6·8KΩ	11p
10 watt	Wire Wound	±5%	10KΩ 15KΩ 20KΩ	25KΩ	17p
15 watt	Wire Wound			10Ω to 6·8KΩ	13½p

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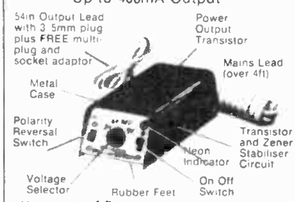

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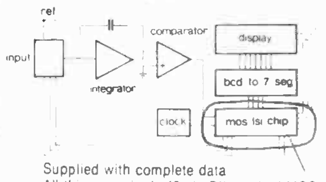

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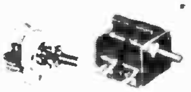

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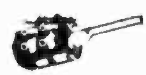
1·5							6½p			
2·2							6½p		8½p	
3·3							6½p			
4·7							6½p		8½p	17p (4µF)
6·8						6½p	6½p	8½p		
8										21p
10					6½p		6½p	8½p		
15				6½p		6½p	8½p			24p (16µF)
22			6½p		6½p		6½p	11p		
33		6½p		6½p		6½p				33p (32µF)
47	6½p		6½p	6½p	8½p	6½p	8p			25p (50µF)
68		6½p		6½p			11p			(350V)
100	6½p		6½p		6½p	8p	14p	25p		
150		6½p		6½p	8p	11p	14p			
220	6½p		6½p	8p	11p	14p	19p	31p		
330	6½p		8p	11p			25p	44p		
470		8p	11p		14p	20p	26p	47p		
680		10p		14p	20p	25p		59p		
1000	13p		14p	19p	22p	29p	44p	79p		
1500		18p	19p	25p						
2200		18p	24p		39p	44p	79p	149p		
3300		26p								
4700	25p			44p	68p	79p	149p	252p		
6800				75p						

Potentiometers



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

Log or lin less switch (and 1kΩ lin)	13p
Log or lin with switch	26p
Dual less switch	44p
Dual with switch 10kΩ, 100kΩ and 1MΩ log only	57p

10kΩ
25kΩ
50kΩ
100kΩ

Single **40p**
Dual **60p**

New Silver and Black Knob **16½p**

Presets

Vertical or Horizontal

0.1 watt **6½p** 0.25 watt **7½p**

100Ω	1kΩ	10kΩ	100kΩ	1MΩ
250Ω	2.5kΩ	25kΩ	250kΩ	2.5MΩ
500Ω	5kΩ	50kΩ	500kΩ	5MΩ

Cermet Type to 1MΩ only **41p.**

VDR's & Thermistors

A15B	96p	GL23	£1·21
CZ1	16½p	R53	£1·49
CZ4	18p	R54	£1·61
CZ13A	16p	VA1005	16p
CZ19	18p	VA1026	16p
E298CD A258	13p	VA1033	16p
E298ED A258	13p	VA1034	16p
E298ED A260	13p	VA1039	16p
E298ED A262	13p	VA1040	16p
E298ED A265	13p	VA1053	16p
E298ED P268	13p	VA1055S	16p
E298ZZ 05	13p	VA1056S	16p
E298ZZ 06	13p	VA1066S	17p
E299DD P336	14p	VA1067S	19p
E299DD P338	14p	VA1077	19p
E299DD P342	14P	VA1098	21p
E299DD P348	14p	VA1104	31p
GL16	£1·21	VA1107	20p

Other types obtainable upon application

PARTRIDGE MAINS ISOLATION TRANSFORMER Pri: 150-250V, 5V steps, Sec: 240V, 13 amps **£15**, carr. pack. £2·25.

GARDNER'S POTTED TRANSFORMER, Pri. 200-250V. Sec. 18V 500m/a, 50V 150m/a, 6V 250m/a output. **£1**, p.p. 28p.

RIPLEY MAINS TRANSFORMER, Pri: 110V-240V, Sec: 12·5V: 0:12·5V 750m/A 7V:0:7V 1A, **£1**, p.p. 25p.

MAINS TRANSFORMER, Pri: 100-250V. Sec: 22:0:22 200m/A. 22:0:22 100m/A 0:24V 20m/A, **80p**, p.p. 25p.

MAINS TRANSFORMER, Pri: 100-240V a.c. 36·5-0-36·5V, 27m/A, 0-21·5, 260 m/A, **80p**, p.p. 25p.

TRANSISTOR OUTPUT TRANSFORMER, Ratio 8:1, 120mH. Centre tap 2 watts. output, **20p**, p.p. 8p.

WODEN MAINS TRANSFORMER, Auto wound. Pri: 200-250V. Sec: 105-135V. 3kVA. **£15**. Carr. £1·50.

HADDON MAINS TRANSFORMER, Pri: 230V. Sec: 20V 1 amp, **£1·60**, p.p. 27p.

MIN. MAINS TRANSFORMERS. Type 606/1. Sec: 6V-0-6V, 100m/A, **75p**. Type 909/1. Sec: 9V-0-9V, 100m/A, **81p**. Type 12012/1. Sec: 12V-0-12V, 100m/A, **86p**, p.p. 5p each.

SMOOTHING CHOKE, 11MH, 1¾in × 1¼in × 1½in, **20p**, p.p. 8p.

FINNED ALUMINIUM HEATSINK, 4½in × 6in × 1in, 2 × 2N3055, **£1**, p.p. 13p.

GOODMANS 8in SPEAKERS 3 Ω **£1·50**, p.p. 28p.

LOUDSPEAKER 2½in Dia., 40 Ω. 300m/watts, **50p**, p.p. 5p.

FINNED ALUMINIUM HEATSINK. 9in × 8in × 1½in, in C., 4 × 2N3055, **£2**, p.p. 29p.

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COMPONENT PANEL, 6 scr's (300V, 1·6A) 6 cond., 12 resistors, 6 diodes, **45p**, p.p. 8p.

COMPONENT PANEL, 6 scr's (200V 4 amps), 6 condensers, 12 resistors, **30p**, p.p. 8p.

COMPONENT PANEL. 1 scr: 100V, 15 amp, 1 diode, 1 cap., 500mfd 50V, **50p**, p.p. 7p.

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LEVER ACTION P.O. 1000 TYPE SWITCHES
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MULLARD & MALLORY SCREW TERMINAL CAPACITORS ~~4,500μF 64V, 7,100μF 40V~~ **50p** each. ~~20,000 30V [illegible]~~ **30p** each, [illegible]

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SOLENOIDS 12 VOLT PULL ACTION
2in × 1in × ¾in, **40p**, p.p. 8p.

