Hobby Electronics

MARCH '82
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65p

For A Down-To-Earth Approach To Electronics

Hobby Dice

A gadget for games of all kinds

By popular request:

Probing the Oscilloscope
The instrument and how to use it

PLUS

Bike Siren and *Stereo Bass Booster* projects, *PCB feature* and *all* our regular columns

Hobby Electronics

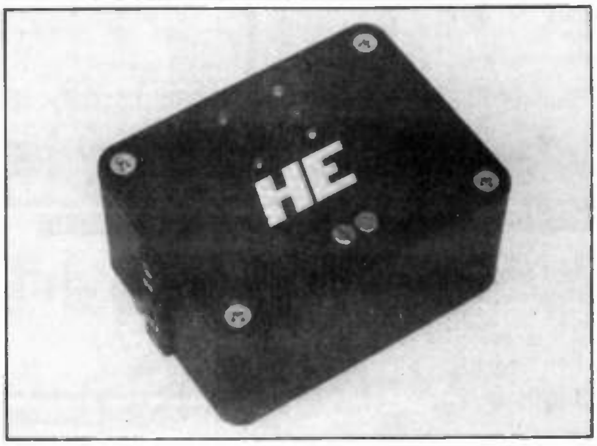
MARCH 1982
Vol 4 No 3

PROJECTS

FEATURES

SPECIALS

REGULARS



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Rapid Electronics

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OPTO

★3mm red	8	★5mm red	8
★3mm green	12	★5mm green	12
★3mm yellow	12	★5mm yellow	12

Clips to suit 3p each

Rectangular			
★red	12	TIL32	40
green	17	TIL78	40
yellow	17	TIL111	60
		ORP12	85

Seven Segment Displays

Com cathode		Com anode	
DL704 0.3"	95	DL707 0.3"	95
★FND500 0.5"	65	FND507 0.5"	90
TIL313 0.3"	105	TIL312 0.3"	105
TIL322 0.5"	115	TIL321 0.5"	115

All seven segment displays are supplied with connection details.
2N5777 45 Dual Colour LED 60

CONNECTORS

DIN	Plug	Skt	Jack	Plug	Skt
2 pin	9p	9p	2.5mm	10p	10p
3 pin	12p	10p	3.5mm	★7p	★7p
5 pin	13p	11p	Standard	16p	20p
Phono	10p	12p	Stereo	24p	25p
1mm	13p	13p	4mm	18p	17p

UHF (CB) Connectors
PL259 Plug 40p Reducer 14p
SO239 Square chassis socket 38p
SO239S Round chassis socket 40p

IEC 3 pin 250V/6A
Plug chassis mounting 38p
Socket free hanging 60p
Socket with 2m lead 120p

CAPACITORS

Polyester Radial Leads 250V 280 type
0.01, 0.015, 0.022, 0.033, 6p; 0.047, 0.068, 0.1, 7p; 0.15, 0.22, 9p; 0.33, 0.47, 13p; 0.68, 20p; 1u 23p.

Electrolytic Radial or Axial leads
0.47/63V, 1/63V, 2.2/63V, 4.7/63V, 10/25V, 7p; 22/25V, 47/25V, 8p; 100/25V, 9p; 220/25V, 14p; 470/25V, 22p; 1000/25V, 30p.

Polyester Siemens PCB
1n, 2n2, 3n3, 4n7, 6n8, 10n, 15n, 7p; 22n, 33n, 47n, 68n, 8p; 100n, 9p; 150n, 11p; 220n, 13p; 330n, 20p; 470n, 26p; 680n, 29p; 1u, 33p; 2u2, 50p.

Tantalum bead
0.1, 0.22, 0.33, 0.47, 1.0 @ 35V 12p; 2.2, 4.7, 10 @ 25V, 20p; 15/16V 30p; 22/16V, 27p; 33/16V, 45p; 47/6V, 27p; 47/16V, 70p; 68/6V, 40p; 100/10V, 90p.

Ceramic 22p-0.01u 50V 3p each.
Polystyrene 5% tolerance
10p-1000p 6p. 1500-4700 8p. 6800p-0.012 10p.
Trimmers Mullard 808 Series
2-10pF 22p. 2-22pF 30p. 5.5-65pF 35p.

REGULATORS

Positive		Negative	
★78L05	25	79L05	65
78L12	30	79L12	65
78L15	30	79L15	65
★7805	45	★7905	45
★7812	45	★7912	45
7815	60	7915	60
LM309K	130	★LM323K	350
★LM317T	120	LM723	40

SOCKETS

★8 pin	7p
★14 pin	9p
★16 pin	10p
18 pin	15p
20 pin	18p
22 pin	20p
24 pin	22p
28 pin	26p
40 pin	32p

Soldercon pins 60p/100

CABLES

20 metre pack single core connecting cable, ten different colours	65p
Speaker cable	10p/m
Standard screened	16p/m
Twin screened	24p/m
2.5A 3 core mains	23p/m
10 way ribbon	65p/m
20 way ribbon	120p/m

TRANSFORMERS

Miniature mains
6-0-6V, 9-0-9V, 12-0-12V all @ 100mA 100p each

High quality, Split bobbin construction
6VA 0-6, 0-6 @ 0.5A, 0-9, 0-9V @ 0.4A
0-12, 0-12V @ 0.3A 220p each.
12VA 0-6, 0-6 @ 1A, 0-9, 0-9V @ 1.2A,
0-12, 0-12 @ 0.5A, 0-15, 0-15V @ 0.4A
275p each (plus 40p carriage)
24VA 0-6, 0-6V @ 1.5A, 0-9, 0-9V @ 1.2A,
0-12, 0-12V @ 1A, 0-15, 0-15V @ 0.8A,
330p each (plus 60p carriage)
50VA 0-12, 0-12V @ 2A; 0-15, 0-15V @ 1.5A,
400p each (plus 70p carriage)
100VA 0-30, 0-30V @ 1.6A
920p each (plus 80p carriage)

PANEL METERS

Sixe 60 × 46 × 35mm

0-50µA	0-500mA
0-100µA	0-1A
0-500µA	0-50V AC
0-1mA	VU
0-10mA	0-300V AC
0-50mA	0-25V
0-100mA	0-30V DC

450p each.

RESISTORS

¼W 5% Carbon film E12 series 4.7Ω-10M 1p each
½W 5% Carbon film E12 series 4.7Ω-4M7 2p each
¼W 1% Metal film E24 series 10Ω-1M 6p each.

CRYSTALS

				5.0M	240	18.0M	240
				6.0M	200	18.432M	220
100KHz	290	2.4576M	220	6.144M	180	19.968M	300
200KHz	370	3.276M	240	7.00M	250	26.69M	300
1MHz	300	3.579M	120	8.0M	170	27.145M	240
1.008M	370	4.0M	150	10.0M	180	38.6667M	320
1.8432M	300	4.194M	150	12.0M	290	48.0M	220
2.0M	270	4.43M	125	16.0M	240	116M	300

SWITCHES

Submin. Toggle
SPST 55p SPDT 60p ★DPDT 50p
Miniature toggle
SPDT 80p SPDT centre off 90p
DPDT 90p DPDT centre off 100p
Standard toggle
SPST 35p DPDT 48p
★Miniature DPDT slide 12p
★Push to make 12p Push to break 22p
Rotary type adjustable stop
1P12W 2P6W, 3P4W, 4P3W all 55p each
DIL switches
4 SPST 80p 6 SPST 80p 8 SPST 100p

DIODES

BY127	12	★1N4001	3
OA47	10	1N4002	5
OA90	8	1N4006	7
OA91	7	1N4007	7
OA200	8	1N5401	15
OA202	8	1N5404	16
1N914	4	1N5406	17
★1N4148	2	400mW zen	6p

BRIDGE RECTIFIERS

1A 50V	22	4A 400V	95
1A 400V	35	6A 100V	80
2A 200V	40	6A 200V	90
2A 400V	45	6A 400V	95
2A 200V	90		

PCB MATERIALS

Alfac transfer sheets	45p
Dalo etch resist pen	100p
Fibre glass board 3.75 × 8"	70p
Ferric Chloride 250ml bottle	100p

BOXES

Dimensions in inches. Aluminium.

3 × 2 × 1	70p	6 × 4 × 2	120p
4 × 3 × 1½	85p	6 × 4 × 3	150p
4 × 3 × 2	100p	8 × 6 × 2	180p

POTENTIOMETERS

Rotary. Carbon track Log on Lin 5K-1M
Single 32p. Stereo 85p each.
Slide. 60mm travel single Log or Lin 5K-500K. 63p.
Preset. Submin horiz 100Ω-1M. 7p.

ORDERING INFO

All prices exclude VAT. Please add to total order. Please add 50p carriage on all orders under £10 in value. Send cash/cheque/PO or Access/Visa number with your order. Our enlarged catalogue costs just 42p (free with orders over £5). Send SAE for discounts list. Official orders welcome from colleges, schools etc.

HARDWARE

PP3 Battery clips	6p
Red or black crocodile clips	6p
Black pointer control knob	15p
Pair Ultrasonics	350p
TO220 twisted vane heatsink	28p
20mm panel fuseholder	25p
4mm terminals (var. colours)	33p
TO18 transistor socket	15p
64mm 64 ohm speaker	70p
64mm 8 ohm speaker	70p

NEW TELEPHONE ORDER SERVICE

Now ordering from Rapid is even easier. Just telephone **0322 863494** with your requirements and your Access or Visa number for immediate despatch. Nothing could be more simple!

VERO

Verobloc 350p.	
Size 0.1 matrix	
2.5 × 1"	22p
2.5 × 3.75"	75p
2.5 × 5"	85p
3.75 × 5"	95p
VQ Board	160p
Veropins per 100	
Single sided	50p
Double sided	60p
Spot face cutter	105p

TRANSISTORS

		BC157	10	BC558	10	BFX84	25	TIP30	45	★ZTX107	8	2N3054	55
		BC158	10	BCY70	18	BFX85	25	TIP30A	40	★ZTX108	8	2N3055	50
AC125	35	★BC159	8	BCY71	18	BFX86	28	TIP30B	50	ZTX109	12	2N3442	120
AC126	25	BC160	45	BCY72	18	BFX87	25	TIP30C	60	ZTX300	14	★2N3702	6
AC127	25	BC168C	10	BD115	80	BFX88	25	TIP31A	45	ZTX301	16	2N3703	9
★AC128	20	BC169C	10	BD131	35	BFY50	23	TIP31B	45	ZTX302	15	★2N3704	6
AC176	25	BC170	8	BD132	35	BFY51	23	TIP31C	55	ZTX304	17	2N3705	9
AC187	22	BC171	10	BD133	50	BFY52	23	TIP32A	45	ZTX341	30	2N3706	9
AC188	22	BC172	8	BD135	50	BFY53	32	TIP32B	55	ZTX500	15	2N3707	10
AD142	120	BC177	18	BD136	30	BFY55	32	TIP32C	60	ZTX501	15	2N3708	10
AD149	80	BC178	18	BD137	30	BFY56	32	TIP33A	50	ZTX502	15	2N3709	10
AD161	40	BC179	18	BD138	30	BRY39	40	TIP33C	75	ZTX503	18	2N3772	190
AD162	40	BC182	10	BD139	35	BSX20	20	TIP34A	60	ZTX504	25	2N3773	210
AF124	60	★BC182L	8	BD140	35	BSX29	35	TIP34C	85	2N697	20	★2N3819	15
AF126	50	BC183	10	BD204	110	BSY95A	25	TIP35A	160	2N698	40	2N3820	40
AF139	40	BC183L	10	BD206	110	BU205	160	TIP35C	180	2N706A	20	2N3823	65
AF186	70	BC184	10	BD222	85	BU206	200	TIP36A	170	2N708	20	2N3866	90
AF239	75	★BC184L	7	BF180	35	BU208	170	TIP36C	195	2N918	35	2N3903	10
BC107	10	BC212	10	BF182	35	MJ2955	99	TIP41A	60	2N1132	22	2N3904	10
BC107B	10	BC212L	10	BF184	25	MJE340	50	TIP42A	60	2N1613	30	★2N3905	6
★BC108	8	BC213	10	BF185	25	MJE520	65	TIP120	90	2N2218A	45	2N3906	10
BC108B	12	BC213L	10	BF194	12	MJE521	95	TIP121	90	2N2219A	25	2N4037	45
BC108C	12	BC214	10	BF195	12	MJE3055	70	TIP122	90	2N2221A	25	2N4058	10
★BC109	8	★BC214L	8	BF196	12	MPF102	40	TIP141	120	2N2222A	20	2N4060	10
BC109C	12	BC237	8	BF197	12	MPF104	40	TIP142	120	2N2368	25	2N4061	10
BC114	22	BC238	14	BF198	10	MPSA05	22	TIP147	120	2N2369	11	2N4062	10
BC115	22	BC308	15	BF199	18	MPSA06	25	TIP2955	60	2N2484	25	2N5457	36
BC117	22	BC327	14	BF200	30	MPSA12	30	TIP3055	55	2N2646	45	2N5458	36
BC119	35	BC328	14	★BF244B	18	MPSA55	30	TIS43	40	2N2904	20	2N5459	30
BC137	40	BC337	14	BF245	30	MPSA56	30	TIS44	45	2N2904A	20	2N5485	36
BC139	40	BC338	14	BF256B	45	MPSU05	55	TIS45	45	2N2905	22	2N5777	45
BC140	30	BC477	30	BF257	32	MPSU06	55	TIS90	30	2N2905A	22	2N6027	30
BC141	30	BC478	30	BF258	25	MPSU55	60	TIS91	30	2N2906	25	40360	40
BC142	25	BC479	30	BF259	35	MPSU56	60	★VN10KM	45	2N2906A	25	40361	50
BC143	25	BC517	40	BF337	40	TIP29	35			2N2907	25	40362	50
BC147	8	★BC547	7	BFR40	23	TIP29A	40	VN46AF	75	2N2907A	25	40408	70
BC148	8	BC548	10	BFR80	25	TIP29B	55	VN66AF	85	2N2926	9	40594	100
BC149	9	BC549	10	BFX29	25	TIP29C	60	VN88AF	95	★2N3053	20		

CMOS

		★4017	43	4036	285	4055	115	4082	20	4502	70	4529	150
		4018	60	4039	295	4059	480	4085	65	4503	50	4532	95
4000	14	4019	35	4040	55	4060	85	4086	65	4507	38	4534	495
★4001	12	★4020	55	4041	75	4063	90	4089	140	4508	200	4538	110
4002	14	4021	65	4042	55	4066	35	★4093	33	4510	65	4543	110
4006	65	4022	70	4043	60	4067	395	4094	14	★4511	50	4549	380
4007	17	4023	18	4044	65	★4068	15	4095	90	4512	70	4553	295
4008	58	4024	40	4046	70	4069	18	4097	340	4514	180	4555	45
4009	30	4025	18	4047	70	4070	18	4098	85	4515	180	4556	48
4010	35	★4026	96	4048	55	4071	18	4099	95	4516	75	4559	390
★4011	13	4027	30	★4049	28	4072	18	40106	50	★4518	45	4560	180
4012	17	4028	55	4050	28	4073	20	40109	100	4520	70	4584	45
★4013	22	4029	75	4051	60	4075	20	40163	100	4521	200	4585	99
4014	60	4030	35	4052	70	4076	60	40173	100	4526	80	4724	140
4015	60	4031	170	4053	60	4077	25	40175	100	4527	90		
★4016	22	4034	170	4054	110	4081	18	40193	120	★4528	75		

LINEAR

		CA3162E	450	LM377	150	LM3900	50	NE566	150	★TDA1022	560
★709	25	CA3189E	290	★LM380	65	LM3909	70	★NE567	100	TDA1024	125
★741	14	ICL7106	790	★LM381	100	LM3911	120	NE571	425	TLO71	45
748	35	ICL8038	320	LM382	120	★LM3914	200	RC4136	90	TLO72	75
AY-3-1270	840	ICM7555	80	★LM386	65	★LM3915	200	SN76013	170	★TLO81	30
AY-3-8910	700	★LF351	40	LM387	120	LM13600	120	SN76018	150	TLO82	70
★AY-3-8912	625	LF353	85	LM393	100	MC1310	150	★SN76477	150	★TLO84	90
		LF356	90	★LM709	25	MC3302	150	TBA641B11	250	★XR2206	300
CA3046	60	LM10	395	LM710	50	MC3340	135	TBA800	80	ZN414	100
★CA3080	55	★LM301A	25	LM725	350	NE515	270	TBA810	95	ZN423	195
CA3089	215	LM311	70	LM733	75	NE529	225	TBA820	80	ZN424	135
CA3090AQ	375	LM318	85	★LM741	14	NE531	150	TBA950	290	ZN425E	390
CA3130E	90	★LM324	40	LM747	75	NE544	185	TCA940	170	ZN426E	330
CA3140E	45	LM339	50	LM748	35	★NE555	16	TDA1004	300	ZN427E	650
CA3160E	100	LM348	90	★LM1458	40	★NE556	45	TDA1008	320	ZN428E	480
CA3161E	140	LM358	50	LM2917	200	NE565	120	TDA1010	225	ZN1034E	200

TTL

		7413	24	7442	40	7480	45	74107	30	74155	60	74177	75
		7414	35	7444	85	7482	70	74109	32	74156	60	74179	65
7400	11	7416	25	7446	60	7483	50	74121	28	74157	43	74180	65
7401	11	7417	25	7447	48	7485	75	74122	45	74160	60	74181	135
7402	12	7420	15	7448	50	7486	25	74123	48	74161	60	74182	75
7403	14	7421	20	7450	16	7489	180	74125	40	74162	60	74190	70
7404	14	7422	20	7451	16	7490	28	74126	40	74163	60	74191	70
7405	17	7427	28	7453	16	7492	45	74132	40	74164	60	74192	70
7406	26	7428	28	7454	16	7492	40	74141	65	74165	60	74193	65
7407	26	7430	15	7460	16	7493	30	74165	65	74167	180	74194	70
7408	15	7432	25	7472	25	7494	35	74147	100	74170	165	74195	63
7409	16	7433	27	7473	28	7495	50	74148	75	74173	60	74196	63
7410	14	7438	27	7474	25	7496	45	74150	75	74174	65	74197	63
7411	20	7437	27	7475	38	7497	120	74153	45	74175	70	74198	95
7412	20	7440	17	7476	30	74100	80	74154	75	74176	55	74199	95

LS TTL

		LS21	15	LS76	20	LS125	30	LS161	42	LS221	60	LS365	38
		LS22	16	LS78	24	LS126	30	LS162	42	LS240	90	LS366	38
LS00	13	LS26	18	LS83	50	LS132	45	LS163	42	LS241	80	LS367	38
LS01	14	LS27	15	LS85	70	LS136	30	LS164	50	LS242	80	LS368	50
LS02	14	LS30	16	LS86	25	LS138	35	LS165	120	LS243	85	LS373	80
LS03	14	LS32	16	LS90	35	LS139	35	LS166	85	LS244	80	LS374	80
LS04	15	LS37	16	LS92	38	LS145	75	LS170	170	LS245	120	LS375	50
LS05	15	LS38	16	LS93	35	LS147	160	LS173	70	LS247	75	LS377	90
LS08	16	LS40	16	LS95	45	LS148	95	LS174	60	LS251	40	LS378	70
LS09	16	LS42	38	LS96	110	LS151	40	LS175	60	LS257	48	LS390	75
LS10	16	LS47	40	LS107	45	LS153	40	LS190	55	LS258	45	LS393	75
LS11	16	LS48	80	LS109	30	LS154	120	LS191	55	LS259	95	LS399	220
LS12	15	LS51	16	LS112	30	LS155	45	LS192	55	LS266	25	LS541	135
LS13	25	LS55	30	LS113	30	LS156	45	LS193	60	LS273	90	LS670	175
LS14	48	LS73	25	LS114	30	LS157	35	LS195	50	LS279	50		
LS15	15	LS74	25	LS122	42	LS158	36	LS196	60	LS283	45		
LS20	15	LS75	27	LS123	55	LS160	42	LS197	68	LS353	100		

COMPONENT KITS

An ideal opportunity for the beginner or the experienced constructor to obtain a wide range of components at reduced prices.

¼W 5% Resistor Kit. Contains 10 of each value from 4.7Ω to 1M (650 resistors) 480p.

Ceramic Capacitor Kit. Contains 5 of each value from 22p to 0.01 (135 caps.) 370p.

Polyester Capacitor Kit. Contains 5 of each value from 0.01 to 1uF (65 caps.) 575p each.

Preset Kit. Contains 5 of each hor. Value from 100Ω to 1M (total 65 presets). 425p each.

Nut and Bolt Kit. Total 300 items. 140p.

SOLDERING IRONS

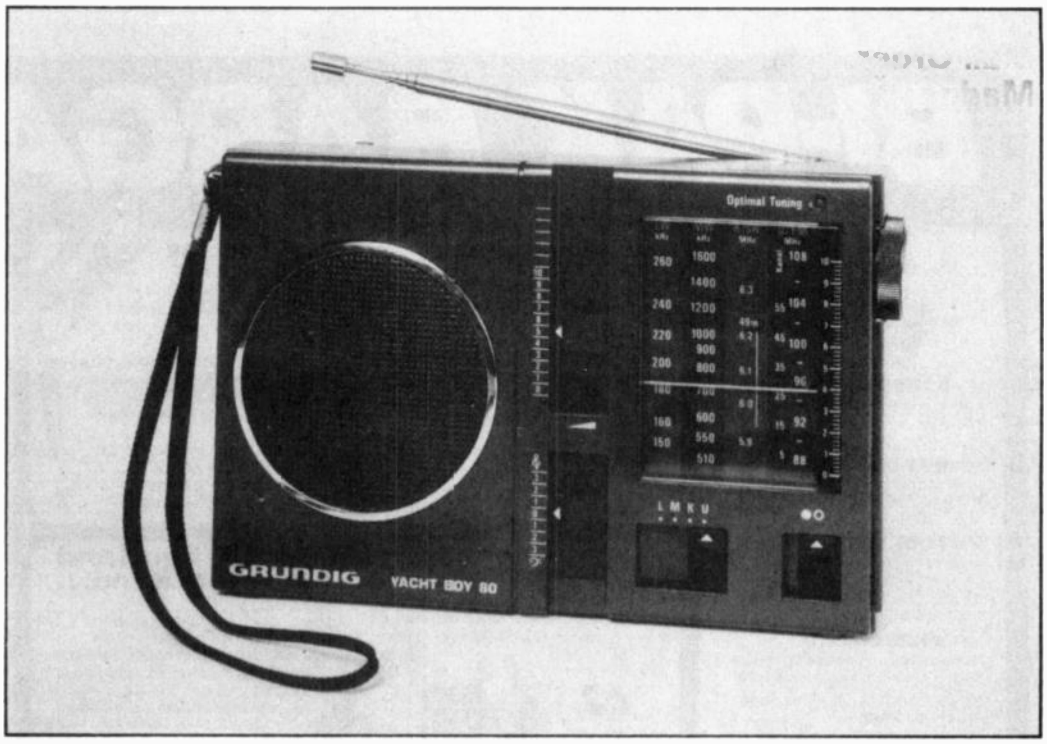
Antex CX 17W Soldering Iron	420p
2.3mm and 4.7mm bits to suit	55p
CX 17W element	190p
Antex X25 25W Soldering Iron	440p
3.3mm and 4.7mm bits to suit	55p
X25 25W element	190p
Solder pump desoldering tool	480p
Spare nozzle for above	60p
10 metres 22 swg solder	100p

TRIACS + SCRS

SCRs		TRIACs	
★C106D	30	400V 4A	60
400V 8A	70	400V 8A	70
400V 12A	99	400V 16A	105

The Rapid Guarantee ★ Same day despatch ★ Competitive prices ★ Top quality components ★ In-depth stock

MONITOR



Portable Music Power

The somewhat curiously named Yacht Boy 80, from Grundig, is a four-band radio designed for maximum portability. It measures a mere 18 x 12 x 4 cm and will comfortably slip into a briefcase or handbag. The bands cover medium, longwave and shortwave plus FM, with a LED indicator to show optimum tuning on any frequency.

The Yacht Boy 80 is powered by either batteries or a separate mains adaptor and its output of 0.6 watts is adequate for comfortable listening without disturbing your neighbours on the beach!

Including carrying strap, the radio is available for about £24, including VAT, in a choice of either silver or brown finish.

For details, contact Grundig International Ltd., Newlands Park, London SE26 5NQ, 'phone 01 659 2468.

Master Crafted

The quest for the highest-fi is never ending. Connoiseurs have long been aware of the superb quality of records produced from a 'half-speed master'; this is a variation of the normal record-cutting process in which both the stereo master tape and the cutting lathe are run at half the usual speed. The result is a more faithful transfer of information from tape to vinyl. Original Master Recordings are produced in America by a small company called MFSL and marketed in the UK by Zerostat Components Ltd. Their half-speed mastered recording of popular titles are produced to "the most exacting standards", with each title limited to a run of 200 000 copies. Each disc is pressed onto vinyl specially developed by JVC and is perfectly flat. To preserve this quality, the packaging is particularly robust.

The titles include some of the best pop music of the last 10 years — Pink Floyd's "Dark Side Of The Moon", the Rolling Stones' "Sticky Fingers", "Parallel Lines" from Blondie and Bowie's "Ziggy Stardust". In addition there is a selection of classical titles, including Holst's "The Planets" and Beethoven's famous Ninth.

Full details of Original Master Recordings and the address of your local stockist can be had from Zerostat Components Ltd., 14 Edison Road, St Ives, Huntingdon, Cambs PE17 4LE, 'phone (0480) 62225.

Calculate By Candle Power

Maintaining their position as one of the most inventive, innovative company in the consumer electronics market, Casio continue to astound and amaze us. This time, it's a candle-powered calculator; actually, it is powered by solar cells but they are so efficient that it really will run from the light emitted by a single candle. It works even better by daylight, of course, when it's less of a strain to read the eight-digit display.

Designated the model SL801, it offers all the facilities of a normal four-function calculator, including square root, percent and independent memory.

Recommended retail price, including a leatherette wallet, is £10.95. This price is the maximum anyone might expect to pay.

A similar calculator, the model SL701, is available in 'credit card' format, priced at £11.95.

Jogging Memories

Readers may recall an item in last month's Monitor about Casio's new Jogger's Watch. The picture, which we were unable to print last month, gives a more accurate idea of the facilities provided. About the only factor the model J-100 (as it is called) won't calculate is the number of blisters-per-mile!

Mail Order Madness

Ace Mailtronix Ltd ('Component supplies for electronic enthusiasts') have made a good start in 1982 with the early release of their new mail order catalogue.

New additions include low-leakage electrolytic capacitors, more cases and an expanded LED range, including rectangular and triangular types, indicators and bargraphs. The IC range has been considerably improved both for linear and logic devices and the keyboard range now includes keyboard switches and complete keyboards.

Their development pack of resistors ought to be of interest to every electronic hobbyist; it consists of 600 resistors with values between 1R and 10M, in quantities of either 5, 10, 15 or 20, depending on popularity.

The Ace Mail Order Electronic Component Catalogue may be obtained by sending 30p to Ace Mailtronix Ltd, 3A, Commercial Street, Batley West Yorks WF17 5HJ.

