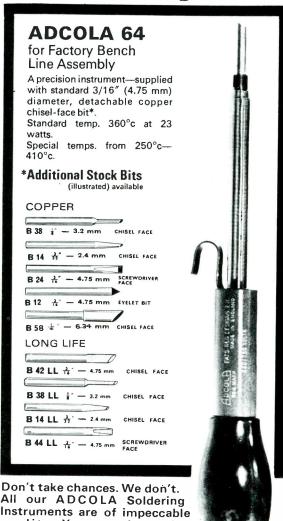
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- AUTO BATTERY CHARGER - RADIO ASTRONOMY TECHNIQUES - PART 1

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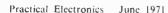
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2N696 2N697	17p	AF119	20p 25p	NKT241 NKT261	277p	6AC7 6AG7	25p 40p	35Z4	80 <sub>1</sub>	PC86	60p 60p
2N698 2N706	42p	AF126	17p 17p	NKT271 NKT272	25p	6AK5 6AK6	80p 57p	50B5	45; 40;	PC97	45p 48p
2N706A 2N708	19p	ATPION	80p 47p	NKT274 NKT275	20p	6AL5 6AM6	20p 88p	80	50g	PCC84	40p
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2N1302 2N1303	201	ASZ17	42p 97p	OA5 OA10	20p 25p	6BH6 6BJ6	45p 45n	DAF96 DF91	42p 25p	PCF800	80p
2N1304 2N1305	25p 25p		7p 12p	OA47 OA70	10p 10p	6BQ7A 6BR7	40p 85p	DF96 DK91	42p	PCF802 PCF805	50p 75p
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2N2147 2N2160	75 n	IBC149	ZUP	OA210 OC19	17p 87p	6F1 6F6G	62p	DY87 E88CC	85 p 65 p	PL36	55p
2N2193 2N2217	65p	BC172	15p 17p	0C20 0C22	97p 50p	6F13	80p 88p	E180F EABC80	95p 35p	PL82	50p 45p
2N2218	40p	IBC182L	25p 10p	OC23	60n	6F14 6F15	65p 65p	EAF42 EB91	35p 20p	PL84	45p 40p
2N2219 2N2368	82p 17p	BC186	12p 25p	OC24 OC25	60p 87p	6F18 6F23	45p 80p	EBC41 EBC81	55p 80p	PL504	75p 80p
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2N2484 2N2613	35p 35p		50p	OC35	62p 50p	6J5 6J5GT	20p 30p	EBF89 EBL21	82p 60p	PY81	85p 80p
2N2646 2N2904	50p 80p	BCY33 BCY34	25p 80p	OC36 OC41	62p 25p	6J6 6J7	20p 45p	EC86 EC88	60p	PY82	80p 88p
2N2923 2N2924	17p	BCY38 BCY42	40p 15p	0C42 0C44	30p 17p	6K8G 6L6GT	35p 45p	ECC40 ECC84	60p 80p	PY88 PY800	40p 50p
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2N2926Y 2N29260	12p	BCY72	15p 40p	0C70 0C71	12p 15p	68A7 68G7	40p 85p	ECF80 ECF82	85p 85p	U26	75p 32p
2N3053 2N3054	25p 50p	DIVIDI	65p 80p	OC72 OC73	25p 30p	68J7 68K7	40p	ECF86	65 p	U52 U191	38p 75p
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2N3704 2N3705	12p	BF181	87p 82p	OC81D OC83	20p 25p	6V6GT 6X4	82p 80p	ECL82 ECL83	85p 65p	UAF42 UBC41	55p 50p
2N3706	15p 22p	BF184	25 p	OC84	25p 25p 25p	6X5GT	80p 27p	ECL86 EF37A	40p 60p	UBC81 UBF80	40p 40p
2N3707 2N3708	15p 17p	BF185 BF194	25p 17p	OC139 OC140	27n	10C2 10F1	50p 90p	EF39 EF40	40p 50p	UBF89 UCC84	85p 49p
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2N3903 2N3904	25p 25p	BF244 BFX12	979	OC201 OC202	60p 75p	12AU7 12AV6	80p	EF86 EF89	80p 28p	UCH81 UCL82	35p 35p
2N 3905 2N 3906	80p 80p	BFX29	25 p 30 p	OC203 OC204	40p 40p	12AX7 12BA6	80p	EF91 EF92	33p 40p	UCL83 UF41	60p
2N 4058 2N 4059	25p	BFX30 BFX44	32p	OC205 OC207	62p 75p	12BE6 12BH7	35p	EF183 EF184			35p
2N4061 2N4062	15p 22p	BFX85 BFX86	40p 82p	OCP71 ORP12	97p 50p	19AQ5 20D1	35p	EH90 EL33	40p	UF85 UF85 UF89	40p 85p
2N 4286 2N 4287	15p 17p	BFX87	82p	ORP60 P346A	40p 25p	20F2	75p	EL34	50p	UL41	66p
2N4288 2N4289	15p 17p	BFY18 BFY20	20p	PL4001 PL4002	14p 15p	20L1 20P1	#1·10 50p	EL42	58a	UL84 UY41	80p 45p
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2N4291 2N4292 2N5354	15p	BFY52	22p	PL4005 PL4006	19p 20p	20P5 25L6	£1-20 45p	EL85 EL91	48p 82p	VR105/30 VR150/30	
2N5355	27p 27p	BFY90 BSX19	175	PL4007	24n			DIODE	•	eawn	
28102 28103	87p	B8X20 B8X21	87p	T1843 T1844	40p 12p	400W	(3-3 to 3	33V)	15p	SEND	
28104 40250		B8X76 B8Y26	17p	T1845 T1846	17p 17p	1.5W (	2·4 to 2 3·9 to 10	00V)	20p 25p	FOR	,
40361 40362	60n	BSY27 BSY28		BC107/8	9	- II	NTEGI	RATED	_	LISTS	-
AC107 AC126	87p 25p	BSY38 BSY39	20g 22g	25+ 100+	10p 9p		CIRC	UITS			on
AC127 AC128	25p	B8Y51	32p	500+ 2N3055	7p	L900 L923		[C-10 👪	40p; 3-50;	12+ a	
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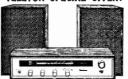
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Output 4 watts per channel. Excellent
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Also available with Garrard 2025T/C.
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Features unique mech-anical 2-way units and anical 2-way units and fitted adjustable level controls. 8 ohm impedance. 20-20,000 cps. Complete with spring lead & stereo jack plug. 27.971. P. & P. 122p.



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C	arr. 374p	extra each item	
Teak Base	and Pers	pex Cover	

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Maxamp 30 Stereo Amplifier 15 + 15 watt r.m.s. with matching Stereomax AM/FM Tuner. Total list price £136.52.

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Low cost high Low cost high performance stereo headphones. Foam rubber ear cups. Adjustable headband. 8 ohm impedance. 25-18,000Hz. With lead and stereo



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SINCLAIR EQUIPMENT
Project 60. Package offers. 2 × 230 amplifier, stereo 60 pre-amp, P25 power supply, \$16.75. Carr. 37½p. 07 with P26 power supply, \$18.85. Carr. 37½p. 27 250 amplifier, stereo 60 pre-amp, P28 power supply, \$30.85. Carr. 37½p. Transformer for P28, \$8.97½ extra. Add to any of the above \$4.87½ for active filter unit and \$16 for a pair of q16 speakers. Project 60 FM Tuner \$50.97½. Carr. 37½p. All other Sinclair products in stock. 2,000 amplifier, \$35. Carr. 37½p. 3000 Amplifier \$85. Carr. 37½p. Neoteric amplifier \$45.97½. Carr. 37½p. Neoteric amplifier \$45.97½. Carr. 37½p.

# See opposite page →

70p

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17p BC107/8 20r 25 + 100 + 500 + 2N 3055 90p 25 + 15p 100 +

350 40p 45p

400 47p 50p 75p 97p

AC154 AC176

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5MHz Pass Band. Separate V1, V2 amplifiers. Calibrated triggered sweep from 0-2µsec to 100msec/cm. Supplied complete with all accessories and instructions, \$87, Carr. paid.



MARCONI CT44/ TF956 AF ABSORPTION WATTMETER

1 µ/watt to 6 watts. £20. Carr. £1.

TE11 TEILL DECADE RESISTANCE ATTENUATOR range 0-111dB. Con-



0-1110 D. The control of the contro

# BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR Sine 18-200,000Hz; Square



Square 18-50,000 Hz. Output max +10dB (10kΩ). Operation internal batterles

Attractive two-tone case 71in × 5in × 2in. Price £17-50. Carr. 171p.

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A.C. VOLTMETER
10 meg. input 10 ranges:
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Decibels - 40 to +50d.B.
Supplied brand new
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TE-65 VALVE VOLTMETER



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High quality instrument
with 28 ranges. D.c. volts.
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25.50. P. & P. 15p.

TMK MODEL TW-50K. 46

TMK MODEL TW-50K. 46 ranges, mirror scales. 50K/Volt d.c. 5K/Volt a.c. Dc. volts: 0-125, 0-25; 1-25, 2-5, 10, 25, 50, 125, 250, 500, 1,000V. Dc. current: 25, 50µA. 25, 50µA. 5, 50, 50 500MA, 5, 10A. Resistance: 10K, 100K, 1 meg., 10 meg. Decibels: -20 to +81-5dB. \$8-87\$; P. & P. 17\$p.



TE-900 20,000 \(\O) VOLT GIART MULTIMETER.

d.c. 02K/2 P. & P. 25p.



MODEL 5025. ranges, glant 5½in meter, polarity reverse switch. Sen-sitivity: 50K/Volt d.c. 5K/Volt a.c.

sitivity: 50K/Voit a.c. 5K/Voit a.c. 5K/Voit a.c. 5K/Voit a.c. 5K/Voit a.c. 5L/Voit a.c. 5L/Voit



MODEL TE12. 20,000 O.P.V. 0/0-6/30/120/600/1,200 / 3,000 / 6,000V d.c. 1/6/30/120/600/1,200V a.c. 0 / 60µA / 8 / 80 / 600MA. 0 / 6K / 600K / 6meg./60. Megohm 50FF. 2 MFD 25-97‡. P. & P. 17½p. P. 25-97‡. P. & P. 17½p.

### FTC-401 **TRANSISTOR TESTER**

RHEOSTATS

25 WATT. 10/25/50/100/250/500/1,000/1,500/2,500 or 5,000 ohms, 72:p. P. & P. 71p. 50 WATT. 10/25/50/100/250/500/1,000/2,500 or 5,000 ohms, £1.05, P. & P. 74p. 100 WATT. 1/5/10/25/50/100/250/500/1,000 or 2,500 ohms, £1:37;. P. & P. 71p.

Full capabilities for measuring A, B and ICO, npn or pnp. Equally adaptable for checking diodes. Supplied complete with instructions, battery with instructions, battery and leads. 26.97½. P. & P. 15p.



HONOR TE.10A. 20kΩ/ Volt 5/25/50/250/500/ 2,500 V d.c: 10/50/100/500 2,500V d.c: 10/50/100/300 1,000V a.c: 0/50µA/2·5mA 250mA d.c. 0/6K/6 meg. ohm. -20 to +22dB. 10-0, 100 mfd. 0-100·0·1 mfd. \$3·47½. P. & P. 15p.



(1)

-20 to

P. & F. 10p.

MODEL TE-800, 30,000
O.P.V. Mirror scale, overload protection 0/0-6/3/15/
60/300/1,200V d.c. 0/5/30/
120/5001,200V a.c. 0/
30µA / 6mA / 60mA /
300mA/600mA 0/8K/80K/800K/8 meg.

-20 to +63dB, \$5.97}, P. & P. 15p.

MODEL PL436, 20% Q/ Volt d.c. 8k Q/Volt a.c. Mirror scale, 0·6/ 3/12/30/120/600V d.c. 3/30/120/600V a.c. 5/30/120/600V a.c. 5/30/120/600V a.c. 0/30/1000K/1 Meg/10 meg Q. —20 to + 46dB. \$6.97j. P. & P. 12jp.

MODEL TE-90. 50,000 O.P.V. Mirror scale, over-load protection. 003/13/60/ 300/600/1,200V d.c. 0/6/ 30/120/300/1,200V d.c. 0:03/6/60/600m A 16K/160K/1·6/16 meg. -20 to +63dB. 27.50, P. & P. 15p.

TMK MODEL TW-200B. Features Resettable Overload Button. Sensitivity: 20 K Ω/Volt d. c. 5 K Ω/Volt ac. D. c. volts: 0-0-5, 2-5, 10, 50, 250, 1,000V. D.c. currents: 0-0-05, 0-5, 5, 50, 500mA. Resistance: 0-5 K, 50 K, 0-500K, 5 meg. Declbels: -20 to +52dB. £11-50. P. & P. 17‡p.

MODEL AS-100D. 100 K Ω/ Volt. 5in, mirror scale.

Built-in meter protection 0/
3/12/60/120/300/600/1,200V
d.c. 0/6/30/120/300/600V
a.c. 0/10µA/6/60/300mA/
12A. 0/2K/200K/2M/200M.

+17dB. \$12.50. P. & P. 17‡p.



short circuit check.
Sensitivity: 100,000
OPV d.c. 5/Volt a.c.
D.c. voltes: 0-5, 2-5,
10, 50, 250, 1,000V.
A.c. volte: 3, 10, 50, 250, 500, 1,000V.
D.c. current: 10, 100µA, 10, 100, 500mA,
10 meg. 100 meg. Decibels: -10 to
49dB. Plastic case with carrying handle,
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SKYWOOD SW-500 50 K Ω/Volt. Mirror scale DC Volts 0.6/3/12/30/300/600. AC Volts 3/30/300/ 600. DC Current 20uA/6/60/600mA.

Resistance 10K/100 els - 29 to +57db K/1Meg/10 Meg. Declbels 27.50. P. & P. 15p.

# 270° WIDE ANGLE

1mA METERS

MW1-6 60mm square 23-97!. MW1-8 80mm square \$4-97!. P. & P.





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WEAS TRANSCRIVERS Large quantity available for EXP Excellent condition. Enquiries invited. EXPORT



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UR-IA SOLID STATE COMMUNICATION EXCEIVER 4 Bands covering 55KHz-30MHz. FET, 8 Meter, Varlahle BFO for SSB. Built in Speaker, Bandapread, Sensitivity Control. 220/240V a.c. or 12V d.c. 12in × 4in × 7in. Brand new with instructions. \$25. 7in. Branc Carr. 37ip.



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General coverage 150-400KHz, 550KHz-30MHz. FET front end, 2 mech. filters, product detector, variable B.F.O., noise limiter, 8 Meter, Bandepread. RF Gain. 15in × 9 fin × 8 fin. 18ib. 220/240V a.c. or 12V d.c. Brand new with instructions. 445. Carr. 50p.

LAFAYETTE
HA-800 SOLID
STATE AMATEUR
COMMUNICATION



3·5-4, 7-7·3, 14-14·35, 21-21·45, 28-29·7, 50-54MHz. Dual conversion, 2 mech. filters, product detector, variable BFO, 8 Meter, 100KHz calibrator. 220/240V a.c. or 12V d.c. 15in × 91in × 91in × 91in. 18b. Brand new with instructions. 457-50, Carr. paid (100KHz Crystal £1.97; extra).

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18021	0-20	ACY22	0.18	BF898	0.28	MJE520	0.88	OC66	0.50
18113	0.15	ACY27	0·18 0·25 0·18	BFX12 BFX13	0.28	MJE2955	1.75	OC70	0-18
18130	0-18	ACY28	0.18	BFX13	0.28	MJE3055	0.98	0071	0·15 0·25
18131	0-18	ACY17 ACY18 ACY19 ACY20 ACY21 ACY22 ACY27 ACY28 ACY39 ACY40 ACY44 ACY44 AD140	0.55 0.15	BFX29 BFX30	0-80 0-88	NKT128 NKT129	0.80	0C59 0C66 0C70 0C71 0C72 0C73 0C74 0C75 0C76 0C77 0C78 0C78D	0.80
18202	0.28	ACY40	0.10	DPAS	0.98	NKTOII	0.25	OC74	0.80
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2G306	0.88 0.80	AD149	0.50	BFX85 BFX86 BFX87 BFX88 BFY10	0.40	NKT216	0.38	OC77	0.40
2G371	0.88	AD161	0-88	BFX86	0.88	NKT217	0.40	OC78	0.20 0.18
2G381	0.25	AD162	0-88 0-80	BFX87	0.88	NKT218	0.40	OC78D	0.18
2G414	0.80	AF106	0.80	BFX88	0.25	NKT219	0.88	OC79 OC81	0-28 0-25
2G417	0.28	AF114	0.88	BFY10	1.00	NKT222	0.20	0081	0.50
2N214	0-48	AF115	0.80	BFY11	1.25	NKT224	0.28	OC81D OC81M	0-20 0-20
2N247	0.25	AF116	0.88	BFY17	0-25 0-25	NKT201	0.25	OCSIDM	0.18
2N250 2N404	0.50	AF117	0.25	BYFIS	0.25	NK 12/1	0.25	OC81DM OC81Z	0-18 0-55
2N697	0-28 0-18	AF118 AF119	0.68 0.20	BEVOA	0.45	NKT973	0.90	OC82 OC82D	0-25
20007	0.43	AF124	0.95	RFV44	1.00	NKT274	0.20	OC82D	0-25 0-15
2N698 2N706	0.48 0-10	AF125	0·25 0·20	BFY50	0.28	NKT275	0.25	OC83 OC84	0.25
2N706A	0-18	AF126	0-18	BFY51	0.20	NKT277	0.20 0.25 0.20	OC84	0.25
2N708	0-15	AF126 AF127	0.18	BFY52	0.28	NKT278	0-25 0-30	OC114	0.88
2N709	0.68	AF139	0.80	BFY11 BFY17 BYF18 BFY19 BFY24 BFY44 BFY50 BFY51 BFY52 BFY63 BFY64 BFY64 BFY90 B8X27	0.18	NKT217 NKT218 NKT219 NKT222 NKT222 NKT2251 NKT271 NKT273 NKT273 NKT274 NKT277 NKT277 NKT278 NKT278 NKT278 NKT304 NKT304 NKT403	0-80	OC122 OC123	0-88 0-50 0-50
2N711	0-88	AF178	0.48	BFY64	0-48 0-68	NKT304	0.85 0.75	OC123 OC139	0.25
2N987	0.58	AF179	0-48 0-58	BEY90	0.50	NK 1403	0.68	00139	0.88
2N1090	0.80	AF180 AF181	0-48	B8X60 B8X76 B8Y26 B8Y27 B8Y51	0.98	NKT404 NKT678 NKT713 NKT773	0.80	OC140 OC141	0.68
2N1091 2N1131	0-88 0-80	APIRE	0.40	BRX76	0.15	NKT713	0.25	OC169	0-20
2N 1131	0.80	AF186 AFY19 AFZ11	1.18	BSY26	0·15 0·18	NKT773	0.25	OC169 OC170	0-25
2N1132 2N1302	0.20	AFZII	0.68	BSY27	0.20	NKT777	0.88	OC171	0-80
2N1308	0·20 0·23	AFZ12	0.68 0.75	BSY51	0.50	078B	0.88	OC200	0.88
2N1308 2N1304	0-25	AFZ12 ASY26	0-25 0-88	BSY95A BSY95	0.15	OA5	0.15	OC201	0-48
2N1305	0-25	ASY27	0.88	B8Y95	0-15	OA6	0.18	00202	0-68 0-88
2N1306	0-25	A8Y28	0.25	BT102/50	0R 0.75	OA47 OA70	0.10	00203	0-40
2N1307	0-25	A8Y29	0.80	BTY42	0.98	0.471	0·10 0·10 0·10	00205	0-68
2N1308	0-80 0-85	ASY36	0-25 0-18	BTY79/1	00 E	OA71 OA73	0.10	OC206	0-75
2N1309 2N1420	0.88	ASY50	0.40	D. 110/1	0.75	0A74	0.10	OC207	0-75
2N1507	0.28	ASY51 ASY53 ASY55	0.20	BTY79/4	00R	OA79	0·10 0·10	OC460	0.20
2N1526	0-22	ASY55	0.20		1.75	OA81	0.10	OC470	0-80
2N1909	2·25 0·75		0.25	BY100	0.18	OA85	0.18	OC201 OC202 OC203 OC204 OC205 OC206 OC207 OC460 OC470 OCP71	0-98 0-50
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2N2784	0-50	BC116A	0.45	5YZ16	0.68	OAZ203	0-48 0-48	8X640 8X641	0-25
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2N2848 2N2904	0.48	BC107 BC108 BC109 BC113 BC115 BC116 BC116A BC118 BC122 BC125 BC126 BC126 BC140 BC147	0.20	C111	0.42	OAZ206	0.48	8X644	0.48
2N2904A	0.80	BC125	0.68	CR81/05	0-65 0-25	OAZ207	0.48	8X644 8X645	0-75 0-50
2N2906	0-80 0-88	BC126	0.65	CRS1/05 CRS1/40	0.48	OAZ208 OAZ209	0.88	V15/30P	0.50
2N2907	0-88	BC140	0-55	CB4B	2.50	OAZ209	0.88		0.88
2N2924	0.02	BC147	0-18	CS10B	8-18	OAZ210 OAZ211	0.88	V60/201	0-88
2N2925	0-18 0-18 0-50	BC148	0-18	DD000	0.15	OAZ211	0-88	V60/201F XA101 XA102 XA151 XA152 XA161 XA162 XB101	0-88 0-10
2N2926	0-18	BC149	0-20	DD003 DD006	0-15 0-18	OAZ222 OAZ223	0.40	X A102	0.18
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2N3820	いるち	BC 133 BC Y34 BC Y38 BC Y39 BC Y40 BC Y42 BC Y70	0.49	GET114	0.15	OC20 OC22	0.48	ZR24	0-68
2N3823 2N5027	0-75 0-58	BCV40	0-48 0-43 0-15 0-20	GET114 GET115	0.45	OC23	0.50	Z8170	0-10
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12AH8	2.25 DAF96	0-86 EF89	0-26 PCC805	0-65 U47	0-68 OC26	0.2
12AT7	0-18 DF33	0-88 EF91	0-13 PCF80	0.80 U49	0.65 OC44	0.1
12AU6	0-28 DF91	0-16 EF183	0-29 PCF82	0-32 U50	0-89 OC45	0.1
12AU7	0-23 DF96	0-86 EF184	0-82 PCF86	0-47 U52	0-81 OC71	0.1
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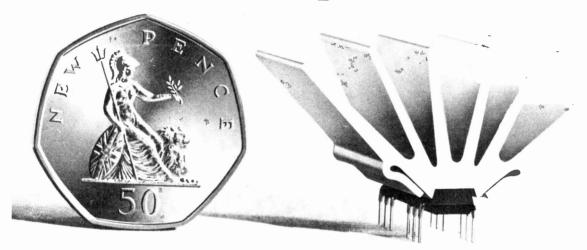
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# Super IC-12



# High fidelity Monolithic Integrated Circuit Amplifier

Two years ago Sinclair Radionics announced the World's first monolithic integrated circuit Hi-Fi amplifier, the IC.10. Now we are delighted to be able to introduce its successor the Super IC.12. This 22 transistor unit has all the virtues of the original IC.10 plus the following advantages;

- 1. Higher power.
- 2. Fewer external components.
- 3. Lower quiescent consumption.
- 4. Compatible with Project 60 modules.
- Compatible with Project to modules.
   Specially designed built-in heat sink.
- No other heat sink needed.

  6. Full output into 3, 4, 5 or 8 ohms.
- 7. Works on any voltage from 6 to 28 volts without adjustment.
- 8. NEW 22 transistor circuit.

Output power 6 watts RMS continuous (12 watts peak).

Frequency Response 5 Hz to 100KHz ±

Total Harmonic Distortion Less than 1% (Typical 0.1%) at all output powers and all frequencies in the audio band.

Load Impedance 3 to 15 ohms.

Power Gain 90dB (1,000,000,000 times) after feedback.

**Supply Voltage** 6 to 28 volts (Sinclair PZ-5 or PZ-6 power supplies ideal).

Size 22 x 45 x 28 mm including pins and heat sink.

Input Impedance 250 Kohms nominal. Quiescent current 8mA at 28 volts.

**Price:** including FREE printed circuit board for mounting. **£2.98** Post free

With the addition of only a very few external resistors and capacitors the Super IC.12 makes a complete high fidelity audio amplifier suitable for use with pick-up, F.M. tuner etc. Alternatively, for more elaborate systems, modules in the Project 60 range such as the Stereo 60 and A.F.U. may be added. The comprehensive manual supplied with each unit gives full circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include car radios, oscillators etc. The very low quiescent consumption makes the Super IC.12 ideal for battery operation.

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# **Sinclair Project 60**



# the world's most advanced high fidelity modules

**Sinclair Project 60** presents high fidelity in such a way that it meets every requirement of performance, design, quality and value and now that the remarkable phase lock loop stereo FM tuner is available, it becomes the most versatile of high fidelity systems. With Project 60, it is possible to start with a

modest mono record reproducer and expand it to a sophisticated stereophonic radio and record reproducing system of fantastically good quality to hold its own with any other equipment, no matter how expensive. Project 60 is a unique high fidelity module system where compactness and ease of assembly are combined with

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circuitry that is far in advance of any other manufacturer in the world. Thus it is extraordinarily easy to assemble any combination of modules using nothing more complicated than the simplest of tools, and you certainly do not have to be experienced to build with complete confidence. The 48 page manual free with Project 60 equipment makes everything easy and you can house your assembly in an existing cabinet, motor plinth, free standing cabinet or virtually any arrangement you wish. Once you have completed your assembly you will have superlatively good equipment to give you years of service and enjoyment. You will have obtained superb value for money because Project 60 is the best selling modular system in Europe and can therefore be produced at extremely competitive prices and with excellent quality control,

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# Sinclair Project 60

# Z.30 & Z.50 power amplifiers



The Z.30 and Z.50 are of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at full output and all lower outputs. Whether you use Z.30 or Z.50 amplifiers in your Project 60 system will depend on personal preference, but they are the same size and may be used with other units in the Project 60 range equally well.