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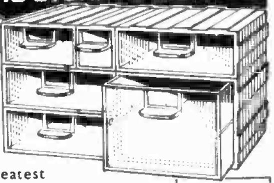

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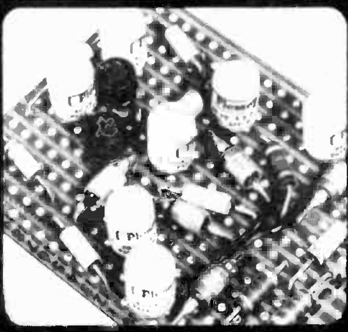

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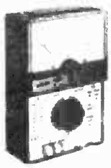

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10k Ω/V 2·5% precision
A—d.c. 0·1-1A—5 ranges
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Ohms—100 to 1M Ω—4 ranges.
Frequency: 45-40kHz—2 ranges.
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Track Length: 30mm. Fixing Centres: 50mm.
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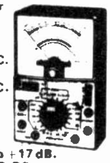
50,000 opv. Mirror scale. Meter protection. 0/·3/3/12/60/120/300/600/1200V DC. 0/6/30/120/300/600/1200V DC. 0/30μA/6/60/300 mA/12 Amp. 0/10K/1m/10m/100 Meg Ohms. –20 to +17 dB.

OUR PRICE £12.50 P&P 20p.

LB4 TRANSISTOR TESTER
Tests PNP or NPN transistors. Audio indication. Operates on two 1.5V batteries. Complete with instructions etc.

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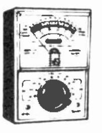
AUDIOTRONIC Model ATM1
Top value 1,000 opv pocket multi-meter. Ranges:– 0/10/50/250/1,000 volt AC and DC. DC current 0-1mA/100mA. Resistance: 0/150k ohms. Decibels: –10 to +22dB. Size 90 x 60 x 28mm. Complete with test leads.

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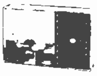
U4323 MULTIMETER
20,000opv. Simple unit with audio/IF oscillator. Suitable for general receiver tuning. Ranges: 0.5/2.5/10/50/250/500/1000V DC. 2.5/10/15/250/500/1000V AC. 0.05/0.5/5/50/500mA DC. Resistance: 5/50/500 ohms/5/10/100k ohms/1Meg. Battery operated. Size: 160 x 97 x 40mm. Supplied in carrying case complete with test leads.

OUR PRICE £7.00 P&P 20p

U4312 MULTIMETER
extremely sturdy instrument for general electrical use. 667opv. 0/0.3/1.5/7.5/30/60/150/300/600/900V DC & 75mV. 0/0.3/1.5/7.5/30/60/150/300/600/900V AC. 0/300uA/1.5/6/15/150/60/600mA/1/1.5/6A DC. 0/1.5/6/15/60/150/600mA/1.5/6A AC. 0/200/3k/30k ohms. DC accuracy 1%. AC 1.5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions.

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KAMODEN 72.200 Multitester
High sensitivity tester. 200,000 opv Overload protected. Mirror scale. Ranges:–0/.06/.3 3/30/120/600/1200V DC. 0/3 12/60/300/11200 V AC. 0/6uA/1.2mA/120mA/600mA/12A DC 0/12A AC. –20 to +63dB. 0/2k/200k/2 Meg/200 Megohms.

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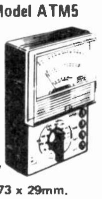
AUDIOTRONIC Model ATM5
Jewel movement, attractively moulded case with edgwise ohms adjustment. Ranges: 0-3/15/150/300/1200V AC, (2500 opv) 0-6/30/300/600V DC, (5000 opv). 0-300 uA/0-300mA DC. Resistance: x 10 & x 100. –10 to +16dB. Supplied with battery test leads and data booklet. Size: 121 x 73 x 29mm.

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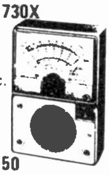
MODEL HIOKI 730X
30,000 opv. Overload protection. 6/30/60/300/600/1200V DC. 12/60/120/600/1200V AC. 60/μA/30mA/300mA. 2K/200K/2 Meg Ohm. 10 to 63 dB.

OUR PRICE £7.50 P&P 15p.

MODEL 500
30,000 opv with overload protection. Mirror scale. 0/0.5/2.5/10/25/100/250/500/1000V DC. 0/2.5/10/25/100/250/500/1000V AC. 0/50uA/5/50/500mA. 12A DC. 0/60k/6 meg/60 megohms.

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Leather case for above £1.75

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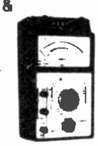
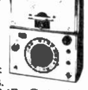
High sensitivity instrument for field and laboratory work. Knife edge pointer, 86mm. mirror scale. Ranges: 100mV/0.5/2.5/10/25/50/100/250/500/1000 V DC. 0.5/2.5/10/25/50/100/250/500/1000V AC. Current: 50uA/0.5/1/5/10/50/250mA/1/5A DC. 0.25/0.5/1/5/10/50/250mA/1/5A AC. Resistance: 0.5/10/100/200 ohms/1/3/30/300k ohms. Decibels: –5 to +10dB Battery operated. Size: 210 x 115 x 90mm. Supplied in carrying case complete with leads.

OUR PRICE £15.00 P&P 20p

U4341 Multimeter & Transistor Tester
27 ranges. 16,700opv. Overload protected. Ranges: 0.3/1.5/6/30/60/150/300/900V DC. 1.5/7.5/30/150/300/750V AC. Current: 0.06/0.6/6/60/600mA DC. 0.3/3/30/300mA AC. Resistance: 0.06/0.6/2/6/20/60/200k ohms/2 Mohms. Battery operated. Supplied complete with probes, leads and steel carrying case. Size: 115 x 215 x 90mm.

OUR PRICE £10.50 P&P 20p

MODEL TE300
30,000opv. Mirror scale. Overload protection. 0/0.6/3/15/60/300/1200V DC. 0/6/30/120/600/1200V AC. 0/30uA/6mA/60mA/300mA/600mA. 0/8k/80k/800k/8 Meg ohms. –20 to +63dB.

OUR PRICE £7.50 P&P 15p

HIOKI 750X VOLT-OHM-MILLIAMETER
43 ranges. 0–0.3/0.6/1.5/3/6/12/30/60/150/300/600/1,200V DC. 0–3/6/15/30/60/120/300/600/1,200V AC. Current: 0–30/60uA/1.5/3/15/30/150/300 mA/6/12A. Resistence: 0–3/300k/3/30Mohms. Decibels: –10 to +17dB. Output:– 0–3/6/15/30/60/120/300V. Accuracy ± 3% DC, ± 4% AC. Sensitivity: 50,000 opv DC, 5,000 opv AC. 4 inch meter. Built in protection. Size: 57 x 102 x 153mm.

OUR PRICE £11.95 P&P 40p

KAMODEN HMG500 insulation resistance tester
Range 0–1,000 Megohms, 500V. Battery operated. Wide range clear meter 4"x4¾". Complete with deluxe carrying case, batteries and instructions.

OUR PRICE £19.95 P&P 30p

MODEL C1092 MULTIMETER
Features 5,000 opv jewel movement and a good selection of range functions. Edgwise ohms adjustment. Ranges:– 0–3/15/150/300/1,200V AC (2,500 opv). 0–6/30/300/600 V DC (5,000 opv). DC current. 0–300uA/300mA. Resistance: R x 10, R x 1,000. –10 to +16dB. Complete with battery, test leads and data booklet. Size: 120 x 73 x 28mm.