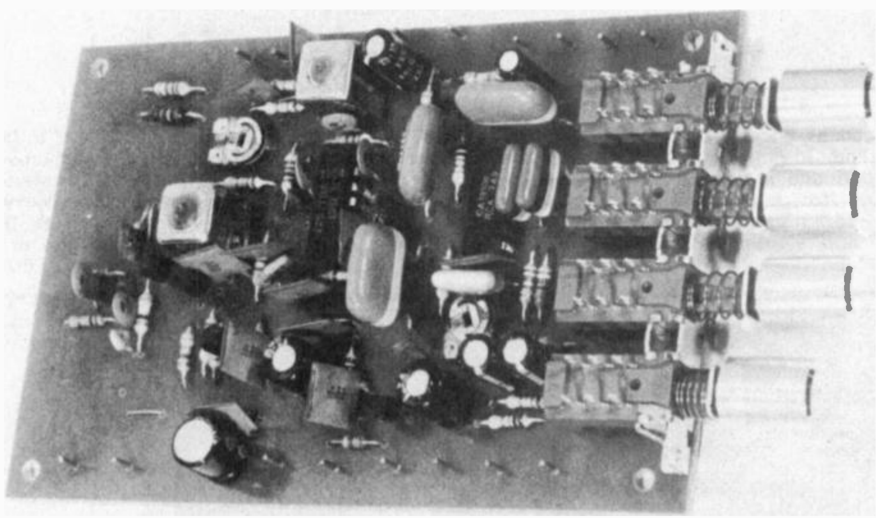
As a special service to hobbyists, Ace is prepared to look for components which the constructor cannot obtain elsewhere, on receipt of a stamped addressed envelope.

Velleman Discovers the UK

Velleman electronic kits, previously available only in other parts of Europe, have landed in the UK and are now available from Velleman UK Ltd.

The kits are designed to satisfy electronics enthusiasts, from the novice to the experienced kit-builder, with projects that range from a simple three-tone bell to a microprocessor-controlled EPROM programmer. Each kit is given a "degree of difficulty" grading to help prospective constructors choose an appropriate project; prices range from £3 to £300.

At present, the kits are available only from Velleman UK, however, they will be more generally available later in 1982. Write for a free catalogue to Velleman UK, PO Box 30, St. Leonards-on-Sea, East Sussex TN37 7NL or 'phone Hastings (0424) 753246. The range of kits is expanding rapidly and already new lines are being added to meet popular demand. Recent additions include a stereo input selector with DC control, a stereo volume and tone control unit and a "very special" microprocessor controlled timer. The technical details are available free on request from the above address.



Bi-Kits

The new S.453 Stereo FM Tuner module from Bi-Pak Semiconductors offers push-button varicap tuning for four fequencies, phase-locked loop decoder for mono or stereo and provision for the addition of a LED stereo indicator, centre-zero tuning meter and a mono/stereo switch.

The tuning range is from 88-108 MHz with a sensitivity of 4 uV for 30 dB signal to noise ratio and the audio output is of the order of 200 mV; operating voltage is in the range 18-25 V.

The module is carefully designed for stability and may be used in a wide range of applications. The price is £21.85 including VAT, plus £0.50 p&p, from Bi-Pak Semiconductors, PO Box 6, Ware, Herts SG12 9AG.

Tooling Up

Meanwhile, the carpenters are hard at work repairing the damage to Monitor's Newsdesk caused by the arrival, with a resounding thump, of two Cooper Tools catalogues.

The Electronic Catalogue, 1981-82, covers the very extensive range of Weller soldering irons and Xcelite pliers and cutters, screwdrivers and nutdrivers and a variety of special tools (eg tweezers and clamps — very useful for fine work).

The general catalogue contains, in addition, the complete range of Nicholson files, Lufkin measuring tapes (for long jobs), Crescent adjustable wrenches and screwdrivers and, for those moments when it's all too much, the range of Plumb hammers and axes.

Mr. Jonathan Bird of Cooper Tools Ltd., Sedling Road, Washington, Tyne and Wear NE38 9BZ (phone Washington (0632) 466063) will be pleased to supply further information on the Cooper Tools range.

Electronics For Hobbyists

A new company, Electronic Hobbies Ltd., has been formed with the specific aim of providing hobbyists, experimenters and small companies with small-quantity orders of high technology electronics and computer products.

The product range includes production equipment and tools such as PCB exposure boxes, hand tools, soldering irons etc;test equipment (low cost oscilloscopes) and microelectronic products (for example, microprocessors and support devices, control circuits etc).

Sample prices are attractive — 'scope prices range from £145 to 355, for example — and a full price list/catalogue is being prepared. The company is based at 17 Roxwell Road, Chelmsford, Essex .

Atari Games

Ingersoll Electronics, UK distributors op the Atari 400 and 800 personal computers, have released a new selection of entertainment packages developed by Thorn EMI Video Programmes. Titles include puzzles with nursery rhyme themes, jigsaws and board games, plane and submarine-attack simulators and a schematic cube problem with 300 variations

All programs make full use of the Atari facilities for full colour graphics and animation, plus authentic sound effects (the darts game, which offers 300 variations for up to four players, even simnulates the sound of a dart hitting a wire!).

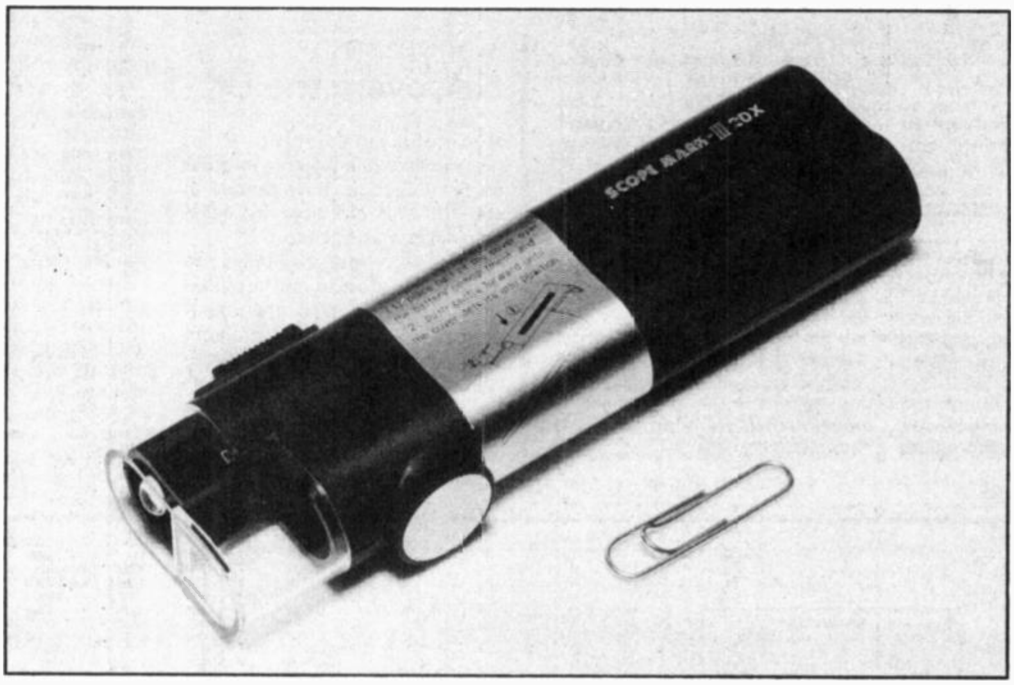
The new titles are available nationwide through the network of Atari dealers or through the rental companies DER, Radio Rentals and MultiBroadcast. For a full list of titles and prices (which range from £14.95 to £29.95), contact your local dealer or write to Ingersoll Electronics Ltd., 202 New North Road, London N1 7BL, 'phone 01 359 0161.

SCHOOLS PRIZE

DASH — Distress Alarm for the Severely Handicapped — is a project developed by Carlton Evans, from Brentwood, Essex. It monitors skin response, indicating pain and stress, or relaxation.

DASH has met with a favourable response from the medical profession, who find it useful for showing the condition of patients otherwise unable to communicate.

MONITOR



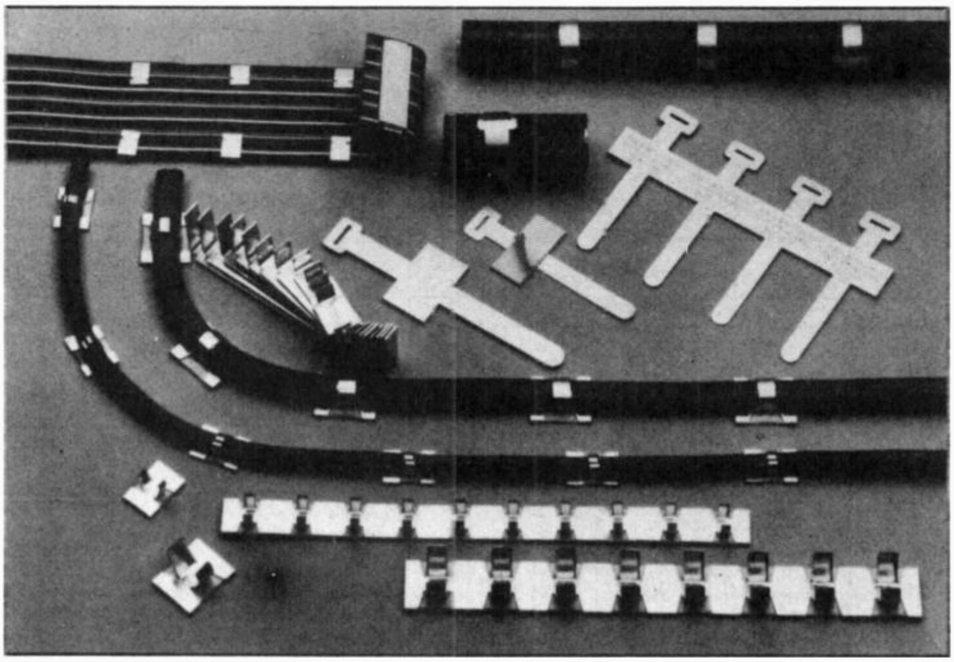
Details Examined

Another new release from Stotron Ltd is a pocket microscope priced at under £20 including stand. It provides 20x magnification and would be a useful tool for laboratories, schools, workshops, service engineers and electronics enthusiasts.

It measures just 125 mm long, has a graticule for linear and angular measurements and is powered by standard 1V5 'penlight' batteries.

A micro-stand, with spring-clips for sample slides, is available, allowing it to be used like a conventional microscope.

Stotron Ltd are located at Unit 1, Haywood Way, Ivyhouse Lane, Hastings, East Sussex; write for a catalogue or phone Hastings (0424) 442160.



Hey, Good Looking

The almost universal use of printed circuit board or Veroboard has made the "rats nest" syndrome (several yards of various-coloured wires snaking through the innards of a chassis) virtually obsolete. Nevertheless, most electronics projects require some off-board components which must be wired to a PCB or Veroboard and if neatness is important to you, some way must be found to keep those wires from tangling potentiometer shafts or snarling-up in a finned heatsink.

If you like your finished works to look good on the inside as well as the outside, Brandauer adhesive cable clips from Stotron Ltd will keep internal wiring in its proper place.

The range can handle single cables or bunches of wires, from a few millimetres diameter up to 19 mm (¾in) or even lengths of flat ribbon cable. The adhesive is instant and the polyethylene pads provide a high level of insulation from the mounting surface.

Apart from their usefulness to the electronics constructor, they would also be handy for DIY wiring jobs around the house.

Brandauer cable clips are available through Stotron's mail order service: write for a catalogue to Stotron Ltd., Unit 1, Haywood Way, Ivyhouse Lane, Hastings, East Sussex or phone Hastings (0424) 442160.

HE

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POLYESTER CAPACITORS: Axial Lead Type
400V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8 11p; 10n, 15n, 18n, 22n 12p; 33n, 47n, 68n 16p; 100n, 150n 20p; 220n 30p; 330n 42p; 470n 52p; 680n 60p; 1µF 68p; 2µ2 82p; 4µ7 85p.
160V: 10nF, 12n, 100n 11p; 150n, 220n 17p; 330n, 470n 30p; 680n, 38p; 1µF 42p; 1µ5 45p; 2µ2 48p.
1000V: 1nF 17p; 10nF 30p; 15n 40p; 22n 36p; 33n 42p; 47n 48p; 100n 50p; 470n 99p.

POLYESTER RADIAL LEAD CAPACITORS: 250V:
10nF, 15n, 22n, 27n 6p; 33n, 47n, 68n, 100n 7p; 150n, 220n 10p; 330n, 470n 13p; 680n 19p; 1µF 23p; 1µ5 40p; 2µ2 46p; 4µ7 60p.

ULTRASONIC TRANSDUCERS
40kHz 395p/pr

ELECTROLYTIC CAPACITORS: (Values are in µF) 500V: 10 52p; 47 78p; 250V: 100 65p; 63V: 0.47, 1.0, 1.5, 2.2, 2.5, 3.3 8p; 4.7 9p; 6.8, 10 10p; 15, 22, 12p; 33 15p; 47 12p; 100, 19p; 1000 70p. 50V: 47 12p; 68 20p; 220 24p; 470 32p; 2200 90p. 40V: 4.7, 15, 22 9p; 3300, 90p; 4700, 120p; 25V: 1.5, 6.8, 10, 22 8p; 33 9p; 47 8p; 100 11p; 150 12p; 220, 15p; 330 22p; 470 25p; 680, 1000, 34p; 2200, 50p; 3300, 76p; 4700 92p; 16V: 40, 47, 100 9p; 125, 12p; 220 13p; 470, 20p; 680 34p; 1000 27p; 1500, 31p; 2200 36p; 3300 74p; 4700 79p.
TAG-END TYPE: 70V: 4700, 245p; 64V: 3300 198p; 2200 139p; 50V: 3300 154p; 2200 110p; 40V: 4700 160p; 25V: 10,000 320p; 15,000 345p.

TANTALUM BEAD CAPACITORS
35V: 0.1µF, 0.22, 0.33 15p; 0.47, 0.68, 1.0µF, 1.5 16p; 2.2, 3.3 18p; 4.7, 6.8 22p; 10µF 28p; 16V: 2.2, 3.3 16p; 4.7µF, 6.8, 10 18p; 15, 36p; 22 30p; 33, 47 40p; 100 75p; 220 88p; 10V: 15, 22, 26p; 33, 47 35p; 100 55p; 6V: 100 42p.

MYLAR FILM CAPACITORS
100V: 1nF, 2, 4, 4n7, 10 6p; 15nF, 22n, 30n, 40, 47 7p; 56 100n, 200 9p; 470n/50V 12p.

MINIATURE TYPE TRIMMERS
2-6pF, 2-10pF, 2-25pF, 5-56pF 30p.

COMPRESSION TRIMMERS
3-40pF, 10-80pF 20p; 20-250pF 28p; 100-580pF 39p; 400-1250pF 48p.

POLYSTYRENE CAPACITORS:
10pF to 1nF 8p; 1.5nF to 10nF 10p.

SILVER MICA (Values in pF) 2, 3.3, 4.7, 6.8, 8.2, 10, 15, 18, 22, 27, 33, 39, 47, 50, 56, 68, 75, 82, 85, 100, 120, 150, 180pF 15p each;
200, 220, 250, 270, 300, 330, 360, 390, 470, 600, 800, 820 21p each
1000, 1200, 1800, 2200 30p each
3300, 4700pF 60p each

CERAMIC CAPACITORS 50V: 0.5pF to 10nF 4p; 22n to 47n 5p; 100n 7p.

POTENTIOMETERS: Rotary Carbon Track 0.25W Log & 0.5W Lin

500Ω, 1KΩ & 2KΩ (Linear only) Single Gang	29p
5KΩ-2MΩ Single Gang	29p
5KΩ-2MΩ Single Gang D/P Switch	78p
5KΩ-2MΩ Double Gang	88p

SLIDER POTENTIOMETERS

0-25W log and linear values 60mm	
5KΩ-500KΩ single gang	70p
10KΩ-500KΩ dual gang	110p
Self Stick Graduated Bezel	40p

PRESET POTENTIOMETERS
Vertical & Horizontal

0.1W 50Ω—5MΩ Miniature	7p
0-25W 100Ω—3.3MΩ horiz.	10p
0-25W 200Ω—4.7MΩ vert.	10p

RESISTORS – Carbon Film High Stability, Low Noise, Miniature Tolerance 5%

	RANGE	VAL	1-99	100+
¼W	2Ω2-4M7	E24	2p	1p
½W	2Ω2-4M7	E12	2p	1p
1W	2Ω2-10M	E12	5p	4p
2% Metal Film 10Ω-1M			6p	4p
1% Metal Film 51Ω-1M			8p	6p

100+ price applies to Resistors of each value not mixed.

Gas and Smoke Detectors TGS 812 and 813 575p

OPTO ELECTRONICS
LEDs with Clips

TIL209 Red	13
TIL211 Grn.	18
TIL212 Yel.	18
.2" Red	14
.2" Yell or Grn	18
Square LEDs	29
ORP12	86
2N5777	45
LD271	46
SFH205	98
TIL32	52
TIL78	54
TIL38	65
TIL100	90
7 Segment Displays	
TIL321 .5 CA	115
TIL322 .5 CC	115
DL704 .3 CCth	99
DL707 .3 CA	99
.3 Green CA	120
DL747 .6 CA	180
FND357	120
MAN3640	175
10 Seg Bargraph	225
LCD 3½ Digits	550

SWITCHES

TOGGLE: 2A 250V-	
SPST	33
DPDT	44
4 Pole on/off	54
SUB-MIN TOGGLE	
SP changeover	60
SPST on/off	54
DPDT 6 tags	75
DPDT c/off	80
DPDT Biased	145
SLIDE 250V:	
1A DPDT	14
1A DP c/off	15
½A DPDT	13

We stock most of the parts for the Projects in this magazine

ACCESS
Just phone your order through. We deal with the rest (but min. £10 please).

SWITCHES Miniature Non Locking Push to Make 15 Push Break 20
ROCKER: SPST on/off 10A/250V 28
ROCKER: Illuminated (black)chrome bezel, lights when on DPST 3A 240V 65
ROTARY: (ADJUSTABLE STOP) 1 pole/2-12 way, 2p/2-6 way, 3p/2-4 way, 4p/2-3 way 45
ROTARY: Mains 250V AC. 4 Amp 52

DIL SOCKETS: 8-pin 8p; 14-pin 10p; 16-pin 10p; 18-pin 16p; 20-pin 22p; 24-pin 25p; 28-pin 28p; 40-pin 30p.

VOLTAGE REGULATORS

1A	TO3	+ ve		− ve	
5V	7805	145p		7905	220p
12V	7812	145p		7912	220p
15V	7815	145p		—	
18V	7818	145p		—	

1A	TO220 Plastic Casing			
5V	7805	45p	7905	55p
12V	7812	50p	7912	55p
15V	7815	50p	7915	55p
18V	7818	50p	7918	55p
24V	7824	50p	7924	55p

100mA	TO92 Plastic Casing			
5V	78L05	30p	79L05	60p
6V	78L62	30p		
8V	78L82	30p		
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	60p

CA3085	95p	LM323K	500p	TAA550	50p
LM300H	170p	LM325N	240p	TBA625B	75p
LM305H	140p	LM326N	240p	TDA1412	150p
LM309K	135p	LM327	270p	78H05	560p
LM317K	350p	LM723	35p	78HG5	550p

JACKSONS VARIABLE CAPACITORS

Dielectric		0 2 365pF with slow motion drive	495p
100/300pF	220p	00 208/176	435p
500pF	250p	00 208/176 with slow motion drive	495p
6:1 Ball Drive 4511/DAF	185p		
Dial Drive 4103 6:1/36:1	775p	C804-5pF: 10: 15: 25: 50pF	278p
Drum 54mm	59p	100, 150pF	350p
0-1.365pF	350p	'L' 3×310pF	725p
00-2.365pF	435p	00-3×25pF	575p

DENCO COILS

'DP' VALVE TYPE		RFC 5 chokes	140p
Range 1 to 5 BL, RD, Tl Wht.	122p	RFC 7 (19mH)	160p
6-7 B-Y-R	110p	13; 14; 15; 16; 17	120p
1-5 Green	150p	18/1.6	135p
'T' type 1 to 5, Bl, Rd. Wht. Yl	150p	18/465	152p
B9A Valve Holder	42p	TOC 1	124p
		MW5FR	122p
RDT2	145p	MW/LW SFR	154p

VEROBOARD

0.1 Pitch	clad	plain
2½ × 3¾	73p	52p
2½ × 5	83p	–
3¾ × 3¾	83p	–
3¾ × 5	95p	79p
3¾ × 17	326p	211p
4¾ × 17	426p	–
Pkt of 100pins	50p	
Spot face cutter	118p	
Pin insertion tool	162p	

COPPER CLAD BOARDS

Fibre glass 6×6"	90p
6×12"	150p
SRBP 9×8	95p
Ferric Chloride 1lb Anhydr	195p

DIODES

BY126	12
BY127	12
CR033	250
OA9	40
OA47	12
OA70	12
OA79	15
OA85	15
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
IN914	4
IN916	5
IN4001/2	5
IN4003	6
IN4004/5	6
IN4006/7	7
IN4148	4
IN5401/2	15
IN5404	18
IN5406	17
IN5408	19
IS44	5
1S921	8
6A/100V	40
6A/400V	50
6A/800V	65

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(plastic case)	p
1A/50V	20
1A/100V	22
1A/400V	28
1A/600	34
2A/50V	35
2A/200V	46
2A/400V	48
2A/600V	85
6A/100V	83
6A/400V	96
6A/600V	125
10A/200V	215
10A/400V	350
25A/200V	240
25A/600V	395
BY164	56
VM18	50

DIAC
ST2 25

SCRs Thyristors

1A200V	58
1A400V	70
5A/400V	40
5A/600V	48
8A/300V	60
8A/600V	95
12A/100V	78
12A/400V	95
12A/800V	188
BT106	150
BT116	180
C106D	38
TIC44	24
TIC45	29
TIC47	35
2N5062	32
2N5064	38
2N4444	130

TRIACS

3A100V	48
3A200V	54
3A400V	56
8A100V	60
8A400V	69
8A800V	115
12A100V	78
12A400V	82
12A800V	135
16A100V	103
16A500V	115
25A800V	220
25A1000V	480
T28000D	120

7400 TTL

7400	11	7441	68	7497	120
7401	11	7442	38	74100	85
7402	11	7443	90	74104	54
7403	14	7444	90	74105	55
7404	14	7445	65	74107	32
7405	18	7446	55	74109	35
7406	28	7447	50	74110	40
7407	28	7448	50	74111	55
7408	16	7450	16	74112	170
7409	16	7451	16	74116	88
7410	14	7453	16	74118	80
7411	20	7454	16	74119	90
7412	20	7460	16	74120	75
7413	24	7470	35	74121	30
7414	32	7472	30	74122	45
7416	25	7473	30	74123	50
7417	25	7474	25	74125	42
7420	16	7475	40	74126	40
7421	20	7476	30	74128	42
7422	20	7480	48	74132	48
7423	22	7481	120	74136	35
7425	28	7482	70	74141	70
7426	30	7483	50	74142	190
7427	27	7484	80	74143	250
7428	28	7485	95	74145	70
7430	16	7486	26	74147	99
7432	26	7489	205	74148	75
7433	27	7490	28	74150	80
7437	27	7491	45	74151	45
7438	27	7492	30	74153	45
7440	17	7493	30	74154	75
		7494	34	74156	75
		7495	50	74157	45
		7496	45	74159	99

74160	60	74182	75
74161	60	74184	99
74162	62	74185	99
74163	84	74188	290
74164	64	74190	70
74165	62	74191	70
74166	65	74192	70
74167	185	74193	65
74170	168	74194	75
74172	290	74195	65
74173	65	74196	65
74174	72	74197	65
74175	72	74198	99
74176	55	74221	80
74177	75	74246	150
74178	95	74247	150
74180	65	74248	150
74181	140		

74LS

74LS00	12	LS48	80	LS151	39
LS01	13	LS55	30	LS153	39
LS02	14	LS63	150	LS155	39
LS03	14	LS73	25	LS157	35
LS04	15	LS74	25	LS158	36
LS05	15	LS75	28	LS160	41
LS06	15	LS76	20	LS161	41
LS08	15	LS83	50	LS162	41
LS09	15	LS85	70	LS163	41
LS10	15	LS86	38	LS164	48
LS11	15	LS90	35	LS165	145
LS12	15	LS92	36	LS166	85
LS13	30	LS93	36	LS173	72
LS14	48	LS95	45	LS174	72
LS15	15	LS96	120	LS175	58
LS20	15	LS107	43	LS181	130
LS21	15	LS109	30	LS190	58
LS22	15	LS112	30	LS191	58
LS26	18	LS113	40	LS192	58
LS27	15	LS114	35	LS193	65
LS28	20	LS122	44	LS195	40
LS30	18	LS123	55	LS196	58
LS32	15	LS124	105	LS197	85
LS33	16	LS125	30	LS221	60
LS37	16	LS126	30	LS240	96
LS38	16	LS132	45	LS241	96
LS40	16	LS133	35	LS242	85
LS42	35	LS136	28	LS243	85
LS47	40	LS138	35	LS244	80
		LS139	38	LS245	118
		LS145	75	LS247	40
		LS147	199	LS248	65
		LS148	99	LS249	68
				LS251	40
				LS253	40
				LS257	48

CMOS

4000	14	4027	38	4054	125	4089	140
4001	14	4028	58	4055	125	4093	43
4002	14	4029	77	4056	120	4094	168
4006	66	4030	50	4057	1915	4095	90
4007	18	4031	170	4059	480	4096	90
4008	62	4032	125	4060	90	4097	320
4009	35	4033	165	4061	1225	4098	88
4010	40	4034	195	4062	995	4099	95
4011	15	4035	95	4063	99	4160	95
4012	18	4036	275	4066	36	4161	99
4013	34	4037	115	4067	399	4162	99
4014	75	4038	110	4068	22	4163	99
4015	66	4039	290	4069	20	4174	99
4016	32	4040	59	4070	26	4175	105
4017	48	4041	78	4071	20	4194	105
4018	68	4042	60	4072	20	4408	790
4019	42	4043	70	4073	20	4409	790
4020	61	4044	65	4075	20	4410	725
4021	70	4045	170	4076	60	4411	695
4022	66	4046	75	4077	26	4412	800
4023	20	4047	75	4078	26	4415	480
4024	45	4048	55	4081	26	4419	280
4025	19	4049	30	4082	21	4422	770
4026	130	4050	30	4085	65	4433	770
		4051	78	4086	70	4435	850
		4052	78			4440	999
		4053	78			4450	350

4451	350
4490	350
4500	675
4501	28
4502	90
4503	50
4504	105
4506	65
4507	40
4508	265
4510	68
4511	68
4512	75

ICs

2114L-3	88	CA3020	186
2708	195	CA3023	191
2716	210	CA3028A	120
4116	85	CA3035	235
6502	450	CA3045	365
6522	350	CA3046	70
6800	375	CA3048	214
709C 8 pin	35	CA3059	195
710	48	CA3075	213
733	100	CA3080E	65
741 8 pin	14	CA3081	190
747C	78	CA3085	95
748C	36	CA3089E	215
753	150	CA3090AQ	375
810	159	CA3123E	150
81LS95	90	CA3130	90
81LS96	90	CA3140	48
81LS97	90	CA3189	295
9400CJ	350	ICL7106E	795
AY-1-1313A	660	ICL7107	975
AY-1-1320	225	ICL8038CC	340
AY-1-5050	99	ICM7205	1150
AY-1-5051	160	ICM7216A	1950
AY-3-8500	390	ICM7217A	790
AY-3-8910	720	ICM7555	80
AY-5-1224A	235	LA4032	295
AY-5-1230	450	LC7120	385
CA3011	110	LC7130	495
CA3018	68		