### SPECIFICATIONS (250 units are interchangeable with Z.30s in all applications). Power Outputs

Power Outputs
2.30 15 watts R.M.S. into 8 ohms using 35 volts:
20 watts R.M.S. into 3 ohms using 30 volts.
2.50 40 watts R.M.S. into 3 ohms using 40 volts:
30 watts R.M.S. into 8 ohms, using 50 volts. Frequency response: 30 to 300 000 Hz ±1dB

Distortion: 0 02% into 8 ohms. Signal to noise ratio; better than 70dB unweighted

Input sensitivity: 250mV into 100 Kohms. For speakers from 3 to 15 ohms impedance.

Size 31 x 21 x 1 in. Z.30

Built tested and guaranteed with circuits and instructions manual £4.48

Built, tested and guaranteed with circuits and instructions manual, **£5.48** £5.48

# Power Supply Units





Designed specially for use with the Project 60 system of your choice.

Illustration shows PZ.5 to left and PZ.8 (for use with Z.50s) to the right. Use PZ.5 for normal Z.30 assemblies and PZ.6 where a stablised supply is essential.

PZ-5 30 volts unstabilised £4.98 PZ-6 35 volts stabilised £7.98 PZ-8 45 volts stabilised (less mains transformer) £7.98 PZ-8 mains transformer £5.98

# Guarantee

If within 3 months of purchasing Project 60 modules directly from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work pe fectly and should any defect ause in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter. No charge for postage by surface mail. Air-mail charged at cost.

# Stereo 60 pre-amp/control unit



Designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout, achieving a really high signal-to-noise ratio and excellent tracking between channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs.

### SPECIFICATIONS

Input sensitivities: Radio-up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A. curve ± 1dB 20 to 25,000 Hz. Ceramic p.u.-up to 3mV: Aux-up to 3mV

Output: 250mV

Signal-to-noise ratio: better than 70dB. Channel matching: within 1dB.

Tone controls: TREBLE + 15 to 10KHz BASS + 15 to 15dB at 100Hz. to -15dB at Front panel: brushed aluminium with black knobs and controls

Size: 81 x 11 x 4 ins.

Built, tested and guaranteed.

£9.98

# **Active Filter Unit**



For use between Stereo 60 unit and two Z.30s or Z.50s, and is easily mounted. It is unique in that the cut-off frequencies are continuously variable, and as attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The A.F.U. is suitable for use with any other amplifier system. Two stages of filtering are incorporated rumble (high pass) and scratch (low pass). Supply voltage – 15 to 35V. Current – 3mA. H.F. cut-off (–3dB) variable from 28k Hz to 5kHz. L.F cut-off (-3dB) variable from 25Hz to 100Hz. Distortion at 1kHz (35V. supply) 0.02% at rated output. Built, tested

and guaranteed

£5.98

# Stereo FM Tuner



first in the world to use the phase lock loop principle

Before production of this tuner, the phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio over other systems. Now, for the first time, the principle has been applied to an FM tuner with fantastically good results. Other original features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stereo decoder and squelch circuit for silent tuning between stations. Sensitivity is such that good reception becomes possible in difficult areas. Foreign stations can be tuned in suitable conditions and often a few inches of wire are enough for an aerial. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically as the tuning control is rotated, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with any other high fidelity system

# SPECIFICATIONS:

Number of transistors: 16 plus 20 in I.C. Tuning range: 87.5 to 108 MHz Capture ratio: 1.5dB

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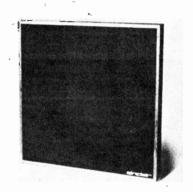
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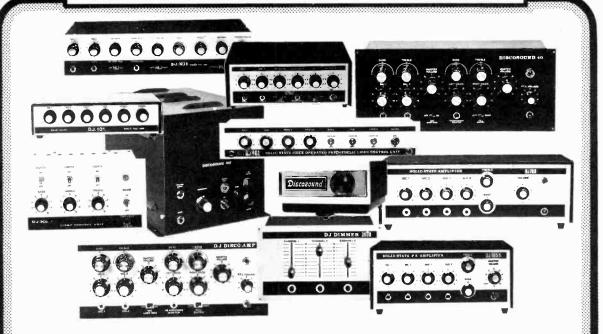
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VOL. 7 No. 6 June 1971

# PRACTICAL ELECTRONICS

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# MAPS, PLANS, AND NEWFANGLED THINGS

In those areas concerned principally with small signal operations, the integrated circuit is fast assuming the role of the most important circuit building block. Coincident with startling reduction in material size is the greatly magnified electronic function of the typical IC. Not just one active circuit but maybe a dozen or more stages are concealed within some tiny prosaic plastic body. And this is not to mention medium-scale, let alone large-scale integration. The future drift is quite obvious. The scaling down in terms of physical size for a given number of circuit configurations will proceed apace, while the staggering possibilities presented by the use of agglomerations of these tiny items bemuse one. Or they do so at the present time. In a couple of years it will all be perfectly normal and acceptable. We will be quite blasé about the whole business.

But what of today. At each new stage of IC development (or further miniaturisation, which amounts to the same thing) the boundaries of possible involvement for the individual designer and constructor are pushed out still further. The complexity of the devices, in terms of fundamental circuit elements, will ever expand but the space they need occupy will continue to diminish.

It is to this world of Lilliputian Electronics that we should now be adjusting ourselves. A world where small scale maps charting the contours of large areas will often suffice, since we will be mainly concerned with only the major topographical features. But even so we will still have to make recourse on occasions to large scale plans for finding our way around certain local areas which may have particular interest or significance.

Yes, while we can most profitably attune ourselves to the "system" approach, and become further accustomed to block diagrams and logic diagrams, we must still keep our eye in for reading and correctly interpreting the finer detail of the conventional circuit diagram. Not even the most sanguine advocate of IC's would declare that all discrete circuit components are ultimately expendable. Electronic circuit building is likely to remain a very mixed affair—much main assembly work with prefabricated circuit blocks, plus the odd bit of jobbing work with individual semiconductors, resistors, and capacitors. Make no mistake, this "odd jobbing" may indeed prove all important; and here the builder may have to be his own architect as well. So it is essential to keep one's hand in with the older traditional skills of circuit design and construction, while at the same time acquiring the knack of dealing with these newfangled things.

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Radio astronomy has enabled astronomers to detect the existence of sources of radiation in the atmosphere and outer space which would never have been discovered by optical means. It has opened up an entirely new avenue of research and already extended our knowledge of the Universe in a manner not foreseen by the early pioneers.

During the course of these articles various practical projects will be outlined and details will be given of the apparatus required. It will become apparent that a simple radio telescope in the back-garden is quite a feasible proposition. It should also be mentioned that there are certain studies and investigations that might well be undertaken as a nation-wide co-operative effort among keen amateur radio astronomers.

Many people when hearing the words "radio telescope" think of the 250ft dish at Jodrell Bank. Perhaps this is natural since it nearly resembles the rather more familiar optical reflector used by visual astronomers. The word telescope implies something that is "looked through" and many people have actually requested the opportunity to "look through" a radio telescope.

So, straightaway, we must make clear what exactly is meant by radio astronomy, and provide some details of the origin of this comparatively young branch of science and technology.

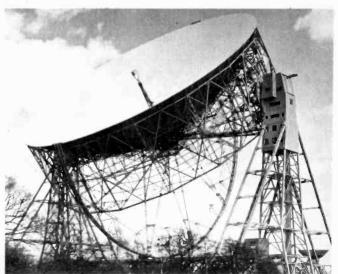
### HISTORICAL BACKGROUND

Radio Astronomy has now completed some 40 years of its existence. Although not called radio astronomy until after the Second World War, it had its beginnings between the years 1928 and 1932.

In 1927 Karl Guthe Jansky, a graduate from the University of Wisconsin, joined the staff of the Bell Telephone Company, and undertook the task of investigating the cause of the interference on transoceanic telephone links.

Jansky noted certain peculiarities about the noises he received; he observed there was a rise in the noise when his aerial was pointed in a certain direction, between the frequencies of 20 and 21Mhz. He developed a large steerable aerial—which he called his "merry-go-round"—and in 1929, after many trials, was able to start some positive observations.

The world's largest fully steerable radio telescope at Jodrell Bank—by permission University of Manchester



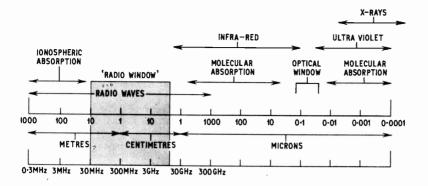


Fig. 1.1. Electromagnetic spectrum, indicating the "radio window" usable for radio astronomy

At first Jansky was under the impression that the radiations he was receiving were coming from the Sun, but as time went on he found that the point from which he could detect the radiations moved further and further away from the Sun until he could detect them in the night. He concluded that they came from outside the earth and from stars in the direction of the Milky Way.

# AMATEUR ENTERPRISE

It is impossible to stress too much the importance of Jansky's discoveries, and although the noises he heard were broadcast at the time, no serious attention was given to them by professional astronomers. It was left to the amateurs, in particular one, Grote Reber, to carry on where Jansky left off.

Reber decided to start at very high frequencies as he assumed he would have a better chance of receiving such signals. Though the theory of this reasoning was sound, it did not work out well in practice, and this was due to the inefficiency of the apparatus at his disposal. He eventually decided that the frequencies at which he was working were too high and designed and constructed for himself a 30ft diameter "dish" aerial. With this apparatus he worked at a frequency of 160Mhz and was thus able to repeat Jansky's work. Reber suggested that the radiations were thermally generated by collision between free electrons and positive ions in the interstellar matter ionised by light.

It was Reber's 30ft dish that was called the first radio telescope". With this he made the first radio map of the sky which is, today, still a reasonably accurate picture of extra-terrestrial radiations.

Reber had proved once again that the activities of the amateur had made their mark upon the history of man's quest for knowledge and opened up an ever expanding field of research. Karl G. Jansky unfortunately did not live to see the extent to which his early discoveries would be pursued.

# BASIS OF A SOUND TELESCOPE

In fact, any aerial system may form part of a radio telescope. The simplest form of radio telescope consists of an aerial system, a receiver, and a recording device.

Thus even the ordinary television set shows (when the normal television transmission has ceased) "noise" in the form of scintillating points or flashes of light on the screen. A tape recorder could be used to store this "noise" which could then be analysed to show on a pen recorder the various components of the "noise" and their values. The recorder could be connected directly to the receiver, as is more frequently the case in radio astronomy.

### NOISE FROM SPACE

The "noise" on this very crude telescope would consist of sources of noise in the receiver itself due to components such as resistors, capacitors, transistors and valves, and poor joints. There would also be the noise due to the aerial itself, and finally the noise signal arriving at the aerial from the atmosphere and outer space. The tiny amount of noise from space is the radiation on which the astronomer focuses his attention.

The improvements in techniques have largely been directed toward the more efficient detection of the infinitesimal noise signal of a finite source of radiation from the background radiation always present in space.

# THE RADIO WINDOW

On earth, the limits of the "radio window" (see Fig. 1.1) through which the universe may be observed are determined by the terrestrial environment. Although this radio window theoretically extends from less than 1Mhz to 30Ghz, it is not possible efficiently to use this whole range. Generally speaking, the lower frequencies below 6Mhz are not used, though there are special circumstances where they have been and are being used. From 6MHz to 40MHz the effect of the earth's ionosphere has a considerable influence and has to be taken into account. This very effect is used to provide data about the ionosphere itself.

When the higher frequencies above 10GHz are considered, there are other factors due to the atmosphere of the earth that have to be taken into account and these limitations are also used to determine the conditions of the terrestrial environment.

The term radio astronomy therefore has become generally accepted as referring to those observations using radio techniques in that part of the electromagnetic spectrum between frequencies of 6MHz and 30GHz.

## **VARIOUS AERIAL SYSTEMS**

Within this frequency range the types of aerial systems used and the projects undertaken are many and varied. Aerials may range from a single dish to arrays of dishes; from simple Yagis to groups of Yagis; from small corner reflectors to large units

nearly a mile in length; from pairs of dipoles to acres of dipoles; and from single helical units to large groups of up to a 100 in one large unit.

The type of aerial system is dictated by the nature of the project involved, and may be of any combination of those that have been mentioned. Sometimes a small unit may be used as a pilot scheme to test the feasibility of a certain line of observation. As an example, an actual project whose object was a closer study of interplanetary scintillation using the quaser 3C48 will be described.

A quaser is a body which is very small in size but whose radiation both in the visible spectrum and the radio spectrum is much greater than would be expected. Since these bodies do not conform to the normal definition of stars, they were given the name of quasi-stellar objects which has become shortened to quaser.

# INTERPLANETARY SCINTILLATION

Prof. A. Hewish, F.R.S., whose team discovered the phenomena, established that the plasma clouds radiating from the sun caused scintillation of the radiation from small objects which were radio sources. Large sources were unaffected by these plasma clouds because radiation was always at a level over an area such that the source showed no marked changes.

Now quasers, though powerful sources of radiation, are small in size and in consequence the variation in the density of the interplanetary medium caused twinkling or scintillation in the same way that a faint star twinkles due to the variation of the density of the atmosphere. It was decided to make a special study of 3C48 because it showed certain characteristics, one of them being a large amount of scintillation.

# **QUASER STUDY PROJECT**

To this end three aerials were planned for three different sites which were so situated so that they formed an equilateral triangle. One was at the Mullard Radio Astronomy Observatory at Cambridge, one at Thetford, and the third at the writer's observatory at Little Clacton.

At each site was a special arrangement of two sets of aerials, consisting of a double line of full-wave dipoles with a reflecting screen. This arrangement constituted an "integrated interferometer" some 760 feet long and oriented in an east-west direction.

The outputs from these three aerials were combined at the Cambridge observatory, the outputs from Thetford and Little Clacton being taken over land line to Cambridge. An example of the recording taken at Little Clacton is shown in Fig. 1.2.

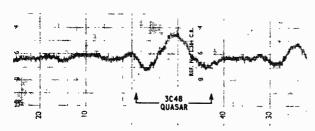


Fig. 1.2. Pen recording of Quaser 3C48. Note scintillation causing rapid variation of trace

This pilot scheme was successful and the next step was to operate from an even larger triangle. This was based on locations at Cambridge, Jodrell Bank and Malvern. The Cambridge aerial was in this case very much larger than that used with the first scheme and covered an acre of ground.

### **DISCOVERY OF THE PULSAR**

It was with this latter aerial that the discovery of the first pulsar was made. (The pulsar, the latest discovery in radio astronomy, is thought to be a rotating neutron star.) So once again, as has happened so many times in the history of radio astronomy, a new discovery was made during the pursuit of a different kind of object. (These two discoveries and his work on the solar wind and interplanetary scintillation earned Dr. Hewish his fellowship of the Royal Society and the Eddington Gold Medal of the Royal Astronomical Society.)

The aerials used in the experiments described were of very simple construction and modest in cost compared with the value of the results obtained. This is one of the advantages of working at frequencies (in this case 81·5MHz) which allow considerable tolerance in mechanical construction. It also allows the amateur with modest resources to enter this exciting field as a participant observer.

To sum up then, a radio telescope can be divided into three principal sections: (1) the aerial system, (2) the receiver, and (3) the recording system.

### **ELECTROMAGNETIC WAVES**

The aerial is a collector of energy and is the link between the receiving system and the free electromagnetic waves in space. The energy impinging on the collector sets up voltages which can be synthesised and evaluated by the receiving system to which it is connected.

The velocity of propagation of electromagnetic waves is 300,000,000 metres (approximately) per second. Thus a wavelength of 300 metres has a frequency of one megahertz. Before the agreement by the principal countries in the world to the use of scientific terms standardised among them, the term for frequency would have been in cycles per second so that 300 metres would have been one megacycle (Mc/s). Both terms are in use still, and all publications prior to 1964 on the subject of radio astronomy are in cycles.

Other terms are also in use to signify various parts of the radio spectrum studied by astronomers and these are: decametre (tens of metres) wavelength, metre wavelengths, decimetre (tenths of metres) wavelengths, centimetre wavelengths, and millimetre wavelengths. The principal reason for this classification is that the various sections each have certain characteristics that differ from the others when looking at an overall spectrum of radiation. Some of these points will emerge from the examples that will be quoted later in this series.

# PLAN OF POLARISATION

In the radio part of the electromagnetic spectrum the greater part of the radiation is produced by the interaction of electrons with ions or with magnetic fields. There are certain special exceptions which will be dealt with separately later.

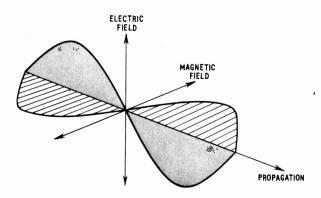


Fig. 1.3a. Radio wave in space, showing the alternating electric and magnetic fields

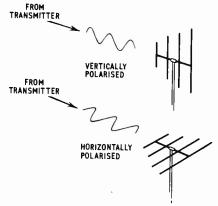


Fig. 1.3b. Vertically and horizontally polarised aerials, such as typically used for television reception

The normal undisturbed radio wave propagated from a transmitter can be represented by an alternating electric and magnetic field. Each of these fields is at any instant, in an isotropic medium, perpendicular to the direction of propagation, see Fig. 1.3a.

The plane in which the electric field vibrates is called the plane of polarisation. This is an important quality for it determines whether or not an aerial will absorb energy from the field. If the aerial is not parallel to the electric field, no current will be induced in it and the radiation would not be detected. This is the reason why in radio communication it is necessary for the receiving aerial to have the same orientation as the transmitter aerial.

In practice, of course, a horizontally polarised aerial will absorb some energy from a vertically polarised transmitter if the power level at the aerial is high enough. The most familiar examples of this are the vertical and horizontal types of aerial for television reception, see Fig. 1.3b.

# SUBJECTED TO VARIATION

Most of the radiation from space is randomly polarised, and depending upon the source and the medium through which it travels, may be subjected to considerable variation. It may be modified in passing through a magnetic field, and at certain frequencies will be modified very considerably as it passes through the ionosphere.

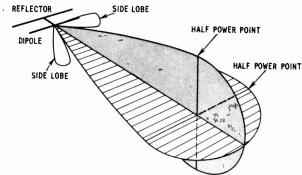


Fig. 1.4. The directional pattern of a simple dipole and reflector

It is possible to determine the amount by which the wave will be polarised by the ionosphere if the frequency, the length of the path through the ionosphere, and number of electrons in that path, are known. Conversely, it is possible to calculate the electron density from the amount by which a wave is modified in polarisation. The source of the radiation may be polarised and it is possible in such cases to determine the strength of the magnetic field by measuring that polarisation.

# **AERIAL PARAMETERS**

Aerial systems for radio astronomy are directly related to the particular project of observation that is to be carried out, but there are certain parameters of aerials which specify the properties required. The most important of these parameters are the directional pattern beamwidth, the effective area, the gain, the directivity, and the bandwidth.

# **Directional Pattern**

The directional pattern of a simple aerial in the form of a dipole and reflector is shown in Fig. 1.4. It is three dimensional and shows the half-power points. There are certain subsidiary or side lobes shown, and if the reflector were not there the aerial would have a second main lobe at 180 degrees from the one shown in the diagram.

Only one main lobe is required for the purposes of radio astronomy. The side lobes are reduced to their smallest practical patterns. It is very important to know the exact effect of these side lobes for in the early days of radio astronomy quite a number of "new sources" proved to be the effect of side lobes.

# **Beamwidth**

The half-power point is indicated in Fig. 1.4. and the beamwidth of the main lobe where the received power is half that of what it would be in the direction of maximum power.

### Effective Area

The effective area is a measure of the wavefront area from which the aerial can absorb power. The effective area varies between 0.5 and 0.9 of the physical area of an aerial. It is also a function of direction since it depends on arrival of the radiation along the main lobe axis.

# Directivity and Gain

The directivity and the gain of an aerial are similar. They represent the extent to which the received radiation is selected from a given direction, and should be down the centre of the main lobe.

The maximum directivity is defined as the ratio of the flux density produced at a great distance to that that would be received if the total power of the source was radiated in all directions.

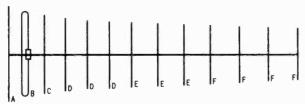
The gain of an aerial is nearly the same. The maximum gain is the ratio of the flux density received along the main lobe axis to that which would be produced at the same distance if the power supplied to the receiver terminals was the same in all directions.

The only real difference between these two properties is that caused by the loss of energy used in heating up the aerial.

# Half-Power Bandwidth

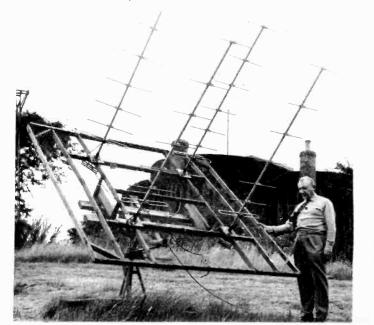
The gain of an aerial of a particular dimension varies with the variation of frequency, being greatest usually at the resonant frequency. The half-power bandwith is the difference between the two frequencies at which the gain is half as great as it is at the frequency of resonance.

The formula for gain is  $G = 4 A/\lambda^2$ , where G is the direction of the main lobe axis where A is the effective area.



LENGTH OF ELEMENTS	SPACING OF ELEMENTS		
A REFLECTOR 0.5λ	A-B 0.15\(\lambda\) TO 0.25\(\lambda\) B-C 0.125\(\lambda\) C-D 0.19\(\lambda\) D-D 0.22\(\lambda\)	D-E 0.22%	
B OIPOLE 0-49λ	B~C 0-1252	E-E 0·25λ	
C 1st DIRECTOR 0・47入	C-D 0-192	E-F 0-25λ	
D-F DIRECTORS EACH 0.98A	D-D 0.55Y	F-F 0⋅3λ	

Fig. 1.5a. Yagi array, with dimensions of elements and spacing between them (photo below shows Yagi's on steerable mount)



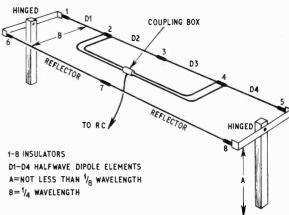
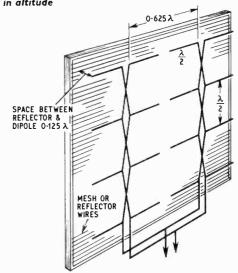
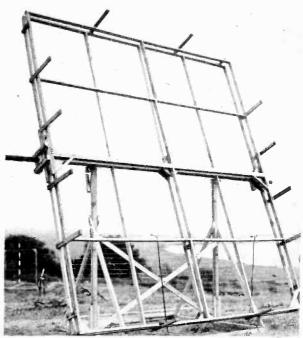


Fig. 1.5b. A pair of full wave dipoles with reflector, steerable in altitude



MESH HOLES = 0.0625  $\lambda$ WIRES SPACED=0.0625  $\lambda$ 

Fig. 1.5c. A modified Kooman array (and photo below)



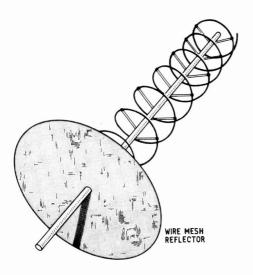


Fig. 1.5d. A helical aerial

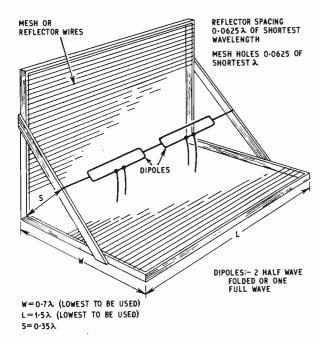


Fig. 1.5e. Corner reflector aerial (and photo below)



# **VARIOUS DESIGNS**

The principles that have been described apply to all designs of aerials and to all the various arrangements that will be given in this series.

So far the simple dipole has been used to illustrate the basic principles. The main differences in aerials are in the reflectors or directors used in association with the dipole. Other differences are the use of horn aerials at high frequencies and the use of helical aerials at certain frequencies, usually above 80MHz.

Various types of aerials will now be briefly described.

### YAGI ARRAYS

Yagi arrays are very useful, though their frequency range in any one range is limited. But for a long term project at a definite frequency, the Yagi array has advantages, since it is compact and mechanically simple, see Fig. 1.5a.

The individual design will depend on the parameters that need to be emphasised. The directivity pattern of the simple dipole and reflector apply here and more elements up to about 13 increase gain and directivity, although they reduce very critically the bandwidth. It is easy to mount Yagis on a steering unit.

## PAIRS OF DIPOLES

When used singly, dipoles have a wide angle of acceptance. They can also be used in interferometer arrays consisting of two or more pairs of dipoles, Fig. 1.5b. The angle of acceptance is then extremely narrow.

A group of dipoles with a reflecting sheet of netting or parallel wires—known as a modified Kooman array—is an easy mechanical assembly, Fig. 1.5c. This was known sometimes as the "pine tree" aerial. It is very suitable for amateur construction.

### HELICAL AERIAL

There are some special properties relating to helical aerials that make them a desirable choice for certain fields of study. The two important properties from the point of view of radio astronomy are that they accept circular polarisation and the other that they are effective over a 2 to 1 range of frequency. See Fig. 1.5d.

# CORNER REFLECTOR

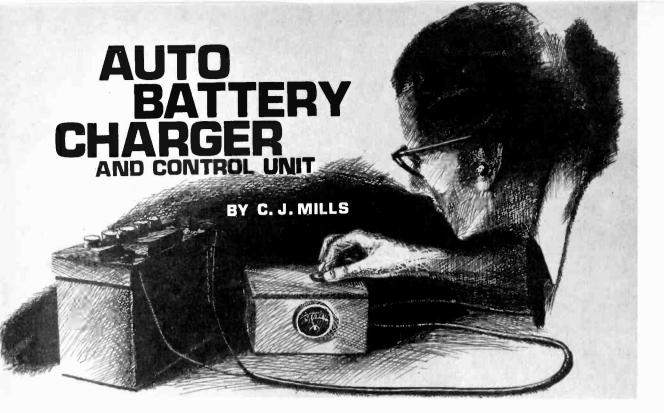
The corner reflector (Fig. 1.5e) has been a great favourite with many radio astronomers and has proved its versatility as well as providing much of the most useful and original data, some of which will be specially noted in the next article.

The gain of a corner reflector is high compared with dipole groups or Yagis. A corner reflector of 90 degrees with a full wave dipole at 0.35 of a wavelength from the apex and sides of one wavelength will have a gain in excess of 12dB.