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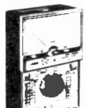
TMK 100K LAB TESTER
100,000opv. 6½" scale. Buzzer short circuit check. Sensitivity 100,000 opv DC. 5k/V AC DC Volts: 0.5/2.5/10/50/250/500/1000V AC. 3/10/50/250/500/1000V DC. current 10/100uA/10/10/100/500mA/2.5/10A. Resistance: 1k/10k/100k/10 Meg/100 Meg ohms. Decibels: –10 to +49dB. Plastic case with carrying handle. Size: 190 x 172 x 99mm.

OUR PRICE £19.95 P&P 25p

S100TR MULTIMETER TRANSISTOR TESTER
100,000opv. Mirror scale. Overload protection. 0/0.12/0.6/3/12/30/120/600V DC. 0/6/30/120/600V AC. 0/12/600uA/12/300mA/6/12A DC 0/10k/1 Meg/100 Meg. –20 to +50dB. 0.01–0.2 MFD Transistor tester measures Alpha, Beta and ICO. Complete with instructions, batteries and leads.

OUR PRICE £15.95 P&P 25p

U4324 MULTIMETER
High sensitivity, overload protected. 20,000opv. Ranges: 0.6/1.2/3/12/30/60/120/600/1200V DC. 3/6/15/60/150/300/600/900V AC. Current: 0.06/0.6/6/60/600mA/3A DC. 0.3/3/30/300mA/3A AC. Resistence: 25/500 ohms/0.5/5/50/500k ohms/5 Mohms. Decibels: –10 to +12dB. Size 167 x 98 x 63mm. Supplied complete with test leads, spare diode and instructions.

OUR PRICE £8.00 P&P 20p

MODEL U437 MULTIMETER
10,000opv. A first class, instrument manufactured in USSR to the highest standards. Ranges: 2.5/10/50/250/500/1000V DC. 2.5/10/50/250/500/1000V AC. DC current 100uA/1/10/100mA/1A. Resistence 300 ohms/3/30/300k/3 Meg. ohms. Complete with batteries, test leads, instructions and a sturdy steel carrying case.

OUR PRICE £4.95 P&P 25p

MODEL U4311 Sub-standard Multi-range Volt-Ammeter
Sensitivity 330 Ohms/Volt AC and DC. Accuracy 0.5% DC. 1% AC. Scale length: 165mm. 0/300/750uA/1.5/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5A DC. 0/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5A AC. 0/75/150/300/750mV/1.5/3/7.5/15/30/75/150/300/750V DC. 0/750mV/1.5/3 /7.5/15/30/75/150/300/750V AC. Automatic cut out device. Supplied complete with test leads, manual and test certificates.

OUR PRICE £49.00 P&P 50p

C15 PULSE OSCILLOSCOPE
For display of pulsed and periodic wave-forms in electronic circuits. VERT. AMP. Bandwidth: 10MHz. Sensitivity at 100kHz VRMS/mm: 0.1–25; HOR. AMP. Bandwidth: 500kHz. Sensitivity ay 100kHz VRMS/mm: 0.3–25 Preset triggered sweep 1–3000usec. Free running 20–200 kHz in nine ranges. Calibrator pips. 220 x 360 x 430mm. 115–230V AC.

OUR PRICE £39.00 Carr. paid

TMK MODEL TW50K
46 ranges, mirror scale. 50k/V DC 50k/V AC. DC Volts: 0.125/0.25/1.25/2.5/5/10/25/50/125/250/500/1000. AC Volts 1.5/3/5/10/25/50/125/250/500/1000. DC current 25/50uA/2.5/5/25/50/250/500mA DC. 10A. Resistance: 10k/100k/1 Meg/10 Meg ohms. –20 to +81.5dB.

OUR PRICE £8.50 P&P 17p

HIOKI MODEL 700X
100,000opv. Overload protection. Mirror scale. 0.3/0.6/1.2/1.5/3/6/12/30/60/120/300/600/1200V DC. 1.5/3/6/12/30/60/150/300/600/1200V AC. 15/30uA/3/6/30/60/150/500mA/6/12A DC. 2k/200k/2M/20MOhms. –20 to +63dB.

OUR PRICE £14.95 P&P 20p

MODEL TH12
20,000 opv. Overload protection. Slide switch selector. 0/0.25/2.5/10/50/150/1000V DC. 0/10/50/250/1000V AC. 0/50uA/2.5/250mA DC. 0/3k/30k/300k/3 Megohms. –20 to +50dB.

OUR PRICE £5.95 P&P 15p

Model HT100B4 MULTIMETER
Overload protected, shock proof circuits. 9.5uA Meter with mirror scale. Sensitivity 100kV. Polarity change switch. Ranges: 0.5/2.5/1-/50/250/500/1,000 Volts DC. 2.5/10/50/250/1,000 Volts AC. DC resistence 0–20/200k/2/20 Meg. ohms. DC current:– 10/250uA/2.5/25/250 mA/10A. AC current:–0–10A. –20 to +62dB. Operates from 2 x 1.5V batteries. Size: 180 x 134 x 79mm.

OUR PRICE £15.00 P&P 40p

TE40 HIGH SENSITIVITY AC VOLTMETER
10 Meg input. 10 ranges: 0.001/0.03/0.1/0.3/1/3/11/30/100/300V RMS. 5cps–1.2MHz. –40 to +50dB supplied complete with leads and instructions.

OUR PRICE £17.50 P&P 25p

RUSSIAN CI16 Double Beam OSCILLOSCOPE
5 MHz pass band. Separate Y1 and Y2 amplifiers. Rectangular 5" x 4" CRT. Calibrated triggered sweep from 0.2usec. to 100 milli-sec/cm. Free running time base, 50Hz–1MHz. Built-in time base Calibrator and amplitude Calibrator. Supplied complete with all accessories and instruction manual.

OUR PRICE £87.00 Carr. paid

HIOKI Model 720X VOM
A versatile, accurate measuring instrument. 20,000 opv. 0/5/25/100/500/1000V DC. 0/10/50/250/1000V AC. 0–50uA/250mA. 0–20k/2 Megohms.

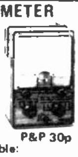
OUR PRICE £5.97 P&P 20p

U435 MULTIMETER
20,000opv. Overload protected. Ranges: 75mV/2.5/10/25/100/250/500/1000V DC. 2.5/10/25/100/250/500/1000V AC. Current: 50uA/1/5/25/100mA/0.5/2.5A DC. 5/25/100mA/0.5/2.5A AC. Resistance: 0.3/3/30/300k ohms. Size: 205 x 110 x 84mm. Supplied complete with leads, crocodile clips and steel carrying case.

OUR PRICE £8.75 P&P 20p

MODEL AS.100D VOM
100,000 opv. Mirror scale. Built-in meter protection. 0/3/12/60/120/300/600/1200V DC. 0/6/30/120/300/600V AC. 0/10μA/6/60/300mA/12 Amp. 0/2K/200K/2M/200 Meg Ohm. –20 to 17dB.