LF351	48	MC1488	62	SAB3210	275
LF355	75	MC1489	82	SAB3271	485
LF356	90	MC1494	694	SN76477	175
LM300H	170	MC1495	350	SP8629	299
LM301A	26	MC1496	92	TAA621	250
LM308	95	MC1648	290	TA7205A	225
LM318	200	MC1709G	90	TAD100	159
LM324	45	MC1710	79	TBA120	70
LM339	68	MC3302	150	TBA641	275
LM348	90	MC3340P	120	TBA800	80
LM349	115	MC3360P	120	TBA810	95
LM358	75	MC3401	52	TBA820	70
LM379	480	MC3403	110	TCA965	120
LM380	75	MFC6040	97	TDA1004	290
LM381	145	MK50398	635	TDA1008	310
LM382	125	MM5303	635	TDA1022	575
LM384	99	NM5307	1275	TDA1024	105
LM386	99	NE529	225	TDA1490	290
LM387	120	NE543	210	TDA2020	320
LM1458	45	NE544	185	TL061	40
LM2917	195	NE555	16	TL063	80
LM3900	60	NE556	55	TL071CP	30
LM3909N	70	NE560	325	TL074	100
LM3911	125	NE561	398	TL081	25
LM3914	220	NE562	410	TL082	45
LM3915	220	NE564	420	TL083	75
LM3916	240	NE565	120	TL084	95
LS7220	280	NE566	150	UAA170	170
M252	625	NE567	150	UAA180	170
M253AA	1150	NE570	450	XR2206	300
MC1304P	260	NE571	420	XR2211	575
MC1310	150	RC4136	69	Z80CPU	390
MC1455	150	S566B	245	Z80ACPU	495
MC1458	45	SAB3209	425	Z80ACTC	325

Z80CTC	300	ZN426E	325
Z80P10	300	ZN427	625
Z80AP10	325	ZN428	478
ZN1040E	675	ZN429	210
ZN424E	130	ZN1034E	200
ZN425E	415	ZN1040E	775

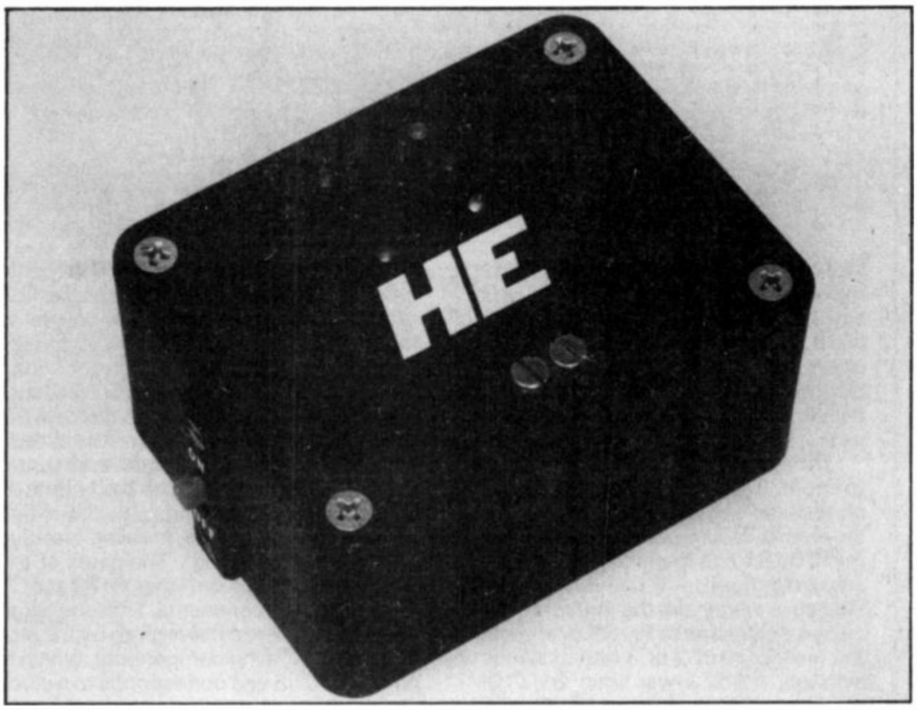
TRANSISTORS

AC125	35	BC477	40	E421	250	TIS44	45	2N3252	46
AC126/7	35	BC516/7	40	MJ2955	90	TIS88A	50	2N3442	140
AC128	30	BC547/8	14	MJE340	54	TIS90	30	2N3568	25
AC141/2	30	BC549	14	MJE370	100	TIS91	32	2N3663	15
AC176/87	30	BC556/7	15	MJE371	100	VK1010	80	2N3702/3	10
AC188	30	BC558/9	15	MJE520/1	95	VN10KM	45	2N3704/5	10
ACY17/18	70	BCY70	16	MJE2955	99	VN46AF	78	2N3706/7	10
ACY20/1	75	BCY71	18	MJE3055	70	VN66AF	85	2N3708/9	10
ACY22	60	BCY72	20	MPF102	66	VN88AF	94	2N3710/11	10
AD140	120	BD131/2	48	MPF103	36	ZTX107/8	11	2N3713	140
AD149	79	BD133	60	MPF104	36	ZTX109	12	2N3771	179
AD161/2	42	BD135	45	MPF105	36	ZTX300	13	2N3772	195
AF115	60	BD136/7	40	MPF106	40	ZTX301/2	16	2N3773	270
AF139	40	BD138/9	40	MPSA05/6	25	ZTX303	25	2N3819	22
AF178	75	BD140	40	MPSA12	30	ZTX304	17	2N3820	45
AF180/6	70	BD695A	85	MPSA55	30	ZTX314	25	2N3822/3	65
AF239	78	BD696A	85	MPSA56	30	ZTX326	30	2N3866	90
BC107/8	10	BDY17	195	MPSU06	55	ZTX341	30	2N3903/4	18
BC108B	12	BDY60	160	MRSU56	60	ZTX500	14	2N3905	15
BC108C	12	BDY61	160	OC28	120	ZTX501/2	15	2N3906	17
BC109	10	BF115	35	OC35	125	ZTX503	18	2N4037	46
BC109B	12	BF167	29	OC36	120	ZTX504	25	2N4058	10
BC109C	12	BF173	27	OC41/2	120	ZTX531	25	2N4061/2	10
BC117	24	BF177	25	OC44	120	ZTX550	25	2N4069	45
BC119	38	BF178	30	OC45/70	40	2N526	58	2N4859	78
BC137	40	BF179	35	OC71/2	40	2N696	30	2N4871	55
BC140/3	30	BF180	38	OC76	50	2N697	23	2N5135/6	20
BC147/8	9	BF194/5	12	OC81/2	50	2N698	40	2N5138	18
BC149	9	BF196/7	12	OC83/4	40	2N699	48	2N5179	45
BC153/4	27	BF198	16	OC170/1	85	2N706	19	2N5180	45
BC157/8	10	BF200	30	TIP29	34	2N918	35	2N5191	75
BC159	11	BF224A	25	TIP29C	60	2N930	20	2N5305	24
BC160	45	BF244	28	TIP30	42	2N961	65	2N5457/8	38
BC167A	10	BF256	35	TIP30A	48	2N1131/2	24	2N5459	36
BC168C	10	BF257/8	32	TIP30C	58	2N1304	65	2N5485	36
BC169C	10	BF259	35	TIP31A	45	2N1305	60	2N5777	45
BC170	15	BF594/5	40	TIP31C	55	2N1306/7	65	2N6027	32
BC171/2	11	BFR39/40	23	TIP32A	48	2N1671B	120	2SA715	60
BC177/8	20	BFR41/79	23	TIP32C	60	2N2160	350	2SC495	70
BC179	20	BFR80/81	25	TIP33A	65	2N2219A	28	2SC496	70
BC182/2L	10	BFX29	28	TIP33C	78	2N2220A	23	2SC1096	85
BC183/L	10	BFX81	45	TIP34A	74	2N2222	25	2SC1173	125
BC184	10	BFX84	26	TIP34C	88	2N2369A	18	2SC1306	150
BC184L	10	BFX85/6	28	TIP35A	160	2N2476	50	2SC1307	220
BC187	26	BFX87/8	28	TIP35C	185	2N2483	27	2SC1449	85
BC212	10	BFY50/1	23	TIP36A	170	2N2497	83	2SC1923	50
BC212L	10	BFY52	23	TIP36C	199	2N2646	45	2SC1945	225
BC213	10	BRY39	40	TIP41A	55	2N2894	30	2SC1953	90
BC213L	10	BSX20	20	TIP41B	60	2N2904	28	2SC1957	90
BC214	10	BSY65	35	TIP42A	60	2N2905A	26	2SC1969	198
BC214L	10	BSY95A	25	TIP42B	75	2N2906/7	26	2SC2028	85
BC307B	14	BU105	170	TIP120	90	2N2926G	10	2SC2029	180
BC328	95	BU205	190	TIP121/2	99	2N3053	26	2SC2078	155
BC338	15	BU208	200	TIP142	120	2N3054	58	2SC2091	85
BC441	34	E113	45	TIP147	120	2N3055	48	2SC2314	85
BC461	34	E176	50	TIP2955	60	2N3121	30	2SC2166	165
				TIP3055	60	2N3133	45	2SC1679	190
				TIS43	32	2N3135	30	3N128	112

3N140	112
40311	60
40313	130
40316	95
40317	60
40324	100
40326	60
40327	70
40347	90
40348	120
40360	40
40361/2	50
40407	60
40408	70
40411	285
40412	65
40467	130
40468	85
40594	105
40595	110
40603	110
40636	175
40673	95

DIGITAL DICE

Roll Them, bowl them!



THE DIGITAL DICE project is, as its title suggests, an electronic replacement for those spotted cube-shaped things. However, instead of being thrown around, ours is operated by touching two screws mounted on the top. The resulting display of red dots show a number from one to six with an equal chance of any number 'turning up' — or, in this case, of turning on!

The unit is powered by a small nine volt battery, so there is no possibility of getting a shock — essential when there are children around. Also, the switch can be triggered by any area of skin, enabling the handicapped to use the dice.

Construction

The Dice is designed for ease of construction and reliability. The PCB contains only three ICs, all of which are CMOS and must be handled with care (if at all!). Use sockets and an insertion tool to mount them or, failing this, make sure you never touch the pins with our fingers.

All the off-board connections are made using PCB pins, following the overlay (**Figure 2**) very closely (note that IC2 is placed upside-down in relation to the others), and remember to check the polarity of the diodes. A nice touch is to mount the resistors with the tolerance band (gold, 5%; silver, 10%) at the bottom end; this looks neat and makes the values easier to read. The PCB slots neatly into the recommended box, eliminating the need for fixing bolts.

The box should be drilled and assembled before soldering any wires to the board. Fit the LEDs to the lid first, following the layout in **Figure 3**. A tip for locating the holes is to use a piece of stripboard as a guide through which a pin is inserted to mark their positions. The holes can then be drilled using a 3 mm drill and the LEDs glued into place with epoxy resin (eg Araldite). The leads from the LEDs should be cropped to a reasonable length for soldering and wired up as shown in **Figure 3**. Links on the PCB must be made using insulated wire, to avoid any chance of short circuits occuring. Our prototype used a special square switch, but any small slide switch may be substituted.

When all the wiring has been checked, the battery can be connected and the unit switched on . . . . and you're ready for a tumble!

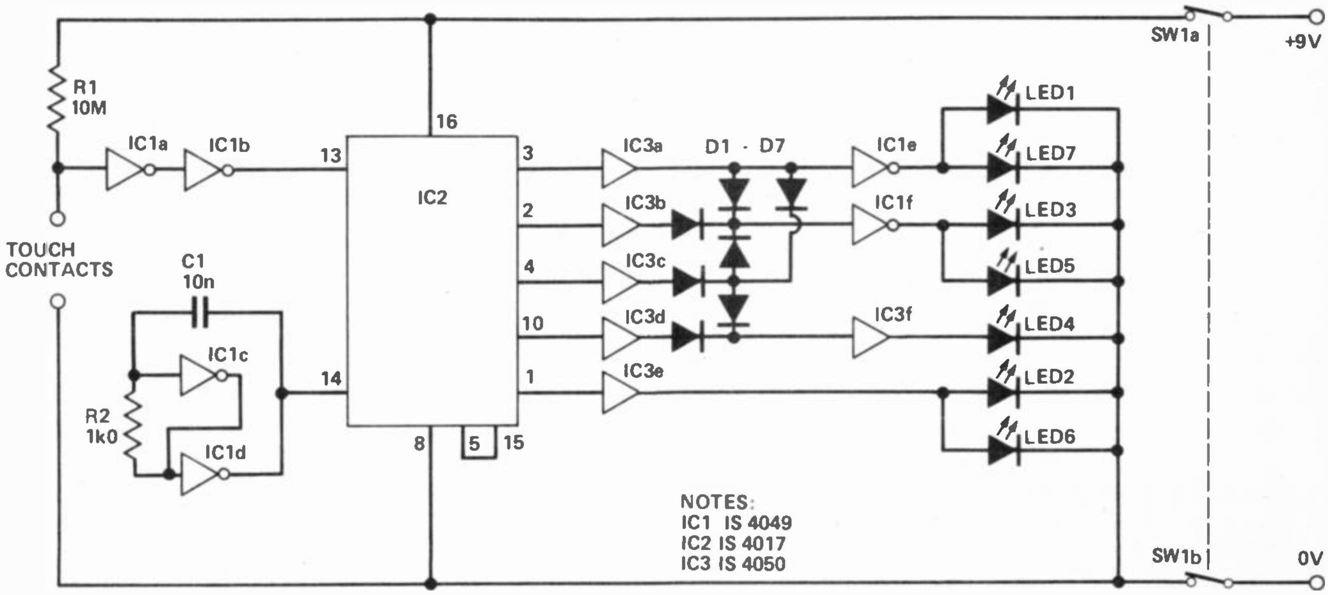
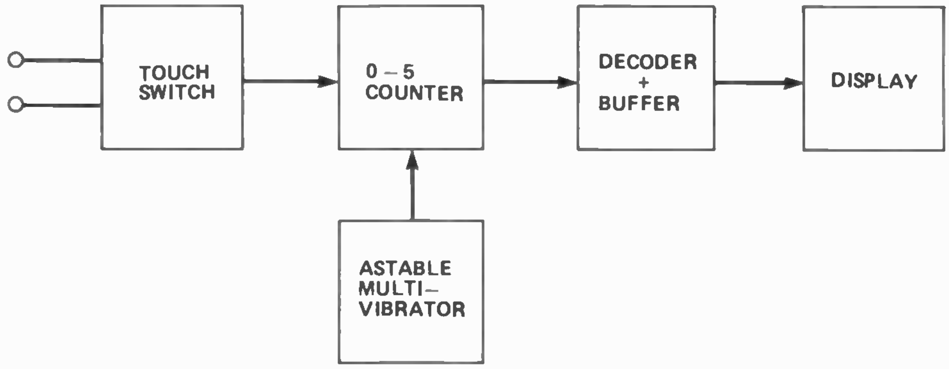


Figure 1. The circuit uses only three ICs.

How It Works



Like nearly all electronic circuits, this one may be understood if it is broken down into small blocks. This is called 'partitioning' and it is a technique used, for example, by engineers to test circuits bit by bit. From the block diagram it can be seen that there are five distinct blocks in the Digital Dice project.

The touch switch tells the counter when to count. It consists of only three parts; a resistor and two gates that are part of IC1, the inverter IC. One gate is kept at nine volts (high) by R1 and therefore its output is at zero volts (low) — it has been inverted. Placing a finger on the touch contacts causes the inverter to switch over because the resistance of 2 or 3 mm of skin is on average, much lower than R1 (10M). Therefore, IC1a input is taken low and its output goes high. The second inverter flips the signal back over, to allow the counter to be switched on — it needs zero volts at its 'enable' input (pin 13) to begin counting.

The astable multivibrator, IC1c, d, supplies a very fast switching waveform to the counter via pin 14. Every time the astable goes from a low to a high state, the counter moves its output on to the next number. The process of changing on the transition from zero to nine volts, is called 'positive going edge triggering'. The gates of the astable are connected in series via R2 and C1 — the timing components. The time taken for one complete cycle is given by the product of the timing components, which is around 10 uS and corresponds to a clock frequency of about 100 kHz, ensuring the numbers change too quickly to be predictable.

IC2 has the job of counting sequentially from zero to five, which is the same as counting from one to six. At each positive going edge from the astable one of the counter outputs goes high. Once the fifth output has been triggered, the count instantly returns to zero due to output six (pin 5) being connected to the reset input, pin 15.

The decoder and buffer circuit, on the outputs of IC2, ensure the correct LED's are lit. Buffers precede each of the six outputs to prevent loading effects, on the counter, by the LEDs. The decoding circuit can be understood with the aid of a 'truth table' (**Figure 5**).

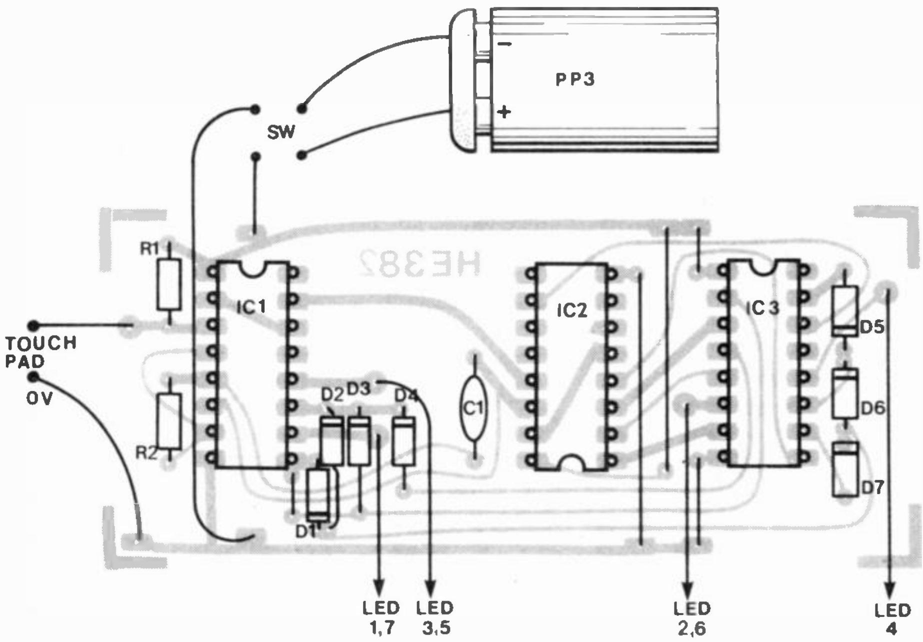


Figure 2. The component overlay; note that IC2 is reversed, relative to ICs 1 and 3.

Figure 3 (right). Truth table showing how the counter outputs are decoded. For example, if Pin 3, "0", is high (+9 V) then all other outputs will be low (0 V). Therefore: IC3a output is high, IC1e out is low and LEDs 1 and 7 are off; Pin 2 is low so IC3b output is low and its diode does not conduct — but the high on IC3a output is coupled via a diode to the input of IC1f, therefore IC1f out is low and and LEDs 3,5 are off; Pin 4 is low so IC3c out is low and its diode if off (there is a high on the cathode of the diode but this only reinforces the high on IC1f input); Pin 10 is low, IC3d out is low and its diode is off, but there is a high on IC3f input coupled, via the diodes, from IC3a, therefore IC3f output is high and LED 4 is turned ON; finally, Pin 1 is low, IC3e is low, LEDs 2 and 6 are off. Any other count can be decoded in a similar fashion.

Buylines

The components for the complete project including the case should cost less than £5. The case is available from: Frank Mozer Limited, 5 Angel Corner Parade, Edmonton., order code HB1.

Parts List

RESISTORS (all ¼ W 10%)

R1	10 M
R2	1 k

CAPACITORS

C1	10 n C280 polyester

SEMICONDUCTORS

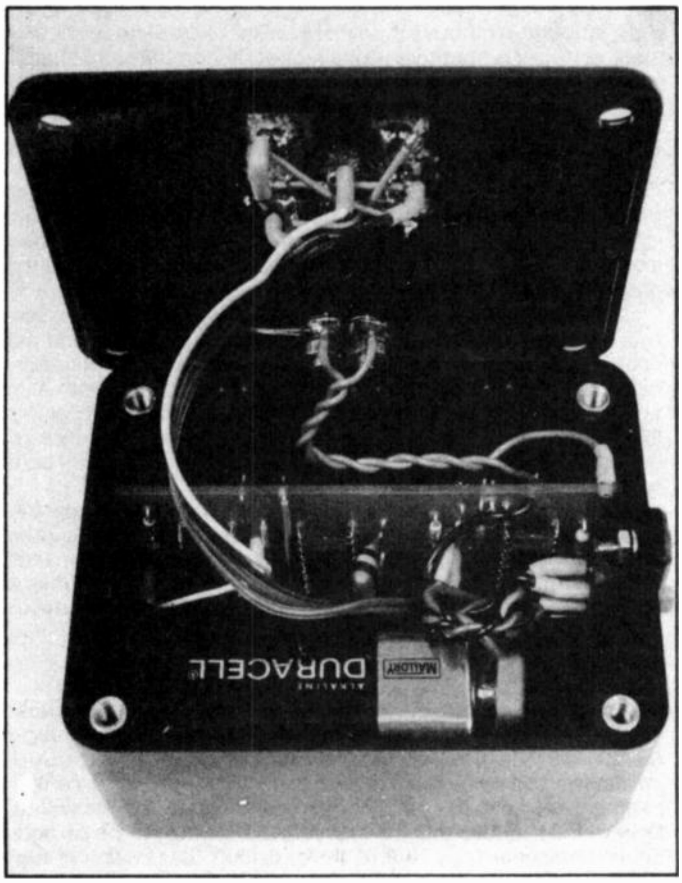
D1-D7	1N4148 or 1N914
IC1	CD4049B
IC2	CD4017B
IC3	CD4050B

LED1-LED7 0.,12" sub-miniature red LED

MISCELLANEOUS

SW1 DPDT slide switch

Case, PP3 battery and clips, nuts, bolts, etc.



COUNT	IC2 OUTPUTS					LEDs				DISPLAY
	PIN 3 "0"	PIN 2 "1"	PIN 4 "2"	PIN 10 "4"	PIN 1 "5"	1,7	2,6	3,5	4	
0	+9V	0	0	0	0	–	–	–	ON	
1	0	+9V	0	0	0	ON	–	–	–	
2	0	0	+9V	0	0	ON	–	–	ON	
3	0	0	0	0	0	ON	–	ON	–	
4	0	0	0	+9V	0	ON	–	ON	ON	
5	0	0	0	0	+9V	ON	ON	ON	–	

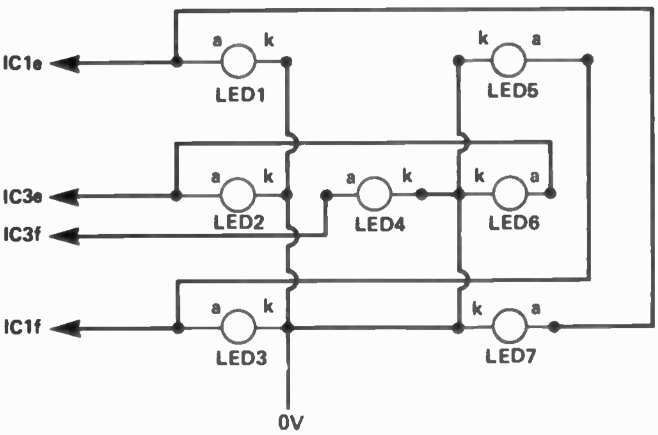


Figure 4. Connection diagram for the LED's.

HE

SCALING the Hi-Fi HEIGHTS Part 3

In may ways, loudspeakers are the most important components of a hi-fi system. After all, "What you hear is what you get".

CHOOSING THE SPEAKER for your hi-fi system involves a fair number of preliminaries. For a start, how much room can you allocate to the enclosures? If you're serious about hi-fi, then go for the most you can, as "the bigger the better" is the rule with speakers. The more air they can move, the better will be the bass and, generally, big boxes move more air than little 'uns.

Look around and decide whether you're going to use shelf-mounted units or floor-standing enclosures (these will have to be allowed for in the budget don't forget). Either approach is a valid one. There are some excellent small speakers which lack nothing but that very bottom octave of gut-moving, window-rattling, bass extension. Does this matter to you? (Really?) Go through the kind of music you intend the boxes to play and make an *honest* judgement.

For the sake of peace, have the arguments before leaving home. You've no idea how silly it looks from the other side of the counter to see people — whatever relation to each other — squabbling over whether teak or walnut finish will match grannies false teeth better, or if those huge Wharfedales will *really* go between the sideboard and the china leopard Aunt Jocasta sent from Kenya last year . . . salesmen are only human and patience is a virtue few of us have in abundance. You'll get better service if you appear organised and clear about your wants at the outset.

Two (or Three) into One

Most of the adverts you read for speakers make great play of the number of drive-units (ones) there are in the box, the tone controls on the back, the materials used, the lasers which dance across the design curves, the side of the forest the trees came from to make the veneer, how often the engineers clean their teeth, etc, etc, etc.

Well, that *might* be an exaggeration, but give the ad men a few years and you never know.

It is all quite pointless. Listen and forget the lot. If you begin by defining the physical requirements for the speakers as outlined above, then you can just settle back into the comfortable demo-room chairs and open up your ears.

At the risk of repetition, it's the sound you're interested in and not the manner by which the speaker achieves it. Use the 'blurb' as an indication to guide you to the area you're interested in — and no more.

Loudspeakers are the voice of the hi-fi system and yet remain the least technically refined. Every unit on the market has an individual character, which is clearly apparent if compared to another. Hence, extensive listening sessions are more vital than ever. Anyone who buys a pair of loudspeakers without hearing three or four competitive models directly compared to them is gambling the cost of his entire system plus that of replacement speakers.

Elephants For Reviewers?

Comparisons *have* to be simultaneous, because a person's audio memory is very short — half an hour after you've heard a speaker is too late to listen to another and try to decide between them. Your mind will have 'enhanced' the earlier impressions, be they good or bad, and rendered the comparision pretty useless.

It takes training (ie a great deal of practice!) to be able to listen to a piece of hi-fi and retain objective criteria of its sound over even a short period of time. General impressions — poor bass, high distortion, etc, are easy, but fine detail such as depth of image, amount of detail in the sound, high frequency quality and the like cannot be accurately 'stored away' indefinitely. The more experienced a person becomes, the more reliable his memory banks will prove to be.

For this reason, have your demonstration of speakers set up in a comparator box which can switch from one set to another, while the music is playing. Also make sure the cartridge in use is the one you intend using at home. This is most important of all, but if you can arrange for the turntable and amplifier to match, so much the better.

Listening

What to listen *for?* Mainly those things in music which appeal to you! Some people consider it desperately important, for instance, that a hi-fi has an excellent stereo image, ie that all the instruments and singers are spread out from the speakers and appear to have an exact position, from which they do not wander. Others will sacrifice this, to a varying extent, to get the particular sound balance they want — excellent bass, sharp high-frequencies, etc, etc.

There are some guidelines, however, which are fairly universal. A good speaker should stand the sound away from its wooden sides, so that you are not aware that the box is the source of the music.

It must also be all things to all frequencies and not stress any particular band. Units which fail this criteria will quickly become tiring at home and lead to dissatisfaction. Look also for the 'ease' with which the speaker lets the music out and lets you listen through it, to what is happening earlier in the system.

As to the type of sound, none is more correct than any other — choose the one you prefer. Just make sure that the cartridge and speaker don't aggravate each other, exaggerating weaknesses in either, or both. Try to aim for a final result which gives you the impression that a spoken voice actually sounds like a *person,* not just a hi-fi playing a voice! Sounds simple does it not? If it were, there would be far fewer brands of stereo around!

One thing to be aware of is that lining up loudspeakers wall-to-wall in a showroom will invariably effect the performance of any and all of them. The bass cones of other speakers, in particular, will move in sympathy with the unit actually playing, modifying the sound you hear. Generally, the effect is to add warmth and remove detail. This can give a totally false impression of the system.

The cure is easy, fortunately. The better dealers will move the pair you select out of the stack, if you ask nicely. Position them as you would in your room and listen again. If the result is what you want, sign the cheque — the salesman's earned it!

A loudspeaker is a transducer — that is, it converts one form of energy into another. In this case electrical energy from the amplifier output is converted into mechanical movements of the air in the listening room, ie sound.

This is achieved by use of the laws of electromagnetic induction and is exactly the same principle which lies behind electric motors — that if you pass an electric current through a wire which is close to a magnet, a force is exerted on the wire proportional to the current flowing through it.