A corner reflector can operate at a number of frequencies and requires only the changing of the dipoles. This again is a comparatively simple mechanical assembly and can be made fully steer-

able.

Next month: Various radio telescope systems will be described and a design suitable for amateur work outlined.



AUTOMATIC control of a battery charger can be very useful both for protection of the battery against overcharging and for maintaining a fully charged battery in emergency power supplies.

Any battery charger can be made automatic by modification of the existing circuit to incorporate the control circuitry or by adding an external automatic control.

In this article constructional details for both a self-contained automatic battery charger and an automatic charger control unit will be given.

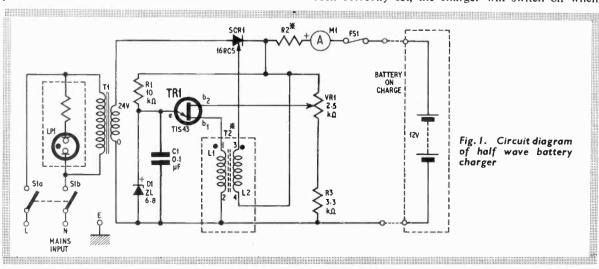
# **BATTERY CHARGER CIRCUIT**

The circuit for the automatic battery charger is shown in Fig. 1. Based on a Motorola design, this presents some unusual features.

The battery to be charged provides the supply for the unijunction transistor oscillator circuit. Here, CI charges via R1 until the trigger voltage of TR1 is reached. The capacitor then discharges producing a pulse at T2 primary which is reflected at the secondary to turn SCR1 on.

The rate, or frequency, at which this takes place depends primarily on the time constant product C1R1. While the unijunction transistor oscillator is running, the thyristor acts as a half wave rectifier for the charger.

As the battery voltage rises, the trigger voltage of TR1 increases until it exceeds the Zener voltage of D1 when the oscillator stops. The voltage at which this occurs can be set by adjusting the b<sub>2</sub> voltage of TR1 by means of VR1. Once the potentiometer has been correctly set, the charger will switch off when



# HALF WAVE CHARGER

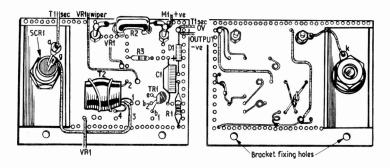
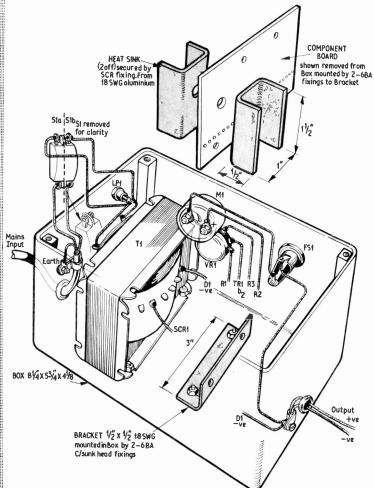


Fig. 2. Layout and wiring details of half wave battery charger components



# COMPONENTS . . .

## HALF WAVE CHARGER

### Resistors

RI 10kΩ ¼W

R2\* see text

R3 3-3kΩ ±W

# Capacitors

C1 0·1μF polyester

# Potentiometer

VRI 2·5kΩ wirewound

# **Semiconductors**

TRI TIS43

SCR1 16RC5 (International Rectifier)

DI ZL 6.8 IW Zener

# **Transformers**

TI Douglas MTI17AT primary 0-230/240

secondary 30V, 6A

T2\* see text

# Miscellaneous

MI 0-5A battery charger ammeter 2in round (G. W. Smith Ltd)

FSI 7A cartridge fuse and panel fuse holder

LPI Mains neon. Diecast box  $8\frac{1}{4}$  in  $\times$   $5\frac{3}{4}$  in  $\times$   $4\frac{5}{32}$  in

Fig. 3. Heatsink assembly and interwiring details of the half wave charger

the battery is fully charged and switch on again when

the battery voltage drops.

If the battery leads are disconnected, shorted or reverse connected, no charging current can flow so that neither the battery nor the charger can be damaged.

### CONSTRUCTION

For charging a 12V battery at 5 amp, a mains transformer with an output of 18 to 24 volts at not less than 6 amp is required and the thyristor rating should be 6 amp mean and not less than 15 amp peak.

The pulse transformer T2 is made up on a 1½in length of ferrite aerial rod. First wind on 100 turns of 26 s.w.g. enamelled copper wire, being very careful not to damage the insulation. Next wind on a

layer of plastic tape.

Over this wind 150 turns of 26 s.w.g. enamelled copper wire in the same direction, or sense, of the first winding. A final protective layer of plastic tape fixed with Selotape completes the transformer.

The circuit components are mounted on a 3 in  $\times$  2 in piece of plain perforated board, as shown in Fig. 2. All junction wiring should be done with

Veropins.

A substantial aluminium heat sink should be used when mounting the thyristor. For efficient heat dissipation a piece should be mounted either side of the board, the whole lot being fixed by the thyristor stud nut.

The ammeter and control potentiometer VR1 are mounted on an  $8\frac{1}{4}$  in  $\times$   $5\frac{3}{4}$  in  $\times$   $4\frac{4}{5}$  in diecast box as in Fig. 3. The perforated board assembly is vertically mounted on a piece of aluminium angle adjacent to the transformer. With all components in position, final wiring should be completed.

Finally, to assist in ventilation, a few holes should

be drilled in the sides and top of the case.

### **BALLAST RESISTOR**

A ballast resistor, R2, is required in series with the ammeter to limit the charging current when a discharged battery is put on charge. The value of this is found experimentally.

Start with something like a 3 ohm, 10 watt resistor and adjust the control potentiometer for maximum current. The ballast resistance is then reduced until the required charging current is reached with the potentiometer again adjusted for maximum current if necessary.

The final current setting of the potentiometer can be found by connecting a fully charged battery and adjusting until the cut-off point of the oscillator is found.

# **FULL WAVE CIRCUIT**

In Fig. 4 the previous circuit is modified for full wave rectification. Here the centre tapped transformer, T1, provides an alternating half cycle voltage input to the thyristors SCR1 and SCR2 to give a charging current of 5 amp.

The principle of gating the thyristors is exactly as before except that the pulse transformer T2 now

has two secondary windings.

If the coils are wound on an LA1 Ferroxcube bobbin, L1 of T2 should first be layer wound, using 30 turns of 26 s.w.g. enamelled copper wire. L2 is next, this being wound in the same direction as shown by the phasing dots in Fig. 3. Here 45 turns of 26 s.w.g. enamelled copper wire are used.

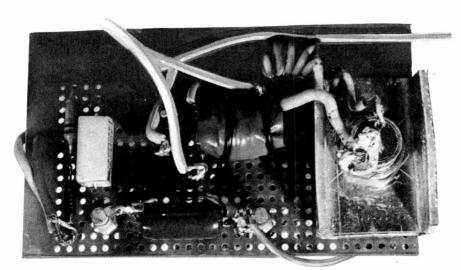
The final layer, L3, consists of the same number of turns and gauge of wire but is wound in the opposite directions. All three windings should be separated by single layers of plastic tape. To identify the start of each winding they should be

marked with a dab of paint.

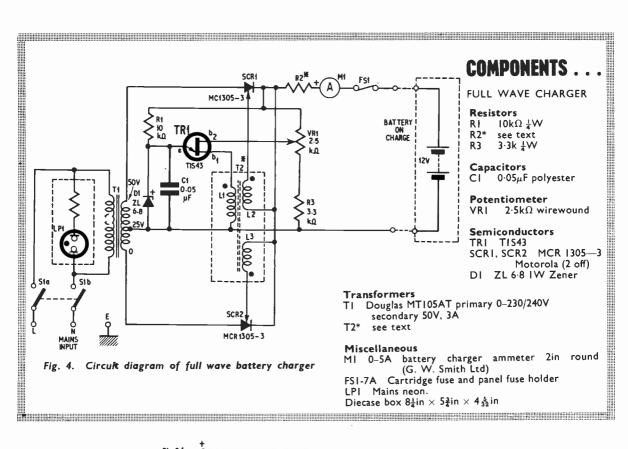
A cheaper core can be made up from a 1½in piece of ferrite rod. For this, L1 primary should consist of 100 turns of 26 s.w.g. enamelled copper wire. The L2 and L3 secondaries are made up of 150 turns of 26 s.w.g. enamelled copper wire, the winding direction of each is again in opposition with each winding separated from the other with a single layer of plastic tape.

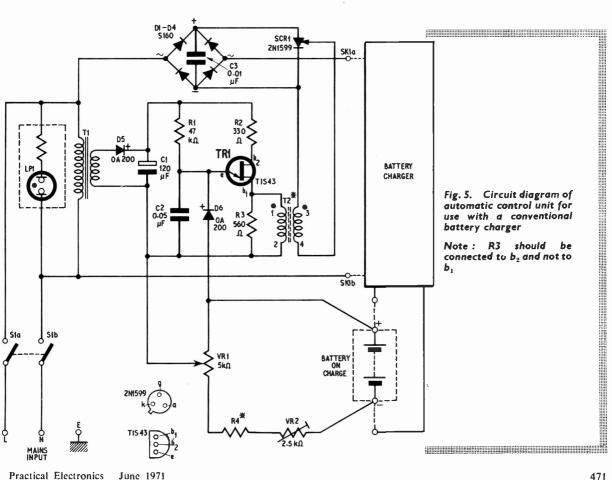
The method of construction for the full wave circuit is similar to the half wave version except that smaller heat sinks can be used for the two thyristors which now share the charging current.

The mains transformer secondary voltage taps to be used are shown in the circuit diagram.



Photograph of half wave charger assembly board. Pulse transformer is retained with lengths of insulated wire





# CHARGER CONTROLLER

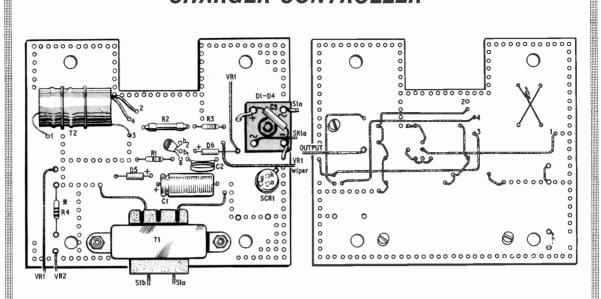


Fig. 6. Layout and wiring diagram of automatic control unit

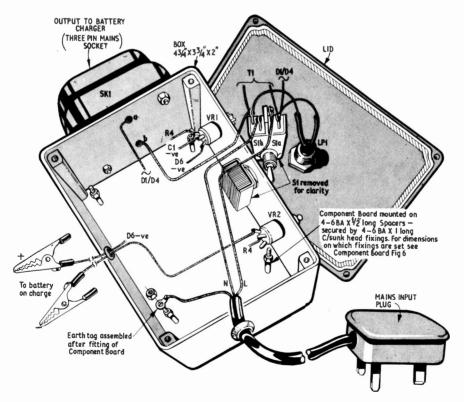
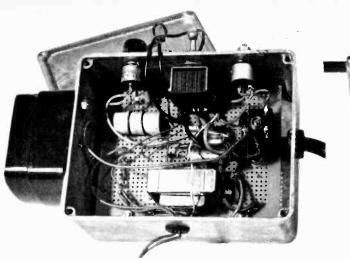
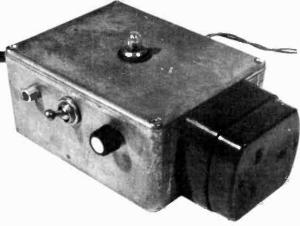


Fig. 7. Interwiring details for the automatic control unit





The completed control unit

# AUTOMATIC CHARGING CONTROL

For automatic control of a conventional battery charger, the circuit of Fig. 5 can be used. It has the advantage that even a flat battery can be recharged because the control oscillator has an independent power supply, and no modification is required to the charger.

The thyristor, SCR1, is connected across a 1 amp bridge rectifier and in series with the input to the charger. The control circuit, comprising TR1, gates this thyristor to switch the charger on and off as required. Power for the transistor oscillator is pro-

# COMPONENTS . . .

### BATTERY CHARGER CONTROL UNIT

# Resistors

RI 47kΩ ½W 330Ω ¼W R2 560Ω ↓W R3

R4\* see text

**Capacitors** 

120μF elect 25V CL C2 0.05 polyester

0.01 polyester 600V

Transformers

Filament transformer primary 0-230/240V,

secondary 6.3V 50mA

T2\* see text

**Bridge Rectifier** 

DI-D4 600V IA type \$160 (A. Marshall Ltd)

**Semiconductors** 

D5-D6 OA200 (2 off) TRI T1S43

SCRI 2NI599 Texas

**Potentiometers** 

VRI  $5k\Omega$  wirewound VR2  $2.5k\Omega$  preset

Miscellaneous

Double pole mains on/off, LPI-Mains neon, Diecast box 43 in by 33 in by 25 in.

vided by the filament transformer T1 and the rectifier D5.

## TRIGGER CONTROL

The circuit is so arranged that the trigger voltage for TR1 is less than 6 volts. A portion of the battery under charge voltage is applied to the emitter of TR1 via D6, so that if the battery voltage is low, then the tapped proportion to the emitter will be less than the trigger voltage; TR1 cannot be held on, so oscillation is maintained.

As the battery charges, the voltage at the emitter increases until it exceeds the trigger voltage. At

this point oscillation and charging ends.

Ideally, the output of the control unit should be fused as a short circuit of the battery clips will damage the rectifier circuitry.

### CONSTRUCTION

Components for the charger control unit are mounted on a piece of 4in by 3in perforated board as shown in Fig. 6. Junction connections are made with Veropins.

The rectifier bridge and thyristor should be mounted adjacent to each other and separate from the rest of the circuit so as to isolate the mains

wiring from the low voltage control circuit.

As the power transfer is low no heat sinks are required, but a capacitor is connected across the bridge rectifier to protect the thyristor from high voltage pulses. Complete interwiring details for the control unit are given in Fig. 7.

# CALIBRATION

To set the unit up it is only necessary to fix the oscillator cut off point. This requires a fully charged 6V or 12V battery being connected across the resistor chain VR1, R4 and VR2. With a 6V battery R4 and VR2 should be shorted out and VR1 is then adjusted so that the oscillator is turned off and no charging current is passed to the battery. With the potentiometer setting marked, the unit is now ready for use.

For a 12V battery R4 should be 5.6 kilohm and the short across R4 and VR2 removed. VR2 is now adjusted to find the new cut-off point without alter-

ing VR1 setting.

The unit is now ready for control of a 6 or 12V charger. The short across R4 and VR2 can be replaced by a link or switch if required.

# SIIIND 9

THE Association of Public Address Engineers held their annual exhibition—Sound '71—at Camden Town Hall from Tuesday, March 16 to Friday, March 19. The exhibition was officially opened by Mr Bob Danvers-Walker who's voice must be one of the best known in broadcasting.

Full use was made of the hall, stage and even behind-stage room, for exhibits. Radio London took up a large part of the stage with a studio from which their mid-day request programme was broadcast, via a transmitting car parked outside the exhibition.

Part of the behind-stage room was occupied by P.E.; the P.E. Gemini and P.E. Aurora were demonstrated. The remaining area behind the stage was used by the Chimes Organisation to demonstrate their range of discotheque equipment, including various lighting effects systems. Light with sound was also a feature on D.J. Products' stand in the main hall.

Another stand displaying equipment not directly concerned with public address was Electronic Music Studio (London) Ltd., who were demonstrating a very impressive looking—and sounding—piece of equipment called the VCS 3 Electronic Music Studio. The complexities of this system are such that they will not be discussed here; suffice to say that this is a type of Moog instrument that can be used to build up a programme on tape or as a live performance instrument.

Westrex launched a new range of public address equipment at the exhibition. This range includes solid state amplifiers of 30 watts and 100 watts, a 5-channel integrated amplifier and a variety of modular control cabinets. The new Westrex range of twoway communications control equipment was also demonstrated.

Megaphones were displayed on some stands and Eagle International showed three new types among the 25 other new products on their stand. The three megaphones were the MV20S, MV8S and MV3—as the names suggest they have 20 watt, 8 watt and 3 watt outputs and range in price from £30 to £14. The MV3 is designed for use in small areas such as gymnasiums.

Many other interesting items were displayed on the numerous other stands; unfortunately, we do not have room to mention more than the most interesting in this column. Almost 40 exhibitors displayed anything from records to 300 watt amplifiers within the comparatively small area of the hall.

The A.P.A.E. have made a provisional booking for exhibition space at the Bloomsbury Centre Hotel, London, for next year's exhibition. At the exhibitors' meeting of Sound '71, it was recommended to pursue this course of action in order to gain a much larger exhibition area with the opportunity of erecting demonstration rooms with air conditioning.

These rooms could be similar to those used at the Olympia Audio Fair, with adjoining display space. It was also agreed that the exhibition should be confined to three days, closing at 6 p.m. each day.

This is a friendly exhibition run by a very likeable and courteous group of p.a. engineers and we hope that it will thrive at its new venue.

# **NEWS BRIEFS**

# Qualified Manpower in the Industry

SERIOUS shortage of technicians in the electronics industry is one of the main points made in a report "Qualified Manpower in the Electronics Industry" published by the industry's Economic Development Committee. The report by the EDC's manpower working group, under Professor G. D. Simms, makes 18 recommendations for action by the EDC, industry, government, education and professional institutions.

The report stresses the need for improved awareness on the part of school-leavers of the growing potential of a career in technician engineering. The universities and the polytechnics are asked as a matter of urgency to develop combined courses in production engineering and electronics to meet a serious shortage of graduate pro-

duction engineers in the industry.

The importance of innovation in the industry is highlighted. Innovation is defined, in broad terms, from the end of the applied research stage, through development, design and production to the delivery of the first acceptable product to the customer. The rapid rate of innovation stems not simply from the continual flow of new ideas and techniques at the technical level, which lead to rapid product obsolescence, but also from the strong international competition which is a characteristic of the industry. The committee have no doubts, however, that a better use of manpower, better management, and control of projects could all make very substantial contributions to more effective innovation.

# Digital T.V. Line-store Converter

A recently demonstrated by the BBC at their Research Department, Kingswood Warren, Surrey.

Line-store converters are used by the BBC and the ITA to derive 405-line signals for their v.h.f. television transmitters from 625-line signals provided through the television distribution networks. The BBC uses some 29 of these converters which are located at main transmitter sites. As it is likely that the 405-line service will continue beyond the useful life of the converters used at present, a programme of work is being carried out by the BBC's Research and Designs Departments to provide a replacement converter with a good performance and high reliability at a reasonable cost.

Since the existing converters were designed, considerable progress has been made in the application of digital techniques to television signals and it has been decided that the new form of converter will process the television signal in digital rather than analogue form, thus providing greater reliability and operational sim-

plicity, compared with earlier converters.

# Television Projector

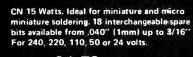
LARGE screen television projector which enables tele-A vision signals to be displayed on cinema type screens has been introduced by Top Rank Television.

With its large screen viewing, the projector—the Teledidaker-overcomes the disadvantages of grouping sections of a large audience around conventional monitors.

Moderately priced, it enables television signals to be displayed on cinema type screens up to a maximum

size of 6ft  $\times$  8ft.

The Teledidaker will accommodate signals from offair receivers, television cameras and television tape recorders. It works to very high standards of performance and is conservatively under-rated for long life and reliability. It may be easily adapted for rear pro-



from £1.70

for your miniature soldering iron.

#### SK2 Soldering kit

In polystyrene pack, containing 15 watt miniature soldering iron, 240 volts fitted with  $\frac{3}{16}$ bit, 2 spare bits  $\frac{5}{32}$ " and  $\frac{3}{32}$ ". Coil of resin-cored solder, heat sink, 1A fuse and booklet "How to Solder".



£2.40

#### SK1 SOLDERING KIT



In rigid plastic "tool box" containing Model CN - 15 watts - 240 volts miniature iron fitted  $\frac{3}{16}$ " bit. Spare bits  $\frac{5}{32}$ " and  $\frac{3}{32}$ ". Reel of resin-cored solder, heat sink, cleaning pad, stand and booklet "How to Solder

Model CN 240/2 - 15 watts - 240 volts



Fitted with nickel plated  $\frac{3}{32}$ " bit and packed in handy transparent box.



Model G · 18 watts. Fitted  $\frac{3}{32}$ " bit. Spare bits  $\frac{1}{8}$ ",  $\frac{3}{16}$ " and  $\frac{1}{4}$ " available. For 240 or 220 volts. £1.83



Model F · 40 watts. Fitted  $\frac{5}{16}$ " bit. Spare bits  $\frac{3}{2}$ ",  $\frac{1}{8}$ ",  $\frac{1}{16}$ "  $\frac{1}{4}$ " available. For 240, 220, 110, 20 volts. From £2.38

Model E  $\cdot$  20 watts. Fitted  $\frac{1}{4}$ " bit. Spare bits  $\frac{3}{32}$ ".  $\frac{8}{8}$ " and  $\frac{3}{16}$ " available. For 240, 220 or 110 volts. From £1.80 Model ES - 25 watts.  $\frac{1}{3}$  bit. Spare bits  $\frac{1}{3}$  and  $\frac{1}{4}$  available. For 240, 220 or 110

volts. From £1-83

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light source with adjustable lens assembly and ventilated lamp housing, to take MBC bulb. Separate

or similar cell. Both units are single hole fixing. Price per pair £2.75 P. & P. 18p.

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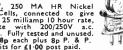
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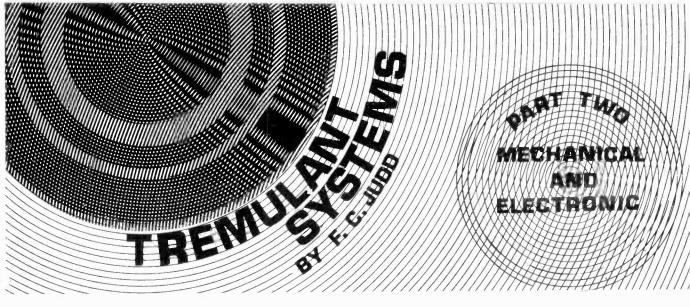
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The rotary horn speaker system described in part 1 requires an enclosure with open sides, front and top. The arrangement shown in Fig. 9 consists of a substantial base board of  $\frac{1}{2}$  inch or  $\frac{3}{4}$  inch thick wood onto which a framework made from 2 inch by  $\frac{1}{2}$  inch batten is assembled. If the framework is constructed to the dimensions given in Fig. 9 the horn and speaker unit can easily be inserted or removed as a whole, via the back of the enclosure.

**ENCLOSURE FINISH** 

When the unit is installed within the frame it must be secured to the base board and to a batten across the top of the frame. The front width of the frame is 20 inches which gives ample side clearance for the speaker unit. It is most important to put felt or foam packing between the speaker and the back panel of the cabinet; this can be seen in the photograph which also shows the completed enclosure framework.

The enclosure framework can be covered with any open weave fabric, such as Tygan although this particular material is very expensive. The hard-board back panel must be removable.

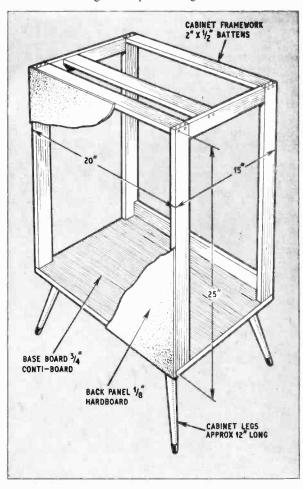
The 8 inch loudspeaker should be one of fairly high sensitivity with an impedance to match that of the amplifier to which it will be connected.

#### MATERIALS . .

For construction detailed in this part only. Batten  $2\text{in} \times \frac{1}{2}\text{in} \times 17\text{ft 6in}$ . Base board  $20\text{in} \times 15\text{in} \times \frac{3}{4}\text{in}$  (ply or chipboard) Back panel  $25\text{in} \times 20\text{in} \times \frac{1}{6}\text{in}$  (hardboard) Cabinet legs 12in long Foam or felt packing C1 and C2  $500\mu\text{F}$  elect. 12V capacitors (2 off) Tygan or similar covering Wire, screws and glue

Fig. 9. Details of the enclosure framework for the rotating horn speaker shown from the back

Remember that a tremulant system of this kind will be connected additionally to the existing speaker system which must, of course, remain in operation. It is also necessary to reduce the bass response of the tremulant speaker as the tremulant itself must be confined to the treble range of the musical instrument, e.g. the keyboard manuals of an organ or the normal range of a plectrum guitar.

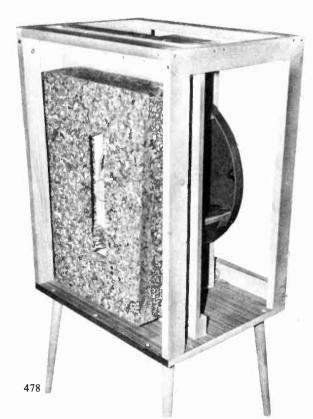


The tremulant effect produced by these systems is quite unsuitable for organ or guitar bass. speaker of the rotary unit must therefore, be connected to the main amplifier via a simple bass filter consisting of two reverse connected capacitors in series as shown in Fig. 10. This produces a quite substantial roll off in bass response but if the bass should appear too predominant or cause overloading at high volume, then one of the series capacitors may be reduced in value.

#### **ANALYSES OF ROTARY SYSTEMS**

It was mentioned in part 1 that the acoustical nature and that as far as rotating horns or deflectors loudspeaker systems was one of a very complex nature and that as far as rotating horns or deflectors are concerned, there is no pitch fluctuation due to Doppler effect. With rotating horn systems it will be realised that the sound is projected through 360 degrees in a vertical plane. Sound is, therefore, heard by the listener from many directions, i.e. directly from the system and by reflection from walls and ceiling. Thus the sound arrives at the listener either in, or out of phase, depending on the length of the path of both the direct and reflected sound. Remember that natural hearing cannot distinguish phase shift by itself. We hear only the product of phase shift caused by the difference in path length from the ears to two sources reproducing the same sound. That product is amplitude variation whereby in phase signals cause an audible increase in volume and out of phase signals a decrease.