OUR PRICE £17.50 P&P 20p.

TE65 VALVE VOLTMETER
28 ranges. DC volts 1.5–1500V. AC volts 1.5–1500V. Resistance up to 1000 Megohms, 200/240V AC operation. Complete with probe and instructions.

OUR PRICE £17.50 P&P 30p
Additional probes available: RF £2.12, HV £2.50

MODEL TE15 GRID DIP METER
Transistorised. Operates as Grid Dip, Oscillator, Absorbtion Wave Meter and Oscillating Detector. Frequency range 440kHz–280MHz in six coils. 500uA meter. 9V battery operation. Size: 180 x 80 x 40mm.

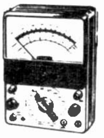
OUR PRICE £19.95 P&P 20p

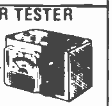
MODEL PL436
20,000 opv DC. 8000 opv AC. Mirror scale ·6/3/12/30/120/600V DC. 3/30/120/600V DC. 60/600μA/60/600mA. 10/100K/1 Meg/10 Meg Ohm. –20 to –46 dB.

OUR PRICE £6.97 P&P 15p.

U91 Clamp VOLT AMMETER
For measuring AC voltage and current without breaking circuit. Ranges: 300/600V AC. Current: 10/25/100/250/500A. Accuracy 4%. Size 283 x 94 x 36mm. Complete with carrying case, leads and fuses.

OUR PRICE £10.50 P&P 20p

KAMODEN HM720B FET VOM
Input impedance 10 Megohms. Ranges:– 0/.25/1/2.5/10/50/1000V DC. 0/2.5/10 50/250/1000V AC. 0/25uA/2.5/25/250 mA DC. 0/5k/50k/500k/5 M 500 Megohms

OUR PRICE £21.00 P&P 30p

LB3 TRANSISTOR TESTER
Tests ICO and B. PNP/NPN. Operates from 9V battery. Instructions supplied.

OUR PRICE £3.95 P&P 20p

Also see following pages

ALL PRICES EXCLUDE VAT

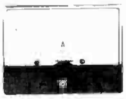
SEW CLEAR PLASTIC PANEL METERS

USED EXTENSIVELY BY INDUSTRY, GOVERNMENT DEPARTMENTS, EDUCATIONAL AUTHORITIES ETC.

Over 200 ranges in stock—other ranges to order. Quantity discounts available. Send for fully illustrated brochure.

*Items with asterisk are Moving Iron type, all others are Moving Coil

CLEAR PLASTIC MODEL SD640
Size: 85 x 64mm

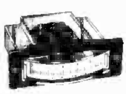


50uA	£3 80		
100uA	£3 75		
200uA	£3 70		
500uA	£3 65		
50-0-50uA	£3 75		
100-0-100uA	£3 70		
1mA	£3 65		
5mA	£3 65		
10mA	£3 65		
50mA	£3 65		
100mA	£3 65	20V DC	£3 65
500mA	£3 65	50V DC	£3 65
1A DC	£3 65	300V DC	£3 65
5A DC	£3 65	15V AC	£3 75
10A DC	£3 65	300V AC	£3 75
5V DC	£3 65	VU Meter	£3 90

CLEAR PLASTIC MODEL SW100
Size: 100 x 80mm

50uA	£4 60		
100uA	£4 50		
500uA	£4 30		
50-0-50uA	£4 50		
100-0-100uA	£4 45		
1mA	£4 30		
1A DC	£4 30		
5A DC	£4 30		
20V DC	£4 30		
50V DC	£4 30	300V AC	£4 45
300V DC	£4 30	VU Meter	£4 90

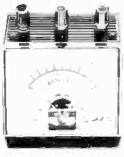
EDGWISE MODEL PE70
Size: 90 x 34mm



50uA	£4 15
100uA	£4 10
200uA	£4 05
500uA	£3 90
50-0-50uA	£4 10
100-0-100uA	£4 05
1mA	£3 85
300V AC	£3 95
VU Meter	£4 30

MODEL ED107 EDUCATIONAL METER
Size: 100 x 90 x 150mm including terminals

A range of high quality moving coil instruments ideal for school experiments and other bench applications. 3" mirror scale. The meter movement is easily accessible to demonstrate internal working.



50uA	£8 50		
100uA	£7 90		
50-0-50uA	£7 90		
1A DC	£7 60		
5A DC	£7 60		
5V DC	£7 60	300V DC	£7 60
10V DC	£7 60	500mA/5A DC	£8 60
15V DC	£7 60	5V/50V DC	£8 60
20V DC	£7 60	5V/15V DC	£8 60
50V DC	£7 60	1A/15A DC	£8 60

CLEAR PLASTIC MODEL MR 85P
Size: 120 x 110mm

50uA	£5 45		
100uA	£5 40		
200uA	£5 35		
500uA	£5 25		
50-0-50uA	£5 40		
100-0-100uA	£5 35		
500-0-500uA	£5 20		
1mA	£5 20		
1-0-1mA	£5 20		
5mA	£5 20		
10mA	£5 20		
50mA	£5 20		
100mA	£5 20	300V DC	£5 20
500mA	£5 20	15V AC	£5 30
1A DC	£5 20	300V AC	£5 30
5A DC	£5 20	S Meter 1mA	£5 20
15A DC	£5 20	VU Meter	£5 55
30A DC	£5 40	1A AC	* £5 20
10V DC	£5 20	5A AC	* £5 20
20V DC	£5 20	10A AC	* £5 20
50V DC	£5 20	20A AC	* £5 20
150V DC	£5 20	30A AC	* £5 20

CLEAR PLASTIC MODEL SD830
Size: 110 x 83mm

50uA	£4 30		
100uA	£4 25		
200uA	£4 20		
500uA	£4 15		
50-0-50uA	£4 25		
100-0-100uA	£4 20		
1mA	£4 10		
5mA	£4 10		
10mA	£4 10		
50mA	£4 10	10V DC	£4 10
100mA	£4 10	20V DC	£4 10
500mA	£4 10	50V DC	£4 10
1A DC	£4 10	300V DC	£4 10
5A DC	£4 10	15V AC	£4 20
10A DC	£4 10	300V AC	£4 20
5V DC	£4 10	VU Meter	£4 40

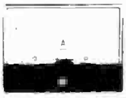
CLEAR PLASTIC MODEL MR 45P
Size: 50 x 50mm

50uA	£3 20		
100uA	£3 15		
200uA	£3 10		
500uA	£3 00		
50-0-50uA	£3 15		
100-0-100uA	£3 10		
500-0-500uA	£2 95		
1mA	£2 95		
5mA	£2 95		
10mA	£2 95		
50mA	£2 95		
100mA	£2 95		
500mA	£2 95	300V AC	£3 05
1A DC	£2 95	S Meter 1mA	£2 95
5A DC	£2 95	VU Meter	£3 40
10V DC	£2 95	1A AC	* £2 95
20V DC	£2 95	5A AC	* £2 95
50V DC	£2 95	10A AC	* £2 95
300V DC	£2 95	20A AC	* £2 95
15V AC	£3 05	30A AC	* £2 95