In a loudspeaker, the wire is coiled around the end of a cone and is extremely close to a very powerful magnet. The audio current from the amplifier is passed through the coil, which moves under the influence of the magnet, taking the cone with it. The movement of the cone in turn creates sound waves in the surrounding air and these will be a good representation of the audio signal from the amplifier. How good depends on the quality of the

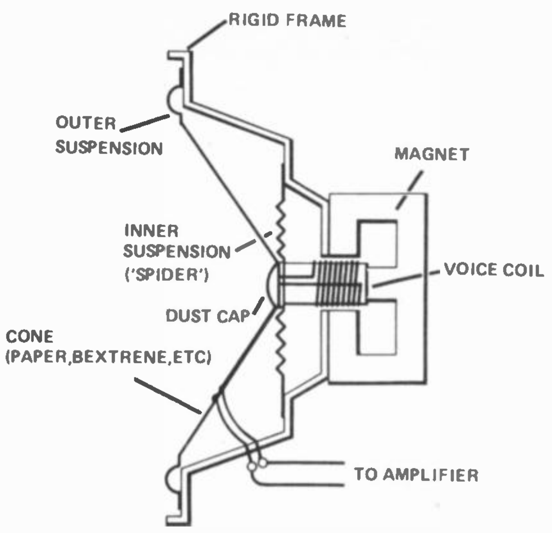


Figure 1a. Moving-coil drive unit. The voice coil (connected to the amplifier) sits centrally in the gap between the magnet poles and the longer the coil is made, the further it can move and still be controlled by the magnet, hence the unit can handle higher currents from the amp (higher power handling). This type of unit is used mainly for bass and mid-range frequencies, as there comes a point when the large cone will be unable to respond fast enough to replay the input accurately.

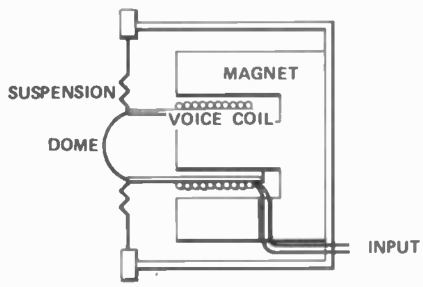


Figure 1b. Domed drive-unit for high frequencies. Here the cone is replaced with a curved 'dome' of material which is more rigid and much lighter, hence more able to respond quickly.

speaker! **Figure 1** illustrates the basics of the moving-coil drive unit, as this type of speaker is termed.

Electro-Statics

There is only one other significant method of sound reproduction on the market and that is the electrostatic loudspeaker. Here the cone and coil are both replaced by the use of a very thin and light conductive plate. This is positioned between two grilles of metal connected to a very high voltage (– 700 V) in such a way that it can move without contacting the grilles. The audio signal, which is to be replayed, is imposed upon the high voltage supply.

Once more, the varying signal imposes a force upon the conductive plate, this time electrostatically, which moves in sympathy, thus creating the required sound-waves. **Figure 2** illustrates this principle. Note that here a transformer is used between amplifier and speaker, both to even out the load and to set correct voltage levels.

Units For All Seasons

Returning to the moving coil loudspeaker — which accounts for 99.9% of all units sold — **Figure 1** shows that, as not all frequencies can be played equally well by one drive unit, most enclosures will contain two or three to handle the entire audio spectrum. The sound is split-up by the crossover network in to the bands suited to each unit so that, for example, the high-energy bass signals do not reach the more fragile high frequency drive unit.

Rarely are drive-units referred to as 'low frequency drive' or 'high frequency-moving-coil-loudspeakers'. For no good reason (other than that someone somewhere thought it amusing no

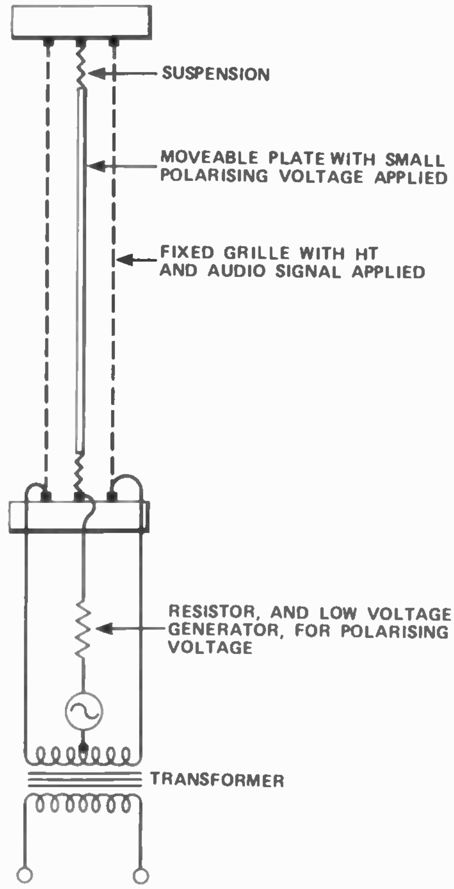


Figure 2. Electrostatic loudspeaker. The polarising voltage is to help maintain the position of the moveable plate, with a large input signal by 'offsetting' it. Note here that no magnets are used and that sound will be emitted in two directions (ie a dipole radiator).

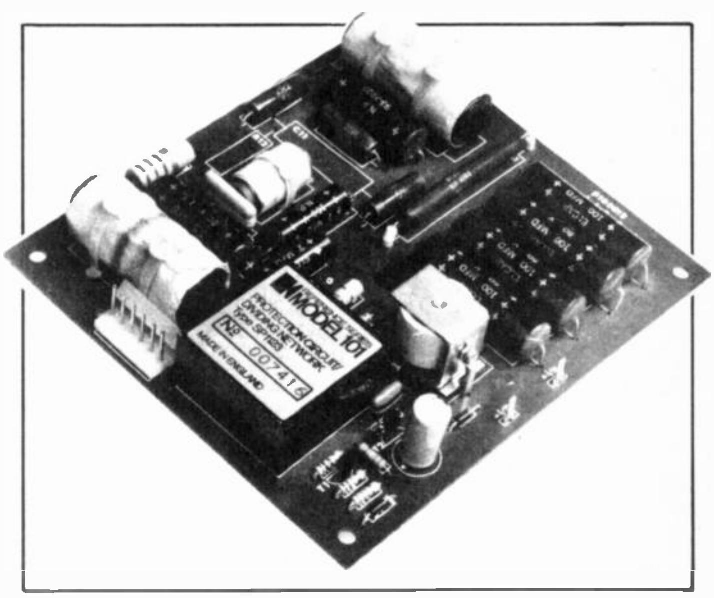


Figure 3. A typical crossover circuit. In this case the unit is the ETI V3 DIY loudspeaker which uses the three units (two of which are domed units) which provide a better spread, or dispersion of sound, than a normal cone.

doubt), bass speakers are termed 'woofers', mid-range 'sqawkers' and high-frequency 'tweeters'.

No comment.

There are also three kinds of box (enclosure) in use for hi-fi: (i) Infinite baffle or acoustic suspension. (ii) Bass Reflex. (iii) Transmission Line or acoustic labyrinth. **Figure 4** illustrates

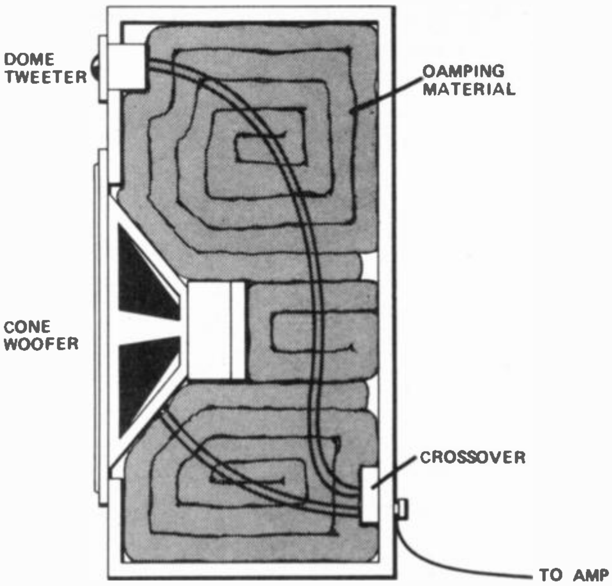
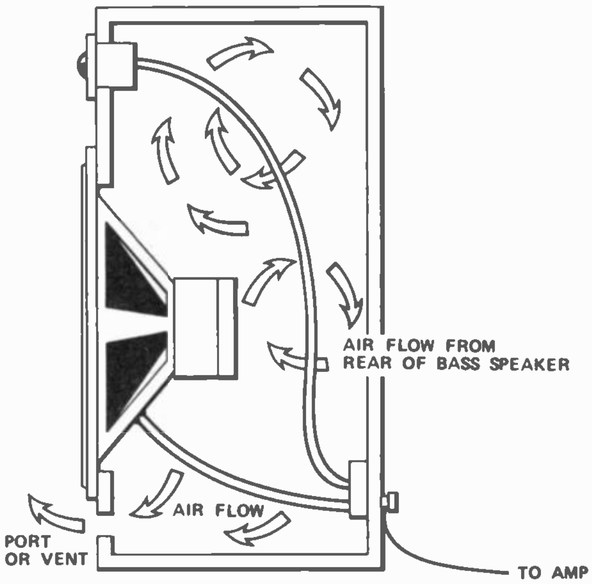


Figure 4. Enclosure types. (i) Infinite Baffle (ii) Bass Reflex (iii) Transmission Line
(i) Infinite Baffle. Box is sealed tight and air trapped inside will act as 'suspension' for the woofer, increasing the unit's power handling.
(ii) Bass Reflex. The vent or post in the front panel will, under the correct conditions, act as a supplimentary speaker unit, thereby raising the overall efficiency of the enclosure.
(iii) transmission line. Since the bass speaker is a long way from the port (and assuming the correct choice of damping materials in the 'line'), it can be considered, for all intents and purposes, to be in an infinitely long pipe! No energy is reflected back on to the unit and the enclosure has virtually *no effect* on the final sound — an ideal situation.



the principles, but as they are largely irrelevant to how a speaker sounds, we are not going to spend too much time on the differences here. Bass reflex enclosures are more efficient than the others, but at the cost of bass output. Transmission lines give the best bass response of the three, but at the cost of larger enclosures.

Take It On Spec

There are comparitively few specifications to cope with for loudspeakers buyers, which means that quite often a manufacturer or dealer will attempt to confuse the issue with the most amazing irrelevancies. As before, let your ears decide. The list below includes all the relevant technical points to watch.

Power Handling: Simply how many watts a unit can handle before disaster sets in. There are many ways of specifying this, with good old fashioned RMS still the most honest.The better manufacturers now specify a range of recommended amplifier power outputs for their units, taking into account the peak output capabilities. Try to place your amp in the centre of the range for safety. If a unit is specified only in terms of 'music' or 'programme' power, halve the figure to get a useful RMS equivalent.

Efficiency/Sensitivity: The former means how well a unit translates input into output with minimal losses and the latter means how much output is obtained for a given input. In other words, the two mean the same thing to a purchaser! Efficiency is usually specified in terms of percentage, ie 20% efficient means that 80% of input is lost. Average loudspeakers — if such things exist — are around 0.3% efficient! So that 99.7% of input ends up as heat and electrical losses! Only horn loudspeakers, where a special method of coupling to the air is used, can exceed 1%. They manage 20% or so but cost the penalty of huge enclosures for bass. It is no exaggeration to say that to have a pair of full range horn speakers at home, you'd be living *in* them rather than *with* them . . . Commercial units are a compromise. Sensitivity is nowadays quoted as the sound output (in dB) for 1 W of full-range input, such as pink-noise. Each *doubling* of power then adds 3 dB to the output. (As 2 dB is about the *smallest* perceptable change the ear can detect, high-power amps become easier to appreciate at this point). As a guideline, 90 dB is loud, 96 dB about the point where your body begins moving to the music (who's dancing?) and 100 dB around the onset of pain. Look for a sensitivity figure above 85 dB and take care with the amplifier output figure. For example: speaker A has 88 dB sensitivity, amplifier 60 W RMS output and amplifier C 200 W output. Amp B can obtain around 106 dB from the speaker and Amp B could reach 108 dB, ie an imperceptible increase. But as the speaker power handling is only 40 W, both blow it to pieces a long way short . . . . Point made?

Impedance: There is no right or wrong for this spec. Nearly all modern units quote 8 ohms anyway and there is little to choose between, on paper. A more important point to note is that impedance is a *nominal* figure and the actual value will vary widely with frequency. A plot of impedance against frequency is the most useful measure — the nearer a straight line the better!

Frequency Response: As with any other hi-fi unit, this is a measure of linearity, ie how evenly the enclosure treats the audio spectrum. Ideally the output should be at the same level for a given value of input, regardless of frequency. Loudspeakers, being partly mechanical in nature, are not as precise as amplifiers, for example. In addition, the room in which the unit is used will limit bass response (unless it's the Albert Hall — in which case you're a squatter and we don't talk to them . . .) Look for 30 Hz — 20 kHz ± 5 dB from a small enclosure and anything which boasts 100 Hz — 20 kHz ± 2 dB is worth a second look!

Distortion: Regardless of type, modern enclosures have made great strides in recent years. Accept nought less than 3% total, preferably 2% if THD is all that is quoted! Electrostatics and the top-end moving-coil types can better 1% from 100 Hz upwards.

Bass Resonance: Often quoted as some sort of 'figure-of-merit' but is, in fact, totally irrelevant. It will be given in Hertz, around 20 Hz-30 Hz and denotes the frequency at which the bass speaker is most efficient or resonant. Below this, the response drops off rapidly into unusability. Once the speaker is fitted into an enclosure, however, this will be compensated for by the box and the crossover network will smooth out the reponse. In other words — ignore it!

Crossover Frequencies: Nearly always given in specs, but not as a good or bad figure — which is a pity as a deal of potentially useful information can be extracted from these seemingly innocuous numbers! A crossover frequency is that point at which the sound output is changing from one drive unit to another. At this point, in theory, it is being played by two units at an equal level. Beyond, it will be quickly 'filtered out' from one, allowing the other to dominate. As the human ear is most sensitive between 1 kHz and 3 kHz, it is best if only one unit replays this band, as even small shifts will be detectable, probably as roughness or brightness. Thus any crossover point between 1 kHz and 3 kHz should be mistrusted. The importance of the mid-range speaker is thus emphasised and experience has shown that the best sounding units can cover something like 500 Hz - 5 kHz. With this in mind, look for a lower crossover above 100 Hz, but below 500 Hz and an upper changeover between 3 kHz and 7 kHz.

Phase Linear/Time Delay Compensated: In order for a loudspeake to sound as 'real' as possible it must reproduce all the aspects of a live sound accurately. Some years ago it was realised that while a musical instrument produces a wide frequency range effectively at one point in space, a multi-unit loudspeaker does not. This is due to the huge difference in physical size between bass drivers and tweeters. The point from which sound appears to radiate is well inside the enclosure for a cone woofer, but will be at the outside edge of the h.f. dome — difference of some 5-12". This is many times the wavelength of frequencies in question and is thus significant. Since sound travels at a constant speed, regardless of frequency, the low frequencies will arrive at the listener after the HF dome — a difference of some 5-12". This is many times the wavelength of frequencies in question and is thus significant. Since sound travels at a constant speed, regardless of frequency, the low frequencies will arrive at the listener after the HF even though they are supposedly from the same instrument. This is termed 'phase distortion' and is audible as a lack of sharpness or precision. The best phase-linear speakers, which 'stagger' the drivers (**figure 5**) to line-up the sound sources, can produce an uncannily believable stereo image and a beautifully clear and sharp sound overall. Units such as this are usually more expensive nowadays, as the fashion for lining up the units in this way has died out. Quite frankly this is probably because very few of the manufacturers *ever* got it right!

Next month our series concludes with a brief look at tape recorders and tuners — and instructions for installing your first hi-fi system.

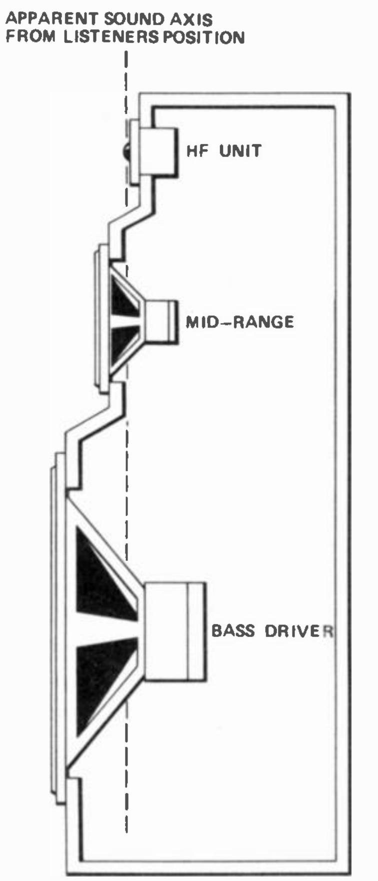


Figure 5. Lining up the sound sources to overcome phase distortion — otherwise known as time-delay compensation.

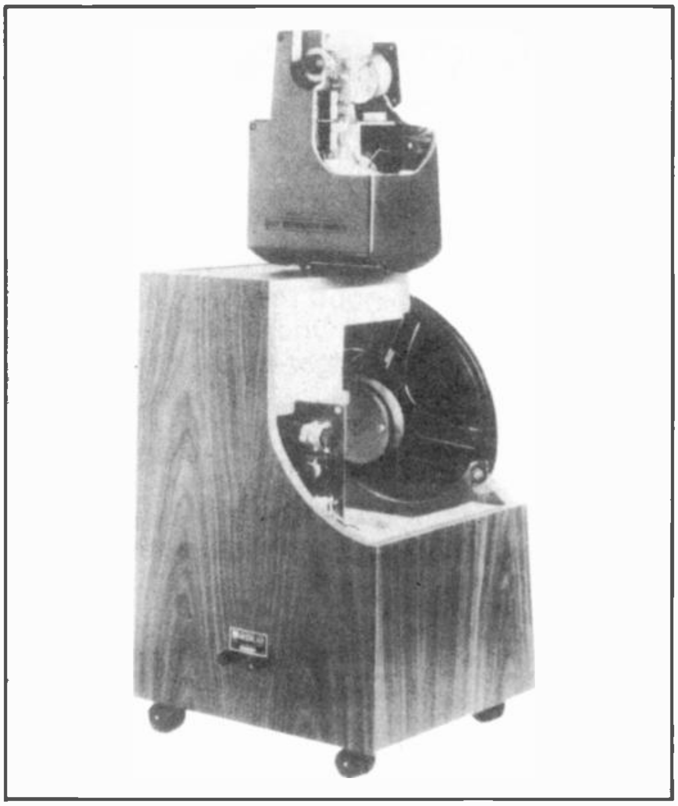


Figure 6. This revealing cutaway of the KEF 105 II loudspeaker shows the level of complexity that top-end designs can require. The bottom enclosure contains the bass-driver and crossover while the pivoted 'head' carries the (cone) midrange and the (dome) high frequency units. You can see the protection circuitry, which makes this speaker virtually invulnerable, behind the rear of the head. This is a design in which practically all the parameters concerned with an enclosure have been optimised. Even the edges of the top enclosure are rounded off, to prevent sharp corners interfering with sound dispersion. In addition, the bass-driver is 'developed' from the box in such a way that vibrations from the framework are prevented from reaching the enclosure itself, where they would colour the output.

Figure 7. One recurring question is that of what to listen for in loudspeaker auditions. Try this: A single vocalist, ie Stevie Nicks, and a single (complex harmonic) instrument, ie a tambourine. Listen to the voice closely; can you pick out the singer clearly, whether the instrument is playing or not? Is the sound of the voice modified in any way by the instrument? Listen for expression in the voice — not what is being sung but HOW. The instrument should be sharp and distinct at all times and you should be able to shift your attention from voice to instrument, and back again, equally well without either one dominating. An exacting test — but they're the best kind!

HE

WHAT'S ON NEXT?

POPULAR COMPUTING No. 1

Our new computing supplement for budding hardware engineers leads gently into the world of bits and bytes, CPUs and I/O Ports. Our first feature explains these terms and many more. Then there's the special feature that separates publicity from practicality; there are many good reasons for owning a computer, but there are also many traps for first-time buyers. Once you've decided, though, our buyer's guide — a survey of the most popular budget-price computers on the UK market — will help you choose the best machine for your purposes.

INTO RADIO

Beyond the CB-Barrier lies a fascinating hobby — Amateur Radio. Every day, thousands of people, of all ages, from all walks of life and from countries all around the world, talk to each other by radio. How can you get into Amateur Radio? Easy. Just follow us .....

CREATIVE RECORDING

You don't have to be a rock superstar to get a recording contract — you can write your own and record yourself using one of the new multitrack recording systems developed in recent years. This new feature series untangles the recording chain, tells you what equipment you'll need and how to use it. The rest is up to you!

DUAL TRAIN CONTROLLER

We've done them in the past, but never has there been one with all the features of our Dual Engine Driver. Completely self-contained, it has separate controls for driving two engines, both with simulated inertia, including a realistic start-up. You can accelerate to the throttle setting, coast, or juggle the acceleration, coast and brake controls to stop right by a platform. It takes practice — but it can be done (using the emergency stop is cheating). If it's scale-accuracy you want, this is the controller you need!

DIGITAL CAPACITANCE METER

Our cousins at Electronics Today Internastional have theirs — but take a look at ours before you decide. It's easy to build, fast and accurate. What more could you need?

BIKE ALARM

Following our Super-Hooter in this month's issue, we present an easy-to-build anti-theft alarm.

INSIDE COLOUR TV

Most of us spend a considerable amount of time looking at the outside of a colour TV — ever wondered what goes on inside? Hobby Electronics' April issue has the full story — inside out, you might say.

That's just part of what's on in the April issue of Hobby Electronics. On sale 12th March.

Although these articles are being prepared for the next issue, circumstances may alter the final content.

Your Letters

This month, as promised, the Editor answers a selection of your letters querying projects from past issues.

The process of turning a designer's circuit diagram and component layout sketch into a work of art suitable for publication is one that is very sensitive. Errors can creep in at any one of the half-dozen or so stages involved.

Lately, however, it seems that the Gremlins (or 'bugs', if you prefer) have been having a field-day. The situation has been complicated by the fact that, due to the Christmas period, we have had to produce two issues in less time than we would normally take to do them. As a result, the collection of unanswered enquiries has grown to an alarming size.

We apologise to all those readers who have been anxiously awaiting a reply and assure you that, in future, all letters sent with an SAE will be answered by the publication date of the following issue.

Corrections, where necessary, will also be published in the very next issue — however, you can be sure that we will be doing our very best to ensure that the word "Errata" disappears from our Contents page!

Doorphone

Dear Sir,
With reference to your "Doorphone" project, featured in the October 1981 issue; I followed your instructions but, on completion, I am sorry to report great frustrations. Discovering a discrepancy between the diagrams on pages 10 and 12 greatly soothed my mind but, before altering anything, perhaps you could advise me which is correct?
I. Merwitzer,
Salford.

Regular readers will be aware that our original title for this project was a registered trademark, hence we have re-named it the "Doorphone". To further complicate matters, several errors slipped through.

1. On the circuit diagram RV1 should be drawn with an arrow through it, ie a potentiometer with one end 'floating'; the battery voltage should be 12V, not 9V.
2. R6 and LED1 should be interchanged.
3. On the component layout, the missing C5 should be inserted between points B10 (+) and B12.
4. There should be a wire from point D1 to the top right of SW1 and a break in the Veroboard at D4.
5. It is not clear from the diagram that LED1 anode is connected to SW2.

Another query on this project was received from Mr. F. W. Andrew of Newbury, Berks; we hope these corrections answer your questions.

Stylish Organ

Dear Sir,
In your November 1981 issue you published a circuit for a Simple Stylus Organ. Being interested in electronics but by no means fully conversant with circuit diagrams such as your Figure 1, I followed the illustration of Figure 2. After connecting all the components as in the upper drawing and making the breaks as in the lower drawing, the organ did not seem to work.

I checked the connections and, as far as I can see, there appears to be discrepencies between the two. Could you please check and inform me which drawing is correct?
E.J. Butler,
Sheffield.

In fact there are several errors in this Quick Project — and not just on the component overlay. On the circuit diagram, RV2 should NOT be connected to pin 6 of IC1 — it should, in fact, be shown as connected to pin 3. On the layout (Figure 2), the lead from RV2 should be connected at F4, NOT F11. Back on the circuit, RV3 should have been drawn with an 'arrow' through it.

In addition, there should be a link from D23 to A23; the link from F15 to I15 should NOT also connect to H15; finally R5 (unlabelled) should connect to B14, not A14. On the underside of the Veroboard, connection points should have been shown at J14 and 16.

In Time, Out Of Place

Dear Sir,
Having just completed the Metronome project from the November (1981) issue, I have these points to make.
1. Veroboard track breaks — none are shown for IC1.
2. Battery, RV1/SW1 and battery leads are rather misleading in that the polarities appear to be reversed.
3. On the component layout, Q1 collector and emitter connections are reversed.
4. SW2 was supplied as a single-pole 12-way rotary.

This being the first project that I have attempted from your magazine (and also the first I have attempted with this IC) the ICs were the last items to be inserted (in sockets) before switching on. However, with SW2 at position 1, LEDs 1 and 2 flash and a tone is produced at every beat. With SW2 in position 2, 3, 4, or 5, LED 1 flashes with every beat, LED 2 flashes on every tenth beat and a tone is produced 4 or 5 times out of ten with a change in pitch when it coincides with LED 2.

Long distance diagnostics of the above symptoms will be quite difficult but I would welcome any suggestions. My assumption is that IC2, the 4017, is unserviceable. I would also welcome your comments on the faults I have found.
J.F. Seaman,
Cornwall.

Long distance diagnostics are always difficult — we can but try! In this case, there are one or two other errors which, when corrected, may solve the problem. For the benefit of other readers who have been troubled by the Metronome, we'll list all the corrections, starting with the ones mentioned in Mr. Seaman's letter.

1. The missing track breaks are at U27, T27, S27 and R27.
2. RV1/SW1 (our artist's impression of a pot-switch); the battery leads should be reversed.
3. Q1 — 'e' and 'c' should be interchanged.
4. This should not make any difference.
5. Swap the leads at J2 and L2.
6. C3 should be connected between M33 and I33.
7. C1 should be between R24 and S24.
8. Remove the link between T29 and V29.
9. Resistor R1 should be R2 and connected between V33 and T33; resistor R2 should be re-labelled R1.
10. The wiper of RV1 should go to point S36.

Special caution is needed with this project because of the small size of the component layout; every connection on the Veroboard should be checked against the circuit diagram — which IS correct.

Understanding Diana

Dear Sir,
I have built the 'Diana' pulse induction metal detector (September, 1981), but it does not work!

Using an oscilloscope, I can get square pulses from IC2 and IC3 but IC4 seems quite "dead" — even a new one made no difference. Also, RV1 and RV2 do not alter the voltages as described.

R12 is not on the Parts List — is it 1M0? I have built other metal detectors, but this one has me puzzled. Perhaps you can let me know where I have gone wrong?
H.J.Fisk,
Suffolk.

We published an Errata on the "Diana" in the November 1981 issue, which you may have missed: R11 should be 2k2, not 2M2, and R12 is 1M0 as you have correctly assumed. The correct value of R11 will probably "revive" IC4.

Telephone Bell Repetition

Dear Sir,
I am very interested in the Telephone Bell Repeater described in the October 1981 issue of HE. However, after checking the design and building instructions I discovered three faults.

First, I failed to find R9 on the component overlay drawing, which leaves the emitter of Q3 open circuit. Second, the connection point of the loudspeaker is not shown. Third, the solder points on the Veroboard strip do not agree with the component overlay.

I look forward to seeing your comments on these points.
P. Smith,
Leics.