With rotary speaker or horn systems both the fundamental notes and their harmonics therefore undergo complex amplitude changes for each revolu-



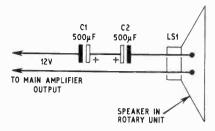
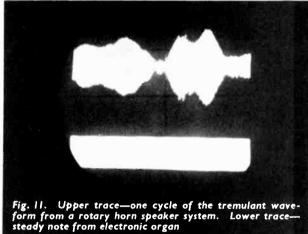


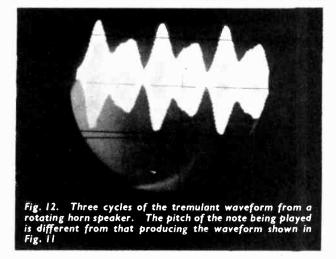
Fig. 10. The series capacitor bass filter (see text regarding adjustment)

tion of the system. It is these changes in amplitude that produce the unusual tremulant waveform which can be quite different for every note played.

The oscillogram in Fig. 11 shows a tremulant waveform from the rotary system for which constructional details have been given. The lower trace is the continuous note from an organ and the upper trace shows one complete cycle of the complex tremulant envelope. The oscillogram in Fig. 12 shows 3 cycles of the tremulant waveform obtained whilst playing a different note.

Many tests with a number of rotary speaker systems all showed the same complex tremulant





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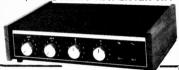
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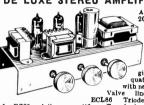
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Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7ijin w. x 4iin. d. x 4iin. b. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wonnd mains transformer and output transformer and output transformer matched for 3 ohm speaker. Separate volume control and now with improved wide range tone controls giving base and treble lift and cut. Negative feedback line. Output 44 watte. Front panel can be detached and leads extended for remote mounting of controls. Complete with knobs, valves, etc., wired and tested for only \$4.76. P. & P. 35p.

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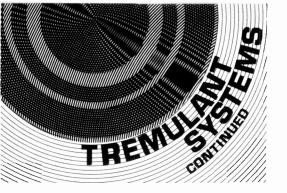
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waveforms which are effected not only by the pitch of the notes being played but also very much by the environment of the system. Nevertheless, the tremulant from rotary speaker systems is very pleasing and hence nearly all domestic electronic organs and external tone cabinets, for home and theatre type electronic organs, are fitted with them.

#### DOPPLER EFFECT

Physically rotating loudspeakers do produce a small change in pitch due to Doppler effect and experiments carried out in 1881 and again in 1927 have proved that the pitch of a sound from a source rotating on a radius of approximately 3 feet at 3 revolutions per second can be changed, because of Doppler effect, by as much as a whole musical tone. However, various tests have subsequently shown that whatever pitch fluctuation may occur with rotating organ loudspeakers, it is masked almost completely by the greater amplitude variations which occur in both the fundamentals and their harmonics.

The amplitude variations of the fundamentals may be as much as 20dB and a large increase in the volume of sound can cause a listener to hear an apparent change in pitch.

#### **ELECTRONIC SIMULATION**

Since the tremulant produced by rotary speaker systems is predominantly one of amplitude variation of both the fundamental notes being played and their harmonics, it might appear relatively easy to produce the effect electronically with fairly simple circuitry. It must be remembered however, that the overall effect is a complex acoustical one, in which

ROTATING POLARIOD DISC PAXOLIN MOUNTING APPROX 2"DIA. PLATE POLARIOD WINDOW 12V D.C. nd on more LDR1 LAMP HOUSING (LAMPS 12V 0-3A) 1001 TO CONTROL CIRCUIT 12V D.C. LDR2 1841111 D.C. DRIVE MOTOR (VARIABLE SPEED) POLARIOD WINDOWA

phase shift, the reflection of sound and natural hearing play a great part. The aural effect might also be described as a spatial one, not unlike that of stereophonic reproduction from two loudspeakers, which also relies upon phasing. Thus, the tremulant from a rotating speaker or horn system cannot be exactly simulated via a single static loudspeaker.

Electronically produced amplitude variation of both the fundamental tones and their harmonics is not difficult to produce, but first a tremulant waveform generator is required that will not introduce a thumping noise due to its own harmonics. Direct voltage control from a low frequency sinewave oscillator is therefore undesirable.

In part 1 a block diagram was given illustrating the use of a light dependent resistor (l.d.r.), which, under control from a fluctuating light source provides a rapidly varying resistance with a range of approximately 100 ohms to 100 kilohms or higher, depending on the rate at which variation is required. L.D.R.'s are commonly used in audio equipment as light operated volume controls and all that is required to producing a tremulant control voltage is a means of actuating one or more l.d.r.'s sinusoidally at between 5 and 10Hz.

#### POLAROID VARIATION

One method that will sinusoidally actuate one or more l.d.r.'s simultaneously is shown in Fig. 13. Here two steady light sources are employed which are sinusoidally interrupted by means of a rotating disc of Polaroid. Each lamp shines through a small Polaroid window mounted on the lamp housing and then through the rotating Polaroid onto the l.d.r. As the Polaroid disc rotates the light on the l.d.r. varies from zero to maximum perfectly sinusoidally and as a consequence the resistance of the l.d.r. will also vary sinusoidally.

The system can be used in various ways—two l.d.r.'s could be used to control an amplifier gain and its frequency response simultaneously or to produce a rapid "panning" effect between two stereo channels. Either of these applications might well provide a new sound effect for pop groups! By rotating the Polaroid windows in front of the l.d.r.'s the phase relationship between the outputs may be varied.

#### **ELECTRONIC TREMULANT**

ROTATION SPEED 2 TO 10 REVS PER SEC.

An extension of the idea mentioned above but without the rotating Polaroid and electric motor can be used to produce a tremulant effect akin to that

Fig. 13. An optical/mechanical system for producing sinusoidal resistance variation in one or more light dependent resistors produced by a rotary horn or speaker system. A practical circuit is given in Fig. 14, which could be modified in various ways to produce different kinds of tremulant effect. As it stands it can be connected between an electronic organ (from the keyboard output) and the main amplifier or between an electric guitar and its amplifier. However, it must be emphasised that the circuit is an experimental one that may require modification to match up with other equipment. Also an oscilloscope and a square-wave generator covering the audio range are necessary for checking the harmonic filter circuits and the performance of the circuit generally.

#### CIRCUIT OPERATION-PRE-AMPLIFIER

The pre-amplifier (TR1 and TR2) has an input impedance of around 100 kilohms and a sensitivity of approximately 50 millivolts with VR2 at minimum resistance. With VR2 all in circuit the gain of the pre-amplifier is much lower but the input signal can then be as high as 300 millivolts. With VR2 set at about half resistance, the input sensitivity will be around 100 millivolts. This setting will ensure maximum treble lift from the tone control VR3. The input volume control VR1 can be used to attenuate an otherwise too high input signal.

The output across R27, with the tremulant circuit switched off, will be approximately 500 millivolts. The average output shown on a valve voltmeter with the tremulant running, will be about 300 millivolts, but remember that the peaks of the tremulant waveform may allow the signal amplitude to rise as high as 1 volt (r.m.s.).

The output signal from the pre-amplifier, at the collector of TR2, is fed through a filter network and

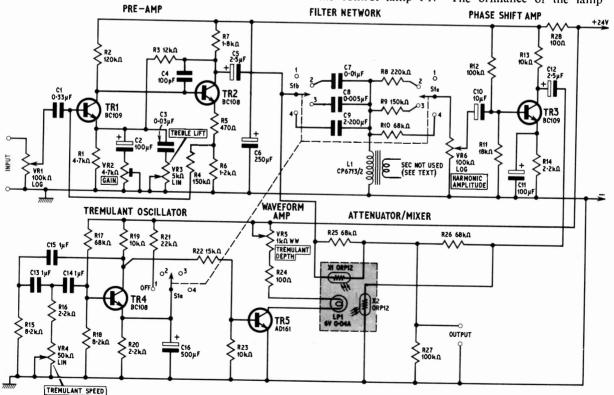
thence to the input of the phase shift amplifier TR3. It is also taken to the attenuator/mixing network comprised of R25, X1 and R27. When the tremulent oscillator TR4 is operating the control lamp actuates X1 and produces the requisite amplitude variation of the fundamental together with its harmonics.

#### **HARMONICS**

With the tremulant circuit in operation—\$1 at positions 2, 3 or 4—the input signal is also fed into the filter circuit. Here the harmonic structure is considerably altered by new harmonics being added and by some being removed. The resultant signal is passed into the phase shift amplifier TR3, and from there to the attenuator/mixing network R26, X2 and R27 where the harmonics may be either in or out of phase with those of the original signal.

The function of the whole unit is such that the harmonics present in the fundamental are made to vary completely at random much as they are with a rotary speaker system. As the two l.d.r.'s are opposed in circuit the amplitude of the fundamental and its original harmonics will be varying in opposition to the signals from the filter and phase shift amplifier circuit; when one is increasing the other will be decreasing. The resultant tremulant waveform is therefore, a complex, similar to that from a rotary system but lacking the aurally spatial effect.

The tremulant oscillator TR4 produces a sinewave which can be varied from about 2 to 8Hz by means of VR4 (tremulant speed). The signal from this is used to drive a small power transistor VR5, the collector of which is taken to the positive line via the control lamp P1. The brilliance of the lamp



is controlled by VR5 which determines the depth of the tremulant.

#### FILTER CIRCUIT

The function of the filter circuit is such that the three positions of S1 allow some variation in the range of harmonics passed by the phase shift amplifier and it is important that this part of the circuit is checked with an oscilloscope and a square-wave signal generator. First a square-wave of between 300 and 400Hz of suitable amplitude is fed to the pre-amplifier input. The control lamp must be disconnected or removed so that it does not light and the treble control turned off. Connect the oscilloscope to C5 negative, the waveform at this point should be an almost uniform square-wave. transfer the oscilloscope to C12 negative. The waveforms for position 2, 3 and 4 of S1 should be as shown in Fig. 15. Variation of the valves of capacitors C7, C8 or C9 will alter the shape of these curves.

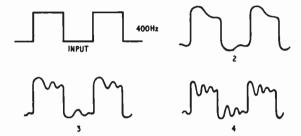


Fig. 15. The waveforms produced by the filter circuit in Fig. 14 for positions 2, 3 and 4 of S1. The numbers under each waveform refer to the switch position

Failure to produce the correct waveform can be due to both capacitor and inductor values; L1 is the primary of a small transformer type CP6713/2 sold by Henrys Radio Limited. This has a d.c. resistance of approximately 500 ohms and therefore, a fairly high a.c. impedance. The 100 kilohm potentiometer VR6 marked "harmonic amplitude" should be set near maximum for all the above tests.

#### SETTING UP

In use the input volume control VR1 should be adjusted according to the input level to avoid overloading the pre-amplifier and the main amplifier, to which the tremulant unit is connected. The harmonic amplitude control VR6 should be used discreetly, for if this is turned too high it can introduce distortion. If the control lamp appears to be over brilliant when the tremulant depth control VR5 is set for maximum depth, then the series resistor R24 (100 ohms) should be increased in value.

The prototype unit was found to be very effective with an electric guitar, the unit producing a pleasing and completely noise free tremulant quite unlike the usual crude, so called, vibrato systems incorporated in guitar amplifiers. With an electronic organ care must be taken to avoid overloading the input circuit and the use of too much harmonic amplitude. Excessive tremulant depth can also introduce distortion or spoil the original voicing of the organ.

Although the electronic unit provides a tremulant which is similar, it cannot exactly simulate that from a rotating horn or speaker system.



#### • THE PIPSQUEAK

A miniature paint pin-hole detector. Invaluable tool for those concerned with the maintenance and preservation of vulnerable metalwork.

#### VOLTAGE STABILISER

This design is self-powered and will provide a stabilised output from 0 to 30 volts at up to 250mA from a suitable d.c. supply. Automatic current limiting and constant current features are included.

## \*\*BEGINNERS' PROJECT

Another interesting, useful, yet inexpensive T-Dec project for the newcomer to electronics. Full constructional details, together with a circuit description, will be given.

This month's article in the P.E. AURORA Series describes some practical arrangements for light displays.



**ON SALE JUNE 18** 

## 

## KERE!

An animal approximation utilising integrated circuits to process optical and tactile sensing together with a random control to give reasonably lifelike responses

THERE has been a considerable amount of correspondence relating to "electronic animals" following the earlier series on Bionics and the articles about EMMA last year. Readers' letters, in the main, have emphasised the need for less expensive drive systems in these "animals" and, among other things, pointed to the shortcomings of the noise cell arrangement used in EMMA.

Unlike the earlier models, XEE employs integrated-circuitry for all its control logic, using discrete components only where it is more simple and cheaper to do so. Further differences include the embodiment of relays in the muscle control circuitry, rather than transistors which only afford a modicum of isolation between logic and drive systems, and which, because of their relatively high  $V_{ce}$  lose volts that could be usefully driving motors.

Related to EMMA, XEE is mechanically a sort of "middi" version; indeed, this new animal represents just the beginning of others which, physically, will tend towards the "mini". We will examine the anatomy of this latest "bug" which, not inappropriately, got its name from a computer that had been programmed to generate random letter and word sequences.

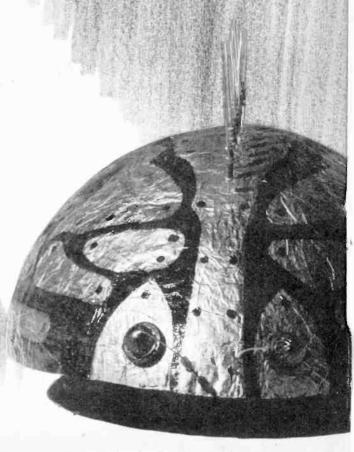
#### SYSTEM CONCEPT

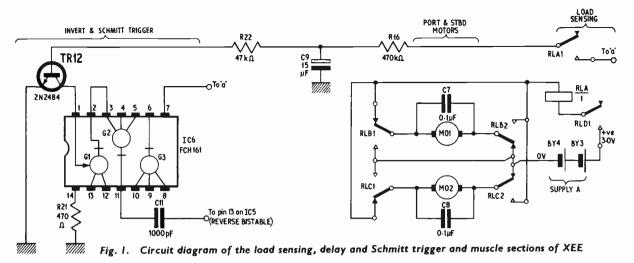
Basically, XEE has two senses; one, an electrooptical sense provided by a pair of photo-sensitive resistors; and the other, a load monitoring arrangement associated with the muscle control circuitry. How XEE ultimately decides to respond as a result of inputs to these senses is determined by a subsystem employing a clock and random verses.

system employing a clock and random generator.

Several degrees of freedom are provided permitting turning to the right, turning to the left, driving forward, driving in reverse, and stopping. These functions, over which there is a fair amount of random control, thus provide XEE with a reasonably lifelike repertoire of responses. The response to optical inputs is additionally in part controlled by a random function, but more about this later on.

By G. Brown





#### CIRCUIT DESCRIPTION-LOAD SENSING

The circuit description will have as a basis only those areas which involve either totally, or in part, discrete components. This will be so since it is the function of the i.c.s that we will be concerned with rather than their internal circuitry. As a consequence, once the "loose ends" have been tied together, we shall consider in detail the system in an entirely logical form.

In order that XEE can sense both direct loads applied to its "body" and be aware of the presence of objects in its path, some means of tactile sensing is necessary. An extremely positive response can be obtained using a "feeler" and microswitch arrangement, but this scheme has the unfortunate disadvantage that the probe, or whatever, is all too easily snapped off!

A better idea, albeit one which displays a somewhat intractable sensitivity, is motor current sensing. No extra "appendages" are required when the latter set-up is embodied, but it does mean the need for a little more electronics.

The sensor itself is the humble reed-switch. Around its circumference are wrapped a few turns of relatively heavy-gauge wire which serve as the operating coil and pass the total motor current.

If, during operation of XEE, some maximum current level is exceeded, the reed switch will close to indicate that the motor load has increased. The switch is shown as RLA in Fig. 1 and its construction will be discussed later in the article.



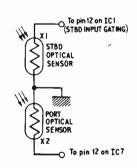


Fig. 2. Connection of the two l.d.r.'s to the logic circuitry

#### **DELAY AND SCHMITT TRIGGER**

Although the load sensing system works well, it might almost be said that it works too well because whenever there is a rise in current, as when the motors change direction (stall current), the reed switch operates. We thus require some way of permitting the load sense to differentiate between transient loads and continuous loads. This can be met quite simply by way of a time-constant circuit (R16/C9) included after the reed switch, providing just long enough a delay to determine a real load. If such a load is present the switch will be closed for a longer time and hence C9 will receive a greater charge. This capacitor is connected across the input of a buffer amplifier controlling a Schmitt trigger. The latter switches whenever the input voltage to the buffer rises above about 0.6 volts. At such times the output of the Schmitt will go towards earth, the required condition for triggering the reversing bistable—mentioned in the section under logical operation.

The Schmitt is formed by coupling a pair of gates within a Mullard FCH161 integrated circuit and connecting a 470 ohm resistor (R21) in the negative supply lead. Since the FCH161 is a "triple-gate," this treatment does have the disadvantage that one of the gates will remain unused. The gates also have a very low input impedance which means that in order to get a delay with the sort of time-constant required, the capacitor used has either got to be very large, or a buffer must separate the delay from the Schmitt. As we have seen, XEE employs a buffer.

#### **OPTICAL SENSE**

XEE has a bilateral optical system; one starboard and one port sensor. The sensors, which are light dependent resistors (l.d.r.'s), are each connected to their respective logical invertors which serve both to amplify and establish the correct logic levels into the remainder of the system (Fig. 2).

#### **NOISE SOURCE**

In an earlier article, randomness was generated by the use of an electrochemical noise cell; this, as I feel sure many readers will appreciate, proved to be a very unreliable source of noise after it had been in service for only a short time. It was therefore imperative that some other scheme be adopted;

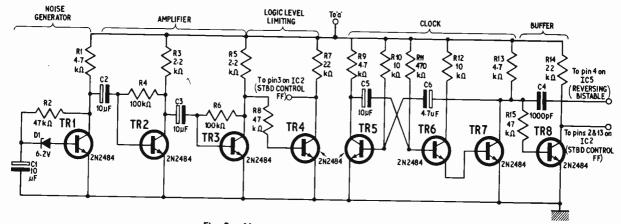


Fig. 3. Noise generator and clock circuitry

the result is shown in Fig. 3. Here, a Zener diode has been enlisted to generate the required noise.

Zener diodes are inherently noisy, particularly when run at very low currents, and it is this characteristic that is exploited here. The amplitude of the noise current, however, is fairly small and so requires some amplification. This is provided by transistors TR1, TR2 and TR3. The resultant noise spikes appearing at the collector of TR3 are taken to a further stage, TR4, which ensures that they are limited, both top and bottom, to levels required by the logic which they will be driving. Thus the spikes will either be there, or not be there; a logical 1 or a 0 is thus made available.

The noise pulses, although having quite a random time relationship, cannot be employed directly because their occurrence rate is far too high, typically  $2 \times 10^3$  to  $5 \times 10^4$  pulses per second. Their further processing is described in the functioning of the system logic.

#### **CLOCK**

Certain areas of the system logic are controlled by a clock or astable. Strictly, this is not performing a true clock function, but it is convenient to refer to it as such, since a number of actions occur which must either have given durations, or which must be initiated at particular times.

The clock, Fig. 3, is, in essence, a kind of "heart-beat" for XEE and comprises a slow-running astable. This circuit is highly asymmetrical; that is to say its output waveform has a large mark to space ratio.

The reason for this is that one of the time periods (the random mode) is comparatively short, about 20ms, while another (the action mode) occupies a period of a little greater than one second. The circuit employs TR5, TR6 and TR7.

Transistor TR6 forms a super-alpha pair with TR7 and permits large time constants to be achieved without the need for large capacitors. In this way TR7 can effectively tolerate quite a sizeable base resistor whilst in no way jeopardising the long time requirement. A further buffer stage has been added after the clock to prevent it being overloaded. This is formed by TR8.

#### **MUSCLE CONTROL**

Control over XEE's motors, or "muscles", is under the direction of three transistor-controlled relays; these are RLB, RLC, and RLD shown in Fig. 4. The relays employed here, in fact, decided the choice of supply voltage, which, although a trifle on the high side, was considered justified in view of the relatively low price of the relays (available on ex-computer circuit boards).

Each relay is connected as the collector load of its associated transistor and incorporates a parallel, reverse-connected diode to minimise the chances of back e.m.f. damaging the transistor. In the energised state, RLD1 contacts ensure that the supply is fed to the motors. At these times, if relays RLB and RLC are not energised, their contacts connect both the motors to run forward. It will be noticed that double pole changeover contacts are employed on

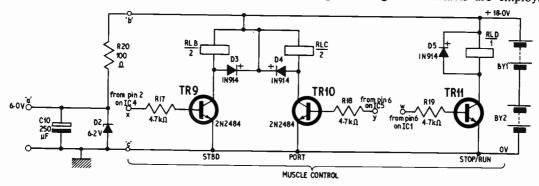


Fig. 4. Muscle control and power supply stabilisation circuitry



#### COMPONENTS . . .

Resi	stors
RI	4.7

RI 4·7kΩ	R12	l0kΩ
R2 $47k\Omega$	R13	4·7kΩ
R3 2·2kΩ	RI4	22kΩ
R4 100kΩ	R15	47kΩ
R5 2·2kΩ	R16	470kΩ
R6 100kΩ	R17	4·7kΩ
R7 $22k\Omega$	R18	4·7kΩ
R8 $47k\Omega$	R19	4·7kΩ
R9 4·7kΩ	R20	$100\Omega 5W + 10\% \text{ w.w.}$
R10 10kΩ	R2I	470Ω
RII 470kΩ	R22	47kΩ
All 16W, ±10% ex	cept wh	ere stated

Capacitors

CI  $10\mu$ F elect. 10VC2  $10\mu$ F elect. 10V

C3  $10\mu\text{F}$  elect. 10V

C4 1,000pF

C5 10µF elect. 10V

C6  $4.7\mu$ F elect. 10V

C7 0·1μF

C8 0·μ1F

 $15\mu$ F elect. 10VC9 CIO 250µF elect. IOV

CII 1,000pF

#### Diodes

DI 6.2V Zener SZ62A or OAZ202

D2 6.2V Zener SZ62A or OAZ202

D3 IN914

D4 IN914

D5 IN914

#### Transistors

TRI to TRI2 2N2484 (12 off)

RLA see text

RLB to RLD Claire, 700 ohm, DPDT (ex-computer type—3 off)

#### Motors

MOI and MO2 Johnson 150 Type, available from Ripmax Ltd (2 off)

#### Integrated Circuits

ICI, 4-7 FCH161 Mullard (5 off) IC2, 3 FCJ101 Mullard (2 off)

#### Miscellaneous

XI and X2 5SP5, or ORPI2 (2 off)

BYI and BY2 PP6 (2 off) BY3 and BY4 HPII (2 off)

Veroboard  $2\frac{1}{2}$ in  $\times$   $4\frac{7}{8}$ in  $\times$  0·lin matrix Veroboard  $\frac{3}{4}$ in  $\times$   $\frac{3}{4}$ in  $\times$  0·lin matrix (2 off)

#### **Hardware**

26 s.w.g. d.c.c. wire for RLA Brass rod, two lengths of 32 in diameter Gear pinions, 10 tooth, Ripmax Ltd (2 off) Gear pinions, 30 tooth, Ripmax Ltd (2 off) Worm and wormwheel, Ripmax Ltd (2 off) Plastic tubing, approx.  $\frac{3}{32}$ in internal diam Aircraft wheels, I in, rubber tyred, Ripmax Ltd Aluminium sheet, see text 4B.A. and 6B.A. screws, nuts and washers.

the relays to obviate the need for a larger, centretapped, battery supply.

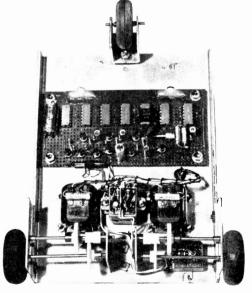
If either RLB or RLC only are energised, the starboard or port motors respectively will be caused to reverse, thus allowing XEE to turn right or left. When the relays are energised together, the model reverses. The remaining relay RLD provides a stop function only when de-energised. In this mode the system logic is arranged to inhibit any existing inputs to TR9 or TR10, thus RLB and RLC are de-energised and so unnecessary current drain, due to the relays, is avoided.

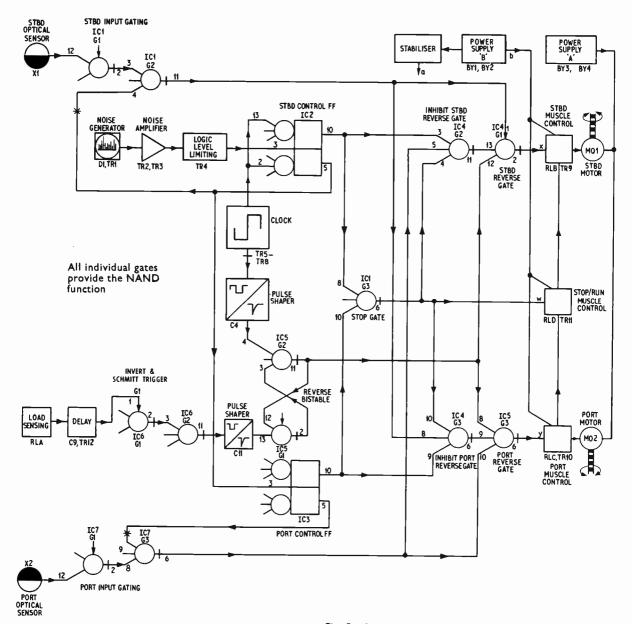
Both motors are of the fairly inexpensive Japanese variety and each has a nominal stall current of 450mA. Under running conditions the current drawn is in the region of 700mA for the pair. Since the motors are run from a separate power supply to the rest of the circuit, most of the electrical noise is isolated to the motor circuit and hence has little chance to interfere elsewhere. However, to prevent any trouble from radiated noise affecting i.c.s which, incidentally, are easily triggered in this way, each motor is equipped with its own suppression capacitor (C7 and C8).