CLEAR PLASTIC MODEL MR 38P
Size: 42 x 42mm

50uA	£3 10		
100uA	£3 05		
200uA	£3 00		
500uA	£2 85		
50-0-50uA	£3 05		
100-0-100uA	£3 00		
500-0-500uA	£2 80		
1mA	£2 80		
1-0-1mA	£2 80		
2mA	£2 80		
5mA	£2 80		
10mA	£2 80		
20mA	£2 80	15V DC	£2.80
50mA	£2 80	20V DC	£2 80
100mA	£2 80	50V DC	£2 80
150mA	£2 80	100V DC	£2 80
200mA	£2 80	150V DC	£2.80
300mA	£2 80	300V DC	£2 85
500mA	£2 80	500V DC	£2 85
750mA	£2 80	750V DC	£2 90
1A DC	£2 80	15V AC	£2 90
2A DC	£2 80	50V AC	£2 90
5A DC	£2 80	150V AC	£2 90
10A DC	£2 80	300V AC	£2 90
15A DC	£2 80	500V AC	£3 00
3V DC	£2 80	S Meter 1mA	£2 80
10V DC	£2 80	VU Meter	£3 20

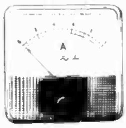
CLEAR PLASTIC MODEL SD460
Size: 59 x 46mm



50uA	£3 50		
100uA	£3 45		
200uA	£3 40		
500uA	£3 35		
50-0-50uA	£3 45		
100-0-100uA	£3 40		
1mA	£3 30		
5mA	£3 30		
10mA	£3 30		
50mA	£3 30		
100mA	£3 30	10V DC	£3 30
500mA	£3 30	50V DC	£3 30
1A DC	£3 30	300V DC	£3 30
5A DC	£3 30	15V AC	£3 45
10A DC	£3 30	300V AC	£3 45
5V DC	£3 30	VU Meter	£3 65

POSTAGE & PACKING 15p

CLEAR PLASTIC MODEL MR 65P
Size: 86 x 78mm

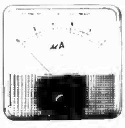


50uA	£3 95		
100uA	£3 85		
200uA	£3 80		
500uA	£3 75		
50-0-50uA	£3 85		
100-0-100uA	£3 80		
500-0-500uA	£3 70		
1mA	£3 70		
5mA	£3 70		
10mA	£3 70		
50mA	£3 70		
100mA	£3 70		
500mA	£3 70	50V AC	£3 80
1A DC	£3 70	150V AC	£3 80
5A DC	£3 70	300V AC	£3 90
10A DC	£3 70	500V AC	£3 80
15A DC	£3 70	S Meter 1mA	£4 10
20A DC	£3 80	VU Meter	£3 70
30A DC	£3 85	1A AC	* £3 70
50A DC	£4 05	5A AC	* £3 70
5V DC	£3 70	10A AC	* £3 70
10V DC	£3 70	20A AC	* £3 70
20V DC	£3 70	30A AC	* £3 70
50V DC	£3 70	50mA AC	* £3 70
150V DC	£3 70	100mA AC	* £3 70
300V DC	£3 70	200mA AC	* £3 70
15V AC	£3 80	500mA AC	* £3 70

BAKELITE MODEL S80 Enlarged Window
Size: 80 x 80mm

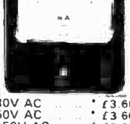
50uA	£4 50
100uA	£4 45
500uA	£4 20
50-0-50uA	£4 45
100-0-100uA	£4 40
1mA	£4 20
1A DC	£4 20
5A DC	£4 20
20V DC	£4 20
50V DC	£4 20
300V DC	£4 20
300V AC	£4 30
VU Meter	£4 70

CLEAR PLASTIC MODEL MR 52P
Size: 60 x 60mm



50uA	£3 70		
100uA	£3 50		
500uA	£3 35		
50-0-50uA	£3 50		
100-0-100uA	£3 45		
1mA	£3 30		
5mA	£3 30		
10mA	£3 30		
50mA	£3 30		
100mA	£3 30		
500mA	£3 30		
1A DC	£3 30		
5A DC	£3 30	S Meter 1mA	£3.30
10V DC	£3 30	VU Meter	£3 80
20V DC	£3 30	1A AC	* £3 30
50V DC	£3 30	5A AC	* £3 30
300V DC	£3 30	10A AC	* £3 30
15V AC	£3 40	20A AC	* £3 30
300V AC	£3 40	30A AC	* £3 30

BAKELITE MODEL MR 65 Size: 80 x 80mm



25uA	£5 25		
50uA	£4 00		
100uA	£3 95		
500uA	£3 65		
50-0-50uA	£3 95		
100-0-100uA	£3 90		
500-0-500uA	£3 60		
1mA	£3 60		
1-0-1mA	£3 60		
5mA	£3 60		
10mA	£3 60		
50mA	£3 60	30V AC	* £3 60
100mA	£3 60	50V AC	* £3 60
500mA	£3 60	150V AC	* £3 60
1A DC	£3 60	300V AC	* £3 60
2A DC	£3 60	500V AC	£3 60
5A DC	£3 60	VU Meter	£4 10
15A DC	£3 60	1A AC	* £3 60
30A DC	£3 60	5A AC	* £3 60
50A DC	£3 80	10A AC	* £3 60
5V DC	£3 60	20A AC	* £3 60
10V DC	£3 60	30A AC	* £3 60
20V DC	£3 60	50A AC	* £3 60
50V DC	£3 60	500mA AC	* £3 60
150V DC	£3 60	50mV DC	£3 75
300V DC	£3 60	100mV DC	£3 75

SINCLAIR Project 80 Modules

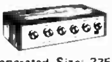
Z40 Power Amplifier	£5.45
Z60 Power Amplifier	£6.95
Stereo 80 Pre-Amplifier	£11.95
Active Filter Unit	£6.95
Project 805	£26.95
PZ5 Power Supply	£4.98
PZ6 Power Supply	£7.98
PZ8 Power Supply	£7.98
Transformer for PZ8	£4.05

SINCLAIR Project 80 Packages

2 x Z40/Stereo 80/PZ5	£25.00
2 x Z40/Stereo 80/PZ6	£27.75
2 x Z60/Stereo 80/PZ8	£30.45

POST & PACKING 35p each.

MP7 MIXER-PREAMPLIFIER



5 Microphone inputs each with individual gain controls enabling complete mixing facilities. Battery operated. Size: 235 x 127 x 76mm. Inputs: Mics. 3 x 3mV 50k; 2 x 3mV 600 ohms. Phono. Mag. 4mV 50k; Phono Ceramic 100mV 1 Meg. Output 250mV 100k.