Dear Sir,
With reference to the Telephone Bell Repeater project, there are several errors:
1. R1 is shown as 47k in the circuit and as 47R in the Parts List. Which is correct, please?
2. R9 is omitted from the component layout on page 58.
3. Pin 11 of IC1 is not shown as soldered on the underside of the Veroboard on page 58.

May I suggest that, when you do have corrections to publish, they be given prominence and not left to be found in reader's letters?
C.R. Munro.

No doubt H.J. Holland of Salisbury, Wilts., and A.B. Ely of Kirkcudbright are also looking forward to seeing our comments on this project! Our apologies for the delay; here they are (at last):
Figure 1, page 57: R1 should be 47R, as shown in the parts list.
There should not be a connection between C1 and R1.
Figure 2, page 58: Insert R9 between points L18 and S18.
C1 should be between points V3 and T3.
The loudspeaker, LS1, connects between V2 and W2.
The socket for IC1 should have all its pins soldered.

Finally, concerning Mr. Munro's last point: We receive a large number of letters every month, many of them straight-forward technical enquiries but also a considerable number of queries on possible errors in projects. Where else can we reply, except in the Letters pages?

In future, however, we will draw your attention to corrections by an entry in the Contents referring to the page (or pages) on which Errata are to be found — as we have done in this and the previous issue.

Baby's Alarming

Dear Sir,
On page 39 of the October '81 issue of HE you published a project for a Baby Alarm. Under the component layout diagram, you mention that six breaks are needed in the Veroboard tracks but you fail to indicate where they should be.

Could you please tell me which track positions are to be broken?
P. Newstead,
Oxford.

We had many letters from readers concerned about these missing track breaks; at first we thought the error was in the text because the layout is such that the project should work without any track cuts at all! The solution was provided in a letter from Mr. Ko Yenlie of Singapore who very cleverly suggested that track breaks will be needed adjacent to the two mounting holes at the end of the board. Accordingly, if you are using or wish to use mounting screws, track breaks should be made at locations A22, B22, C22 and at H22, I22 and J22. The mounting screws should come after the breaks, at the end of the board. Our collective thanks to Mr. Ko!

R.P.M. Meter

Dear Sir,
I have made up the above item, but I am surprised no correction or reader's letter has been published.

The overlay, which is very faintly printed and almost impossible to work from, is shown the same as the printed circuit pattern (on page 62), ie the parts would be mounted on the copper track side. Presumably the circuit foil pattern should have been a mirror image of the overlay outline. Fortunately, by mounting the IC sockets on the foil face and other components as normal, all is well. Wish I'd spotted the error before I had etched the board, as I might have done had the overlay been clearer.
I.M. Tasker
Grantham, Lincs.

Murphy's Law strikes twice. Mr. Tasker is perfectly correct; the PCB pattern on page 62 is shown from the top, that is, the component side. A solution to the problem is to trace the pattern on to clear paper, then flip it over to present the correct orientation for transfer to a blank PCB.

The track outline on page 54 is very faint indeed, but at least it is possible to refer to page 62 for a clearer picture!

Hobby Organ

Dear Sir,
Having made, and played, the HE Organ (which, I might add, sounds pretty good to me), I am rather surprised by one of the items in the Errata box in the August 1981 issue. Referring to C3 in Figures 2 and 3, has it really been turned around?

Also your (Oops) in the June issue re. points 1, 2 and 3; 0 volts does not go to R2 — is this not the amplifier input?
E.G. Elliott,
Taunton, Somerset.

Quite obviously, the Gremlin-fixer has been fixed and the Errata printed in the August issue is itself — in error. The correct corrections are as follows:
In Figure 2, C9 should be 220u, not 220n (the Parts List is correct). However, C12 can be 22n and C13 can be 10n as neither is critical.

In Figure 2, C32 (not C3, as we said in August) should be turned around; that is, its positive plate should be at the bottom.

In Figure 3, the positive plate of C34 (not C3) should be at the right-hand side and capacitors C28 and C32 should both be turned around.

Regarding "points 1, 2, and 3", we are unable to make out what 'oops' they are in reference to. Could you be a bit more specific?

Kitchen Timer

Dear Sir,
A few months ago I made up the Kitchen Timer described in the October 1980 issue of HE. However, I have never managed to get it to work. I have changed a number of components, checked connections and polarities and also checked resistors and joints with a multimeter. Are there any other checks I could make?

Hoping you can help,
A. Webb,
Glasgow.

Firstly, R17 should be 3k9, NOT 82k, as shown on the circuit and in the Parts List. The incorrect value may well be the source of your troubles. If, after changing R17, the Kitchen Timer still fails to "do its thing", you can isolate the fault to either the timing section or the multivibrator by metering pin 3 of the 555; it should go high (+9V) when the timing period is started and go low (0V) when the IC "times out". Then, at least, you will have narrowed the possibilities.

Mast-Head Amplifier

Dear Sir,
Would you please let me know where I can purchase the IC, OM355, for your Mast-Head Amplfier project? Also, am I right in saying that pin 1 goes towards the output socket and the aerial cable goes to the input socket of the amplifier?
H. Joyce,
Bembridge, I. W.

We made an error — there are other words for it — in giving RS Components as a supplier for this IC. However, it is available from Magenta Electronics.

The last point is correct, but the data sheet for the OM355 clearly shows that pin 1 is the input, NOT the output, as suggested. Due to production problems last month (we'll spare you the horrifying details), the component overlay is somewhat difficult to read; pin 1 is to the right of the IC, ie the one that stands alone. **HE**

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VIDEO DISC

Reflections on a Philips Videodisc.

The battle lines have been drawn and World War III (for the domestic videodisc market) is about to commence.

DISCS WERE WIDELY USED for audio recording long before magnetic tape recorders became widely available. The pattern has been completely reversed in video recording with video tapes and cassettes available whilst we still await the first commercially available videodiscs! However, the battle for the videodisc market is rapidly heating up.

The videodisc market is believed to be extremely attractive and more and more manufacturers are deciding to take part in its development. Indeed, US consultants forecast that, within three years, videodisc machine production should exceed that of video cassette recorders.

They expect that over half of American homes will have a video disc player by this time.

Laser Optics System

The Philips/MCA system has a price tag of US $750. The surface of the (12") disc is covered with a reflective coating into which tiny pits are burned by a laser. A small helium-neon laser is used to read information from the spiral tracks of the disc on playback. Each disc has 54 000 tracks and each track contains the information for a single picture frame. The disc rotates at 1800 rpm to provide a playing time of up to 30 minutes. However, it is possible to extend the playing time to one hour per side of the disc by adjusting the speed of rotation in proportion to the decreasing circumference, so that the laser tracks the disc at a constant velocity.

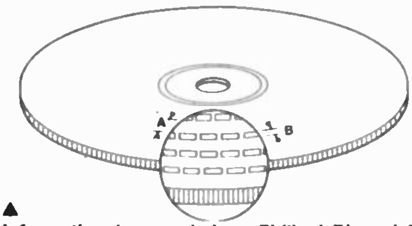
The Philips playback system requires precise tracking of the laser spot beam together with servo control and time base correction to account for any warping of the disc. It is claimed that the laser modulated discs provide excellent picture resolution together with a long life, while the pits provide very high information storage density. The video bandwidth can exceed 8 MHz, and it seems likely that this system may offer sharper images than capacitive tracking systems.

RCA System

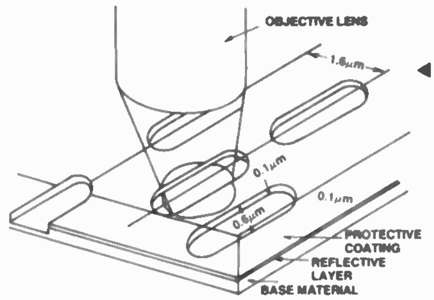
The RCA Selectavision system employs a metal electrode attached to the back of a diamond stylus. This stylus follows the track of a groove, cut in a vinyl disc, which is electrically conductive and uses the capacitance variations arising from small depressions (known as 'pits') at the bottom of the groove. These changes in capacitance modulate the amplitude of a carrier which is subsequently decoded and fed into the aerial terminals of a television receiver.

It is claimed that this capacitive stylus system offers the principal advantages of low cost and ease of manufacture. The selling price of the RCA type players has been forecast to be less than US $500 in the world markets. This may make it the cheapest videodisc system to become available in the fairly near future.

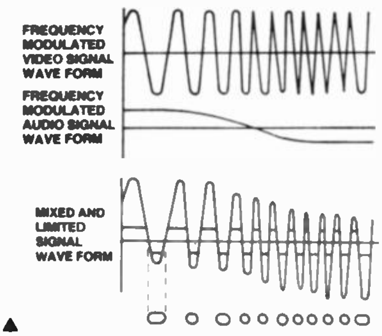
The RCA system employs a 300 mm disc rotating at 450 rpm will provide up to an hour's playing time per side. No tracking control mechanism is required in this system. The main disadvantages are stylus wear, which is understood to limit the life of the capacitive pick-up to some 500 hours of playing time, and the relatively limited video and audio bandwidths.



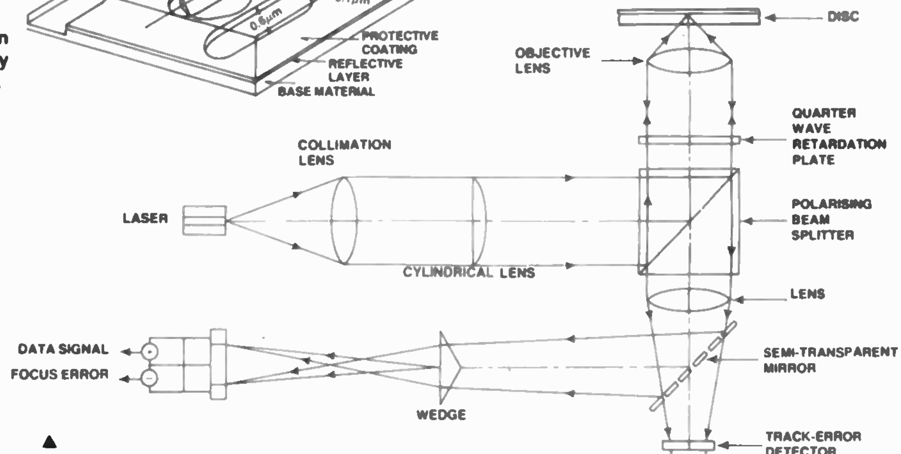
▲
Information is encoded on Philips' Discovision disc as tiny pits only 0.6 μm wide (dimension B) by 0.1 μm deep, spaced 1.6 μm apart (dimension A).



◀ **A laser reads the *length* of the microscopic pits, which contains the encoded information.**



▲
The optical pulses from the micropits are demodulated to produce both video and audio carrier signals, which are subsequently converted into picture and sound.



▲
Philips' optical playback system employs a laser and a complex tracking and lens system to follow and read the 54 000 tracks on the disc. The Pioneer system is similar but uses different optics.

JVC System

The Video High Density (VHD) system is also a capacitive pick-up type, but does not depend on grooves in the disc for guiding the movement of the stylus across the disc. Encoded tracking information is included on the disc alongside the video information. The stylus does not move in a groove, but sits on the smooth surface of the disc. Minute indentations or pits provide capacitive variations to the pick-up which translates them into electrical signals. Movement of the stylus is controlled by a servo-mechanism which uses the tracking information on the disc.

The VHD capacitive system provides audio bandwidth to 20 kHz with a signal-to-noise ratio of 60 dB.

The life of the stylus is of the order of 2000 hours (four times that of the RCA system), but the servo mechanism required raises the cost of both the discs and of the euipment.

The discs are somewhat smaller than used in the Philips and RCA systems (260 mm dia.) and revolve at 900 rpm. This system has been developed by the Japanese Victor Company (JVC) and will be manufactured in the USA by General Electric Company and by Thorn-EMI in Europe. Players for these videodiscs can also replay suitable digital audio discs.

The VHD system provides access to any point randomly chosen on a disc more quickly than those systems in which the stylus must follow some form of groove. It can provide special effects such as a still picture, fast or slow motion replay, etc. It is rather remarkable that the discs can be manufactured using existing audio disco pressing equipment.

In the recording process for the production of the master disc, a single laser beam is split into two parts, one half being used for recording the information and the other half being used to record the tracking signal. The master disc is made of glass coated with a photosensitive material and the recording must be carried out in a dust-free room. The laser beams are moved along a radius of the disc at constant speed, whilst the disc rotates at 900 rpm. Fine pits are thus recorded spirally on the glass disc which is then used to make a metallic master disc by the conventional process used for audio recordings.

The VHD discs sold to consumers are of conductive polyvinyl chloride (PVC) and have a life of some 10 000 playings. A sapphire stylus is employed, mounted at the end of a cantilever arm with a magnet on the opposite end. Fixed coils are mounted near the magnet and a single coil is wound around (but not in contact with) the magnet. In addition, a pair of vertical coils are mounted on either side of the single coil in opposition to one another. This arrangement

The JVC VHD system videodisc player.

enables the stylus to be moved as the current flowing in the coils varies. The coil currents are controlled by the tracking error signals and timebase error signals. However, a command to move the stylus to a particular track can also be used to control the coil current.

JVC claim that their use of a relatively conventional disc production technique is a great advantage of their system over optically based videodisc systems.

Matsushita (who market Technics and Panasonic products) have decided to abandon their own videodisc system in favour of the JVC system and have now made an agreement with JVC. The original Matsushita system employed a direct contact stylus and a rigid disc.

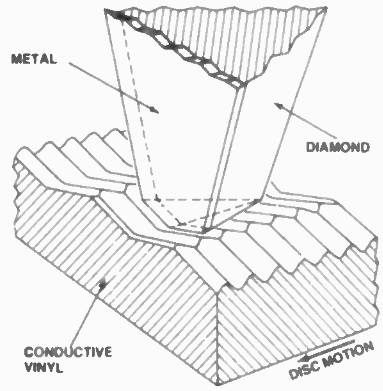
Conclusions

It seems probable that the three incompatible videodisc systems will exist side by side at least in the early 1980s, so this could mean that people who want to be able to play any videodisc will be involved in expensive investments.

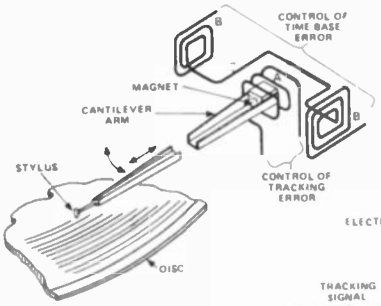
In spite of the current interest in videodiscs, one must remember that people may not want to replay their favourite videodisc as often as they play their favourite audio discs and this may well affect the chances of videodiscs attaining the widespread use essential for their success. However, if a wide range of material is available on disc at reasonable prices, it seems certain that there is a pretty good market for high quality systems.

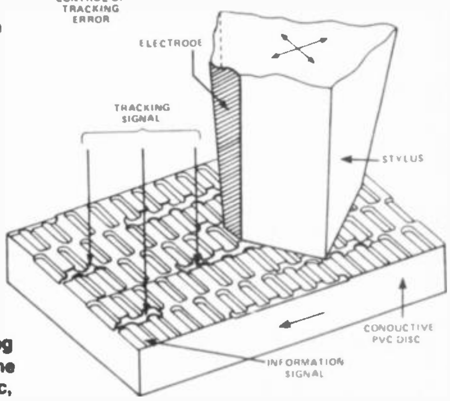
The picture quality provided by videodiscs is certainly superior to that from domestic video cassette recorders. The most expensive videodisc system (Philips) will be cheaper than videotape systems (apart from its better quality pictures) and will be one of the most flexible disc systems. The JVC system offers the highest storage density of any of the videodisc systems.

It is interesting to note that videodiscs are no longer limited to the domestic consumer market. Videodiscs are very suitable for the storage of computer type information and it could well be that this application will help enormously to spur manufacturers to invest more heavily in videodiscs generally, since there is also an enormous potential market in the business and other data storage computer fields.



RCA's Selectavision system uses a metal diamond composite stylus running in modulated grooves on the disc. The stylus tip is only 5 μm by 2 μm and the groove pitch is 2.6 μm. Wear is said to be its biggest problem.

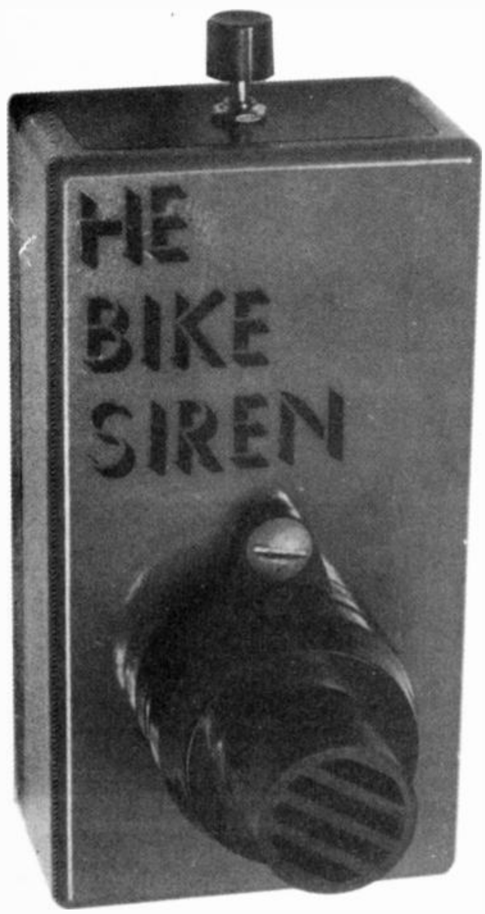




The VHD system from JVC employs a capacitive pickup system reading microscopic pits in the conductive plastic disc, tracking signals encoded on the disc providing information to a servo system that drives the stylus across the disc. Stylus life is said to be around four times that of the RCA system. HE

RCA's SelectaVision videodisc player.

BIKE SIREN



"Knock-knock"
"Who's there?"
"Isabel"
"Isabel who?"
"Isabel necessary on a bike, when you have the HE Push-bike Siren?"

IT'S TRUE, you know — never again will you have to slam on the anchors or swerve to avoid jaywalkers who step from the pavement into the road ahead — but only if you build this project. All you'll need to do then is give a brief warning blast of the siren as you ride along and everyone will know you're coming!

The HE Push-Bike Siren makes a realistic sounding imitation of a wailing police-car siren — 'Starsky 'n 'Hutch' style. Its piercing — nay, irritating — sound will make all but the doziest of 'peds' (ie, pedestrians) jump out of your path.

The siren sound is created by a combination of clever, but simple, electronic circuitry and a special solid-state audible warning device; the complete project is battery-powered — a couple of PP3-sized batteries will last for many months, depending on usage.

Construction

Following the Veroboard layout shown in Figure 2, make all required track breaks. This should be done with either the correct cutting-tool or, simply,a hand-held, small (about ⅛") drill bit. Press the cutting edge of the tool/bit against the hole in question and turn it back and forth until the copper is cut into a clean circular break. Make sure there is no loose copper swarf which can form electrical bridges between tracks.

Insert and solder all components individually into the board, starting with links, followed by resistors, capacitors and finally semiconductors. Links should be formed out of single-strand, tinned-copper wire.

Use an IC socket to hold IC1 — this prevents the need to solder-in the clip, which is a CMOS type. Mark and drill the box to fit the push-button and the holes required to mount the solid-state warning device (ie, one for the mounting-bolt, one for the connecting leads). Solder two leads (about 6" long) to the solid-state warning-device. Use a different colour for each lead, say red and black, because the device is polarised and must not be connected the wrong way round. Push the free ends of the two connecting leads

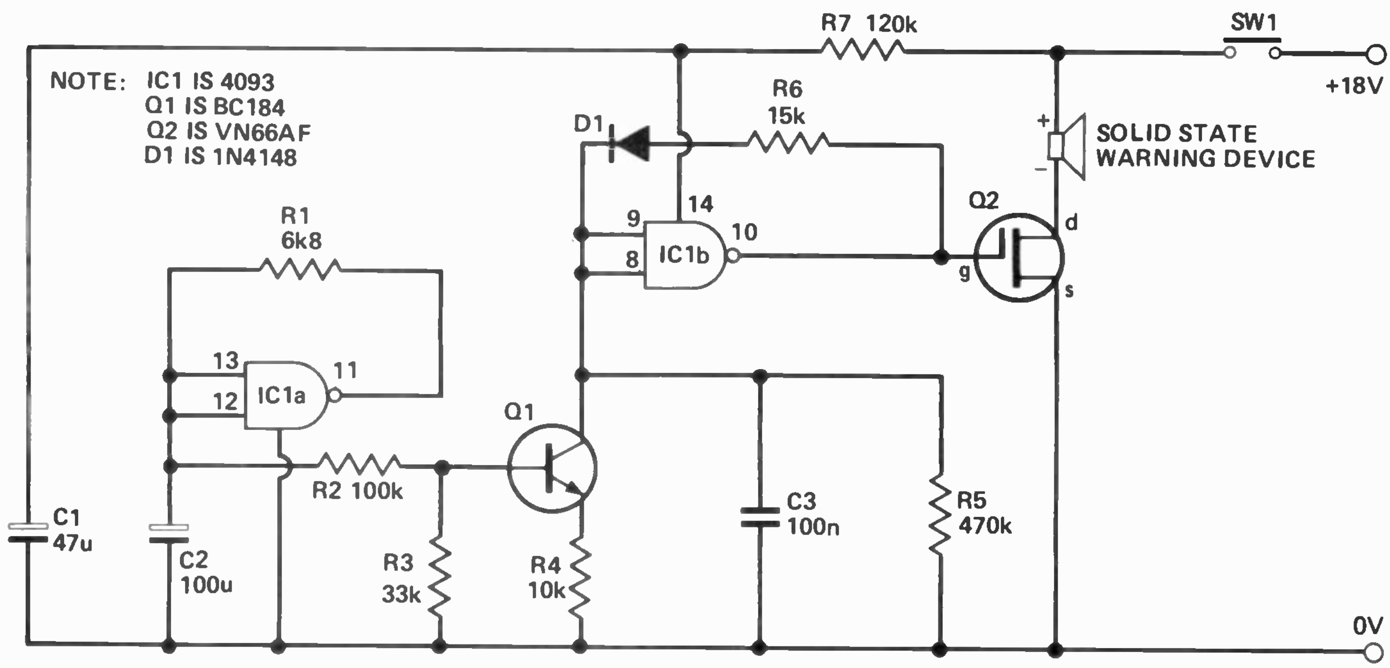
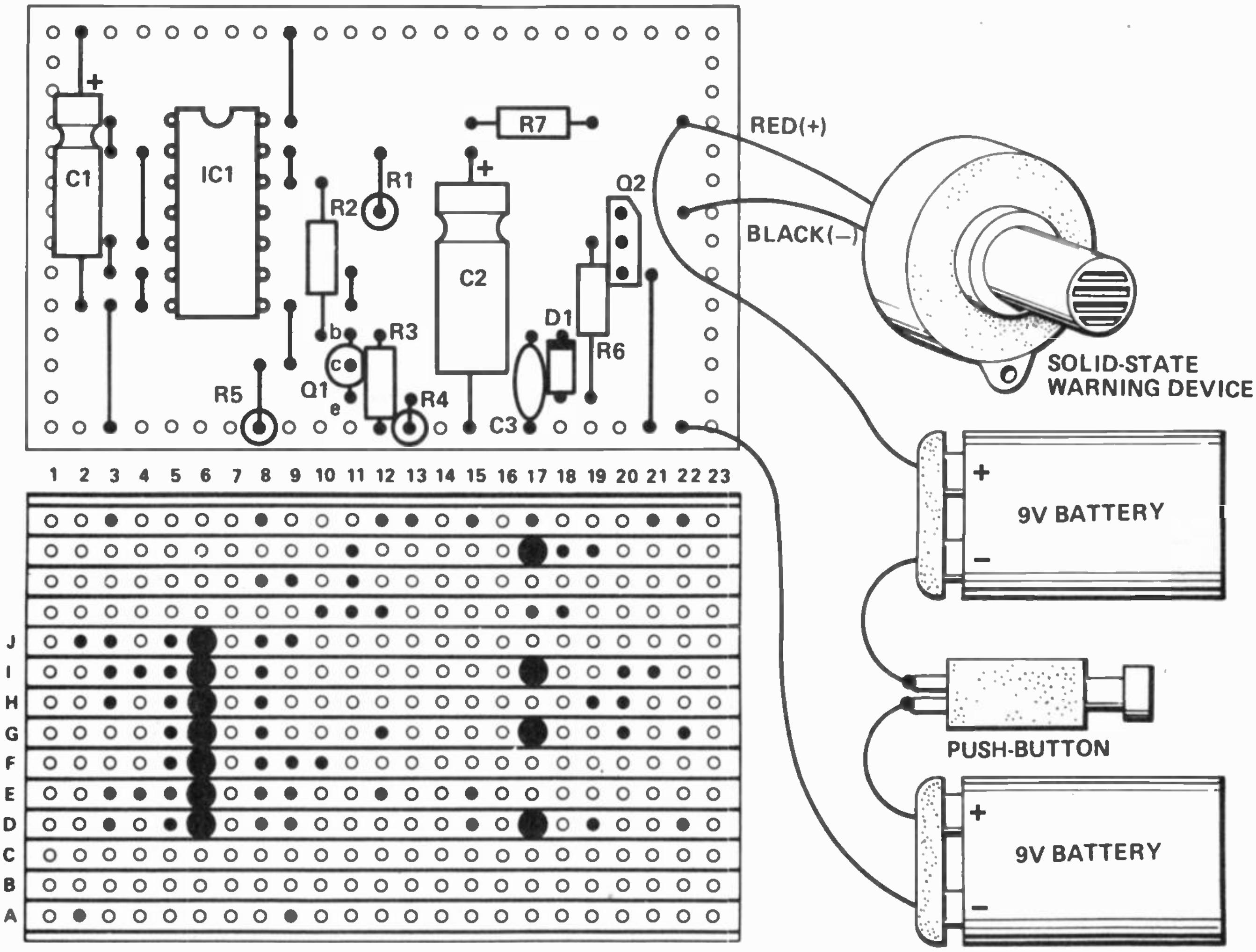
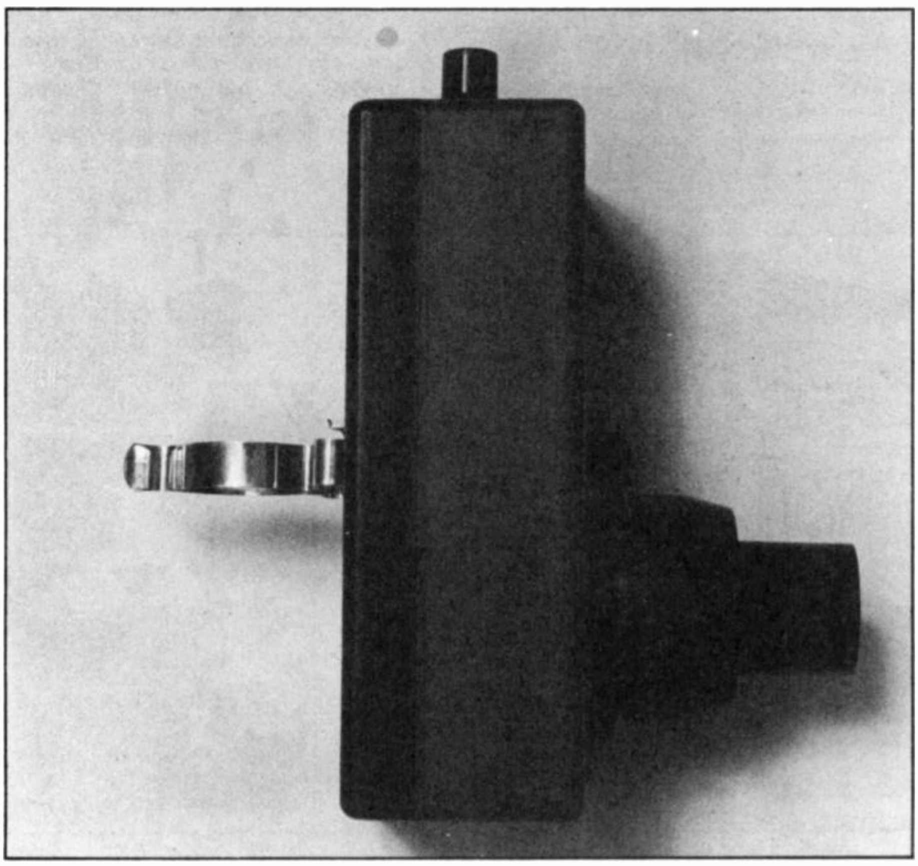


Figure 1. Circuit of the HE Push-bike Siren



▲
Figure 2. Veroboard layout, showing underside track breaks and component locations, with connection details of the project.



through their holes and fasten the warning device to the box, using glue as well as the mounting bolt, to make the join between device and box lid as rainproof as possible.