#### **POWER SUPPLIES**

Quite a number of factors helped to govern the ultimate choice of power supplies; indeed, the final outcome is more compromise than choice! Since, economically, the model's cost must be kept as low as possible, such luxuries as expensive gear-boxes and small-current motors cannot be permitted. And yet the motors used must be capable of developing sufficient drive-torque to carry an all-up weight of approximately 1lb 10oz for, at least, long enough to allow satisfactory observation of the animal's characteristics. The batteries employed give fairly tolerable operation for about 20 minutes of intermittent use.

Motor supplies are provided by a pair of seriesconnected HP11 type batteries, while the electronics derive their various needs from two series-connected PP6 batteries. The respective voltages available from this set-up are 3.0V and 18.0V. The latter supplies the muscle control circuitry direct, but is taken to a suitable level (nominally 6.0V) for operation of the





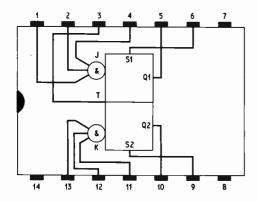


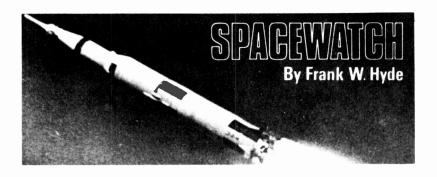
Fig. 5. Logic diagram of XEE. This shows the complete system and indicates the positions of the various gates and i.c.s. Also shown are the JK flip-flop connections for the FCJ101 i.c.s.

i.c.s and remaining electronics. This last supply is maintained by the Zener diode, D2, and its attendant components, R20 and C10.

#### LOGIC OPERATION

For an overall understanding of the system logic, the reader is referred to Fig. 5. From this it will be noticed that the sensory and control sub-systems have a hierarchy which is ordered effectively from the load-sensing, which takes priority over all except the clock. The random function is the next down the list of priorities, and finally, at the bottom of the list comes the optical sense.

Next month: logic system explanation and constructional details



#### **TOPSIDE SOUNDINGS**

Space scientists from the Soviet Union have entered the field of "Topside Sounding" of the ionosphere. The Canadians were the pioneers in this field during the years 1962, 1965 and 1969. They used the *Alouette* and *Isis* satellites for this work.

The Russian satellite, Cosmos 381, is in a near circular orbit some 625 miles above the earth. The ionosonde techniques are employed at frequencies between 2.0MHz and

13·4MHz.

Signals are bounced off the outer layers of the ionosphere by sweeping the transmission between the two frequencies. The reflections provide data about the density and distribution of the electrons in the medium and the manner in which these factors vary.

The majority of this work has in the past been done from ground based stations and apart from the Canadian groups the technique of topside sounding has not been very widely applied. The entry of the Russians into this area of observations is another point of co-opera-

tion in research.

#### MONITORING PLATFORMS

The Explorer-43 spacecraft is in the class of Explorers called interplanetary monitoring platforms. They are characterised by the fact that they operate in extremely elliptical orbits from close to the earth at perigee and halfway to the moon at apogee.

Launched on March 13, 1971, the Explorer-43 moves in a path from 244km at perigee to 206.049km at apogee. Each orbit takes four days and the path traced out will provide a cross section of space weather

activity.

Twelve sets of instruments are carried and these have been devised by seven universities and three government departments. The particular combination of sensors that are being flown in this spacecraft has not been used in such a path on a single spacecraft. The sensors will correlate the behaviour of space radiation, solar radiation, magnetic fields, and electric fields.

#### STAR PROBE

The target for a concentrated attack from observational astronomers has been the object known as Sco X-1. Over some ten years now the study of this peculiar object has yielded data over a wide spectrum. This detailed survey has extended from radio frequencies, infra-red, and optical. To this are added soft and hard X-ray frequencies.

There does not appear to be correlation between the radio and optical observations, in regard to the variation of intensity. In the last search no optical flares appeared and this may be because the object is slowly decreasing in intensity optically, though it continues to be active in the radio region. This lack of correlation between optical and radio measurements suggest that the radio envelope is large compared with the central source and is energised only directly by the X-ray source.

The latest picture that emerges is that of a small dense star in a low density gas which contains many energetic electrons. It has already been established that the falling of this low density gas on to the star can produce energetic

X-rays.

#### NEW DISCOVERY

Much work has been done over the years by astronomers on the evolution of ordinary stars. When something different from the usual appears there is a tendency to dismiss the matter by saying that it is a peculiar object. However, when this happens to what is otherwise a perfectly ordinary star, the matter cannot be so easily dismissed.

Such is the case with the "White Dwarf" star R548. This star has been found to behave somewhat out of character, for it has a periodic variation over a period of some 200 seconds. This new feature was discovered by B. Lasker and J. Hessor of the Chilean observatory at Cerro Tololo.

It was thought by astronomers that the "White Dwarfs" were well understood and previous theories have predicted that any pulsations that might occur would be of the

order of once in twenty seconds and could be discounted. The new discovery which shows a rate ten times longer than the predictions may have Pulsar characteristics.

A new name will have to be found, for the term Pulsar is now generally accepted as applying to rotating neutron stars. No doubt there will be a concentration of observations to discover if there are more of these objects.

#### **MOON GAS**

Results from the instruments left behind on the Moon by the astronauts indicate that the Moon is far from being dead. Escaping gas has been detected and this may be the cause of moonquakes, or the cracks resulting from moonquakes may allow the gas to escape.

The latest findings come from the instruments left in the Fra Mauro area by astronauts Shepard and Mitchell. The instruments involved are part of the nuclear powered unit in which is included a seismometer and a "cold-cathode" ion

gauge.

A burst of gas which occurred on February 22 was thought, by mission control at Houston, Texas, to have been gas escaping from the landing stage of Antares, the part of the lunar module that was left behind by Apollo 14. This had to be dismissed as the cause, because about 14 hours after the first event another burst of gas was detected. This gas did not disperse for some nine hours.

At the time the second burst was recorded the seismometer nearby showed a moonquake. The gas clouds seem to be directly related to the seismic activity, and it has been noted that the events increase in frequency and intensity every time the Moon makes its closest approach to the Earth. The Earth/Moon system does in fact move in a rather special way; it revolves round what is know as the barycentre, which is about a thousand miles below the Earth's surface.

The result of this interaction of the two masses raises strains in both the Earth and the Moon, and the gravitational stresses set up on the Moon would seem to be the cause of the opening up of the surface of the Moon, allowing the gas to escape. On the other hand, the moonquakes may be the result of the force of the gas escaping.

In order to check this the space centre has asked all observers of the Moon to keep watch in future for signs of a blue glow or any flashes of light. In particular, they were asked to check their records to see if any event was noted at 16.38 GMT on February 22.

There have in the past, long before spaceflights, been many reports by amateurs of seeing such phenomena.

### ELECTRONORAMA

#### VISITS THE ELECTRIC THEATRE

A LL THE world is a stage and the players are merely the people thereon. But the stage setting or scenery can be altered by the players, hence the environment is created. The player in the "Electric Theatre", an exhibition of contemporary creativity at the Institute of Contemporary Arts, was the visitor, but the stage was already set for him.

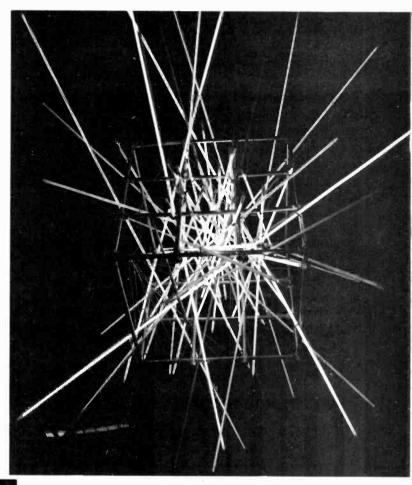
The environment was sub-divided on two levels to avoid inter-action between the exhibition pieces. The lighting was subdued but sensibly harnessed. Any player with a fear for the unknown was lured into a sense of tranquillity, often directly related to his own actions.

Of course, in a production such as this there are no words, but prompters appear

in the form of description cards made available to any player. In some acts sound effects are provided, some of which cannot be described, but they do add to the mysti-

cism of the particular settings.

Electronics played an important role in this venture; without it the effect would have been as of a graveyard in moonlight. The most creditable part of the exhibition was not so much any one particular setting. but in the co-ordination and continuity of all the items into a two-tier production. The visitor on completion of his tour, is brought gradually back to reality through the materialistic, but indispensable cup of tea (or coffee) in the integrated indoor "tea garden", with his environment still influenced by the distant sounds and lights.





#### **Electronic Switching**

Creations of lighting effects must be supported by physical structures, some of which were extremely ingenious, others open to perhaps a better interpretation of the idea. Gerry Duff's illuminated opal plastic boxes was a good demonstration of electronic switching at preselected speeds selecting any combination of four colours. The visitor is in full control with a bank of switches bringing in electronic digital circuits. But the method of displaying the lighting could have been more subtle. The plastic boxes were immediately present in a similarly random, but confused arrangement—see photograph left.

The "living room" made use of a geo-

The "living room" made use of a geometric structure based on an equilateral triangle. In each of six corners is a small loudspeaker, emitting what seemed like garbled whispering. The sound increases discreetly as the activity of several persons within the area increases. Electronic feedback arrangements control the sound.

#### Photo-sensitive Shapes

"Soft-boiled egg" is the name of the suspended creation by Roger Dainton involving a tubular steel framework with coloured neon tubes. The apparent movement of coloured light is achieved when the visitor interferes with a photo-electric light beam. A fascinating piece this, but why such a description—see photograph left. "Super Shadow", by Bruce Lacey, is a

"Super Shadow", by Bruce Lacey, is a clever gimmick which amuses all ages. Here the visitor is being mocked and imitated by a wall of cadmium sulphide photocells which pick up his shadow and cast it aside in lights adjacent to him. The photocells correspond in position to the lights so that the shadow is "reversed" into intense light.

This is bound to make the self-conscious beat a retreat into the adjacent room, where the strains of a Mozart symphony are accompanied by and used to drive our own "P.E. Aurora", commissioned from and created by Mike Leonard. The electronic matrix switching array, designed by Mike Hughes, acted as a useful back-up when mirrored in the walls. The music may seem to be out of context to some, being some 200 years old, but strangely blended to provide a soothing background.

#### Stereo "Synthi"

In stark contrast, the back projected light mural (top right) also created by Mike Leonard was accompanied by ultra modern electronic music, pulsating in rhythm and growing in strength, emanating from a stereo tape recording. In character with the setting the sounds, created on the "Synthi VCS3" from Electronic Music Studios (London) Ltd., gave an impression of spaciousness, remote from the down to earth activities outside. An eight minute programme of sound and coloured light was programmed continuously by an electric timer.

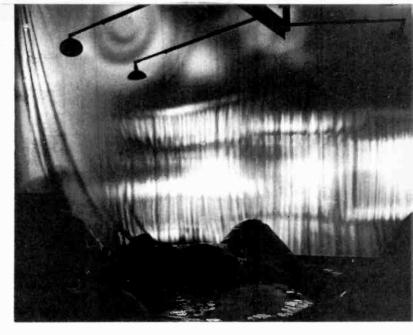
#### The Gallery

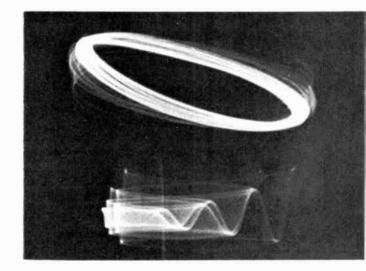
The "Dreamscreen" (bottom right), a form of which is now commercially available, is a large box about 6ft by 4ft by 1ft containing individually styled light reflector heads, which rotate as the lights are turned on at each side. Wispy patterns of changing colour appear at the centre of the screen, while music is fed to thyristor lamp controllers, varying the intensity of light projected. The display can be altered in basic character by operating "colour" and "shape" switches.

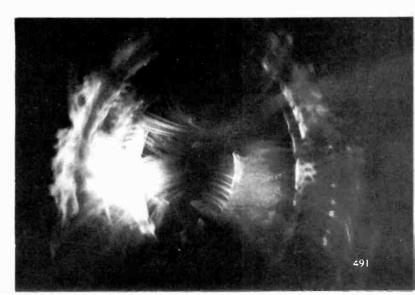
Lasers must be the most exciting source of light display recently developed. By modulating the laser, the projected beam can be made to move and produce simple patterns. This was illustrated by a contact board, made from printed circuit board, etched so that contact between the main horizontal "string" on the contacts changed the pitch of the tone fed to the laser, so changing the pattern (centre right).

The organisers of "Electric Theatre" must

The organisers of "Electric Theatre" must be complimented for attempting such an exhibition of viewer participation. Let us hope that they may do something like it again sometime and tidy up some of the regrettable gaps in the gallery.







# AUDIO TRENDS By F. C. JUDD

The first "Sonex" audio exhibition last year at the Skyway Hotel, near London Heathrow airport, which was sponsored by the Federation of British Audio, attracted some 6,000 visitors from the trade and more than 40,000 members of the public and was considered highly successful.

On the strength of this a second exhibition, "Sonex 71", was recently held at the same venue and attracted an even greater number of visitors to see and hear the performance of audio equipment by an even greater number of exhibitors. This year the exhibition occupied nearly 150 rooms on three floors of the hotel.

An hotel room is, as the exhibition organisers put it, "a boon very much appreciated by visitors to an exhibition of sound equipment". What they presumably mean is that visitors can listen to hi fi equipment operating in an acoustic environment closely resembling that of their own living room.

Perhaps they should have added—"providing the demonstrators keep the doors closed and the volume controls turned down"!

#### **CASSETTE SYSTEMS**

However, those who were able to enjoy demonstrations of the latest in hi fi, with the door closed, were no doubt intrigued by the considerable advancement in the use of tape cassette (or cartridge) systems as a hi fi signal source, the increasing popularity of multiple channel stereo systems, and the integration of noise reduction systems (originating at the Dolby Laboratories) with tape record/replay units now being marketed by various prominent audio manufacturers.

One manufacturer, Bell and Howell, makes the claim that their design 1700 tape cassette unit with a built-in Dolby noise reduction system, has a performance equal to that obtainable from an LP disc record and transcription unit. They even go so far as to question the future of the gramophone record.

The Design 1700 will record with the noise reduction system in use, as well as replay pre-recorded conventional music tapes. The unit is expensive, however, at £106.50 (including purchase tax) and it still requires a hi fi amplifier and speakers for reproduction.

The Wharfedale Dolby DC9 cassette deck also incorporates the Dolby system and will record with noise reduction, or play conventional music tapes that have not been treated for noise. Like other units of its kind it has inputs for microphone and line signal sources such as a radio tuner and takes standard BASF C90 tape cassettes. Recording or replay is quarter-track mono or stereo.

Two of the greatest aids (apart from the Dolby noise reduction system) to achieving hi fi performance from the DC9 tape cassette units is the use of 1 micron head gaps and specially designed tape drive mechanisms, which have enabled wow and flutter to be reduced to better than 0.2% at 7% in/second. The Wharfedale Dolby DC9 unit retails at £115 including purchase tax, but requires an amplifier and speaker system for full replay.

SEEN
AT
SONEX-71
AUDIO
EXHIBITION



Dolby system incorporated in the Bell & Howell type 1700



JVC Nivico MCA V7E four channel stereo amplifier

#### **COMPLETE RECORDER**

The only British made complete tape recorder on show at Sonex 71, and a fairly new one at that, was the Brenell Mark 6 stereo unit. It retails at £190.85 and features the new Brenell three motor tape deck

with four operating speeds.

The Mark 6 has A-B switching for on- or off-tape monitoring, completely separate stereo record and replay channels, twin VU meters and mixing facilities. The recorder is available for quarter or half-track recording and has an electrical and mechanical performance bordering that expected for professional studio use. The Brenell Mk 6 deck is also available separately with or without tape heads for those who like adding their own electronic equipment.

#### **FOUR CHANNEL STEREO**

Now that one can completely surround oneself with sound from a two channel or four channel signal source, it is inevitable that Japanese equipment, such as the Nivico MCA-V7E amplifier would appear. This amplifier has four separate channels, four VU meters and four loudspeaker outputs each capable of providing 50 watts r.m.s. to an 8 ohm loudspeaker.

The amplifier has been designed for signals from four channel pre-recorded stereo tapes and discs and, if the BBC ever get around to it, 4-channel f.m. radio. It features SFC (sound field composer) the function of which the sales leaflet does not make very clear, but with "all systems go" claims to create the acoustic atmosphere of the concert hall in your own living room. This is providing, of course, it is large enough to accommodate the amplifier, four separate loudspeakers and a four-channel tape recorder.

The Nevico Model MCA V7E amplifier brochure can be obtained from Denham and Morley (Overseas) Ltd., Denmore House, 453 Caledonian Road, London, N.7.

#### "SURROUND STEREO"

Among the Akai products handled by Rank was their new "surround stereo" simultaneous four-track tape recorder—yes four separately useable tracks!

The recorder is designed for operating convenience with vertical tape deck and control panel. Each channel has its own VU meter. Two erase heads are fitted, one two-channel and one full tape width, providing compatibility with two-channel stereo machines. The channels are designated front and rear, left and right, for easy identification. Nominal tape speeds are  $7\frac{1}{2}$  and  $3\frac{3}{4}$  in/second at better than 0·15%. Four line output jacks are provided and two headphone jacks. Inputs are available for microphones (0·4mV) and 40mV line.

The recorder is distributed by Rank Audio Products, P.O. Box 70, Great West Road, Brentford, Middlesex. The Akai "surround stereo" recorder model 1730 SS has been designed for operation with their AA 6100 "surround stereo" amplifier, but can be used for conventional mono or two-track stereo

recording and playback.

Another four-channel stereo tape system is the Sansui-QS1, which actually has a knob with a position marked "concert hall". The makers call their system a "quadphonic synthesiser" in which the electronics have been designed to simulate all kinds of acoustic listening conditions from normal two-channel stereo to surround sound. The QS1 is a self-contained unit but requires the addition of two stereo amplifiers and four loudspeakers.

Altogether expensive if you want synthesised sound distribution as well as high quality. Full technical details and prices of matching amplifiers, loudspeakers and tape recorders to use with it are available from Vernitron Limited, Thornhill,

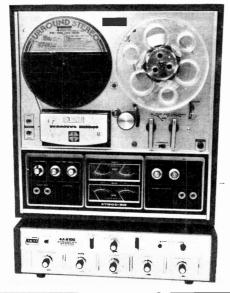
Southampton SO9 5QF.

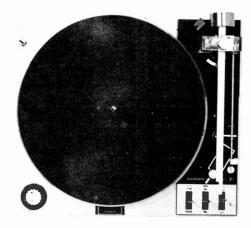
#### PARALLEL ARM PICK-UP UNIT

A new transcription unit, the Garrard "Zero-100" made its debut at Sonex although it will not be on sale in the U.K. until September. The "zero" means zero tracking error due to a new pick-up arm incorporating a pivoting head. As the arm moves across the record the head pivots, maintaining a true tangential angle to the radius over the whole tracking distance.

Apart from the elimination of tracking error, the "Zero-100" offers a good overall mechanical perfor-

Akai "Surround Stereo" four channel tape recorder with the matching AA6100 four channel amplifier





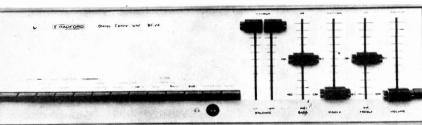
Garrard Zero-100 transcription turntable with parallel arm tangential tracking pick-up



Philips GA308 turntable unit

Bowers and Wilkins B & W Model 70 Continental style with satin white finish

Radford SC24 stereo control unit with slider controls and push button function selection





mance and various other facilities, such as a built-in stroboscope, touch tab controls, automatic play of up to six records, a fine speed control and a wow performance of better than 0.1%. The price has not yet been announced but it looks like being a very popular auto transcription unit, especially suited to package deal systems.

Philips' new two-speed record player GA308 operates at 33 and 45 rev/min, and is supplied with plinth and Perspex cover. It will be available without a cartridge but will accept almost any cartridge with half-inch between fixing screw centres. It will retail at £39 including tax and has a counter-balanced pick-up arm with low friction bearings, a damped lifting and lowering device, and adjustable side thrust compensation. At the end of a record the pick-up arm is raised automatically and the motor is switched off.

Goldring introduced a new turntable unit Model 705/P which uses belt drive and is aimed at the "popular" market.

Cosmocord showed a new ceramic stereo transcription cartridge with a single stylus assembly for fine groove records. This is their type 104 and it will operate with RIAA corrected inputs of low impedance or linear inputs of 1 Megohm impedance.

#### **AMPLIFIERS**

Radford were showing a brand new stereo control unit SC24 for use with matching power amplifiers such as their own PA50 or PA25 models. The technical specification of the SC24 is impressive and the control over input signals with regard to selection and correction is fairly extensive. This is a rather expensive product at £80 but then it seems that most of the new and more versatile equipment on show this year was up in the higher price brackets.

One new exhibitor, Amstrad, was catering for those with limited spending with their Stereo 8000 amplifier at approximately £25-95 and their "Apollo 8" matching speaker system for £13-50 per loudspeaker. The amplifier circuitry has been simplified to a considerable degree but the specified performance provides good value within the generally accepted requirements for hi fi. Further details from

Amstrad Electronics Limited, 34/35 Great Sutton Street, London, E.C.1.

#### **LOUDSPEAKERS**

Following the success of the Ditton 15 and Ditton 25, Rola Celestion showed the new Ditton 120, which received a warm reception at the Audio Fair last October. Also at that Audio Fair, but not found sufficient space at the time was the Bowers and Wilkins (B. & W.) Model 70. It appeared again at Sonex 71, styled into what is called the "Continental" version with satin white finish and pedestal stand. The unit consists of a bass radiator which does show the listener that 40Hz can really be heard. The electrostatic mid- and h.f. range unit on the top of the main cabinet is designed to give excellent results above 400Hz. In all, this is a superb speaker system, as it should be for the price—£159.50. although one should not be detracted from the excellent performance of the B. & W. DM3 at £63 or £69.50 in rosewood or satin white finish.

Poly-planar wafer speakers are a new range of loudspeakers without cones, but which have a wide variety of applications, particularly where space is limited. Details from Highgate Acoustics, 184 Gt. Portland Street, London, W.I.

#### IN BRIEF

Koss stereo headphones are widely known although fairly expensive. They introduced a new set type K711 at Sonex which are lightweight, have a wide response and are less expensive. Koss headphones are usually of very high quality, this being maintained in the K711, which retails at £10 and will be available through hi fi dealers soon.

The Bib audio accessory range is already comprehensive but Multicore Solders Ltd. introduced another six new items at Sonex. Two recording care kits, a stylus balance, a cassette tape case, high quality splicing tape and a cassette salvage kit.

From Quad (Acoustical Manufacturing Co. Ltd.) a new stereo tuner retailing at £58:00 plus £15:95 purchase tax. This is the FM3 and features MOSFET's and integrated circuits.