OUR PRICE £8.97 P&P 20p

ALL PRICES EXCLUDE VAT

1021 Stereo Listening Station

For balancing and gain selection of loudspeakers with additional facility for stereo headphone switching. Two gain controls, speakers on—off slide switch, stereo headphone socket.

OUR PRICE £2.25 P&P 15p

AUDIOTRONIC LOW NOISE CASSETTES

TYPE	5	10	25
C60	£1.57	£3.00	£7.08
C90	£2.24	£4.25	£10.00
C120	£2.73	£5.17	£12.24

AUDIOTRONIC CrO2 CASSETTES

TYPE	5	10	25
CR60	£3.92	£7.72	£19.12
CR90	£5.32	£10.46	£25.22

AUDIOTRONIC 8 TRACK CARTRIDGES

TYPE	Each	5	10
40M	85p	£4.00	£7 50
80M	£1.15	£5.40	£10.25

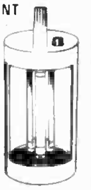
P&P Cassettes 3p, Cartridges 5p each
OVER 10 of either POST FREE!

AUDIOTRONIC AHA101 Stereo Headphone Amplifier

All silicon, transistor amplifier operates from magnetic, ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9V battery. INPUTS: 5mV and 100mV. OUTPUT: 50mV per channel.

OUR PRICE £8.50 P&P 20p

HITACHI FLUORESCENT LANTERN L1901



A portable battery operated lantern ideal for home, motoring, camping etc. Approx. 10 tall. Provides brilliant light from 9 1.5v batteries (not supplied)

OUR PRICE £7 90
P&P 25p

EA41 REVERBERATION AMPLIFIER

Self contained, transistorised, battery operated. Simply plug in microphone, guitar etc. and output to your amplifier. Volume control and depth of reverberation control. Beauwalnut cabinet. 184 x 77 x 108mm.

OUR PRICE £7.50 P&P 20p

SPECIAL PURCHASE LIMITED QUANTITY! Tannoy 12" DR/8 Bass Speakers

8 ohms 30 watt
Heavy duty, ideal for Hi-Fi P.A. Group
OUR PRICE £12 50
P&P 50p

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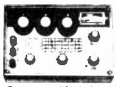
A new portable bridge offering excellent range and accuracy at low cost Ranges R 1 11 1 meg 6 Ranges ·1% L 1 H – 111 HENRY 6 Ranges 2 % C 10pF 1110mFd 6 Ranges · 2% TURNS RATIO 1 1/1000–1 1 100 6 Ranges · 1% Bridge voltage at 1 000 cps Operated from 9 volts 100 A Meter indication Attractive 2 tone metal case Size 7⅛ x 5 x 2in
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5 ranges, 400kHz to 30 MHz. An inexpensive instrument for the handy-man. Operates on 9V battery. Wide easy to read scale. 800kHz modulation. Size: 149 x 149 x 92mm. Complete with instructions and leads.
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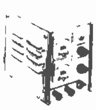
Input 88–125V AC or 176–250V AC. Output 120V AC or 240V AC. 200V/A rating. P&P 50p
OUR PRICE £11.97

PS100B Regulated POWER SUPPLY UNIT

Solid state. Output 6, 9 or 12V DC up to 3 Amp. Meter to monitor current. Input 220/240V AC Size: 100 x 82 x 159mm.
OUR PRICE £11.97 P&P 25p

PS200 Regulated POWER SUPPLY UNIT

Solid state. Variable output 5–20V DC up to 2 Amp. Independent meters to monitor voltage and current. Output 220/240V AC. Size: 190 x 136 x 98mm.
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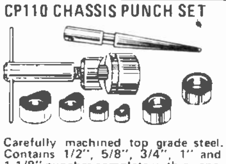
CP110 CHASSIS PUNCH SET

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OUR PRICE £24.95 per pair
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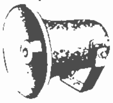
NB. Licence required for use in UK

RUH6 Reflex Horn Speaker

Built in driver unit. Impedence 16 ohms. Power rating 10W. Response 380–7000Hz. Size app. 6" x 6" Weather and shock protected.
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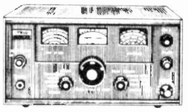
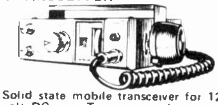

Four bands covering 550kHz to 30 MHz continuous and electrical bandspread on 10, 15, 20, 40, and 80 mtrs. 8 valve plus 7 diode circuit. 4 to 8 ohm output and phone jack. SSB–CW, ANL, variable BFO. S Meter and separate band spread dial. IF frequency 445kHz, audio output 1½ watt. Variable RF and AF gain controls. 115/250V AC, with instructions.
Our Price £42.50 CARR. PAID

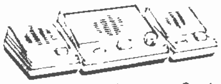
TRIO TR2200 TRANSCEIVER

Fully transistorised portable VHF transceiver Will transmit and receive on six channels between 144–146MHz. 1 watt transmitter. 12V DC internal or external supply. Built-in charger for Ni-Cad cells. Power/volume switch, squelch control, channel selector, mic. socket, earphone/external speaker socket. Complete with microphone and 144.48, 144.72 & 145.32 crystals. Size: 134 x 58 x 180mm.
OUR PRICE £79.50 Carr.paid

BELTEK W5400 CAR TRANSCEIVER

Solid state mobile transceiver for 12 volt DC neg. Transmits and receives on any 12 of 28 channels between 144 and 146MHz. Power output 10W and 1W switchable. Controls. On/off/volume, squelch and channel select or. Internal 3" speaker. Complete with dynamic mic. PTT switch, three sets of crystals for 144.48, 144 6 and 145MHz, mounting bracket and instructions. Size: 150 x 70 x 220mm.
OUR PRICE £75.00 P&P 50p

DT55G DIGITAL CLOCK MECHANISM

Features 24 hour alarm setting, on/off and auto alarm 'sleep' switch. Illuminated rotary dial with hours, minutes and seconds. Automatically turns off radio, TV, light etc. and with auto-switching will turn on again when required. 240V AC operation. Switch rating 250V–3 Amp.
OUR PRICE £5.95 P&P 30p

KE630 3 Station INTERCOM

Master and two sub stations. Can be used on desk or wall mounted. Complete with cable and batteries
OUR PRICE £5.25 P&P 50p

LH02S STEREO HEADPHONES

Light weight headphones with padded ear pieces. 4/16 ohms 20–20,000Hz. Complete with 6' lead and plug.
OUR PRICE £1.97 P&P 30p

TE1018 Deluxe Mono High Impedence Headset.