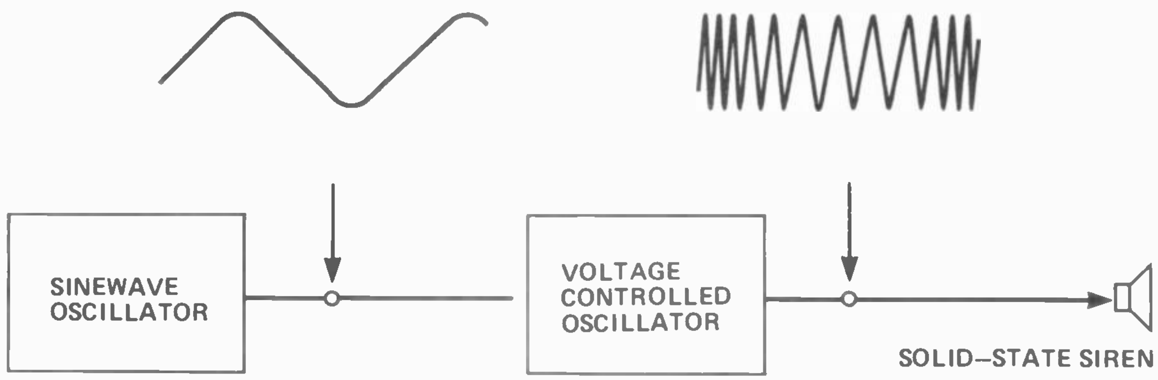
Fasten the push-button to the box. Now, wire-up your project as shown diagramatically in **Figure 2.** Fasten the batteries and the circuit board to the bottom of the box using self-adhesive pads. Finally, bolt-on a suitably-sized Terry clip to the box base and fasten the whole project on the handlebars of your bike.

Buylines

The solid-state audible warning device is available from Magenta Electronics Ltd for £3.07. Please add 40p to cover p&p. The box is type BOC430R from West Hyde Development Ltd.

All other components should be easily obtained. Approximate price of parts for the project (excluding box and batteries) will be £6.

How It Works



A low frequency (about 2 Hz) oscillator provides a sinewave control voltage. for a voltage controlled oscillator (VCO). Thus the VCO output frequency varies, up and down, at a rate of 2 Hz (ie, twice a second). The resultant output is used to switch on and off a solid-state audible warning device to produce a sound effect similar to American police car sirens.

Schmitt trigger NAND-gate, IC1a, is configured as an astable multivibrator. Resistor R1 and capacitor C2 define the overall frequency of this multivibrator: reducing the value of either of these components will increase the frequency; increasing their value will reduce the frequency. With the values shown, the multivibrator frequency is about 2 Hz.

An astable multivibrator produces a squarewave output, but a sinewave is needed so, instead of using the voltage at the output of the multivibrator, the voltage across the capacitor C2 is used. This resembles a sinewave closely enough for our purposes.

NAND-gate IC1b, with associated components, form another astable multivibrator oscillator. Transistor Q1 is connected across C3, the multivibrator timing capacitor. The resistance of the transistor defines the charging rate of the capacitor and thus controls the overall frequency of the multivibrator. Varying the voltage at the base of the transistor varies the transistor's resistance so, by applying the voltage obtained from the low frequency multivibrator to the transistor base, the second multivibrator frequency is controlled by the first.

Transistor Q2, a VFET, is switched on and off by the output of the voltage controlled multivibrator and powers the solid-state warning device to create a loud sound output. By setting the centre frequency of the voltage controlled multivibrator to the resonant frequency of the warning device, the sound output becomes particularly irritating!

Parts List

RESISTORS (All ¼W, 5%)

R1	6k8
R2	100k
R3	33k
R4	10k
R5	470k
R6	15k
R7	120R

CAPACITORS

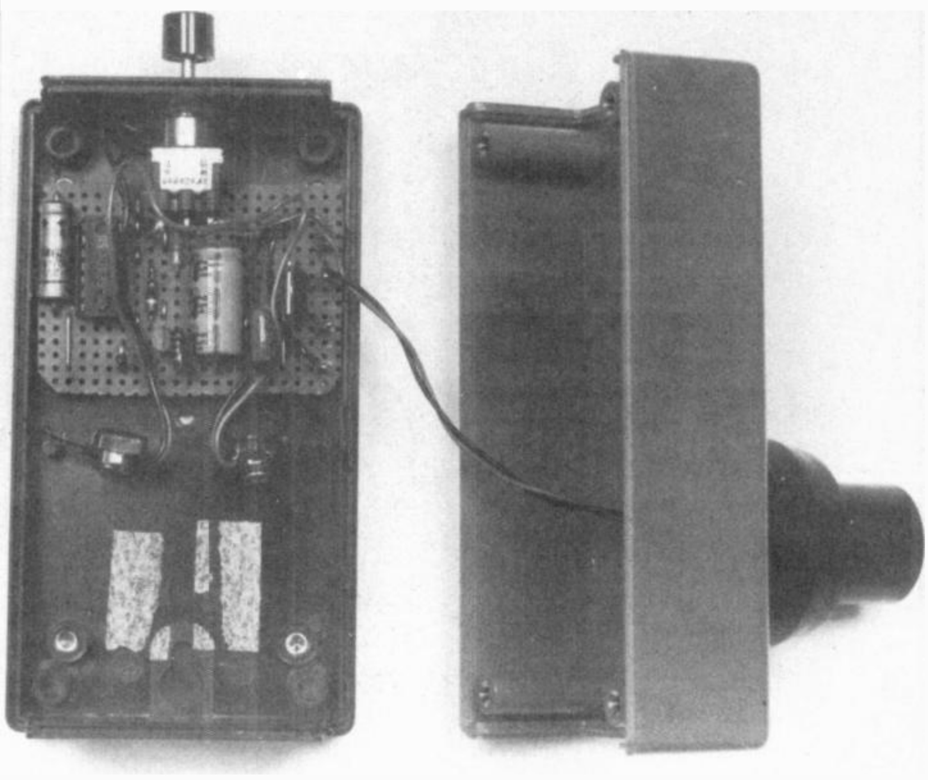
C1	47u, 25 V electrolytic
C2	100u, 16 V electrolytic
C3	100n polyester

SEMICONDUCTORS

IC1	4093 quad, Schmitt trigger NAND-gate
Q1	BC184 NPN transistor
Q2	VN66AF VFET transistor
D1	1N4148 diode

MISCELLANEOUS

SW1 single-pole push-button
Solid-state audible warning device,
12V 2 x PP3 sized batteries + clips
Box to suit
Terry clip

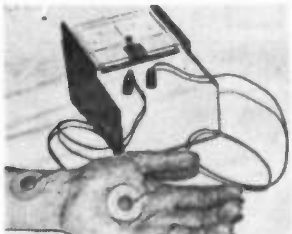


HE

GREENWELD

443F Millbrook Road, Southampton, SO1 0HX

All prices include VAT at 15% — just add 50p post



LIE DETECTOR

Not a toy, this precision instrument was originally part of an "Open University" course, used to measure a change in emotional balance, or as a lie detector. Full details of how to use it are given, and a circuit diagram. Supplied complete with probes, leads and conductive jelly. Needs 2 4½ batts. Overall size 155 x 100 x 100mm. Only £7.95 — worth that for the case and meter alone!!

AMAZING! COMPUTER GAMES PCBs FOR PEANUTS!!

A bulk purchase of PCBs from several well-known computer games including Battleships, Simon and Starbird enable us to offer these at incredible low prices:

COMPUTER BATTLESHIPS

Probably one of the most popular electronic games on the market. Unfortunately the design makes it impractical to test the PCB as a working model, although it may well function perfectly. Instead we have tested the sound chip, and sell the board for its component value: SN76477 sound IC; TMS1000 u-processor; batt clips, R's, C's etc. Size 160 x 140mm. Only £1.50. Instruction book and circuit 30p extra

STARBIRD

Gives realistic engine sounds and flashing laser blasts — accelerating engine noise when module is pointed up, decelerating noise when pointed down. Press contact to see flash and hear blast of lasers shooting. PCB tested and working complete with speaker and batt clip. (needs PP3). PCB size 130 x 60mm. Only £2.95

MICROVISION CARTRIDGES

These are a small PCB with a micro-processor chip, designed to plug in to the microvision console. Only snag is, we don't have any consoles!! However, they can be used as an oscillator with 4 different freq. outputs simply by connecting a battery and speaker. Tested and working (as an osc) with pin out data. PCB size 72 + x 60mm ONLY 25p each!!

'SIMON'

The object of this game is to repeat correctly a longer and longer sequence of signals in 3 different games. (Instructions included) PCB contains chips, lampholders and lamps, and is tested working, complete with speaker. Needs PP3 and 2 x HP11. PCB size 130 x 130mm Only £3.95

LOGIC 5 PANEL

Tested Logic 5 now sold out — but we have some PCB's with 10 LED's and chip on, but no keyboard. Not tested. 50p

OPTO/REGS/OP-AMPS

FNA5220 2 digit ½" 7-seg display on PCB, CC With data, £1.50
7-seg displays FNO360, 367, 501, all 50p; 530, 847, 850, all £1.50.
Regs. TO3 case: 7924 120p, 7885 100p, 7808 100p, 7912 100p, 78CB 230p. Others on B/L 13
Op Amps: uA4136 130p; uA776 145p; uA777 300p; uA318 245p.
Isolators: FCD831, IL15, TIL118, all 60p.
TIL311 Hexadecimal display with decoder, 0-9 and A-F With data, £3.50.

COMPONENT PACKS

K503 150 wirewound resistors from 1W to 12W, with a good range of values £1.75
K505 20 assorted potentiometers, all types including single ganged, rotary and slider £1.70
K511 200 small value poly, mica, ceramic caps from a few pF to 02uF. Excellent variety £1.20
K514 100 silver mica caps from 5pF to a few thousand pF Tolerances from 1% to 10% £2
K520 Switch Pack, 20 different, rocker, slide, rotary, toggle, push, micro, etc Only £2.
K521 Heatshrink Pack, 5 different sizes each 200mm, 50p

PANELS

Z521 Panel with 16236 (2N3442) on small heatsink, 2N2223 dual transistor, 2 BC108, diodes, caps, resistors, etc 60p
Z482 Potted Oscillator Module works from 1 20V, can be used as LED flasher (3V min) Supplied with connection data, suitable R, C & LED £1
Z527 Reed relay panel — contains 2 x 6V reeds, 6 x 2S030 or 2S230, 6 x 400V rects + Rs 50p
Z529 Pack of ex-computer panels containing 74 series ICs. Lots of different gates and complex logic. All ICs are marked with type no. or code for which an identification sheet is supplied. 20 ICs £1; 100 ICs £4.
A504 Black case 50 x 50 x 78mm with octal base. PCB inside has 24V reed relay, 200V 7A SCR, 4 x 5A 200V rects, etc 60p

RELAY/TRIAC PANEL

Z537 PCB 100 x 75mm containing a wealth of components:
2 x 12v DPCO min. relays, 2 x 47uf 16v tants, SC146E 10A 500v triac, C112d 8A 400v SCR, 555 timer, 10 x IN4001 diodes, 2N5061, 2 x 3mm leds 3 x 2N3704, also R's and C's.
Amazing value!! — if bought separately parts would cost around £8!! — Price for the panel just £2.00

1W AMP PANELS

A011 Compact audio amp intended for record player on panel 95 x 65mm including vol control and switch, complete with knobs. Apart from amp circuitry built around LM380N or TBA820M, there is a speed control circuit using 5 transistors. 9V operation, connection data supplied ONLY £1.50.

TOROIDAL TRANSFORMER

110mm dia x 40mm deep. 110/240V pri., sec 18V 4A, 6.3V 1A, 240V 0.3A. Ideal for scopes, monitors, VDUs etc. Reduced to £5.95

1,000 RESISTORS, £2.50

We've just purchased another 5 million preformed resistors, and can make a similar offer to that made two years ago, at the same price!!! K523 — 1,000 mixed ¼ and ½W 5% carbon film resistors, preformed for PCB mntg. Enormous range of preferred values. 1,000 for £2.50; 5,000 £10; 20k £36.

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K524 Large variety of values/voltages, mostly cropped leads for PCB mntg. 1-1000uF, 10-63V. All new full spec. components, not chuck outs!! 200 £4; 1,000 £17.50.

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Z653 7 seg display 12.5mm high. Ideal for TTL operation, taking 5V 8mA per seg. Std 14 DIL package. Only £1 each, 4 for £3.00. Data supplied.

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24 ac coil, but works well on 6V DC. 2 x 10A. c/o contacts Ex equip, only £60p

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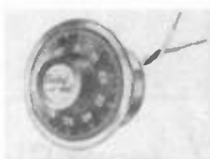
Exclusive Greenweld design, fully variable 0-28V & 20mA-2A. Board contains all components except pots and transformer. Only £7.75. Suitable transformer and pots £6. Send SAE for fuller details



ELECTRO-DIAL

Electrical combination lock — for maximum security — pick proof. 1 million combinations!! Dial is turned to the right to one number, left to a second number, then right again to a third number. Only when this has been completed in the correct sequence will the electrical contacts close these can be used to operate a relay or solenoid. Overall dia. 65 x 60mm deep Only £9.95

Also available *without* combination Only £3.95

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K001. 50V ceramic plate capacitors, 5%, 10 of each value 22pF to 1,000pF, total 210. £4.00.
K002 Extended range 22pF to 0.1. Values over 1000pF are of a greater tolerance. 10 of each value 22 27 33 39 47 56 68 82 100 120 150 180 220 270 330 390 470 560 680 820 1000 1500 2200 3300 4700 6800 .01 .015 .022 .033 .047 .1. PRICE: £7.66
K003 C280 or similar Polyester capacitors, 10 each of the following: .01, .015, .022, .033, .047, .068, .1, .15, .22, .33 and .47μF PRICE: £5.40.
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K007 Electrolytic capacitors 25V working small physical size axial or radial leads. 10 each of the following: 1, 2.2, 4.7, 10, 22, 47, 100μF Total 70 capacitors. PRICE: £3.59.
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K051 LEDs — pack of 60, comprising 10 each red, green and yellow 3mm and 5mm, together with clips. PRICE: £8.95.

CAPACITOR BARGAINS

2200uF 100V cans 77 x 35mm dia. 75p; 10/£5.50.
220uF 10V axial 5p; 100 £2.30; 1000 £16.
400 + 100uF 275V 102 x 44mm dia. 75p; 10 £5.50.
200uF 350V, 100 + 100 + 50uF 300V can. 75 x 44mm dia. 40p; 10/£3; 100/£20.
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MIXERS, FADERS, VU METER DRIVERS AND MORE – ALL NEW FROM ILP!

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MIXERS

Model No	Module	What it does	Current required	Price inc VAT	Price ex VAT
HY 7	Mono mixer	Mixes eight signals into one.	10 mA	£5.92	£5.15
HY 8	Stereo mixer	Two channels, each mixing five signals into one	10 mA	£7.19	£6.25
HY 11	Mono mixer	Mixes five signals into one — with base/treble controls.	10 mA	£8.11	£7.50
HY 68	Stereo mixer	Two channels, each mixing ten signals into one.	20 mA	£9.14	£7.95
HY 74	Stereo mixer	Two channels, each mixing five signals into one — with treble and bass controls.	20 mA	£13.17	£11.45

AND OTHER EXCITING NEW MODULES

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HY 13	Mono VU meter	Programmable gain/LED overload driver.	10 mA	£6.84	£5.95
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HY 72	Voice operated stereo fader	Provides depth/delay effects	20 mA	£15.07	£13.10
HY 73	Guitar pre-amp	Handles two guitars (bass and lead) and mic with separate volume/bass/treble and mix.	20 mA	£14.09	£12.25
HY 76	Stereo switch matrix	Provides two channels, each switching one of four signals into one.	20 mA	To be announced	
HY 77	Stereo VU meter driver	Programmable gain/LED overload driver.	20 mA	£10.64	£9.25

For easy mounting we recommend:
B 6 mounting board for modules HY6 -HY13 £0.90 inc. VAT. (0.78 ex. VAT.)
B 66 mounting board for modules HY66-HY77 £1.12 inc. VAT. (0.99 ex. VAT.)

*All modules are encapsulated and include clip-on edge connectors. All operate from ±15V minimum to ±30V maximum, needing dropper resistors for higher voltages. HY67 can be used only with the PSU 30 power supply unit. Modules HY6 to HY13 measure 45 × 20 × 40mm. HY66 to HY77 measure 90 × 20 × 40mm.

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STAY AHEAD. STAY WITH US

POCKET TV

The prototype Microvision pocket TV.

The new Microvision flat-screen TV, from Sinclair Research Ltd, will be going into production late in 1982.

THE pocket-sized computer system is now very close to being realised with the development of a new visual display unit which consumes little power and is roughly the size of a pocket calculator. It is now possible to construct a pocket computer with printer, central processor unit, visual display and printout on to photo-sensitive paper.

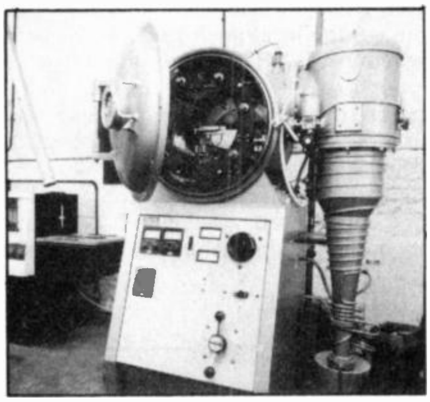
"The slim-line pocket TV is here and is going into production", says Clive Sinclair, founder and director of Sinclair Research Ltd. The company has been responsible for developing pocket calculators, small TVs, etc, and has now overcome the formidable problems of designing and producing a miniature (20 mm thick) cathode ray tube (CRT).

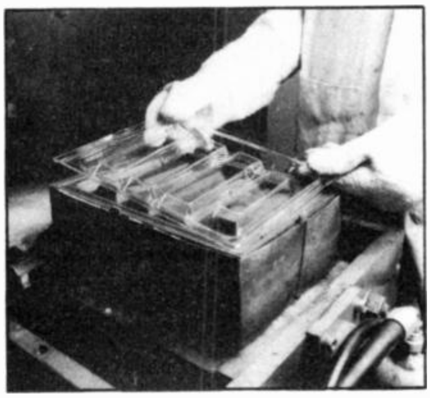
A manufacturing plant is being set up to produce a pocket TV/radio with a 75 mm diameter black and white screen. Mr. Sinclair expect this to be available late in 1982 and he predicts that a colour version will be produced shortly afterwards. Owing to the radical design of the flat CRT, the brightness of the screen is three times that of the conventional CRT. This makes it ideal for use in projection TVs with up to 1250 mm diameter wall-mounted screens.

A great deal of energy and money has been spent over the last decade to produce a miniature VDU which consumes low power. The announcement by Sinclair of a flat CRT, where the electron gun is mounted to the side of the screen, is a breakthrough because the development of a low cost solid state device still seems years away. It is certainly possible to construct a complete screen from individual LEDs or liquid crystal elements, but the cost of manufacturing and the complex circuitry needed to control it is prohibitive at the moment. In addition, such a system would inevitably give poor visual definition and, if liquid crystal displays were used, the contrast would be unsatisfactory.

The Sinclair CRT is shown in **Figure 1**. It measures 100 x 50 x 20 mm and is half the volume, three times as bright and consumes one quarter to one tenth the power of a conventional CRT of the same screen size. The device is constructed from a fairly conventional electron gun, collimator, and vertical and horizontal electrostatic deflection plates mounted at the side with the axis parallel to the phosphor screen. A positive electrode behind the screen, and a negative electrode inside the front face cause electrons to be deflected towards the screen. The negative electrode at the front is made of a tin oxide coating which is transparent to light. The vacuum enclosure is made of glass and a plastic Fresnel lens is mounted outside the front surface.

Although the design concept is very simple, the fact that the electron beam does not strike the screen at right angles means that one or two tricks are needed to produce images which are well-defined and undistorted. First of all, good definition of a picture requires that the electron beam spot should be circular and as small as possible. The situation without the electrostatic field is shown in **Figure 2a**. It can be seen that at point A the angle of incidence is greater than at point B, so that the beam spot is much less elliptical here. **Figure 2b** shows the situation when an electrostatic field is applied. The angle of incidence is constant across the screen and the spot is therefore of constant size.





Top: The man himself, Clive Sinclair, holding the prototype of the Microvision 2700.

Middle: Machinery for making flat CRTs — it's a vacuum metaliser, used to deposit an aluminium backing surface for the tube screen.

Bottom: The flat CRT can easily be mass produced. This particular machine, at the company's pilot production plant at St Ives, Cambs., was designed by Sincliar engineers and produces 14 glass covers every 2 minutes.

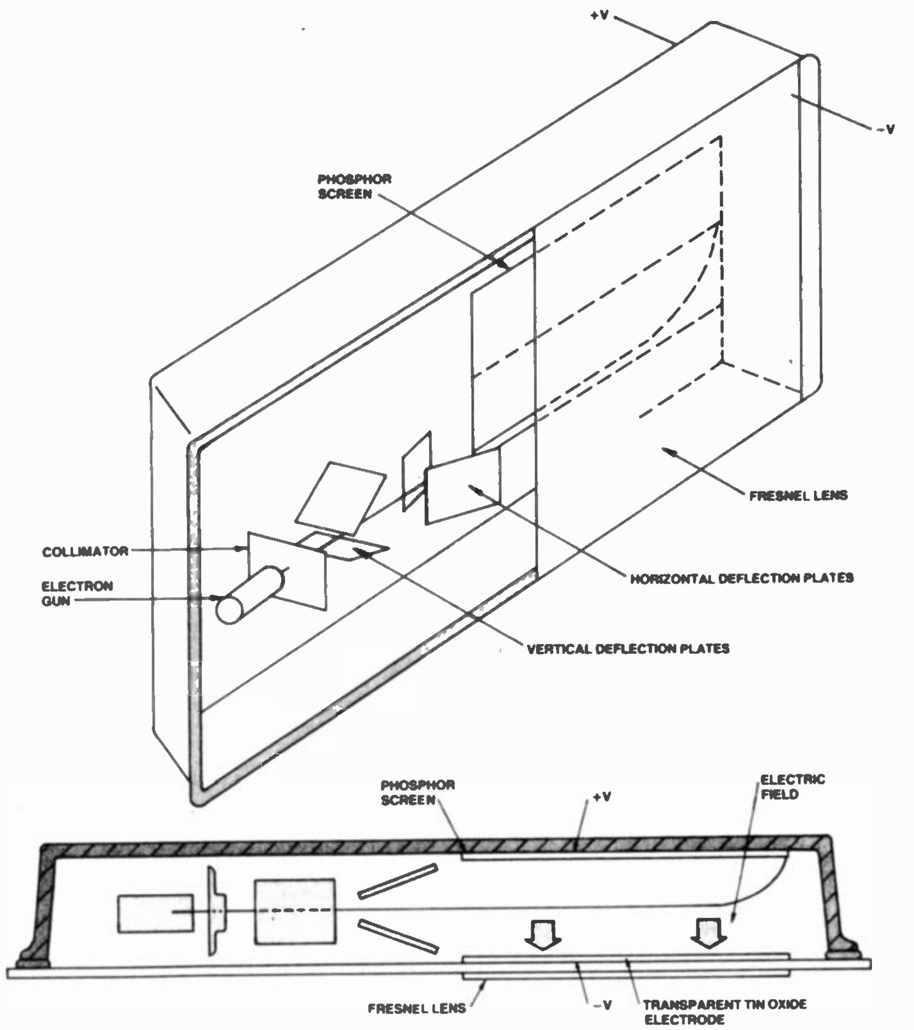


Figure 1. **General construction (simplified) of the Sinclair miniature flat screen picture tube (see also picture over the page).**

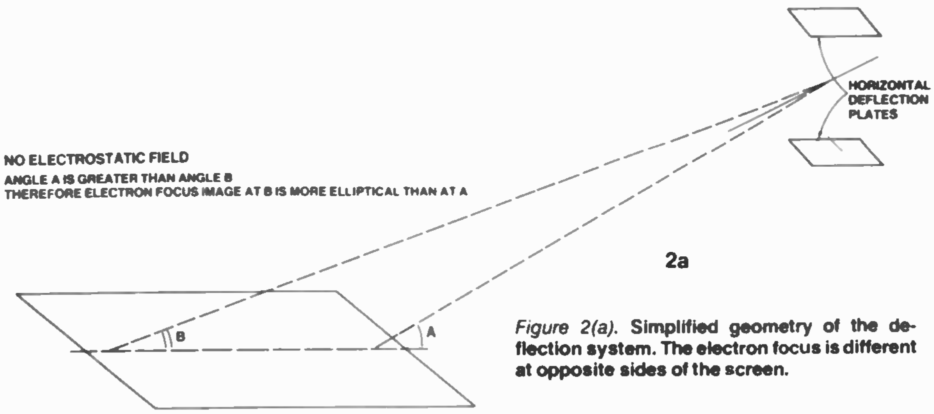


Figure 2(a). **Simplified geometry of the deflection system. The electron focus is different at opposite sides of the screen.**

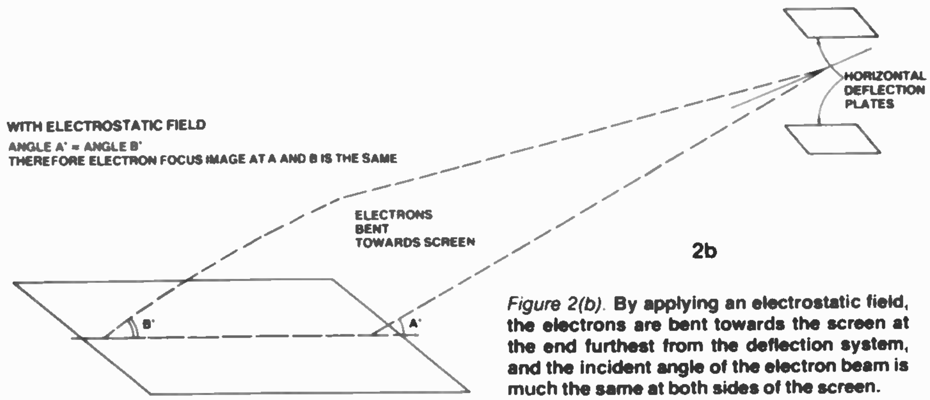
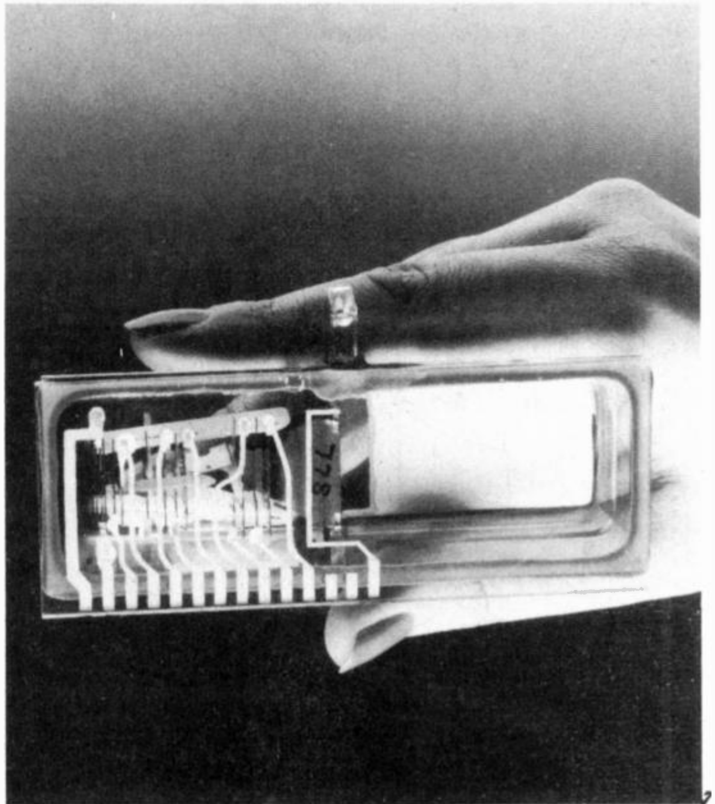


Figure 2(b). **By applying an electrostatic field, the electrons are bent towards the screen at the end furthest from the deflection system, and the incident angle of the electron beam is much the same at both sides of the screen.**



The flat CRT — a triumph of British ingenuity. They are now being mass-produced at the Timex factory,at Dundee, ready for assembly into complete units later this year.