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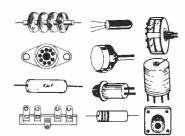
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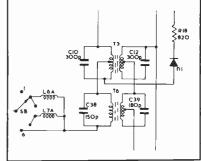


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DF9			40p	EM84	37 p	PCF86	61p	QV03-12		U191	721p	6BA6	471p	6F13	35p	6U8	35p	128G7	35p	35D5	850
DF9			49p	EM87	55p	PCF200		R19	65p	U193	410	6BB6	600	6F14	60p	6V6GT	321p	128H7	25p	35L6GT	
DK9		ECL83	571p	EN91	821p	PCF801	61p	R20	75p	U301	85p	6BH6	421p	6F15	55p	6X4	25p	128J7	25p	35W4	250
DK9		ECL86	49p	EY51	40p	PCF802		8U2150A		W729	55p	6BJ6	42 p	6F18	40p	6X5GT	271p	128K7	40p	35Z3	55p
DL9				EY80	45p	PCF805	65p	TT21	£2-40	Z759	£1-221	6BK7A	50p	6F22	821p	6X8	55n	128L7GT		35Z4G	25p
DL9			£1.50	EY81	40p	PCF806	61p	TT22	£2.50	OA2	82 1p	6BL8	85p	6F23	771p	6Y6G	¢09	128N7GT		35Z5GT	871p
DL9			52 p	EY83	55p	PCF808	67 p	U18/20	67 <del>}</del> ₽	OA3	45p	6BN5	421p	6F24	67 p	7¥4	60p	128Q7	40p	50A5	65p
DM7			40p	EY86	40p	PCH200		U20	67 <u>₹</u> ₽	OB2	82 i p	6BN6	40p	6F25	75p	9BW6	421p	128R7	821p	50B5	35p
DY8			50р	EY87	421p	PCL82	51p	U25	75p	OB3	50p	6BQ5	25p	6F26	85p	10C2	50p	1487	80p	50C5	85p
DY8 E551			41p	EY88	42 p	PCL83	61p	U26	75p	OC3	25p	6BR7	75p	6F28	70p	10D1	40p	20D1	45p	50L6GT	
E880			66p 40p	EZ35 EZ40	27 p	PCL84	51p	U31	45p	OD3	821p	6BR8	95p	6F29	82 <del>]</del> p	10D2	40p	20L1	£1-00	83A1	90p
E130			421p	EZ4I	45p 45p	PCL85 PCL86	521p	U37 U50	£1-50 30p	3Q4 384	40p 85p	6BW6	821p	6F30	85p	10F1	90p	20P1	50p	85A2	871p
E180			50p	EZ80	2710	PD500	£1.521	U52	80p	3V4	40p	6BW7 6BX6	69p 25p	6J4 6J5GT	471p	10F9 10F18	50p	20P3 20P4	60p £1-00	90AU 90Cl	£2-40 60p
EAB			471p	EZ81	271p	PFL200	740	U76	25p	5R4GY	55p	6BZ6	821p	6J7	421p	10L1	40p 40p	20P5	£1.00	90CU	£1.25
EAF			771p	EZ90	250	PL36	64p	U78	250	5U4G	30p	6C4	20p	6K6GT	50p	10LD11	55p	25C5	45p	807	474p
EBC		EF95	621p	G810C	25-00	PL38	902	U191	75p	5U4GB	871p	6C5GT	35p	6K7	321p	10P13	56p	25L6GT	371p	811A	21-50
EBC			56p	GY501	80p	PL81	51p	U201	35p	5V4G	40p	6CD6G	£1-40	6K8G	80p	10P14	£1.00	2524G	80p	612A	£3-25
EBC			35p	GZ30	871p	PL81A	621p	U281	40p	5Y3GT	80p	6CA4	271p	6K23	50p	12AB5	50p	25Z6GT	50p	813	£8-75
EBC			£2·10	GZ31	80p	PL82	36p	U282	40p	5 <b>Z</b> 3	45p	6CA7	521p	6K25	75p			30A5	40p		
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ECC			421p	PC86/8	51p	PY80	821p	UCL82	51p	6AL5	16p	6DK6	421p	682	40p	12AY7		30L15	85p	7360	£1.80
ECC			82 p	PC95	36p	PY81	41p	UCL83	61p	6AM5	25p	6DQ6B	60p	684A	55p		671p	20L17	85p		
ECC			25p	PC97		PY800	4lp	UF41/2	55p	6AM6	221p	6D84	75p	68A7	871p	12B4A	50p	30P12	80p	7586	£1-25
ECC			35p		41p	PY801	41p	UF80/5	871p	6AQ5	82 p	6EA8	55p	68G7	82 p	12BA6	821p	30P18	35p	9002	82 <u>1</u> p
E880	XC 621	EL360	£1-15	PCC84	46p	PY82	35p	UF89	41p	6AQ6	50p	6EH7	821p	68J7	87 <u>1</u> p	12BA7	32 <del>]</del> p	30P19	75p	9003	50p

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AW43-88	CM E1705	£6-60	£4-621	A59-23W/R		£12-60	£10-50
AW47-90				A61-120W/R	CM E2413	£13-50	£11.50
AW47-91	A47 14W	£5-95	24-87	A65-11W COLOUR T	CME2501	£16-50	£14-50
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A47-11W	CME1905	\$8-861	£7-00	A28-14W		£9-16}	Not
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G.E.C.	2014	24-75	Pye	Mod. 36	24-75		
G.E.C.	2018	24.75	Pye	Mod. 40	24-75		
G.E.C.	2043	24-75	Thorn	800-850	24-75		
G.E.C.	2048	\$4.75					
	STYLII—BI	RITISH	MANUF	ACTURED			
All type	s in stock.						
Single T	ip ''8"	18p	Doub	le Tip ''8''	88p		
Single T	ip "D"	87p	Doub	ie Tip "D"	47p		

"8"=Sapphire

	C	AKIL	KIDGES				1
Inc.   P.T.   each	GP94-1 GP94-5 GP95 GP96 Acce104 1-10 11-25 25-50 51-499	Inc. P.T. each \$1.55 \$1.80 \$1.24 \$1.57 \$2.09 \$1.99 \$1.91 \$1.77	B.S.R. X3M 8/8 X3H 8/8 X5H 8/8 X5M 8/8 8X5H 8/8 8X5H 8/8 8X5M D/8 8X5M D/8 8X5M D/8 6OLDRING 6800 G8000E G800 Super E	#5-25 #7-85 #15-00	RONETTE   105   8/1   106   8/2   DC400   8/2   DC4008C   8/2   105   8/2   106   D/2   DC4008C   D/2   SONOTO   8TA   D/2   9TA   D/2	8 99p 8 99p 8 70p 8 70p 8 21-111 8 21-111 8 21-111 8 34p 8 84p	0C25 0C26 0C28 0C29 0C35 0C36 0C42 0C44 0C45 0C70 0C71 0C72
G1 00-1 SI-24	51-499	\$1.77	G800 Super E	£19·50	9TAHC D/	8 #1-79	OC75

#### **TRANSISTORS**

50p	LOC76	23p	BSY29	17 <del>1</del> p	BSY90 574p
38p	OC77	28p	B8 Y32	25p	B8Y95A121p
68p	OC78	25p	B8Y36	25p	B8W41 421p
75p	OC81	20p	BSY37	25p	BSW70 271p
40p	OC81D	20p	BSY38	221p	D16P1 371p
68p	OC83	25p	B8Y39	22 p	D16P2 40p
25p	OC84	25 p	B8Y40	82 p	
20p	OC139	88p	B8Y51	32 p	
18p	OC140	87p	B8Y52	82 p	D16P4 40p
15p	OC170	80p	B8Y53	87 p	GET102 80p
15p	OC171	80p	B8Y54	40p	GET113 20p
12p	OC200	37p	B8Y56	90p	GET114 20p
12p	OC202	47p	B8Y78	47‡p	GET118 20p
88 <sub>p</sub>	OCP71	75p	B8Y79	45p	GET119 20p
23p	B8Y28	17 <b>‡</b> p	B8Y82	52‡p	GET120 521p

"D" = Dlamond



## MUSIC INSPIRED LIGHT AND COLOUR PART 3 EIGHT-CHANNEL FILTER By M.J. HUGHES M.A.

THE filter unit incorporated in the "P.E. Aurora" controlled light display system has been designed to achieve realistic proportional control of lamp intensity versus audio level and frequency.

It soon becomes apparent after some experimentation that there is considerable difference between the responsive ranges of the ear and the eye, i.e. the ear is able to detect and distinguish small variations in an extremely wide range of audio levels, whereas under normal conditions the eye is only able to differentiate between comparatively wide changes in light level.

#### **8-CHANNEL FILTER**

To achieve sufficiently wide variations in light intensity from an audio signal the dynamic range of the light source can be rapidly exceeded. The net result is that audio controlled light sources (as found in some discotheques) tend to drive the lamps on or off with very little control in the linear region between these two states. While the flashing result achieved may very well be acceptable in that environment there are, perhaps, other times when a less violent display is required.

The filter unit to be described here accepts a wide range of audio signals, compresses the dynamic range, separates the amplitudes of the various fre-

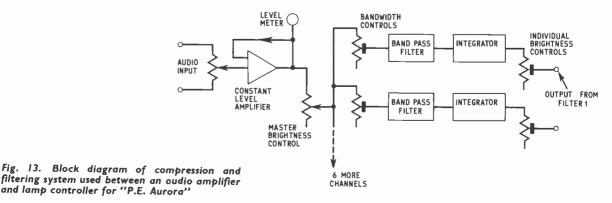
quencies into eight discrete channels, and provides a d.c. output level in the order of 0 to 3V from each channel suitable for driving the lamp controller that was described in the last two issues.

Fig. 13 shows the overall filter system in simplified form. The constant level amplifier has a high input impedance, therefore it can be connected to various audio signal sources, although it is recommended that in general the loudspeaker terminals of an amplifier be used. This unit has been used successfully on equipment ranging from a 500mW record player amplifier to the 30W "P.E. Gemini" at full output, using the lamp controller to drive the display.

#### **CONSTANT LEVEL AMPLIFIER**

The circuit of the constant level amplifier (or dynamic range compressor) is shown in Fig. 14. Emitter follower TR6 provides a high impedance input; VR3 is a course gain control which has to be adjusted for the equipment in question to ensure that the drive into the base of TR6 is of the order 30 to 500mV (this is the effective range over which the amplifier gives a constant level output).

Transistor TR7 is an f.e.t. which in this circuit operates as a voltage sensitive resistor in series with the base of TR8. It receives its control signal via the



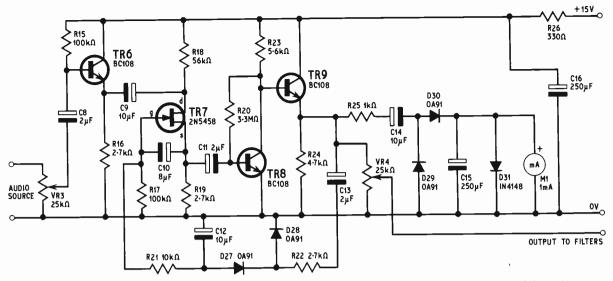


Fig. 14. Constant level pre-amplifier (dynamic range compressor) with level monitoring meter. If desired, the input impedance can be reduced by omitting TR6, R15, C8, R16, and connecting VR3 wiper direct to C9.

feedback loop containing C13, R22, and R21. Diodes D27 and D28 provide a d.c. bias level for TR7. The level of this is integrated by C12 to provide a delay to prevent total loss of signal character (associated with heavy negative feedback).

The more negative the level of the control signal, i.e. the higher the output level, the higher the effective resistance between source and drain of TR7; this, coupled with the shunting effect of R19, reduces the level of audio applied to TR8. If the audio into TR7 falls below 30mV the output level of the whole amplifier falls proportionally, but from 30mV to approximately 500mV the output is more or less constant.

If the input level exceeds 500mV, distortion is likely to occur.

Although not essential it was felt that a monitor of the output level of the amplifier would be useful—especially as the prototype was to be used with a wide variety of amplifier equipment. This is provided by a 1mA meter driven via the detector circuit D29 and D30. Diode D31 is included to provide meter protection in the event of a switch-on surge.

The audio signal at the emitter of TR9 should always have a mean value of approximately 1V.

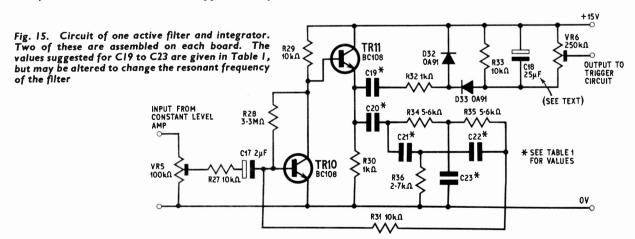
This is greatly in excess of the input requirements of the eight filters, so VR4 is included as an overall brightness level control raising or lowering the signal level to all filters in exact proportion.

#### **FILTERS**

Active parallel-T filters are used to provide very narrow pass bands for the eight sound channels used in the prototype, but of course this can be increased or decreased as desired. Fig. 15 shows the circuit of a single channel; all others are identical apart from the capacitor values in and around the twin-T network.

A proportion of the constant level output of the amplifier is fed to TR10 via VR5 which in effect controls the bandwidth of the filter over a reasonable range. TR11 provides a low output impedance to the feedback loop comprising the twin-T circuit.

The frequency determining components are C21, C22, C23, R34, R35 and R36. The nominal frequency of operation can be calculated at  $1/(2\pi CR)$  where R is the value of one of the series resistors in ohms and C is the value of one of the series capacitors in farads. In practice, other components influence the exact frequency of operation, therefore the following



empirical table may be used in determining values for frequencies other than those suggested (see Table 1).

In determining these values for the capacitors, R34 and R35 were fixed at  $5.6 \mathrm{k}\Omega$  and R36 at  $2.7 \mathrm{k}\Omega$  throughout the range of frequencies. Readers should not expect to obtain frequencies exactly corresponding to those obtained theoretically because with preferred value components and normal production tolerances it is difficult to provide the precise ratio of component values to satisfy the theory for such a circuit.

The filtered audio at the emitter of TR11 is detected by the combination of D32 and D33 and the negative going waveform is integrated by C18 which has a constant bleed R33. The voltage on the negative terminal of C18 is a mean d.c. level corresponding to the amplitude of audio at the frequency of the filter.

If the capacitance of C18 is increased the response time of the circuit will be slower, but produce a more gentle variation of signal level; reducing its value will do the converse and hence will make the lights more prone to "flash" or "strobe" in time with the music. Readers may like to experiment with different values for C18 to see the damping effect on the light display. Some delay is inevitable with C18, so an optimum compromise must be made between display character and delay effects with the value chosen for the type of music to be used.

At peak signal levels (obviously dependent on the settings of VR4 and VR5) the level at C18 can be as high as 3 volts negative with respect to the +15V rail. For linear control the lamp controller requires levels in the range of -0.5 to -1.0V, therefore a preset control VR6 is included to provide a degree of balance in sensitivity between channels.

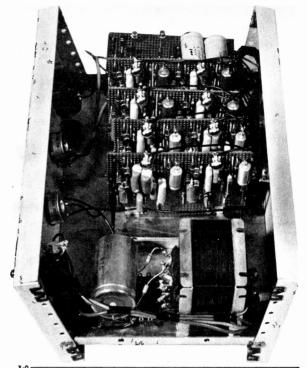
#### **FILTER CHARACTERISTICS**

It is worth considering the characteristic of the active filters—the response curves for two frequency bands are shown in Figs. 16a and 16b. It can be seen that the filters respond to fundamentals below the actual tuned frequency.

This is not such a disadvantage as it might seem because, due to the very narrow band of the filter, it is conceivable that in some passages of music the fundamental frequency of the filter might not be hit exactly. This sensitivity to sub-harmonic frequencies provides a degree of overlap although this is not excessive. It can be seen that the relative amplitude of the output decreases by a factor of two (6dB) for each sub-harmonic.

Table I. CAPACITOR VALUES FOR THE TWIN-T FILTER

Channel	Nominal Frequenc	:v	Сар	acitors (μβ	ors (μF)			
	(hertz)	7 C19	C20	C21 & C22	C23			
хI	160	0.68	0.68	0.22	0.47			
x2	480	0.068	0.47	0.068	0.15			
x3	1,100	0.068	0.47	0.033	0.068			
×4	2,400	0.068	0.47	0.015	0.033			
yΙ	220	0.22	0.47	0.15	0.33			
y2	800	0.068	0.47	0.047	0.1			
ý3	1,600	0.068	0.47	0.022	0.047			
ý4	3,700	0.068	0· <b>4</b> 7	0.01	0.022			



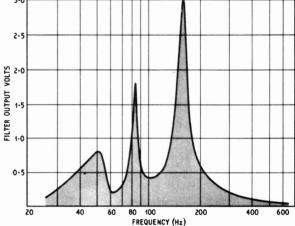


Fig. 16a. Frequency response of 160Hz active filter. The output voltage was measured across C18 as a d.c. level for a constant level sine wave input

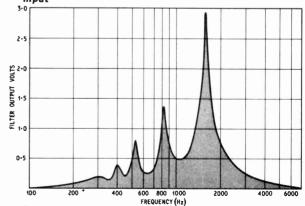


Fig. 16b. Frequency response of 1,600Hz active filter. Both this and the curve above show the relative susceptibility of the filters to lower frequencies

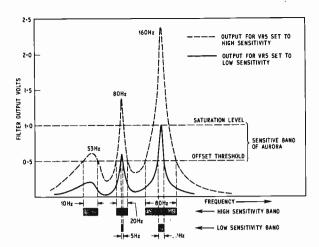


Fig. 17. Relationship between filter sensitivity and bandwidth for the 160Hz active filter

#### COMPONENTS . . .

#### **8-CHANNEL FILTER UNIT**

#### **POWER SUPPLY**

One of each of following except where stated

#### **Transformer**

T3 Mains transformer. Pri. 230V; sec. 12V at 500mA

#### Diodes

D34 to D37 IN4004 (4 off) or 25V IA bridge rectifier

#### Capacitor

Č24 5,000µF elect. 25∨

#### Miscellaneous

S2 Double pole, on/off, toggle switch

LP2 Neon indicator with ballast resistor for 250V a.c. mains

Tag component board

3-core mains cable

Contil Mod-2 type C case (West Hyde Developments)

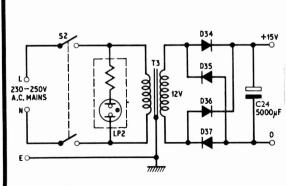


Fig. 18. Suggested circuit for a simple 15V power supply for feeding the filters

#### **BANDWIDTH CONTROL**

As mentioned earlier, VR5 has the effect of varying the effective bandwidth of the filter. This is not quite true in the pure sense. Fig. 17 shows the characteristics of the 160Hz filter for two settings of VR5. This control adjusts the sensitivity of the filter and, due to the high slopes, broadens the band which enters the sensitive voltage band of the light controller.

Naturally when set to high sensitivity (i.e. a broad bandwidth) there will be a tendency to saturate if a frequency exactly on the fundamental of the filter is encountered. Adjustment of VR6 will have a similar effect but is not so dramatic on the bandwidth. When in use both these controls have to be set carefully to ensure a desirable effect. As the effect is purely subjective it is difficult to give precise rules, but one way of setting up will be described later.

#### **POWER SUPPLY**

There is no reason why the filter unit should not be run off the same supply as the controller. For the purposes of this article it was felt that some readers might prefer to make the controller first and then use various control circuits as optional extras. Thus it was assumed that the options ought to be entirely self sufficient regarding their power requirements. The supply used on the prototype was the simplest possible (shown in Fig. 18).

If it is desired to use the controller power supply, it would be sensible to introduce a degree of decoupling, but this should not be excessive. If the decoupling introduces more than 0.5V drop into the filter positive supply line, it will be impossible to ensure that the lights go off in the absence of signal. This is due to the coupling arrangement between the filter and the controller, using the positive supply line.

The experienced constructor will realise that this problem can be overcome by placing the series decoupling resistor in the negative supply rail between filter and controller. A reasonable value for this resistor would be approximately 100 ohm and the capacitor approximately 500/F should be across the supply lines of the filter. Having said this, however, the constructional details which follow will assume an independent supply for each unit and no decoupling for the filter itself.

#### CONSTRUCTIONAL DETAILS

The constructional technique is very similar to that of the controller. The constant level preamplifier and meter drive circuit are assembled on one piece of Veroboard, the layout of which is shown in Fig. 19. Layout is not critical if alternative techniques are used but it should be noted that the audio input lead ought to be screened owing to the relatively high input impedance of the amplifier. Apart from this there should be no troubles using unscreened wire for the remainder of the system.

Two filter channels, together with the integration components, are assembled on each of four boards. Fig. 20 shows the layout. If preferred the circuits may be built individually by ignoring the layout on one side of the dotted line. It should be noted that the wiper connection to VR6 is not soldered to the copper strip on the board but directly to a flying lead taken to the output socket. Some difficulty

#### **8-CHANNEL FILTER UNIT**

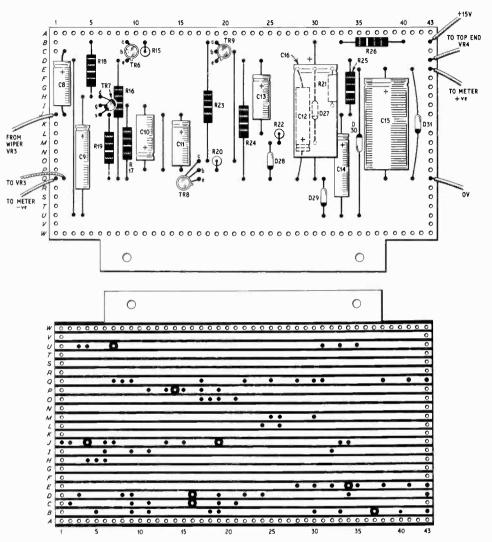


Fig. 19. Layout and wiring of the constant level pre-amplifier on Veroboard H

#### COMPONENTS ...

#### PRE-AMPLIFIER

One of each of the following except where stated

R16 2·7k Ω 10% R20 3 R17 100k Ω R21 1	2·7k Ω 10% R23 5·6k Ω 3·3M Ω R24 4·7k Ω 0k Ω 10% R25 1k Ω 2·7k Ω 10% R26 330 Ω 10% ept where stated	Transistors TR6 BC108 TR7 2N5458 or any general purpose n-channel f.e.t.  j W TR8 BC108 TR9 BC108
Potentiometer *VR3 25k Ω linear contro *VR4 25k Ω linear contro	ol	Diodes D27 to D30 OA91 (4 off) D31 IN4148 or any small signal silicon type
Capacitors  C8 $2\mu$ F elect. 15V  C9 $10\mu$ F elect. 15V  C10 $8\mu$ F elect. 15V	CI3 2µF elect. I5V CI4 I0µF elect. I5V CI5 250µF elect. 25V	Miscellaneous  *Veroboard 0·lin matrix 4½in × 2¾in  *Meter, ImA "level" indicator  *Knobs for VR3, VR4. 3-pin DIN socket

250μF elect. 25V 250μF elect. 25V \*Aluminium angle strip for Veroboard  $2\mu F$  elect. 15V C16 10μF elect. 15V All components above mounted on Veroboard H (Fig. 19) except

 $8\mu F$  elect. 15V

CIO

CII CI2

#### **8-CHANNEL FILTER UNIT**

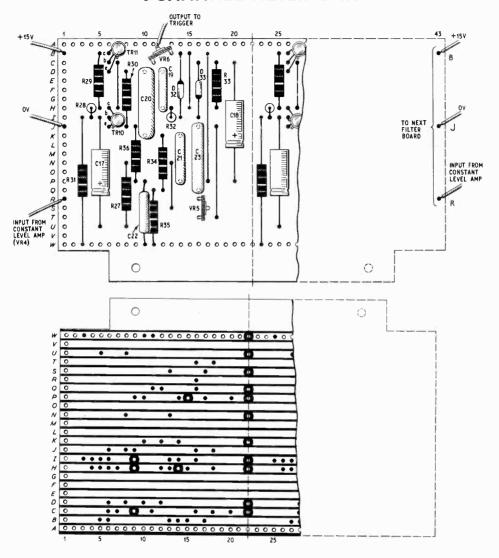


Fig. 20. Layout and wiring of two of the filters on one board

#### COMPONENTS . . .

#### FILTER BOARDS

Eight of each of following except where stated

$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Capacitors C17 $2\mu$ F elect. ISV C18 $100\mu$ F elect. 6V C19 to C23 See Table I for values (polyester types) Transistors TR10 BC108 TR11 BC108 Diodes D32 OA91 D33 OA91
Potentiometers $ \begin{array}{ll} \text{VRS} & \text{I00k } \Omega \text{ skeleton preset miniature} \\ \text{VR6} & \text{250k } \Omega \text{ skeleton preset miniature} \end{array} $	Miscellaneous *Veroboard 0·lin matrix $4\frac{1}{4}$ in $\times$ $2\frac{3}{4}$ in (4 off) *5-pin DIN sockets (2 off) *Aluminium angle strip for Veroboard

All components above mounted on Veroboards I to L, two channels per board (Fig. 20), except those shown (\*) which are mounted on chassis or case (Fig. 21).

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RANSISTORS

			111111				241010	30- 2012714	25 251270	
	BRAND	NEW F	ULLY G	UARAN	TEED DE	VICES	2N918 2N929	30p 2N2714 22p 2N2904	25p 2N3704 25p 2N3705	
AC107	15p   AF115	17p BC140	35p BCY31	22p BF272	80p EC403	15p   ORP60	40p 2N930	25p 2N2904A		
ACI13	20p AFI16	17p BC141	35p BCY32	25p BF273	30p GET880	27p ORP61	40n 2N1131	20p 2N2905	25p 2N3707	7   13p
ACH15	23p AFI 17	17p BC142	45p BCY33	17p BF274	30p MAT100	15p ST140	12p 2N1132	22p 2N2905A		
ACI25	17p AFI18	30p BC143	40p BCY34	20p BF308	35p MATIOI	17p ST141	17p 2N1302	17p 2N2906	25p 2N3709	
ACI26	17p AF124	21p BC145	45p BCY70	17p BF309	37p MAT120	15p TIS43	40p 2N1303 27p 2N1304	17p 2N2906A 20p 2N2907	27p 2N3710 25p 2N3711	
AC127 AC128	17p AF125 17p AF126	20p BC147 20p BC148	17p BCY71 12p BCY72	30p BF316 15p BFW10	75p MATI21 55p MPF102	17p UT46 43p V405A	27p 2N1304 25p 2N1305	20p 2N2907A		
ACI4IK	170 AF127	20p BC149	17p BCZ11	20p BFX29	27p MPF105	43p V410A	45p 2N1306	22p 2N2923	13p 2N3820	
ACI42K	17p AF139	33p BC 150	17p BD121	85p BFX84	20p OC19	30p 2G301	19p 2N1307	22p 2N2924	13p 2N3903	
ACI51	15p AF178	50p BC151	20p BD123	85p BFX85	27p OC20	50p 2G302	19p 2N1308	27p 2N2925	13p 2N3904	
ACI54	15p AF179	50p BC152	17p BD124	75p BFX86	22p OC22	30p 2G303	19p 2N1309	27p 2N2926	2N3905	
AC155	17p AF180	50p BC153	27p BD131	80p BFX87	25p OC23	33p 2G304	20p 2N1613 35p 2N1711	17p (G) 20p 2N2926(	12p 2N3906 Y) 11p 2N4058	
AC156 AC157	17p AF191 17p AF186	50p BC154 45p BC157	30p BD132 20p BDY20	80p BFX88 £1 BFY50	22p OC24 20p OC25	45p 2G306 25p 2G308	35p 2N1711 35p 2N1889	35p 2N2926	2N4059	
ACI65	17p AF239	37p BC158	17p BF115	22p BFY5	20p OC26	25p 2G309	35p 2N1890	45p (O)	10p 2N4060	
AC166	17p AFZII	37p BC159	20p BF117	45p BFY52	20p OC28	40p 2G339	17p 2N 1893	37p 2N3010	80p 2N4061	12p
AC167	20p AFZ12	45p BC167	I3p BFI18	60p BFYS3	17p OC29	40p 2G339A	15p 2N2160	60p 2N3011	20p 2N4067	
AC168	20p AL102	85p BC168	13p BF119	70p BSX19	15p OC3S	33p 2G344	15p 2N2147	75p 2N3053	20p 2N5172 50p 2N5459	
AC169 AC176	14p AL103	85p BC169	13p BF152	35p BSX20	15p OC36 15p OC41	40p 2G345 20p 2G371	15p 2N2 48  3p 2N2 92	60p 2N3054 30p 2N3055	50p 2N5459 63p 2S034	75p
ACI77	23p ASY26 20p ASY27	25p BC170 30p BC171	12p BF153 13p BF154	35p BSY25 35p BSY26	15p OC42	22p 2G371B	10p 2N2193	30p 2N3391	17p 25301	50p
AC187	30p ASY28	25p BC172	13p BF157	45p BSY27	150 OC44	15p 2G374	17p 2N2194	27p 2N3391A	20p 25302A	45p
AC188	30p ASY29	25p BC173	13p BF158	25p BSY28	15p OC45	12p 2G377	27p 2N2217	20p 2N3392	17p 25302	45p
ACY17	25p ASY50	25p BC174	13p BF1S9	30p BSY29	15p OC70	15p 2G378	15p 2N2218	25p 2N3393	15p 25303	60p
ACY18 ACY19	20p ASYSI	25p BC175	22p BF160	30p BSY38	15p OC71	9p 2G382 12p 2G401	15p 2N2219 30p 2N2220	27p 2N3394 22p 2N3395	15p 25304 20p 25305	£1-10
ACY20	22p ASY52 20p ASY54	25p BC177 25p BC178	17p BF162	30p BSY39 35p BSY40	15p OC72 30p OC74	12p 2G401	30p 2N2221	22p 2N3402	22p 25306	41-10
ACY21	20p ASYSS	25p BC179	17p BF164	35p BSY41	35p OC75	15p 2G417	25p 2N2222	27p 2N3403	22p 25307	£1-10
ACY22	19p ASY56	25p BC180	20p BF165	35p BSY95	12p OC76	15p 2N388	30p 2N2368	17p 2N3404	32p 25321	60p
ACY27	IBp ASY57	25p BCIBI	22p BF167	22p BSY95A	12p OC77	25p 2N388A	50p 2N2369	15p 2N3405	45p 25322	50p
ACY28 ACY29	19p ASY58 30p ASY58	25p BC182 25p BC182L	10p BF173	22p BUI0S 35p CIIIE	60p OC81	15p 2N404 15p 2N404A	22p 2N2369A 30p 2N2411	15p 2N3414 50p 2N3415	20p 25322A 20p 25323	45p 60p
ACY30	25p ASZ21	40p BC183	10p BF177	35p C400	30p OC82	15p 2N524	55p 2N2412	50p 2N3417	37p 25324	€1:20
ACY31	25p BC107	10p BC183L	10p BF178	45p C407	25p OC82D	15p 2N527	60p 2N2646	55p 2N3525	74p 25325	£1-20
ACY34	18p BC108	10p BC184	13p BF179	50p C424	17p OCB3	20p 2N696	12p 2N2711	22p 2N3702	2p 25326	£1 20
ACY35	18p BC109	IIp BCI84L	13p BF180	30p C425	40p OC84	20p 2N697	15p 2N2712	22p 2N3703	12p 25327	£1:20
ACY36 ACY40	30p BC113 15p BC114	25p BC186	27p BF181	30p C426	30p OC139 20p OC140	15p 2N698 17p 2N699	24p 55p <b>NI</b> (	DDES & R	<b>ECTIFIER</b>	
ACY41	18p BC115	30p BC187 30p BC207	27p BF182	30p C428 30p C441	27p OC170	17p 2N699 15p 2N706	37P UI	ADEO OF U	EUIIFIEN	3
ACY44	35p BC116	35p BC209	IID BFI84	25p C442	35p OC171	15p 2N706A	8p AAII9	8p BYZII	32p OA81	7p
AD140	40p BC117	35p BC209	IIp BFI8S	30p C444	37p OC200	25p 2N708	12p AA120	8p BYZ12	30p OA85	7p
AD142	40p BC118	25p BC212L	Hp BF188	30p C450	17p OC201	27p 1N709	45p BAI16	22p BYZ13 22p BYZ16	25p OA90 35p OA91	6p
AD149 AD161	43p BC119 35p BC125	45p BC213L 35p BC213L	IIp BF194	23p C720 24p C722	12p OC202 25p OC203	27p 2N711 25p 2N717	40p BA126 42p BY100	ISD BYZI7	35p OA95	7p 7p
AD162	35p BC126	35p BC214L	12p BF196	30p C740	25p OC204	25p 2N718	24p BY101	12p BYZ18	30p OA200	6p
AD161/	BC132	25p BC225	25p BF197	35p C742	17p OC205	35p 2N718A	50p BY105	ISP BYZ19	25p OA202	7p
162(MP)	63p BC134	30p BC226	35p BF200	45p C744	17p OC309	35p 2N726	27p BY114	12p OA5	17p SO10	4P
ADTI40	50p BC135	30p BC317	12p BF222	80p C760	17p P346A	17p 2N727	27p BY 126 17p BY 127	15p OA10 17p OA47	7p   SO19	4p 6p
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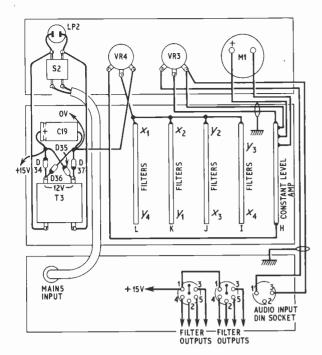