Sensitive magnetic headset with soft ear pads. Impedence 2,600 ohms (600 ohms DC). Frequency response 200–4,000Hz.
OUR PRICE £2.25 P&P 30p

DH02S STEREO HEADPHONES

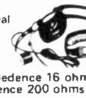
Wonderful value and excellent performance combined. Adjustable head band. Impedence 8 ohms. 20–12,000Hz. Complete with lead and plug.
OUR PRICE £2.50 P&P 30p

TE1035 Stereo HEADPHONES

Low cost with excellent response. Foam rubber earcups. Adjustable headband. 8 ohms impedence. Frequency response 25Hz–18kHz. Complete with cable and stereo jack plug.
OUR PRICE £2.60 P&P 30p

SH80V MONO/STEREO HEADPHONES

Volume control for each channel. 4/16 ohms impedence. Frequency response 20Hz–18kHz. Complete with 10ft coiled lead and jack plug.
OUR PRICE £4.97 P&P 30p

BH001 HEADSET and Boom Microphone

Moving coil. Ideal for language teaching, communications etc. Headphone impedence 16 ohms. Microphone impedence 200 ohms
OUR PRICE £5.95 P&P 30p

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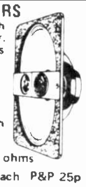
Model 350 13 x 8" with single tweeter/crossover. 20–20,000Hz. 15 watts RMS. Available 8 or 15 ohms.
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Model 450 13 x 8" with twin tweeter/crossover 55–13,000Hz. 8 watts RMS. Available 8 or 15 ohms
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HF65 FM transmitter	£2.70
HF75 FM receiver	£2.87
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HF325 Deluxe FM tuner	£24.12
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Amateur Electronics by Josty-Kit, the professional book for the amateur –covers the subject from basic principals to advanced electronic techniques. Complete with circuit board for AE1 to AE10.
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2 TRANSISTOR RADIO KIT

No Soldering required. All connections made with spring clips. Kit includes all parts and wire including ear-piece. Will receive all normal broadcasts on Medium Wave 535–1605kHz. Operates from standard 9V battery or Solar Cell included.
OUR PRICE £1.30 P&P 30p

SPECIAL BARGAIN !! STEREOSOUND SPEAKERS

Matched pair of stereo bookshelf speakers. Deluxe teak veneered finish. Size: 368 x 229 x 190mm. 8 ohms. 8 watts RMS. 16 watts peak. Complete with Din lead.
OUR PRICE £12.95 P&P 50p

SPECIAL BARGAIN! FERGUSON 3406 HI-FI SPEAKERS

High quality 2 way speaker systems. 25 Watts. 4–8 ohms. 40Hz–18kHz. Size. 560 x 340 x 255mm. approx. Wood grain finish with black fronts.
OUR PRICE £26.95 PR. P&P £1

Model A1018 FM TUNER

6 transistor high quality unit – 3 IF stages and double tuned discriminator. For use with most amplifiers. Covers 88–108MHz. Powered by 9V battery.
OUR PRICE £13.50 P&P 30p
Stereo multiplex adapter £5 95 extra.

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7 transistors, 7 diodes

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7 transistors, 7 diodes

SA100 £10·90
100W RMS 45–70V
11 transistors, 6 diodes

- ★ 25Hz–25kHz
- ★ 0·2% distortion
- ★ Noise—80dB
- ★ 500mV into 20K
- ★ 4–16 ohms
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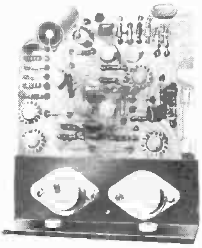
120 watt module complete with built-in supply—extra heavy duty £19·75 Carr. 60p



THE SA100 MODULE

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MT45	Transformer for above	£3·50	Carriage 30p
PS70	Suits 2 SA100	£4·90	Carriage free
MT70	Transformer for above		

N.B. **PS70 is not suitable for the SA50**

Mk II STEREO DISCO MIXER £19·75
Carr. 30p

This well tried unit mixes two decks, handles any ceramic cartridge, and features mic over-ride plus separate full range bass and treble controls on both mic and deck inputs. Ample headphone power is available for P.F.L. May be used for mono and is mains operated. Fitted with sturdy screening case. Controls: Mic vol, bass, treble. Left/Right fade, deck volume, bass, treble, h/phone select, vol, Mains. Size 17½in × 3in × 4in deep.

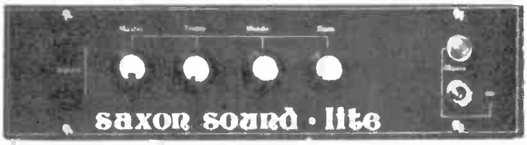
DISCO MODULE £8·00 Carr. 20p

Thousands sold of this extremely popular mono version. A mic input may be fitted using the VA30 (see below). Low consumption from a 9V battery. Features the same high standards of reproduction as the Stereo version. Controls: H/phone select, vol, Left deck vol, Right deck vol, bass, treble, master vol. Size 12¾in × 3in × 2in deep.

3-CHANNEL SOUND-LITE £22·50 Carr. 30p

Only SAXON can supply such incredible value for money. This unit features 3kW power handling, full-wave control, bass, middle, treble AND master controls. Twin loudspeaker jacks for "through" connections. It may be used free standing or will panel mount next to either of the above. Also features unique CUT-BACK circuitry for extra wide range response. Size 12in × 3in × 2½in deep. Professional standards at a price you can afford!

SINGLE CHANNEL VERSION £7·50
Carr. free
Recently reduced in price due to increasing sales, handles 1kW. Full wave operation



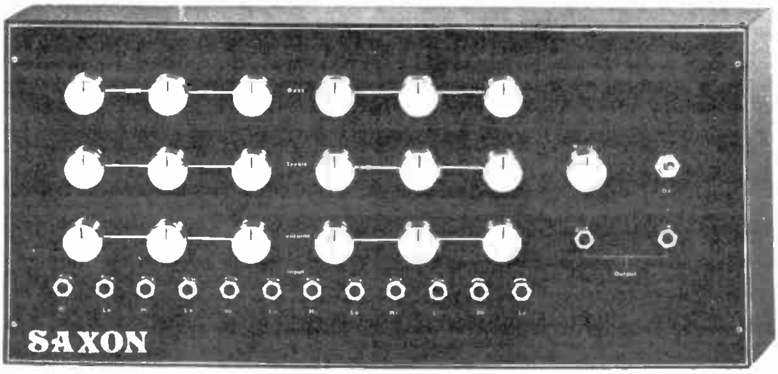
MULTI-PURPOSE MIXERS

M4HL £18·50 Carr. 50p
M6HL £27·50 Carr. 50p

Featuring multiples of our VA30 module, the M4HL and M6HL fulfil the requirements of all clubs, groups, etc. where a high quality mixer is required. Each channel has one high and one low impedance input, plus volume, treble and bass controls. Input impedances may, if required, be easily changed. The M4HL has four channels, and one output, and the M6HL six channels (12 inputs) and a master control and two outputs. Either unit may be used free-standing or panel mounted. These mixers will feed all types of amplifier. Recommended for their versatility and high performance, and excellent value for money.