Achieving an undistorted image is difficult because the distance from the collimator to the screen is comparable to the screen dimensions. Without correction the shape of the scan would be as shown in **Figure 3a**. A combination of optical and electronic methods is used to rectify this shape as much as possible.

The verticle deflection angle of the beam is reduced to make the resulting image more nearly rectangular and the vertical dimension is then magnified optically by the Fresnel lens in front of the screen. The horizontal dimension is unchanged.

A modulation voltage is applied to the vertical deflection plates during each frame to change the image as shown in **Figure 3b**. Image MNOP changes to M' N' O' P', which is more nearly rectangular and distortions are therefore reduced to a minimum.

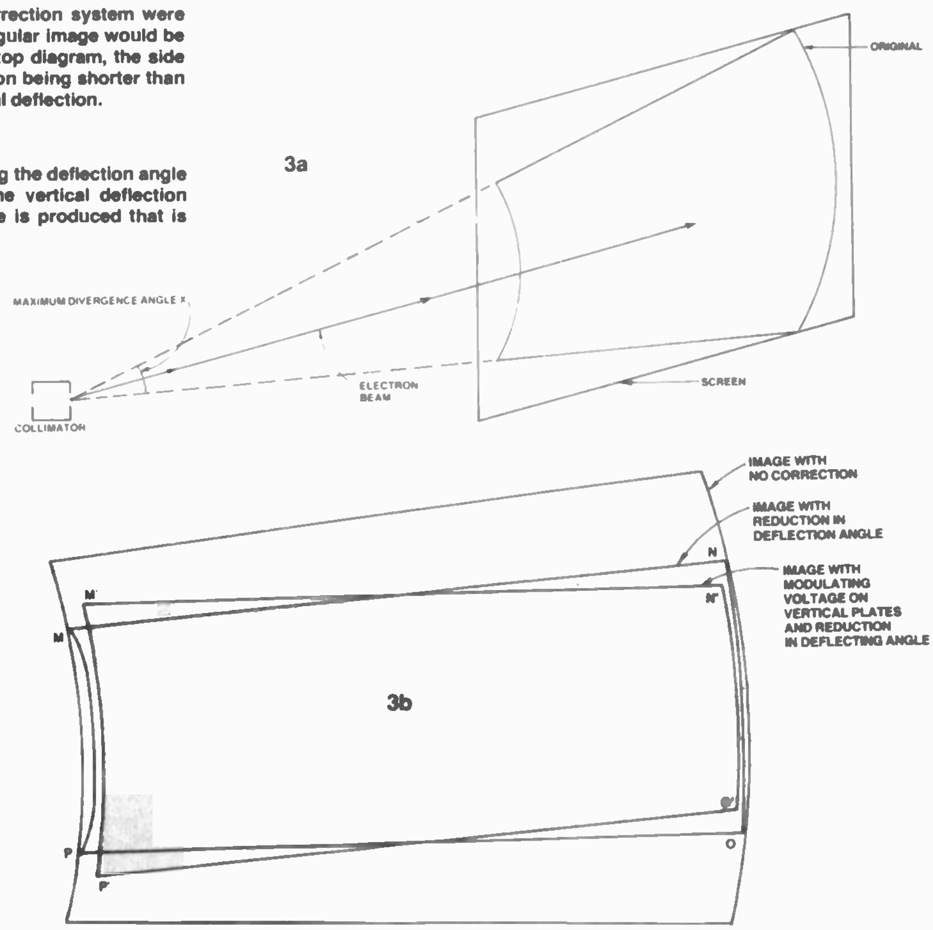
Sinclair point out that the construction of the CRT lends itself to mass production technology in that, for example, connections to the electron gun and deflection assembly are screen-printed on the inside of the faceplate and the assembly is attached in a single operation.

The feature that makes the CRT ideal for projection TV is that the image is viewed from the side of the phosphor that the electrons strike. This results in a much brighter image in comparison to the conventional CRT where the image is observed through the phophor layer. It can be seen that a heatsink placed directly on the backing plate of the screen allows the phosphor to be driven much harder by the electron beam without thermal damage.

In the future the miniature CRT could well be used in pocket oscilloscopes and other test equipment once the techniques of obtaining perfectly distortion-free images are mastered.

Figure 3(a). **If no image correction system were applied the normally rectangular image would be distorted as shown on the top diagram, the side nearest the vertical deflection being shorter than that furthest from the vertical deflection.**

Figure 3(b). **By both reducing the deflection angle and suitably modulating the vertical deflection voltage waveform an image is produced that is more nearly rectangular.**



HE

FEEDBACK

THEY KEEP USING THIS WORD feedback, don't they? The amplifier you've just built sounds a bit loud and fuzzy and you're told it needs feedback. Another one just howls all the time, and you're told it's caused by feedback. OK, then, let's unwrap the mystery.

First of all, sort out what we mean by an amplifier. Whatever its made from, you can put a signal into it and you get a signal at the output which is a good copy of the input signal's shape but of much greater amplitude. When the input signal is a sine wave, its voltage amplitude (peak-to-peak) is the voltage difference between the opposite peaks. For example, a signal with its positive peak at 2 V and its negative peak at − 2 V is a signal of 4 V peak-to-peak amplitude. It's this that an amplifier amplifies; a few types (called current amplifiers) are intended to amplify not the voltage but the current amplitude. The point is, though, that the amplifier doesn't miraculously cause amplitude to become greater; it actually creates a new waveform whose amplitude is greater than the signal input, and which is controlled by the signal input, so that it ought to be a good copy. If it isn't, we say that the output signal is distorted.

Now the signal at the output of an amplifier can be connected to other circuits and, if we're reasonably careful about it, these connections won't make much difference to the amplitude of the signal. The care we need to take is not to connect the signal onto a circuit with resistance much lower than that of the output of the amplifier. An amplifier that is designed to feed a loudspeaker can, for example, happily feed its signal into the low resistance of a loudspeaker but voltage amplifiers, which are *not* intended to feed loudspeakers, can't cope with low resistances. If we stick to fairly high resistance circuits, though, we can make connections to the output of a voltage amplifier without reducing the signal.

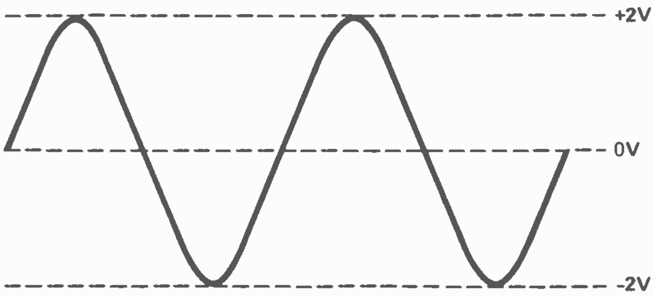


Figure 1. Voltage amplitude. This wave has a voltage amplitude of 4 V peak-to-peak.

Feedback Loops

Now this is where feedback comes in. Feedback is a connection made through a resistor, or through a set of resistors and capacitors called a network, which connects the signal at the output of an amplifier back to the input of the amplifier. This connection is called the feedback loop and, when a feedback loop is connected, the behaviour of the amplifier is considerably changed. The reason is that the amplifier is no longer making a copy just of the input signal, but of a mixture of signals — the input signal and the feedback signal. What happens now depends on how the mix is arranged.

One way of arranging it is to have the feedback signal in phase with the output. 'In phase' means that the signals are exactly alike (except for amplitude) with the peaks happening at exactly the same time. When the mixing of signals is done this way, the feedback is said to be positive — the signal coming back through the feedback network or resistor looks just like the input signal and when we mix this with the genuine input signal the two add together to make a higher amplitude input for the amplifier. This in turn produces a greater amplitude of output which will result in more feedback signal and so on.

If we use an attenuating network in the feedback loop (remembering that an attenuator network reduces the amplitude of a signal) and we make sure that the attenuation of the feedback loop is more than the gain of the amplifier, the whole thing comes to balance; the amplifier behaves as if it had much more gain because the feedback is providing some of the input signal. At the same time, any distortion that the amplifier produces is greatly increased because the distorted signal is being fed back to be amplified again.

Earthy Problems

If, however, the gain of the amplifier portion is greater than the attenuation of the feedback network, then the output signal will provide enough feedback to the input to produce the output signal all by itself, with no other input needed. This arrangement makes an oscillator — it continually generates an output signal with no input. If an amplifier oscillates, it's because of positive feedback somewhere, perhaps from signals passed along the power supply line if the oscillation is at a low frequency. Even a careless arrangement of earth connections can cause oscillations, if the amplifier has a large amount of gain.

Positive feedback is used, therefore, to make oscillator circuits and to boost amplifier gain but, because it's difficult to control, high quality audio amplifiers avoid using positive feedback. Oscillator circuits control the positive feedback carefully so that it operates only at one frequency, the frequency of oscillation.

Negative Feedback

Negative feedback is the other option. Negative feedback is what we get if the feedback network is connected to an amplifier whose output signal is in antiphase with the input signal. An-

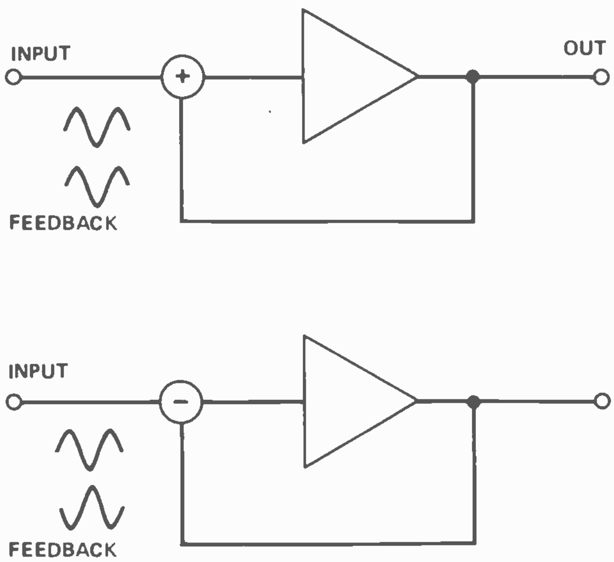


Figure 2. Feedback: (a) in phase, adding to the signal at the input (positive feedback); (b) in antiphase, subtracting from the signal at the input (negative feedback).

tiphase means that the signals (apart from the differences in amplitude) look like mirror images of each other. When we add signals in antiphase, the effect is of subtracting one signal voltage from the other. The result of negative feedback, then, is to make the signal into the amplifier less than the genuine input signal. The amplifier is still doing its stuff, but there is less signal for it to work on so that it looks as if the gain of the whole arrangement is less than it was before the feedback was connected.

At first signt this doesn't look like a very good bargain. Gain, after all, is what we want from an amplifier and it doesn't seem to make sense to do anything that reduces gain. The advantages of negative feedback, however, greatly outweigh the small disadvantage of a loss of gain. Gain, after all, is easily obtained; if you want more gain you can use more transistors. What negative feedback does is to stabilise gain — a much more valuable feature. Think of it this way. Suppose you built twenty samples of two stage voltage amplifiers. There's precious little chance that all of them would have the same gain figure; because of the differences between transistors, we might find gain figures ranging from 500 to 8,000. Now if these were all negative feedback amplifiers, we could design for a gain of 250 — and find values ranging from 230 to 260.

This is a much smaller spread of gain values and illustrates the value of negative feedback for the designer. It's possible, using negative feedback, to design an amplifier whose gain can be exactly calculated, whatever the tolerances of the transistors. The use of integrated circuit amplifiers makes negative feedback even more important because the gain of an IC amplifer simply cannot be closely controlled when the IC is manufactured.

How much gain can we expect from an amplifer fitted with negative feedback? If the amplifier has a large amount of gain before the feedback is added, the answer is fairly simple. Find the attenuation of the feedback network — this amount is then equal to the gain of the complete amplifier when feedback is added. For example, if the feedback network causes the output signal amplitude to be divided by 50 then the gain of the complete amplifier will be 50 times, provided that the original gain of the amplifier, before the feedback was added, was much more than 50 (perhaps 500 or more). This figure should remain fixed throughout the life of the amplifier, even if transistors are replaced.

Noise and Distortion

Being able to design for a definite gain figure, then, is one good reason for using negative feedback but it's certainly not the only one. Another compelling reason is the reduction of some types of distortion. Remember that what an amplifier does is to create a larger-scale copy of an input signal. Any difference, apart from the difference of amplitude, between output and input is distortion. One kind of distortion in this sense is noise — unwanted signals which are generated inside resistors, transistors and all other conductors by the movement of electrons. Because the noise generated inside an amplifier is not present as a signal at the input of the amplifier, the use of negative feedback reduces the noise by cancelling it with an antiphase signal at the input. Hum signals picked up from a poorly-smoothed supply line can be reduced in the same way.

Another type of distortion is frequency distortion. An amplifier may not treat signals of different frequencies in the same way; very often, the gain of the amplifier for signals of low frequencies (below 50 Hz) or high frequencies (above 10 kHz) is less than for 'mid-band' frequencies in the range 400 Hz — 1 kHz. A negative feedback connection will reduce the gain but also make the lower value of gain one which holds true for a much greater range of frequencies. The effect is shown on the graph of **Figure 3**; the amplifier can cope with low and high frequencies at low values of gain and applying negative feedback brings the gain of the amplifier for the middle range of frequencies down to the same value.

Cure All?

Negative feedback is so useful that we fall into the habit of assuming that it can cure all sorts of nasty complaints which amplifiers are prone to. What we have to remember, though, is that negative feedback works according to the book only when the gain of the amplifier is very high in the first place. If the amplifier gain without feedback is low, then feedback has little or no effect. Would we use negative feedback on such an amplifier? In the normal course of events we wouldn't, but we sometimes forget that an amplifier can have low gain in patches. For example, **Figure 4** shows the graph of signal-out plotted against signal-in for an amplifier output stage which is not correctly biased. Most of the graph is fine, showing a healthy gain, but the small section marked AB at the centre is not so good. In this section there is no output for a small range of input, so there is no gain and this means that negative feedback will not correct the distortion which this sort of shape also causes; and yet we often assume that this 'cross-over' distortion, as it's called, is removed by negative feedback. A good general rule is that negative feedback can make a good amplifier a bit better; but it can never make a lousy amplifier into a good one! **HE**

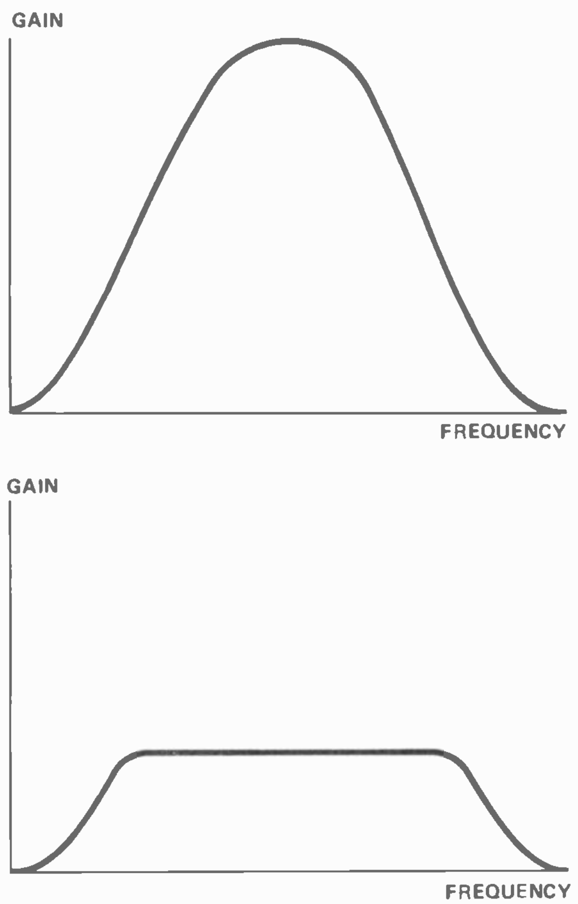


Figure 3. Reducing frequency distortion by negative feedback; (a) Graph of gain plotted against frequency for an amplifier without feedback; (b) the effect of negative feedback is to reduce the gain, creating a flat portion of graph.

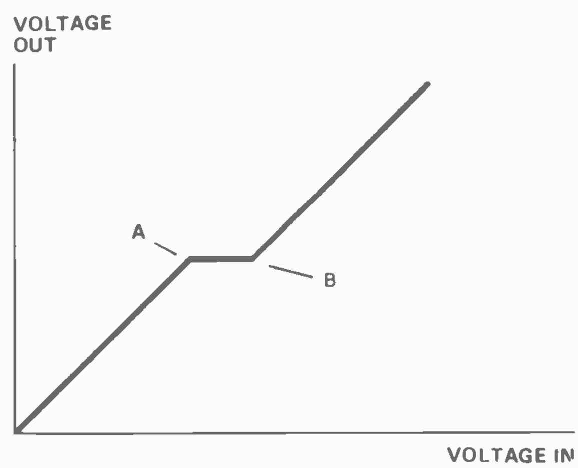


Figure 4. Effect of bias faults. The graphs shows a region A-B in which there is no gain, so that negative feedback cannot operate.

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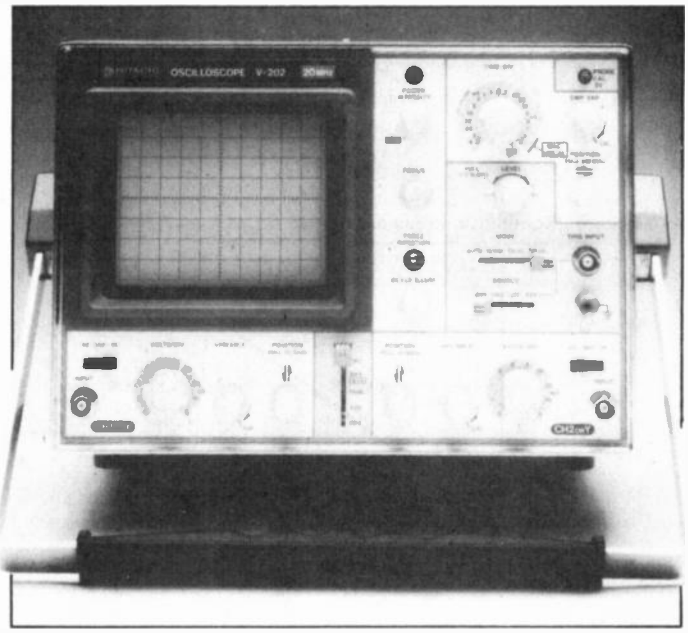
THE OSCILLOSCOPE REVISITED

Since our articles on the subject in February and June last year — and the Special Offer which many readers found too good to refuse — we've had many requests for a follow-up describing, in greater detail, how to use this most useful tool of the electronics trade. Ready then? Here we go.



the instrument and how to use it

THE OSCILLOSCOPE is one of the most versatile and useful electronic test instruments ever invented (Allen B. Du Mont — the 'inventor' of the oscilloscope — is the subject of this month's Famous Names). It's true that they are not cheap (though second-hand bargains are available) and that you can do a lot of trouble-shooting without one, but it's equally true that some faults are virtually impossible to pinpoint without using a 'scope and that any sort of circuit design or modification work is just not on. Pulse circuits, in particular, are extremely difficult to trouble-shoot without a 'scope because steady voltage readings are meaningless in pulse circuits — all you can check is whether an IC has a voltage supply or not. Let's take another look, then, at this remarkable instrument and how it's used.

The heart of a 'scope is, of course, a cathode-ray tube (CRT). The CRT has already been described in detail (HE, February 1981), but to refresh memories, the principle of the CRT (whether it's in oscilloscope or in a TV receiver) is that a beam of electrons can be generated by a heated cathode, focused in to a thin beam and made to travel towards a positively charged anode — the cathode and focusing mechanism together make up an 'electron gun'. The anode is a glass screen, coated with a material (phosphor) which gives off light when struck by the beam, making a spot of light on the screen. The brightness of the spot can be controlled but, more importantly, so can its position. The spot can be guided (deflected) to any part of the screen, or even pushed right off the edge, by applying a varying electric or magnetic field; oscilloscope tubes invariably use electrostatic deflection, while TV tubes use the magnetic method because it allows greater deflection to be obtained from a reasonably short tube. In a 'scope tube, guidance is achieved by the deflection plates — four of them altogether arranged in pairs called the X plates and the Y plates. As you look at the screen the Y plates deflect the spot vertically, up or down, while the X plates move it from side to side. The beam swings over towards the more positive deflection plate so that, by changing the voltages on the four plates, the beam can be positioned anywhere you like on the face of the screen. Unlike the needle of a meter, though, a beam of electrons has no mass to speak of, so it can be pushed around with incredible acceleration and made to trace out complicated patterns at very high speeds; that's the key to the oscilloscope.

Sweeping Up

Every oscilloscope contains a built-in oscillator, the timebase or horizontal sweep circuit. This circuitry generates a voltage waveform with a sawtooth shape and this is amplified and fed to the X plates. The result is that the spot on the tube face moves at a steady speed, from left to right as we look at the screen. The speed can be controlled and, even more important, measured; its value, in time per centimetre of movement across the tube face, can be read off the TIME/CM (sometimes labelled TIME/DIV) control on the front panel. During the time the spot is moving across the screen, a voltage fed to the Y plates will cause the spot to move vertically. If this voltage is a sinewave then the vertical movement of the spot, combined with its steady horizontal speed, will trace out the shape of the wave, in light, on the screen (Figure 2). Adjusting the controls labelled SYNC or TRIG will produce a steady pattern on the screen, showing the waveshape of the voltage which is being fed to the Y-plates. An amplifier (the Y amplifier) is provided and its gain control is calibrated in volts per centimetre of (vertical) movement so that the peak-to-peak voltage of the waveform can be calculated easily. From such a display, then, you can see the waveshape, measure its frequency and also its peak-to-peak amplitude in volts, so that every measurement that can be carried out on a waveform is possible. Very useful — but how do we go about it?

Screen Test

Suppose you're sitting there in front of an oscilloscope, ready to switch on for the first time. Be patient; keep that main-switch finger away for the moment. Start with nothing — not even the mains plug — connected and take a look at the controls on the front panel. They might not look exactly like the examples we've shown here but the same controls have to be there somewhere. There has to be a BRILLIANCE (or INTENSITY) control and a FOCUS control, and there must also be X and Y POSITION (or DEFLECTION) controls. Find these and you're well on the way to knowing your way about — but there's one more. It may be labelled TRIG, SYNC or LEVEL. Whatever it's called, turn it fully clockwise (that's full on);if there is a STABILITY control with an AUTO position, set it to auto. Now make sure that the brilliance/intensity control is turned fully off (anticlockwise). Next step is to plug in and switch on. There may be a separate toggle switch for on/off or the mains switch may be combined with the brilliance/intensity control; if this control has to be turned (clockwise) to switch on, turn it only as far as is needed to click the switch — then leave the 'scope, for a minute so that the CRT heaters can warm up. Older oscilloscopes (which use valves) will also need this minute for the valve heaters to warm.

While the 'scope is warming up, set the volts/cm to the highest value of the range and the time/cm to 1ms/cm, or the nearest value to this. Adjust the vertical and horizontal position (deflection) controls to midway round their travel and, when warming-up is complete, gradually advance (clockwise) the setting of the brilliance/intensity control. If all is well, you should eventually see the horizontal line of the trace on the screen.

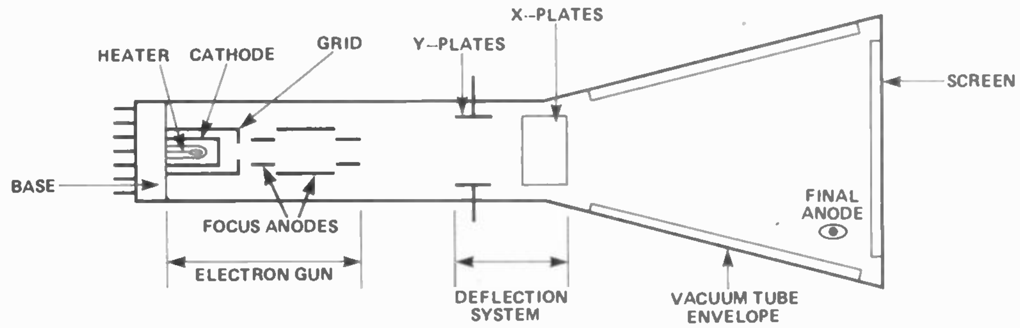


Figure 1. Schematic cross-section of a Cathode-Ray Tube (CRT).

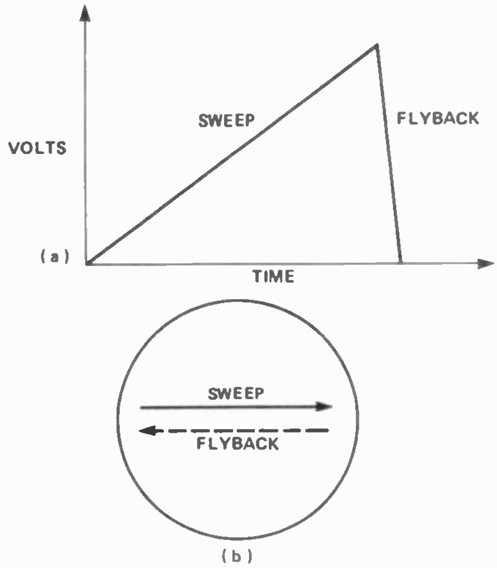


Figure 2. (a) The timebase (sweep) waveform is a sawtooth wave. The voltage rises at a steady rate, then returns rapidly to its starting value: (b) The spot moves steadily from left to right, then rapidly returns with the 'flyback'.

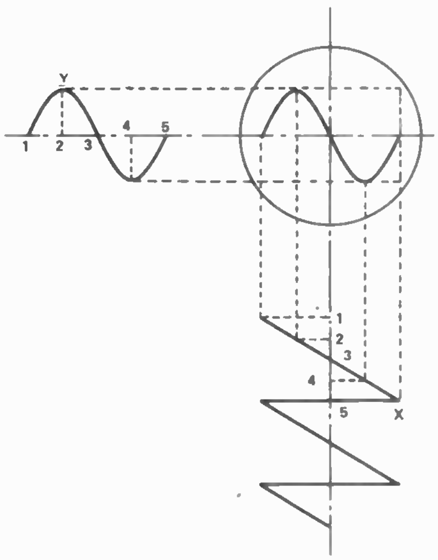


Figure 3. The deflection waveforms, applied to the X and Y plates, cause the electron beam to sweep out a faithful replica of the Y-input waveform.