Fig. 21. Layout of chassis and case mounted components with the filter boards

might be encountered in fitting C19 and C20 on to the 160Hz filter board as they are larger components than used in other channels, but careful bending of the leads facilitates this.

Final assembly is made in a Contil Mod-2 type C cabinet. The individual boards are mounted on \(\frac{1}{2}\) in aluminium angle bolted or riveted to the sub-chassis supplied with the case. The layout shown in Fig. 21 shows a blank position; this can be used for any other board that may be required to extend the

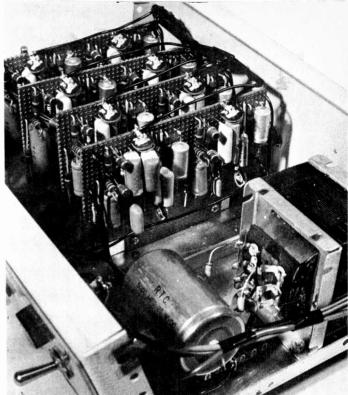
The output connections from the filter boards are taken to two 5-pin DIN sockets on the rear panel. Pin 1 is commoned to the positive rail and the individual output pins are connected direct to the wipers of VR6. If both output sockets are to be used, only one of the common line connections to +15V through pin 1 on one socket should be used. This will avoid the possibility of hum loop effects. The power supply components are mounted between the mains transformer and a component tagstrip adjacent to it.

It should be noted that while the chassis of the cabinets of both cases are earthed for safety, the common supply line should not under any circumstances be grounded or connected to the chassis. Apart from hindering the operation of the system, a grounded rail might cause damage to the power amplifier which is used to drive the system.

#### **TESTING AND SETTING-UP**

The following paragraphs are most important to achieve the best results; apparent poor response can usually be attributed to inadequate or incorrect setting-up.

Undoubtedly an audio signal generator and an oscilloscope would be useful in testing the circuits but nevertheless the following details should be of help to those without these facilities. It is, however,



assumed that the reader has access to a simple multivibrator audio frequency square wave generator (if not, a very simple one can be built in a few minutes from details in other articles published from time to time). Ideally, testing should be carried out before the boards are assembled within the cabinet otherwise access to some preset potentiometers may be difficult.

#### CONSTANT LEVEL AMPLIFIER

The constant level amplifier should be tackled first. Apply power and note any deflection of the meter. There should be no indication apart from perhaps an initial "flick", but after this the meter should settle slowly back to zero.

Set VR3 to maximum sensitivity and touch the finger on the live audio input terminal. Over a period of a few seconds the meter should indicate approximately half scale deflection which is hum pick-up due to an open input.

If a signal generator is to hand, set it for any frequency in the range 100Hz to 5kHz (1kHz is a common reference) and connect across the input terminals. Slowly increase the signal level from zero volts.

Up to an input of approximately 30mV the meter should respond in proportion to the signal but from here on up to approximately 500mV the meter will show half scale deflection. Above 500mV the meter may show a drop back due to clipping and other forms of distortion. This is quite normal.

While carrying out this test allow time for the meter needle to stabilise as it is very heavily damped by C15 and may take a second or two to display the correct level.

#### **FILTERS**

Now connect the output of the pre-amplifier through VR4 to each of the filters in turn. Set VR4

and VR3 halfway and the signal generator to an output of 500mV (approx)—the meter should still show half scale deflection.

Connect a voltmeter (4V full scale) across the wiper of VR6 and the positive rail and set VR6 to maximum (i.e. wiper is at negative end of track).

Adjust the frequency of the generator to match that of the filter; set VR5 to maximum sensitivity. The voltmeter should now read up to approximately 3V, but if not, slowly adjust the frequency of the generator until this happens. It should be found that a full output of 3V is obtained for reasonable wide frequency ranges.

Now try reducing the sensitivity by adjusting VR5. The same 3V should still be obtained but over a narrower range of frequencies. It is difficult at this stage to set the bandwidth because we have no visual indication of any subjective effect; nevertheless it is worth setting VR5 approximately halfway as a start point.

Tune the generator to give maximum output at VR6 and then reduce the output level by adjusting the latter until the voltmeter reading is approximately

This procedure should be carried out for each filter in turn, and when satisfactorily completed, permanently wire each board into the case. In the prototype the outputs of the 160, 480, 1,100 and 2,400Hz filters were taken to one socket (for the x-axis on the matrix system) and the 220, 800, 1,600 and 3,700Hz to the other (for the y-axis).

#### IN-LINE OPERATION WITH THE LAMP CONTROLLER

It was explained in the articles on the lamp controller that there are two modes of operation of the lamp controller and lighting display: (a) in-line and (b) in-matrix. Operation in-line is the simplest when all that is necessary is to connect each output of the filter unit to a corresponding channel on the lamp controller. Eight light channels can thus be controlled each one reacting to the amplitude output of its associated filter. In this mode setting up is fairly straightforward.

Connect the input of the filter unit to the loudspeaker terminals of the amplifier (no effect of loading on the audio output should be noticed) and switch on both the filter unit and the controller. All the manual controls of the controller should be turned down, as should the front panel controls of

the filter unit.

Feed an audio signal (e.g. from a record) into the amplifier and set the volume of the amplifier to normal listening level; slowly turn up VR3 until the meter reads half scale then test the effect of the constant level amplifier by varying the volume of the main amplifier to extreme limits.

If necessary readjust VR3 until the meter continuously reads half scale throughout the full range of volume level. Obviously there are practical limits to this setting and the best compromise should be

accepted.

High quality amplifiers might exceed the range of control owing to their wide dynamic range. It is stressed that adjustment of VR3 should be carried out slowly because it takes a few seconds for the integrating components within the system to respond.

Having set VR3 (which is much quicker than this

explanation might suggest) slowly advance VR4 until the lamps start to respond to the audio signals. The level of VR4 should be set so that on the loudest signals the lamps should just be fully on.

It is now necessary to carry out a final adjustment to the preset control on the top of the filter boards.

Firstly, adjust VR5 to a low sensitivity so that it will just about maintain some response from the lamps (this has the effect of reducing the bandwidth and will ultimately give the best frequency discrimination between filters). While doing this the level of illumination from the lamps will diminish; this can be recovered by adjustment of VR6.

Careful adjustment of each of these components for each filter will produce completely different balance and colour movement effects and some experimentation is worthwhile. Once set for a particular amplifier it is not necessary to readjust this balance unless, of course, a completely different overall effect is required. Under normal circumstances occasional adjustment of VR3 and VR4 allow for wide variations in amplifier volume and overall brightness required from the lamps.

#### MATRIX OPERATION WITH THE LAMP CONTROLLER

When operating in matrix mode there are many alternatives open to the user. One which can be used immediately is to matrix frequency bands on one axis against frequency bands on the other by feeding alternate filters (in ascending order) to the X and Y of the controller. If the DIN sockets have been wired up exactly as explained this must happen. To obtain any output at the lamps we must ensure a signal on both the X and Y axes at the same time. If the filter pass bands are too narrow we might be so selective in frequency that this is unlikely to happen, hence it is necessary to broaden the pass bands by increasing the sensitivity of each filter

Another method of operation in matrix mode is to use four of the filters feeding, say, the X axis of the display. The four possibilities of Y axis could be represented by sets of lamps spacially separated and by using the manual Y axis controls it is possible to select (at the turn of a knob) any set of lamps to respond to the audio and at the same time the maximum level of illumination is set by the level of the. manual control. Naturally in this mode it is possible to have all the Y controls set to maximum in which case the user will have four sets of four lamps operating identically.

#### FINALLY

This equipment has been designed to give a gentle variation in light level and although some sense of music rhythm will be seen through the display, this is not too harsh to the eyes. If a more dramatic effect is required (e.g. for discotheques) the integrating capacitor on each filter should be reduced in value (for example to 10µF) but the best value will be found by experiment. If too fast a response is obtained the matrix mode of operation might not be satisfactory owing to the fact that there may not be coincident signals on both the X and Y axes when operating frequency versus frequency.

Next month: Some ideas and suggestions on lighting effects in conjunction with the electronic system so far described.

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32/450V 20p 8+16/450V 20p 32+32/350V ... 18p
32/450V 20p 8+16/450V 20p 32+32/350V ... 33p
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10H MYE SHIGLE. 25pF, 50pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 55p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF +25pF, 50p; 500pF slow motion drive 365pF with 25pF +25pF, 50pF, 50p; 500pF slow motion drive 365pF +385pF with 25pF slow mot

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State 3 or 8 or 15 ohm. Post 15p each Also with twin tweeters. With crossover, 10 watt. State 8 or 8 or 15 ohm.

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25 watt 27 35 watt 29
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HORN Tweeters 2-16Kc/s, 10W 8 ohm or 15 ohm ±1:50.

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10 UUNSPEAKERS P.M. 30 MHMS. 6;in, ±1:10; 8×5in, ±1:25;

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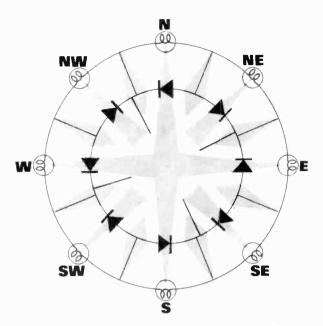
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## WIND DIRECTION INDICATOR

By C. RICHMOND

A DISADVANTAGE of most ordinary windvanes is that one has to be in a position to see them! It is not very pleasant looking up through a rainstorm and trying to estimate which way the vane is pointing. To get round this, the windvane can be arranged to drive some form of indicator which can be put in a handy position indoors. One obvious possibility is a magslip or similar generator on the mast, connected to a compass-type repeater indoors. However, this arrangement is relatively complicated and expensive and the components are not easily obtainable by the experimenter.

Another possibility is to use an ordinary single pole 12 way switch, connected to eight neon indicator lamps as shown in Fig. 1. The switch is modified so that it can rotate freely, rather than clicking

round between stops.

If the neons all have resistors included, resistor R1 will not be needed, but if they do not have resistors, R1 will serve for all of them since only one neon is alight at any time.

The value of R1 is not critical, say  $100k\Omega$ ; it is chosen to give a reasonable brightness. Its value will depend on the operating voltage of the neons, and on the supply voltage, which may be 100 to 250 volts a.c. or d.c.

However, this system needs a 9 core cable between the mast head unit and the indicator. Such cable could be expensive if a long distance is involved and care must be taken with the installation because of the voltage concerned and the all weather capability of the unit; hence a second system was devised.

#### **ULTIMATE SYSTEM**

This system uses low voltage bulbs and switching and only requires a 6 core cable between mast head and display.

Let us deal with the indicator end first. Small filament lamps are used, which are brighter than neons. They are connected in series in a ring as shown in Fig. 2, with a diode across each, alternating in polarity. Any type of diode which will pass the bulb current (in the forward direction) will do.

In the prototype 6 volt 0.06 amp bulbs are used, and ZS10A diodes—simply because these were to hand, and will pass a current of 100 milliamps in the forward direction.

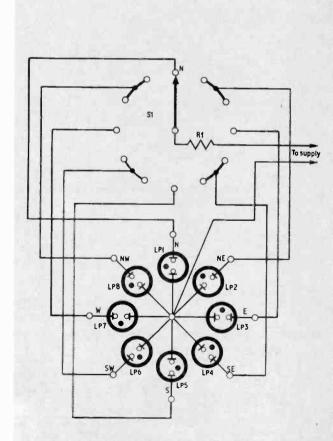


Fig. 1. Original system using Neon indicators

If 6 volts d.c. is applied between A and B, only one of the bulbs will light, depending on whether A or B is positive. The other bulb is, in effect, shorted by its diode. The remaining six bulbs will have less than two volts across each and so will not be visibly lit. It is quite easy now to arrange the switching system to apply 6 volts across AB, BA, BC, CB, CD, DC, DA, AD, as necessary to light the appropriate bulb.

The switch, shown in Fig. 3, has two wafers, each one pole, 12 way, modified for easy rotation by removing the spring position selector either by cutting it off or bending it free.

The switch connections are as shown in Table 1; the four leads marked A, B, C and D go to A, B, C and D respectively, on the indicator unit (Fig. 2).

#### **POWER SUPPLY**

A further two leads, from the switch poles, go to the supply. A 6 volt battery could be used for the supply, but if the unit is to be left on continuously such a battery would not last long. Hence a small 6V filament transformer and rectifier is used to produce the necessary voltage from the mains supply, see Fig. 4.

It is not necessary to smooth the rectified output and the supply does not need to be anywhere near the indicator or the mast head unit. The power

Switch Position	positive pole	negative pole
N I	В	A
NE $\left\{ \begin{array}{c} 2\\3 \end{array} \right.$	A	В
E 4	A C B	В
SE { 5 6		B B C C D
5 7	B D	C
sw { 8 9	Č	Ď
W 10	C C A	D
NW [!]	Ĝ	Ä
1848 {12	D	A

supply should be mounted in a metal case and wired up as shown in Fig. 5. The display could be incorporated in the lid of this case.

#### MAST HEAD UNIT

To weatherproof the mast head unit, the prototype switch was installed in a small aluminium screw top tin mounted upside down. The connecting cable

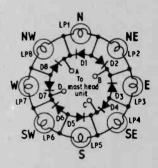


Fig. 2. Indicator system using low voltage bulbs and a four way connection to the mast head unit

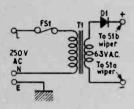


Fig. 4. Simple mains power supply for the low voltage builbs

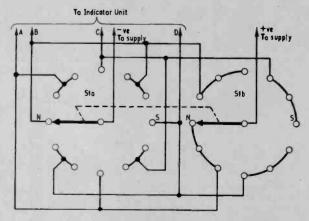


Fig. 3. Wiring diagram of the most head unit switch for the indicator shown in Fig. 2

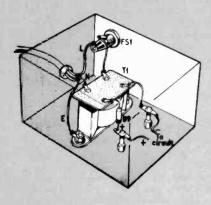


Fig. 5. Wiring diagram of the power supply mounted in a metal case

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25 100, 250V. Ohms—100, x1, x100,
x1Mohni. Watts 500mW and 5W. Load Z
5, 10, 25, 600, 2,000, 5,000 ohms. Mains
I/P C/W RF Probe. 11/in/84jin/84jin,
One only working order. £10 (carriage £1).

Connects anything electrical in seconds without plugs or sockets. No more worries about dangerous live wires. Now you can make electrical consect Now you can electrical con-



make electrical connections safely, in seconds with the revolutionary new Keynector. Cuts out plurs, sockets and saves time. A huntred different uses in the home, and a must for the do-it-yourself enthusiast. Available from your local Stockist.

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TELESCOPIC CABINET LID STAYS



Lift lid once stays open. Lift twice catch releases and allows lid to close. Closed length 71in, open length 10; in. Finished dull plating brand new. 4 for £1.

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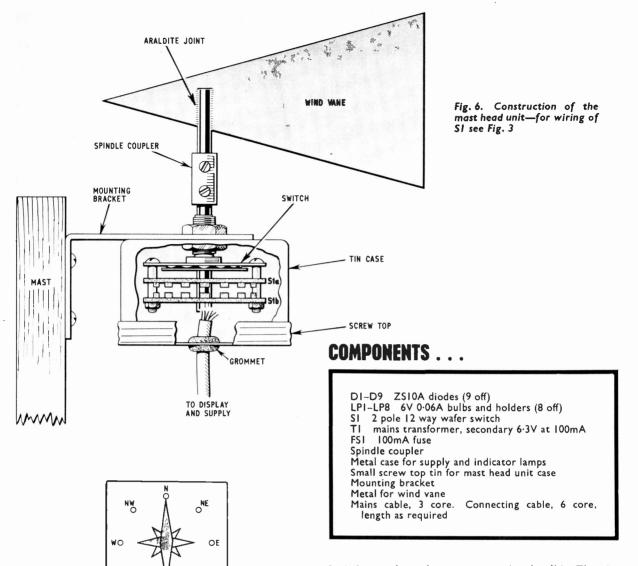
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is led out through a grommet in the lid (Fig. 6). The switch spindle bush should be greased before installation.

A standard 4 inch spindle coupler joins the switch shaft to the vane, which can be whatever design one likes, so long as it is large enough to rotate the switch in light airs, and is not so heavy as to distort the tin when it is mounted to the mast. All metal parts should be painted, before using the unit, to protect them from the elements.

#### **INDICATOR**

The indicator bulbs can be mounted on a suitable panel in any way one likes and labelled N, NE, E, SE, S, SW, W, and NW, corresponding to LP1, 2, 3, etc. Such a display is shown in Fig. 7.

The mast head unit must be lined up so that the correct bulbs come on as the vane is turned. This is easily accomplished by aligning the vane to point to the north—using a small compass—and revolving the tin and switch until the lamp indicating "N" comes on. The tin can then be fixed to its permanent mounting either by a large capacitor type clip or by a bracket as shown in Fig. 6.

D3 LP2 A LP8 D8 D LP7 D7 D7 D5 D6 LP6 D6 LP6

SW

O SE

Fig. 7. Wiring of the indicator, wires A, B, C and D go to the corresponding positions on the mast head unit