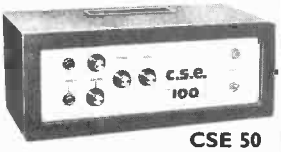
VA30 CHANNEL MODULE £3·50 Carr. free

This is the basic channel module in the above mixers and may also be used for extra inputs on either the mono or stereo mixers. Fitted with volume, bass and treble controls, requires just a jack and supply (9–100V)



SAXON CSE 100 COMPLETE AMPLIFIER
£34·90
Carr. free

100W of speech and music—Two separately controlled inputs. Wide range bass and treble controls. Sturdy and attractive vynide case. Twin outputs. Ideal for groups, discos, etc. Fully tested and guaranteed. 50W version identical in appearance.



CSE 50
£29·50 Carr. free

SAXON 100 COMPLETE AMPLIFIER
£53·00
Carr. free

Four individually controlled FET input stages plus wide range bass and treble controls. 120W of speech and music output from twin loudspeaker sockets. Sturdy case, and an attractive facia make this excellent value for money. Hundreds in use by groups, discos, clubs, etc. 50W version identical in appearance.

SAXON 50
£37·50
Carr. free

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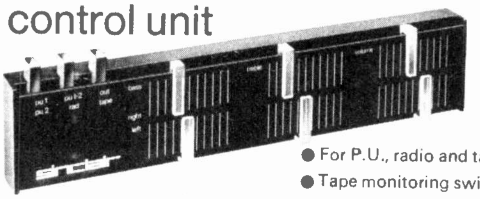
new thinking in modular hi-fi

Stereo 80 pre-amplifier and control unit



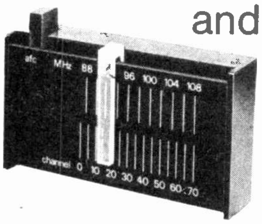
- For P.U., radio and tape
- Tape monitoring switch
- Simplest ever fixing

Each channel has its own separate tone and volume controls operated by sliders, enabling ideal environmental matching to be obtained. A virtual earth input stage forms part of the up-dated circuitry that ensures the finest possible quality from all signal sources. Generous overload margins are allowed on all inputs. Clear instructions with template are supplied.

TECHNICAL SPECIFICATIONS
Size – 260 × 50 × 20mm (10¼ × 2 × ¾ins)
Finish – Black with white indicators and transparent Sliders
Inputs – Magnetic pick-up 3mV RIAA corrected. Ceramic pick-up 300mV
Radio 300mV; Tape 30mV
Signal/noise ratio – 60dB
Frequency range – 20Hz to 15KHz ± 1dB. 10Hz to 25KHz ± 3dB
Power requirements – 20 to 35 volts
Outputs – 100mV + AB monitoring for tape
Controls – Press button for tape radio and P U. Sliders for volume, bass (+ 12dB to – 14dB at 100Hz) treble (+ 11dB to – 12dB at 10KHz)

R.R.P. £11.95 +£1·19 V.A.T.

Project 80 FM tuner and stereo decoder



- Twin dual varicap tuning: 4 pole ceramic filter: switchable A.F.C.
- On the decoder, solid state stereo indicating beacon.

Making the Project 80 F.M. tuner and decoder available separately gives a wider choice of systems and saves money where stereo reception may not be required. The tuner is a triumph of electronic design and assures excellent performance. The decoder gives a 40dB channel separation with 150mV output per channel. Both units may be used with other than Project 80 systems.

TECHNICAL SPECIFICATIONS OF TUNER
Size – 85 × 50 × 20mm (3½ × 2 × ¾ins)
Tuning range – 87·5 to 108 MHz
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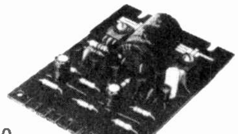
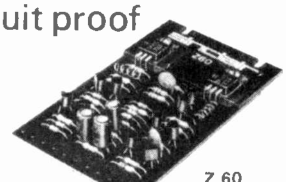


Z.40



Z.60

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Output – 15 watts RMS continuous into 8 Ω (35v)
Frequency response – 10Hz – 100KHz ± 1dB
Signal/noise ratio – 64dB
Distortion – at 10 watts into 8 Ω less than 0 1%
Power requirements – 12 to 35 volts

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Size – 55 × 98 × 15mm (2¼ × 3¾ × ⅝ins) 12 transistors
Input sensitivity – 100-250mV
Output – 25 watts RMS continuous into 8 Ω (45V).
Distortion – typically 0·03%
Frequency response – 10Hz to more than 200KHz ± 1dB
Signal/noise ratio – better than 70dB
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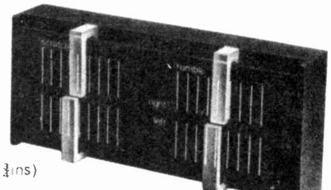

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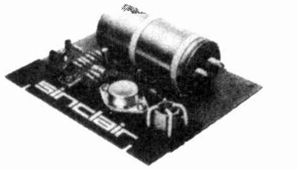

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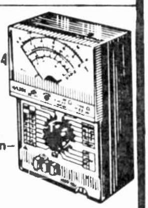

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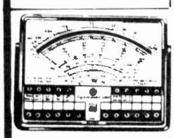

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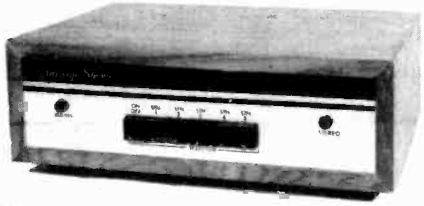

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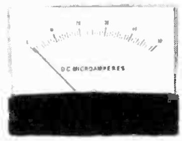

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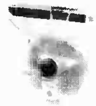

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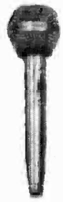

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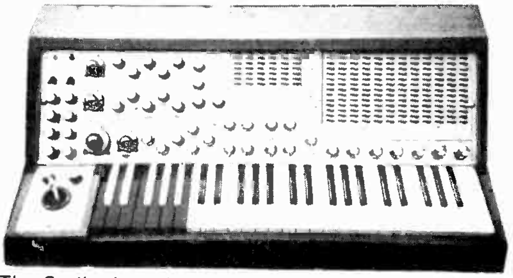

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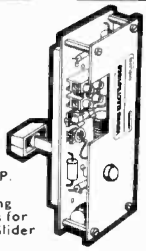

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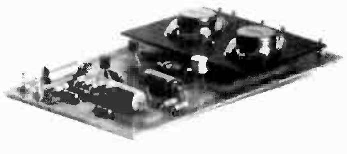

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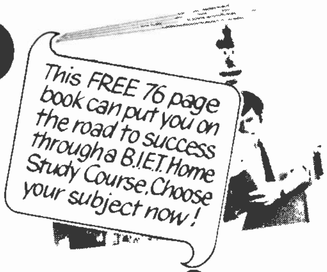

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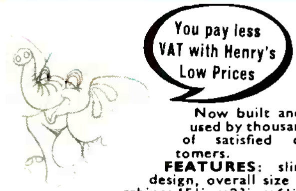

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As featured by Practical Wireless 1972

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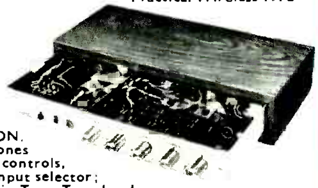

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