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0-05	0-09	0-06	0·14	0·20	0.24	1.00
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0-07	0·16	0.10	0-23	0-84	0-45	1-85
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Q17	3 NPN 1 ST141 & 2 ST140	0-50
Q18	4 Madt's 2 MAT 100 & 2 MAT 120	0-50
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Q20	4 OC44 germ. trans. A.F.	0.50
Q21	3 AC127 NPN germ. trans	0-50 0-50
Q22 Q23	10 OA202 sii. diodes sub-min	0-50
Q24	8 OA81 diodes	0-50
025	6 IN914 ail diodes 75PIV 75m A	0-50
Q26	8 OA95 germ. diodes sub-min. 1N69 . 2 10A 600 PIV sil. rects. IS45 R	0-50
Q27	2 10A 600PIV sil, rects. IS45R	0-50
Q28	2 Sil. power rects. BYZ13	0-50
Q29	4 Sil. trans. 2 × 2N696, 1 × 2N697,	
	1 × 2N698	0.50
Q30	6 9il switch trans, 2N/00 NFN	0-50 0-50
Q31 Q32	3 PNP sil. trans. 2 × 2N1131,	0.00
422	1 × 2N1132	0-50
O33	1 × 2N1132	0-50
Q34	7 Sil. NPN trans. 2N2369, 500MHZ	0.50
Q35	7 Sil. NPN trans. 2N2369, 500MHZ 3 Sil. PNP TO-5 2 × 2N2904 &	
	1 × 2905	0.50
Q36	7 2N3646 TO-18 plastic 300MH2	
007	NPN	0.50
Q37 Q38	3 2N3053 NPN sil. trans	0-50 0-50
039	7 NPN trans. 4 × 2N3703, 3 × 2N3702 7 NPN trans. 4 × 2N3704, 3 × 2N3705	0-50
Q40	7 NPN amp 4 x 2N3707 3 x 3N3708	0.50
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Q43	7 BC107 NPN trans	0.50
Q44	7 BC107 NPN trans. 7 NPN trans. 4 × BC108, 3 × BC109	0.50
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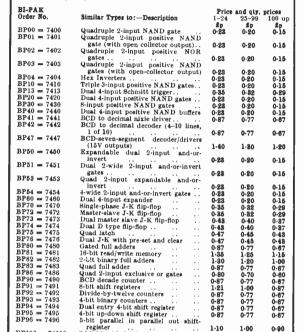
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BP935	Expandat	ole Hex Inverter				25p	23p	20p			
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m ***	pull-up					25p	23p	20p			
BP945		ve JK or R8				35p	32p	29p			
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$UIC03 = 12 \times 7403N$	50p UIC60 = 12 × 74	
$UIC04 = 12 \times 7404N$	$50p$ UIC70 = $8 \times 74$	
$UIC05 = 12 \times 7495N$	50p UIC72 = 8 x 74	
$UIC10 = 12 \times 7410N$	$50p$ UIC73 = $8 \times 74$	
$UIC20 = 12 \times 7420N$	50p UIC74 = 8 × 74	
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TAA 263—	TO-72	4	A.F. Amp	70p	60p	55p
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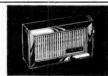
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2N21219 312 BC 158 176 M152955 879 7472 Single JM rip Flop—logge l liggered. 40p 35p 30p 25p 2N2122 30p BC 159 20p	1000MC/S Motorola 25 + 60p Unijunction 100 + 55p 25 + 44p 500 + 50p 100 + 37p 500 + 33p
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2N2905 37p BCY33 25p NKT214 15p 7493 Divide by 16. 4 Bit Binary Counter £1:00 90p 80p 75p 2N2906 30p BCY34 30p NKT216 37p 7494 Dual Entry 4 Bit Shift Register £1:00 90p 80p 75p 2N2906A 37n BCY38 40p NKT217 40p 7494 Library 4 Bit Shift Register £1:00 90p 80p 75p	25 + 25p Mullard V.H.F. 100 + 22p
2N2926 12p BCY40 50p NKT403 75p Data available for above in booklet form, price 10p. (Ref. No. 30) 12N3031 13p BCY41 15p NKT404 42p Larger quantity prices, Extn. 4. Dual Inline 14-pin Sockets 30p each. 16-pin 35p each.	OC170Mullard25p 25 + 21p 100 + 17p 500 + 15p Mullard 6A 200V
2N3054 50p BCY43 20p OA9 10p 2N3055 75p BCY58 25p OA10 25p 2N3555 61-10 BCY59 25p OA47 10p 2N3702 12p BCY70 20p OA70 10p Type Volts rent 1-49 50+ 100+ 500+	25 + 20p 100 + 17p 500 + 15p
2N3703 14p BCY71 30p OA79 10p SC35A 100 3A 90p 75p 65p 60p CA3003 61:20 CA3035 £1:25 2N3704 17p BCY72 15p OA79 10p SC35B 200 3A 95p 80p 70p 65p CA3011 75p CA3036 90p 2N3705 15p BCY78 30p OA81 10p SC35D 400 3A £1:00 85p 75p 70p CA3012 90p CA3039 85p 2N3707 15p BCY79 30p OA85 12p SC40A 100 6A £1:00 85p 75p 70p CA3014 £1:45 CA3044 £1:10	25 + 27p 100 + 22p BC107, BC108 BC109 12p each LT.T. Planars
2N3709 12p BCZ10 30p OA39	Mullard 1,000V 25 + 11p 1 amp Plastic 100 + 10p
2N4058   17p   BD123   80p   OA202   10p   SC45D   400   10A   £1-50   £1-35   £1-20   £1-30	25 + 17p 100 + 15p 500 + 13p 0 CP71 97p
28301 50p BD152 62p OC24 60p SC40E 500 6A 61-50 61-25 61-10 61-00 INTEGRATED CIRCUITS 25302 50p BD156 57 OC25 37p SC50E 500 15A 61-25 61-50 61-35 61-55 7A 629 BD16 57 OC25 37p SC50E 500 15A 62-25 62-00 61-75 61-55 7A 626 Wattrum 62-65 25303 60p BD10 61-25 OC26 25p DIAC ST2 20p 75B	BCII3 SGS 25p 25 + 20p 100 + 17p 500 + 15p 100 + 80p 500 + 75p
12304   75p   BDY11   11-50   OC239	OA202 10p OC28 62p Mullard Power
AAY30 10p BDY61 £1-23 OC41 25p 1 AMP MINIATURE WIRE ENDED UL914 Fairchild 40p. AAY42 15p BDY62 £1-00 OC42 30p PLASTIC RECTIFIERS UL923 Fairchild 40p. AAZ13 12p BF115 25p OC43 40p PLASTIC RECTIFIERS LATER AAZ17 10p BF152 30p OC44 17p Type PLV 1.49 50 100 500 1000 MC1304 Meterols 4755	25 + 8p 100 + 6p 500 + 5p 1000 + 4p 1000 + 4p
ACI26 25p BF158 30p OC70 12p IN4001 50 8p 7p 6p 5p 4p ZENER DIODES ACI27 25p BF159 60p OC71 12p IN4002 100 9p 8p 7p 5jp 4jp ZENER DIODES ACI28 25p BF159 75p 60p OC71 15p IN4003 200 10p 9p 7jp 6p 5p 400M/W 5% 1 WATT 5%	OC42 Mullard 30p 25 + 12p
ACI67 25p BFI70 35p OC73 30p OC74 30p IN4005 600 12p 10p 9p 75p 7p BTYSB range all WIRE ENDS ACI88 30p BFI77 40p OC75 25p IN4007 1000 20p 16p 13p 12p 11p 9p voltages 3:3V 68V all voltages ACY17 100 BFI78 75 OC75 75p IN4007 1000 20p 16p 13p 12p 10p 33V 15p each pages to 100V	25 + 25p 100 + 23p 500 + 21p 1000 + 18p
ACY18 25p BF180 37p OC61 25p PLASTIC RECTIFIERS 100 + 10p 100 + 10p 25 + 20p 100 + 10p	ORP12Mullard50p 25 + 45p 100 + 42p 25 + 13p 100 + 12p 500 + 40p
ACY22 17p BF184 25p OC84 25p PL4001 50 10p 9p 8p 7p 6p any one type ACY39 50p BF185 25p OC139 25p PL4002 100 11p 10p 9p 8p 7p 3 WATT ADI40 50p BF194 17p OC140 37p PL4003 200 12p 11p 10p 9p 8p PLASTIC 7 WATT	500 + 12p 500 + 10p 1000 + 8p 2N930 25p 25 + 23p
AD161 37p BF197 15p OC170 25p PL4005 600 15p 13p 11p 10p 9p 5% MOUNTING  AD161 37p BF197 15p OC171 30p PL4006 800 17p 15p 13p 12p 10p 5% MOUNTING  AD162 37p BF200 37p OC200 40d PL4007 1000 20p 17p 15p 13p 12p 10p All voltages 6·8- 5%	OC75 Mullard 25p 25 + 21p 100 + 17p 500 + 15p
AFII5 25p BFW87 25p OC202 75p 3 AMP PLASTIC WIRE ENDED 25 + 27p   5-1V-100V 40p   45p   45p BFW88 23p OC203 40p   45p BFW88 23p OC203 40p   45p BFW89 23p OC204 40p   50 100 500 1000 500 + 23p   25 + 35p   45p BFW89 23p OC205 75p   45p BFW89 23p OC205 7	1000 + 13p O C72 Mullard 25p 25 + 20p
AF124 25p BFW91 20p OC206 90p PL7001 30 40p 18p 17p 16p 14p any one type any one type PL7002 100 10p 18p 17p 15p 15p 170 BFX93 30p OCP71 97p PL7003 200 22p 20p 19p 18p 16p	0 C 20 Mullard 100V 25 + 85p 100 + 80p 500 + 15p 1000 + 13p
AF139 306 BFX37 326 ORP60 406 PL7005 600 266 246 232 220 200 SILICON RECTIFIERS STUD AF138 476 BFX84 300 ORP61 420 PL7006 800 276 256 246 236 216 MOUNTING 6 AMP RANGE AF139 476 BFX85 406 ZTX107 150 PL7007 1000 300 286 267 249 220 P.I.V. I-49 50+100+100	OC44 Mullard 17p 100 + 17p
AFI86 420 BEX87 32p ZTX500 20p (SILICON) SIZE \$\frac{1}{2}\lin \times \frac{1}{2}\lin \times \frac{1}\lin \times \frac{1}{2}\lin \times \	25 + 15p 100 + 13p 500 + 11p 1000 + 10p 1000 + 10p
ASY2B 25p BFY51 20p DISCOUNTS 4002 400 2A 80p 75p 70p 65p 5K203 200 50p 45p 42p 6 ASY2B 25p BFY52 22p 10% 12+ 1004 100 4A 70p 60p 55p 50p 5K403 400 55p 50p 45p 45p	25 + 20p 25 + 20p 25 + 20p 500 + 15p 100 + 17p 1000 + 13p
ASZ21 42 BFY90 65p Any one type 6002 600 2A 90p 80p 75p 70p 65p 8A164 100 BSX21 37p LASCEP 6004 600 4A 90p 80p 75p 70p IS AMP RECTIFIERS 6004 600 4A 90p 80p 75p 70p IS AMP RECTIFIERS	500 + 15p AF239 42p CC81 Mullard 25p 25 + 35p
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× 2ln, 5 transistor, 3-85hm output, operated a 9V battery or from mains with 12V transformer, £1.25.

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30 SECOND DELAY UNIT. This requires 24V 30 SECOND DELAY UNIT. This requires 24V a.c. or d.c. to operate. A higher or lower voltage would decrease or increase the delay time within limits. The switch, which is isolated from the operating voltage, is normally open and closes after delay. It will remain closed for a period of 30 to 60 seconds depending upon how long the delay voltage is applied and the external condition which delays cool down. Made by A.E.I., these have many uses, i.e. to delay switching on fan of central heating switching until the boiler has properly fired. Price 75p. If you wish to delay the switching of instead of the switching on then use a relay. We can supply suitable one at 62p.

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2 small hose connectors, Model 2 for one small
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Normally open, closes when activated. This is made by Asco their type No. 8030 A2. This is a heavier and somewhat superior water valve with an all metal body suitable for connecting in line with it in pipe. The solenoid is not waterproofed but is enclosed in a metal casing with in conduit entry. To facilitate electrical connection the solenoid casing may be rotated through 380 deg. Well made, should give years of trouble free service. Price ii-78, post and insurance 30p.

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MICEO SWITCH. REFERENCE BW18. An ultra sensitive switch operated by spring lever only slightest pressure needed to operate. Contacts rated at 10 amps. Price 20p.

rated at 10 amps. Price 20p.
PUBH BUTTON SWITCH. TYPE 14 D.M.G. A
very fine switch made by Honeywell. The switch
is intended for mounting on panel through oblong
hole. No screws required for fixing, it's sprung
clips secure it quite firmly. The operating button
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quality gear. Frice 40p. 84 per dox.

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SEW-TRIC PUMP MOTOR. Very powerful series wound so easily controllable from speed point of view, size 3½in × 3in approx. For mains working, price \$1.75 plus 30p post and insurance.

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20 AMP ELECTRICAL PROGRAMMER Learn in your sleep: Have Radio playing and kettle boiling as you awake—awitch-on lights to ward off intruders—have warm house to come home to. All these and many other things you can do if you invest in an Electrical Programmer. Made by the famous Smiths Instrument Company. This is essentially a 230/240 volt mains operated Clock and a 20 amp Switch, the switch-off time of which can be delayed up to 12 hours (continuously variable not stepped). Similarly the switch-on time can be delayed. This is a beautiful unit, size 51 × 37 × 31 m deep. Metal encased, glass fronted with chrome surround. Offered at 25.40 plus postage and insurance 23p.

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1 pole	60p	60p	60p	60p	60p	88p	88p	10 way	88p
2 poles									
	60p	60p	60p	60p	60p	38p	38p	55p	55p
3 poles	60p	60p	60p	60p	£1	55p	55p	75p	76p
4 poles	60p	60p	60p	£1	£1	55p	55p	95p	95p
5 poles	60p	60p	#1	#1	\$1-40	75p	75p	£1-15	£1-18
6 poles	60p	#1	#1	£1	£1.40	75p	75p	£1-35	£1.35
7 poles	60p	#1	#1	\$1.40	\$1'80	95p	95p		
8 poles	£1	#1	#1	£1-40	\$1.80	95p	95p		
9 poles	£1	#1	£1	£1-40	\$2.20	£1-15	£1-15		A
10 poles	#1	#1	£1-40	\$1-80	£2.20	£1-15	21-15		♣
11 poles	41	£1-40	\$1-40	£1.80	42-60	£1-35	\$1.35		-
12 poles	#1	£1-40	£1.40	£1.80	\$2.60	£1.85	£1.85		

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with dashboard control switch—fully extendable to 40in or fully retractable. Buitable for 12V positive or negative earth. Supplied complete with fitting instructions and ready wired dashboard switch. 36 plus 25p post and ins.

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#### 24-HOUR TIME SWITCH

Made by Smiths these are AC mains operated, NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A sector such or can be outst into box with 13A socket. 2 completely adjustable time periods per 24 hours, 5 anp changeover contacts will switch circuit on or off during these periods. 82-56, post and ins. 23p. Additional time contacts 50p pair.



#### DISTRIBUTION PANELS

Just what you need for work bench or lab.

4 × 13 amp sockets in metal box to take
standard 13 amp fused plugs and on/off switch with neon warning light. Supplied
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\$2.56 with fitted 13 amp plug; \$2.40 with fitted 15 amp plug, plus 23p P. & I.

#### BARGAIN OF THE YEAR

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transistor Key chain Radio in very pretty
case, size 2½ × 2½ × 1½m—complete with
acts leather sipped bag, Specification:—
Circuit: 7 transistor superheterodyne.
Frequency range: 530 to 1,600 Kc/s.
Sensitivity: 5 mv/m. Intermediate
frequency: 465Kc/s av 55Kc/s. Power
output: 40mW. Antenna: ferrite rod.
Loudspeaker: Permanent magnet type.
In transit from the East these sets suffered
allebt corregion as the batteries were left if

in transit from the East these sets suffered slight corrosion as the batteries were left in them but when this corrosion is cleared away they should work perfectly—offered without guarantee except that they are new. Price only \$1.25 plus 13p post and insurance, less batteries. 6 for \$7, post free. Pair of rechargeable batteries and charger 85p.

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With this you can vary the voltage applied to your circuit from zero to 270 volts without generating undue heat. One obvious application therefore is to dim lighting. Ex equipment but little used-as good as new offered at approx. half price-\$5 plus 75p post and ins.





CONTROL DRILL SPFFDS

#### CONTROLLER

CONTROLLER
Electronically changes
speed from approximately 10 reva to
maximum. Full power at
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BALANCED ARMATURE UNIT 00 ohm, operates speaker or micro-hone, so useful in intercom or similar ircuits, 33p each, 23-50 doz.



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MULTI-SPEED MOTOR
Replacement in many well known food mixers. Six speeds are available 500, 850, and 1,100 r.p.m. from either or both of the nylon sockets (where the beaters of the food mixers normally go) and 8,000, 12,000 and 15,000 r.p.m. (ideal polishing speeds) from the main drive shaft. Very powerful and useful motor size approx. 2 in. diameter 5in. long. Price 90p plus 23p post and ins.



MAINS OPERATED CONTACTOR
220/240V 50 cycle solenoid
with laminated core so very
silent in operation. Closes 4
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Extremely well made by a
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Overall size 2½ x 2 x 2in.



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MAINS TRANSFORMER output variable 24/88V. 50 c.p.d. primary 230/240V. Voltage from secondary depends upon the setting of a plug connector and may be varied from 24V to 38V approximately in 4 stops. Secondary rated at 40 watts. Price 95p, post 20p.



# 10

MAINS MOTOR Precision made — as used in record decks and tape recorders— ideal also for extractor ideal also for extractor fan, blower, heaters, etc. New and perfect. Snip at 50p. Postage 15p for first one then 5p for each one ordered.

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Very slight pressure closes both contacts, 6p each, 60p doz. Plastic push-rod suitable for operating, 5p each, 45p doz.

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2N916 2N918	17ip 2N3715	85p BCY71 421p BSY29	171P NKT406 621p	IN4007 2239 AA129 109	BAY18 171p OA5 171p BAY31 71p OA9 10p
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2N1131 2N1132	25p 2N3855 27 p AC128 25p 2N3855A 30p AC154	20p BD123 821p BSY40	32ip NKT674F 30p	18130 121p BA115 71p	BY124 15p OA79 9p BY126 15p OA81 71p BY127 171p OA85 71p
2N1302 2N1303	17 p 2N3856 30p AC176 17 p 2N3856A 35p AC187	25p BD131 75 p B8 Y 52	32ip NKT713 20p 32ip NKT781 30p	18132 15p BA142 824p	BY164 57ip OA90 7ip
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	30p 2N4291 171p AF126 \$1-071 2N4292 121p AF127 30p 2N4303 471p AF139	17 p BF200 52 p GET880 87 p BF224 20p GET887	80p OC44 20p 20p OC45 124p	ST2 DIAC	16p MPT36 87\fp
2N2368 2N2369	171p 2N5027 521p AF178 171p 2N5028 571p AF179	71 BF225 20 GET889 72 BF237 22 GET890 72 BF238 22 GET890 52 D BF234 22 GET896	221p OC46 15p 221p OC70 15p		GIC IC's
2N2369A 2N2410	17 p 2N5029 47 p AF180 42 p 2N5030 42 p AF181	121p BF244 821p GET897	22ip OC71 12ip 22ip OC72 12ip 22ip OC74 32ip	WE ARE NOW ABL	E TO SUPPLY FROM
2N2483 2N2484	27#p 2N5172 12#p AF239 82#p 2N5174 52#p AF279	471p BFW60 25p MJ400	22 p OC74 32 p 21-07 OC75 22 p 21-12 OC76 22 p	SIOCK LOWEST P	RICE TTL's. BRAND
2N2539 2N2540	22 p 2N5175 52 p AF280 22 p 2N5176 45p AFZ11	32 p BFX 12 22 p MJ421	#1.101 OC77 80n	INETT AIND GOARAI	NTEED. SEE FACING
2N2613 2N2614 2N2646	85p 2N5232A 80p A8Y26 80p 2N5245 45p A8Y27 521p 2N5246 421p A8Y28	371p BFX29 30p MJ440	95p OC81D 22ip 97ip OC83 25p	MULLARD AND RC	A IC's STOCKED.
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2N2712 2N2713	25p 2N5266 \$2.75 A8Y50	25p BFX 68 671p MJ491	£1.871 OC140 3219 OC170 30p	PIV 50 100 200 300 400	CAPACITORS A large and comprehensive
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2N2904 2N2904A	30p 2N5307 37ip A8Y86 32ip 2N5308 37ip A8Z21	821p BFX87 271p MJE521 421p BFX88 25p MJE5955	87 p OC201 75p		Trimmers, Tuners. Examples:
2N 2905 2N 2905 A 2N 2906	8719 2N5309 6219 AU103 409 2N5310 4219 BC107	12ip BFX93A 70p MJE3055	21-27 OC204 42 p	Also 12A 100 PIV, 75p; 2N3525 at £1.27;	2,000mF 25V, 374p
2N2906A 2N2907	25p 2N5354 27ip BC107 27ip 2N5355 27ip BC108 30p 2N5356 32ip BC109	121p BFY11 421p MPF102	42 P OC207 75p	VEROBOARD 0-15 0-1	2,500mF 50V, <b>57</b> 4p 3,000mF 25V, <b>45</b> p 5,000mF 50V, <b>97</b> 4p
2N2923 2N2924	15p 2N5365 47 p BC113 15p 2N5366 82 p BC115	12ip BFY17 22ip MPF103 20p BFY18 32ip MPF104 27ip BFY19 32ip MPF105	871p ORP12 621p 871p ORP61 50n	Matrix Matrix	WIRE-WOUND RESISTORS
2N 2925 2N 2926	15p 2N5367 57ip BC116A 2N5457 87ip BC118	821p BFY20 21.60 MPS3638 421p BFY21 421p NKT0013	82 P P346A 22 P	2½in × 3½in 17½p 20p 2½in × 5in 21p 24p 3½in × 3½in 21p 24p	2.5 watt 5% (up to 270 ohms only), 74p.
" Green " Yellow	14p 28005 75p BC121 12ip 28020 42 BC122	20p BFY24 45p NKT124 20p BFY25 25p NKT125	42 p TIP30A 60p	3½in × 5in 27½p 27½p 5in × 17in (plain) 65p —	5 watt 5% (up to 8.2k $\Omega$ only), 10p. 10 watt 5% (up to 25k $\Omega$ only),
" Orange 2N3011	121p 28102 50p BC125 30p 28103 25p BC126	35p BFY26 20p NKT126 35p BFY29 50p NKT128	274p T1P32A 75p 274p T1P33A 21-05	Vero Pins (bag of 50), 25p; (bag of 100), 40p.	12 p.
2N3014 2N3053 2N3054	32ip 28104 25p BC140 25p 28501 32ip BC147	17 p BFY41 50p NKT135	274p TIP34A 22-05 824p TI834 624p	Vero cutter, 45p; Pin insertion Tools (0.1 and 0.15 matrix) at 55p.	POTENTIOMETERS Carbon:
2N3055 2N3133	50p 28502 85p BC148 75p 28503 27ip BC149 80p 3N128 70p BC159	12ip BFY50 22ip NKT210 17ip BFY50 22ip NKT211	30p TIS43 40p 30p TIS44 12ip	HEAT SINKS	Log. and Lin., less switch, 16p. Log. and Lin., with switch, 25p.
2N3134 2N3135	30p 3N139 #1-271 BC157 25p 3N140 771p BC157	20n DENTES 1819 NKT213	30p TI845 121p	4.8 × 4 × 1 in Finned or Two	Wire-wound Pots (3W), 37 p. Twin Ganged Stereo Pots, Log.
2N3136 2N3390	25p 3N14I 72 p BC158 25p 3N142 55p BC159	17ip BFY56A 57ip NKT214 20p BFY75 80p NKT215	221p TIS47 121p 221p TIS48 121p	TO-3 Trans., 47ip. 4.8 × 2 × lin Finned, for One TO-3 Trans., 32ip. For 8O-1, 2ip. For TO-5,	and Lin., 40p.
2N3391 2N3391A	20p 3N143 67 p BC160 30p 3N152 87 p BC167	15p BFY76 42ip NKT217	421p TI850 171p	5p Finned. For TO-18, 5p Finned. For TO-18, 5p Finned.	PRESETS (CARBON) 0-1 Watt 6p
2N3392 2N3393	17 p R.C.A.:— BC168B 15p 40050 55p BC168C	14p BFY90 67 p NKT219 15p BPX25 41.85 NKT223	271p T1851 121p	RESISTORS	0·2 Watt 6p 0·3 Watt 7ip
2N3394 2N3402	15p 40244 22 p BC169B 22 p 40251 32 p BC169C	14p BPX29 £1.80 NKT224 15p BPY10 £1.45 NKT225	22ip T1853 22ip 22ip T1860 22ip	Carbon Film	THERMISTORS
2N3403 2N3404	22 ip   40309	15p BSW41 42ip NKT237	30p T1861 25p	1 watt 5%, lp. 1 watt 5%, lip. 1 watt 5% 2n	R53 (STC) \$1-27; K151 (Ik) 12;p VA2705 871-
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2N696	20p	2N2924	20p	AC107	46p	BC153	19p	BFY50	23p
2N697	22p	2N2925	22p	ACI26	20p	BC (54	20p	BFY51	20p
2N706	12p	2N2926	iip	ACI27	20 <sub>D</sub>	BC157	19p	BFY52	23p
2N930	29p	2N3053	27p	ACI28	20p	BC158	ĺΫρ	BSX20	16p
2N1131	36p	2N3055	75p	ACI53K	25p	BC159	18p	C407	17p
2N1132	40p	2N3702	13p	AC176	27p	BC167	13p	MC140	25p
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2N1304	23p	2N3075	13p	ADI40	56p	BC177	17p	NKT211	25p
2N1305	23p	2N3706	13p	ADI42	50p	BC178	15p	NKT212	25p
2N1306	33p	2N3707	13p	ADI49	60p	BC179	17p	NKT214	23p
2N1307	33p	2N3708	13p	ADI6I	40p	BC182L	13p	NKT274	18p
2N1308	36p	2N3709	13p	AD162	40p	BC183L	Hp	NKT403	65p
2N1309	36p	2N3710	13p	AFI14	30p	BC184L	13p	NKT405	79p
2N1613	23p	2N3711	13p	AFII5	30p	BC212L	25p	OC71	29p
2N1711	26p	2N3819	35p	AFI17	28p	BC213L	25p	OC81	25p
2N1893	54p	2N3904	35p	AF124	30p	BC214L	25p	OCBID	25p
2N2147	95p	2N3906	35p	AFI27	28p	BCY70	19p	ZTX300	12p
2N2218	34p	2N4058	20p	AFI39	48p	BCY71	33p	ZTX301	16p
2N2218A	43p	2 N 4059	20p	AF239	49p	BCY72	15p	ZTX302	22p
2N2219	38p	2N4060	20p	ASY26	27 p	BFI15	23p	ZTX303	22p
2N2219A	53p	2N4061	20p	ASY28	27p	BF167	27p	ZTX304	27p
2N2270	62p	2N4062	20p	BC107	I4p	BF173	31p	ZTX500	18p
2N2369A	19p	2N4124	18p	BC108	12p	BFI94	17p	ZTX501	21p
2N2483	35p	2N4126	27p	BC109	14p	BF195	18p	ZTX502	25p
2N2484	42p	2N4284	15p	BC125	15p	BFX29	31p		
2N2646	54p	2N4286	15p	BC126	22p	BFX84	25p	ZTX503	22p
2N2904A	42p	2N4289	I5p	BC147	15p	BFX85	34p	ZTX504	52p

#### RESISTORS

Code	Power	Tolerance	Range	Values available	I to 9 (see no	10 to 99 te below)	100 up
00000 M W W W	1/20W 1/8W 1/4W 1/2W 1W 1/2W 1W 3W	5% 10% 5% 10% 2% 10%±1/20Ω 55%	82Ω-220ΚΩ 4-7Ω-330ΚΩ 4-7Ω-10ΜΩ 4-7Ω-10ΜΩ 1-7Ω-10ΜΩ 1-7Ω-10ΜΩ 1-7Ω-10ΜΩ 1-7Ω-10ΚΩ 1-7Ω-10ΚΩ	E12 E24 E12 E24 E12 E24 E12 E12	7    -2 2-5      -7	6-5 0-8 0-8 1 2 3-5 7	6 0.7 0.7 0.9 1.9 3 6

Codes: C = carbon film, high stability, low noise.

MO = metal oxide, Electrosil TR5, ultra low noise.

WW = wire wound, Plessey.

alues: 12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades, 24 denotes series: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

ZENER DIODES 5% full range E24 values: 400mW: 2-7V to 30V, 15p each; 1W: 6-8V to 82V, 27p each; 1-5W: 4-7V to 75V, 60p each. Clip to increase 1-5W rating to 3 watts (type 266F), 4p.

CARBON TRACK POTENTIOMETERS, long spindles. Double wiper ensures minimum noise

CARBON Incomplete wiper ensures minimum noise level, spindles. Double wiper ensures minimum noise level, Single gang linear 100Ω to 2·2MΩ, 12p; Single gang log.47KΩ to 2·2MΩ, 42p; Dual gang log. 47KΩ to 2·2MΩ, 42p; Dual gang log. 47KΩ to 2·2MΩ, 42p; Dual antilog. 10K only, 42p. Any type with ½A D.P. mains switch, 12p extra. Only decades of 10, 22 and 47 available in ranges quoted.

CARBON SKELETON PRE-SETS Small high quality, type PR, linear only: 100 \( \Omega\_2 \text{220} \), 470 \( \Omega\_1 \text{ XZ}, 4K7, 10K, 2ZK, 47K, 10KK, 2ZK, 47K, 10KK, 2ZK, 47K, 10K, 2MZ, 5M, 10M\( \Omega\_1 \text{ Vertical or horizontal mounting}, \omega\_2 \text{ peach}.

COLVERN 3 watt Wire-wound Potentiometers. 100, 150, 250, 500, 1000, 2500, 5000, 1K, 1-5K, 2-5K, 5K, 10K, 15K, 25K, 50K, 32p each.

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions on total value of resistor order.)

MULLARD polyester C280 series 250V 20%: 0·01, 0·022, 0·033, 0·047 3p each; 0·068, 0·1, 4p each; 0·15, 4p; 0·22, 5p, 10%: 0·33, 7p; 0·47, 8p; 0·68, 11p;  $1\mu$ F, 14p; 15 $\mu$ F, 21p; 22 $\mu$ F, 24p.

MULLARD SUB-MIN ELECTROLYTICS
C246 range, axial lead
Values (uF/V): 0.64/64: 1/40: 1-6/25; 2-5/16; 2-5/16;
1/10: 4/40: 5/64: 6-4/6-4: 6-4/25: 8/4: 8/40: 10/2-5;
1/0/16: 10/64: 12-5/25; 16/40; 20/16; 20/64: 25/6-4;
25/25; 32/4: 32/10: 32/40: 32/64: 40/16: 40/2-5;
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●At full power 0:3%

distortion.

• At full power—Id 11 c/s to 40 kc/s.

Response—IdB II c/s to 100 kc/s.

LOOK AT THE SPECIFICATIONS! Rise time 2usec.

> Short circuit proof plus limiting cct.

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