No trace of the trace? Don't panic just yet — it's surprising how difficult it can be to find the trace, even for an experienced operator! Modern oscilloscopes have a TRACE LOCATE push-button; pressing this useful 'twit-switch' produces a spot at the centre of the screen and, as the switch is released, the spot *slowly* moves off to wherever it was before. This way, you can recover a trace which was lost because the position/deflection controls were badly set. If your oscilloscope doesn't have this humanitarian device, sort it out as follows:

1 . Turn the brilliance/intensity right up and the timebase (time/cm) control to its slowest speed (but not off). You should now see some light appearing on the screen, moving slowly.
2 . If there is still nothing to be seen, advance (clockwise) the trig/level control; a low setting can prevent the timebase from starting.
3 . With something happening inside, twiddle the vertical position control until the trace appears; some adjustment of the horizontal position control may be needed as well.

If that lot doesn't produce some sort of trace then you have every right to start wondering if the thing is working — but unplug the mains and check the fuses before you do anything drastic!

Assuming that these actions have produced some sort of trace on the screen, we can start to lick it into shape for useful measurements. The first step is to centre the trace — with the time/cm control reset to 1ms/cm — using the vertical and horizontal position controls, so that the horizontal line starts just at the left-hand side of the screen and is along the centre-line. If there is a control marked TRACE EXPANSION or X-GAIN, it should be set so that the width of the trace is just enough to stretch across the screen, but no more.

Now reduce the brilliance/intensity setting to a comfortable level and adjust the focus control (sometimes labelled spot size) so that the line is as thin as possible. It's usually impossible to obtain a fine, focussed line if the brilliance/intensity control is set too high. If necessary, use the oscilloscope in a corner where there are no lights shining directly on the screen.

Now, sitting there with a working oscilloscope in front of you, how about looking at a waveform? You don't need a signal generator just yet because there's a waveform available literally at you fingertips — its the mains waveform which your body picks up from the wiring all around you. Set the time/cm control to 20 ms/cm and the volts/cm to 1 V/cm, or to a lower value if this is available. Now connect a probe or a lead to the Y input and hold the other end; you should see a 50 Hz mains waveform, a sinewave, probably with some distortion, on the screen. If the whole wave is moving, adjust the control labelled SYNC (on older 'scopes) or TRIG LEVEL (on more up-to-date models); this control is used to start the timebase at the same part of the waveform on each sweep, so that the trace appears stationary. If you simply can't get the trace to stay still ('locked'), check if there is a switch labelled TRIG INT-EXT (or SYNC INT-EXT). If there is, make sure that it is on the INT (for internal) setting. In this position the timebase is locked to the signal into the Y-input (TRIG, EXT or, on older models, the X-input). On a few oscilloscopes, a FINE TIME/CM control may have to be adjusted, to obtain perfect lock.

With the waveform locked on the screen, its vertical size can be changed by altering the volts/cm switch. Changing this to a more sensitive setting, such as 0V2/cm will make the display look larger while changing to a less sensitive setting, such as 5 V/cm, will make the display look smaller. If the sensitivity is reduced too much, so that the vertical size of the pattern is less than 1 cm overall, the timebase lock will be affected and the pattern will start to shift horizontally. The best setting for the volts/cm switch depends to some extent on the size of the screen, but 4-5 cm overall is usually convenient.

All oscilloscopes worthy of the name allow measurements to be made on the displayed waveform. The usual method is to have an engraved plastic sheet, called the graticule, which fits snugly over the screen. The graticule is engraved with parallel lines, 1 cm apart, with small divisions on the centre lines to indicate 0.2 cm; both horizontal and vertical lines are engraved, so that both time and voltage measurements are possible. On modern 'scopes, the graticule may be generated as a display.

For voltage measurements the method is to count the number of centimetres on the vertical scale from the negative peak to the positive peak, then to mulitply this number by the setting of the volts/cm switch. For example, if the volts/cm switch is set to 5 V/cm and the waveform measures 3.2 cm from peak-to-peak, the waveform voltage is 3.2 x 5 = 16 V peak-to-peak. The time measurement we most often have to make is that of the time (period) of one complete cycle, so that we have to measure the horizontal distance between two identical points on neighbouring waves. This distance is then multiplied by the setting of the time/cm switch to calculate the period of one cycle. The inverse of this time (that is 1/time) is the frequency of the wave. For example, if the peaks of the waveform are 2.5 cm apart and the time/cm switch is set to 100 uS/cm, the time of one wave is 2.5 x 100 = 250 uS and the frequency is 1/250 uS = 4 kHz.

It's usual, on modern 'scopes, to find a choice of AC or DC coupling, by means of an AC/DC switch at the Y-input. In the AC position, the signal on the Y-input is passed via a coupling capacitor and, therefore, any DC voltage also present in the signal is blocked. With the switch in the DC position, however, the Y amplifier is completely DC coupled from the input all the way to the plates; this is very useful. Connecting a 1V5 dry cell to the input will, for example, cause the whole trace to shift vertically. If the volts/cm switch is set to 1 V/cm then the trace will shift by 1.5 cm for 1V5. If the negative terminal of the cell is connected to the oscilloscope's earth and the positive terminal of the cell to the Y-input, the trace will shift upwards. If the connections are reversed, the trace will shift downwards; that is, positive voltages are represented by upward movements and negative voltages by downward movements. Now if you disconnect all signals from the front panel of the 'scope and short the Y-input to earth, the Y position/deflection control can be set so that the trace lies along one of the horizontal graticule lines — and this line will now represent earth voltage. Attach a signal now and you can measure the DC level of the signal relative to earth — a measurement you can't possibly make with a multimeter. With the input switched to AC, set some convenient part of the trace, such as a peak, to lie on one of the horizontal lines. Now switch to DC, and see how far up or down the peak shifts; the amount shifted represents the average DC level of the wave. The shift, in centimetres, is multiplied by the setting of the volts/cm switch as usual.

For comparing waveforms, a double beam 'scope is essential. In a double beam 'scope two traces appear on the tube face, each using the same time-base and X deflection, but with separate Y-input controls. The two traces are separate and different waveforms can be displayed, but with the same timebase setting so that time/frequency differences between them can be measured.

Several different methods are used to obtain double beam displays and these include:

(a) beam splitting, in which the beam from an electron gun is split in two after it has passed the X plates but before reaching the Y plates.

(b) separate guns, in which two separate electron guns, mounted vertically one above the other are used, with the X-plates connected together but with separate Y plates.

(c) by beam-switching, using a single gun CRT.

The beam-splitting method was used in old double beam 'scopes and served well, providing you remembered that upwards meant postive on one beam and, negative on the other. Double guns made it easier to relate the waves to each other, but it was difficult to ensure that both beams were perfectly focused and equally deflected by the timebase. Most modern double-beam scopes use beam switching and, since it's purely a circuit technique, a double-beam switch can be added to any normal single-beam tube.

Beam-switching makes use of DC coupling into the 'scopes Y-amplifier. At the start of a timebase sweep, one of the two input signals is applied to the Y-input of the amplifier, with some DC level decided by a Y-shift control. On the next sweep, the other signal is applied to the Y-input but and at a different DC level, so that the traces are at a different vertical positions.

When this is done rapidly enough, it looks as if two traces are there simultaneously. The method doesn't work at low timebase speeds (a slow sweep speed means you see first one trace, then the other — but never both at once!), so a 'chopping' method of switching is used instead. In this switching system, input A is displayed for a short time, then the trace is shifted up (or down) so that input B can be displayed. If the beam and the inputs are switched at a frequency many times that of the timebase sweep, each trace appears continuous. At high sweep speeds (approaching the 'chopping' frequency), however, the traces will appear as dashed lines!

Double beam arrangements are very useful when looking at circuits which make use of pulse triggering, synchronisation,

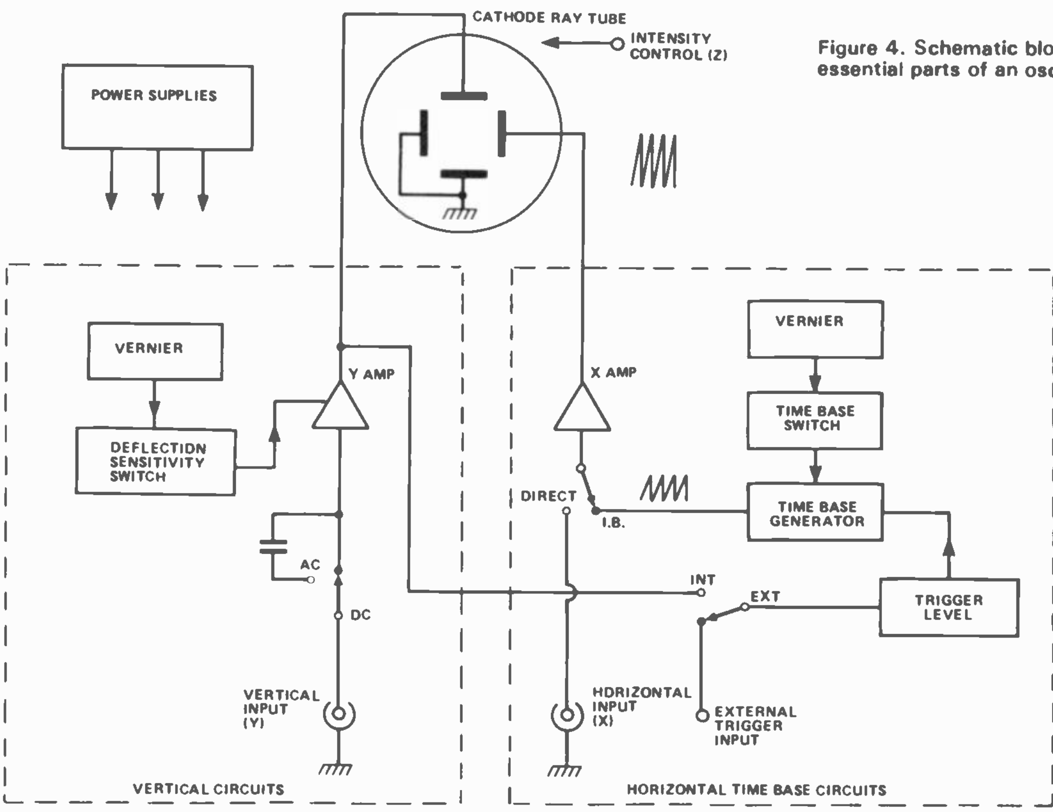


Figure 4. Schematic block diagram of the essential parts of an oscilloscope.

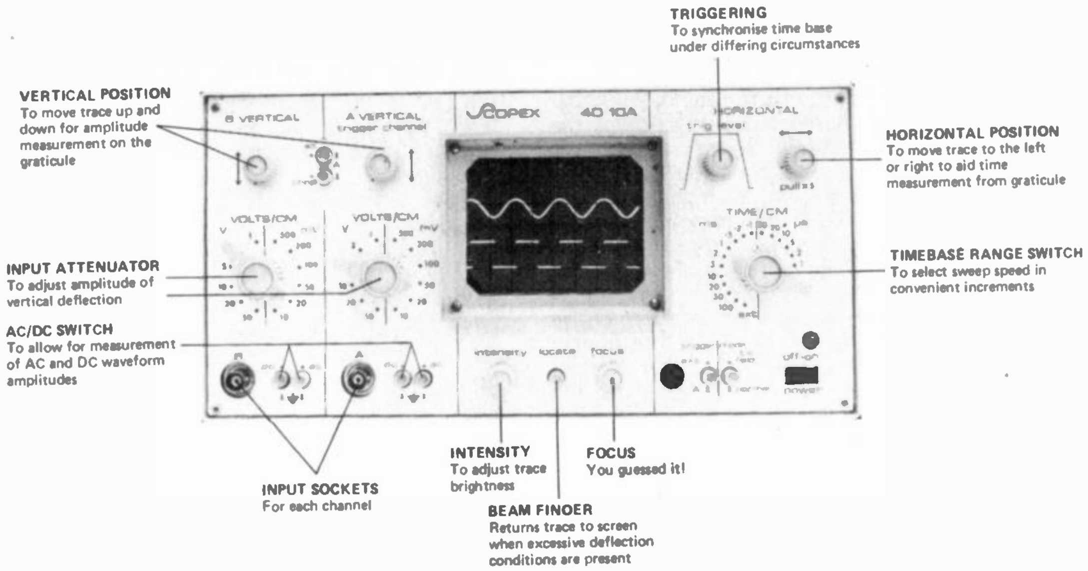


Figure 5. Front panel layout of a SCOPEX 4D 10A, a modern double-beam 'scope.

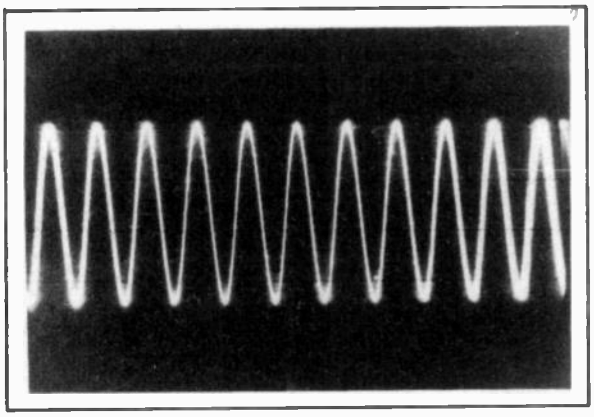
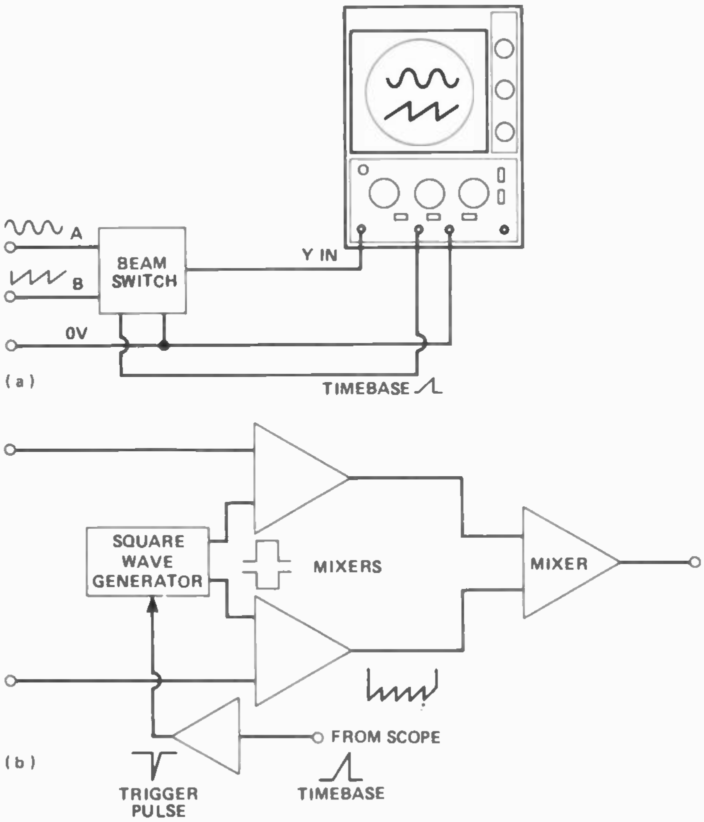


Figure 6. A 50 Hz waveform produced by touching the input of a 'scope.



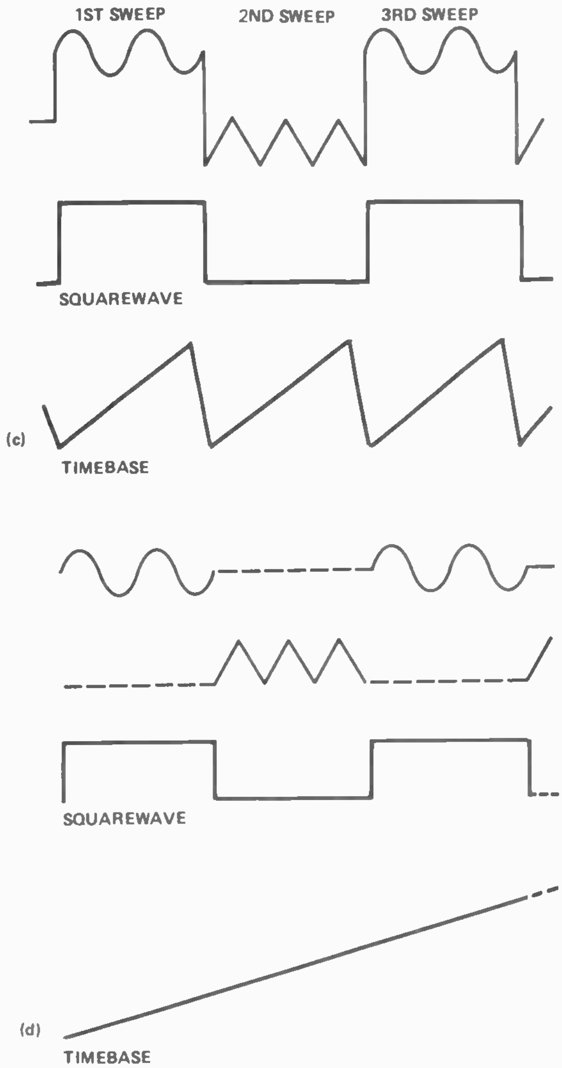


Figure 7. Beam switching techniques produce a dual-beam oscilloscope: (a) Connecting the beam-switch to a 'scope: (b) The waveforms are added to the level parts of a squarewave and the DC voltage difference between the positive and negative levels produces the separation of the traces. The squarewave generator is triggered by the flyback of the timebase: (c) At high sweep speeds, the beam is switched on alternate traces: (d) At low sweep speeds, the beam is 'chopped' at a high frequency so that each waveform is traced out, alernately, in sections.

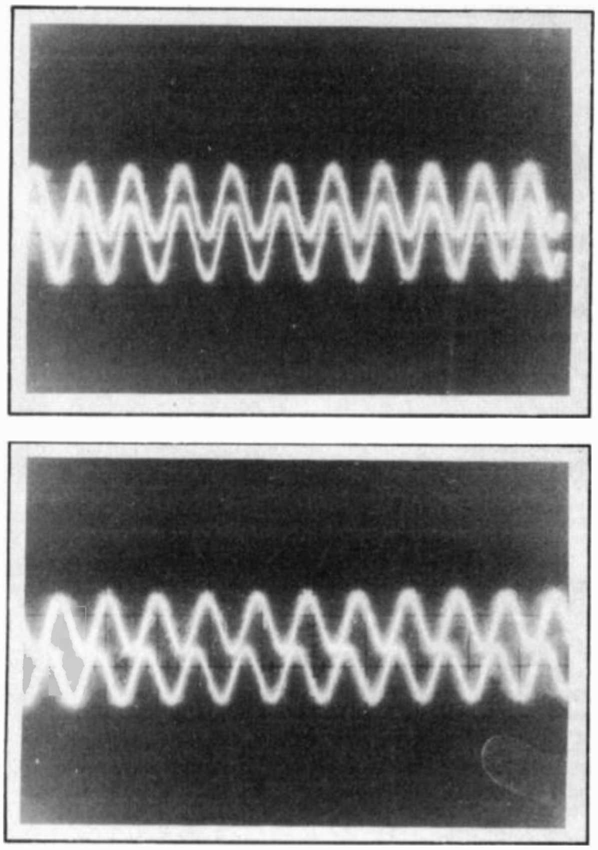


Figure 8. Comparing waveforms on a double-beam 'scope: (a) Sinewaves in phase: (b) Sinewaves out of phase.

phase sensitive detection or similar techniques. Remember, however, that unless the two sets of waveforms have the same frequency or are at related frequencies, it will be difficult (if not impossible) to get both traces 'locked' on screen. This is usually not a problem with pulse circuits or when phase-locked loops are used to synchronise sinewaves.

Another use for the oscilloscope is to compare frequencies and the method is particularly useful for comparing frequencies which are to be adjusted so as to be equal or in some simple relation. The method is an old one called 'Lissajou Figures'; the connections needed are shown in **Figure 9**. The method depends on being able to switch off the timebase and make a direct connection to the X-amplifier.

If the two signals are sinewaves and are synchronised, the pattern produced by this arrangement will be stationary. For equal frequency sinewaves, the pattern can vary from a diagonal line to a circle. Why the difference? The reason is the *phase* difference between the waves — a difference of 90° produces the circle whereas 0° (or 180°) produces a straight line. If the frequencies are not quite identical, then the pattern will change and the number of complete cycles of change per second is equal to the difference in frequency of the two signals. Suppose for example, that two signals are supposed to be equal at 1.075 MHz but the pattern 'rolls' at a rate of one complete changeover per second. This makes the frequency difference 1 Hz! Using this method, we can detect frequency differences of less than one cycle per minute, so that an accuracy of 0.01 Hz is easily attainable. It is, for example, an excellent way of testing the frequency stability of one crystal, in an oscillator, as compared to another and it is also an excellent method of testing how well a phase-locked loop does its stuff. Another trick is to compare signal generator outputs with 50 Hz mains, or with the crystal-controlled frequency picked up (by a search coil) from a digital watch.

For anyone working with fast repetitive pulses (TTL or CMOS) a very useful addition to a simple 'scope (often built-in to more expensive models) is a pulse delay. This consists of a mono-stable circuit which, when triggered by an input wave, delivers a sharp output pulse a short time later — the time delay can be adjusted, usually, in a range up to several milliseconds. How do we use it? The set-up is shown in **Figure 10**. The input signal is also used to trigger the delay and the delayed pulse in turn operates the EXT TRIG circuits of the 'scope. The delay and timebase controls are adjusted until the edge of the pulse can be seen, which lets you estimate the rise or fall time. The delay is needed because a triggered timebase cannot be started instantaneously; by the time a normal triggered timebase has started, the pulse you want to see is just about finished so that all you ever see even with a fast timebase is the end of the pulse. The delay prevents the timebase from starting until just before the *next pulse* is due, so that the timebase starts just before the next pulse. Obviously, this scheme cannot work with single pulses, but it is a very satisfactory method of looking at the leading or trailing edge of repetitive pulses, such as clock pulses.

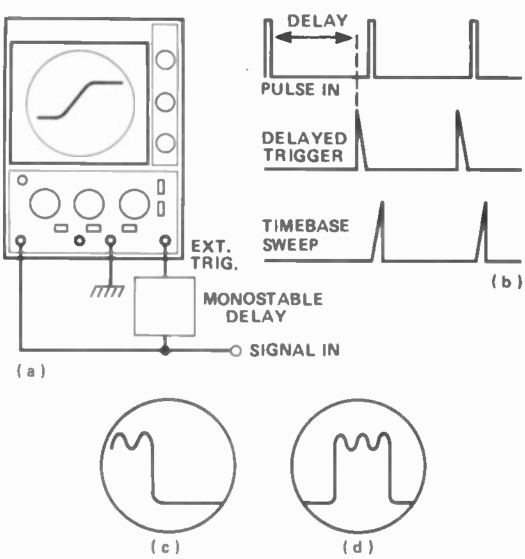


Figure 9. Lissajou figures: (a) Arrangement required for comparing frequencies: (b) Trace with frequencies equal and in phase (or 180° out of phase): (c) 90° out of phase: (d) Phase shift between 0° and 90°. If the pattern moves then the frequencies are not exactly equal.

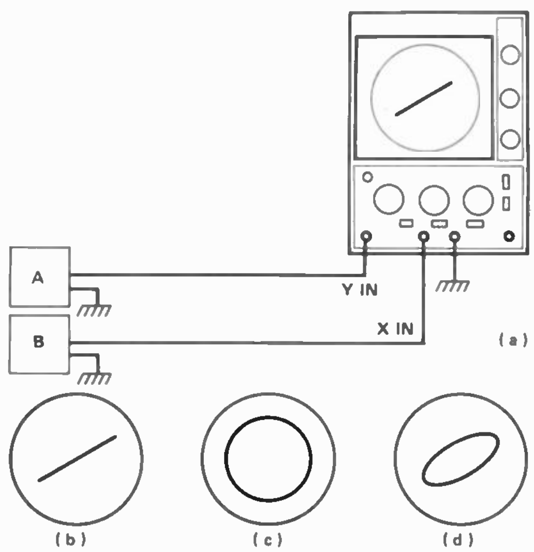


Figure 10. (a) Using a delayed timebase: (b) The monostable is adjusted to produce a trigger pulse (which fires the 'scopes timebase generator) just before the next input pulse: (c) With no trigger delay, the pulse would appear as shown: (d) Adjusting the delay as described enables the leading edge to be seen.

If you want to read more about the 'scope, then the ETI book service can help you, but nothing quite beats the satisfaction of using an oscilloscope for yourself. Once you appreciate what this remarkable instrument can do, you'll never want to return to simple fault-finding routines again and you may very well feel confident enough to tackle design and modification work so have another look at the piggy-bank, and think of the gentle art of oscilloscopy! **HE**

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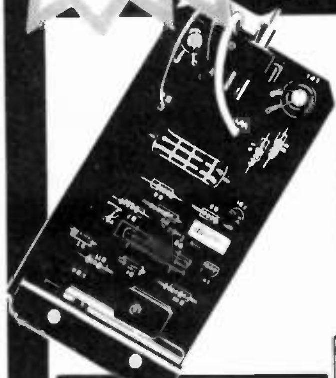

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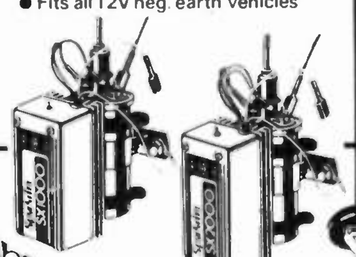

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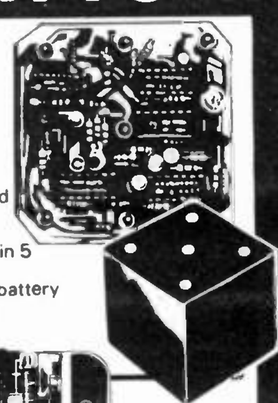

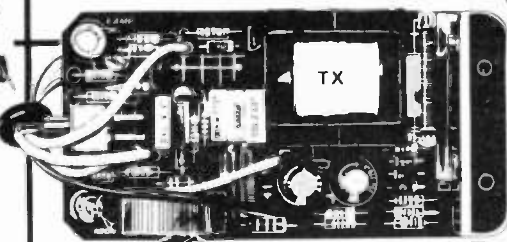

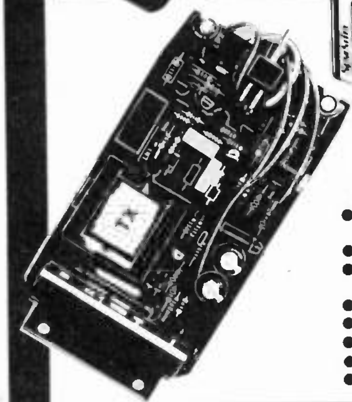

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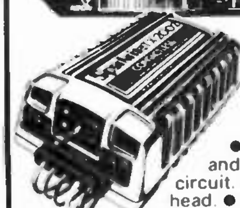

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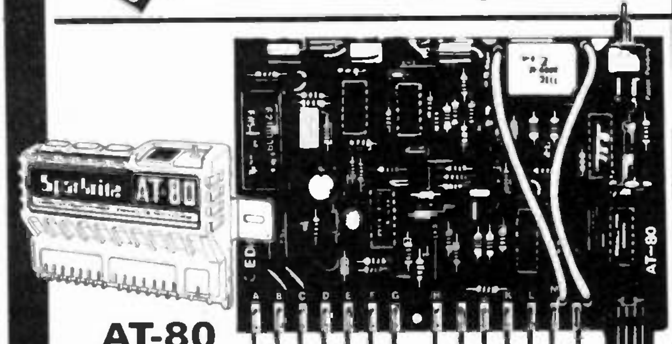

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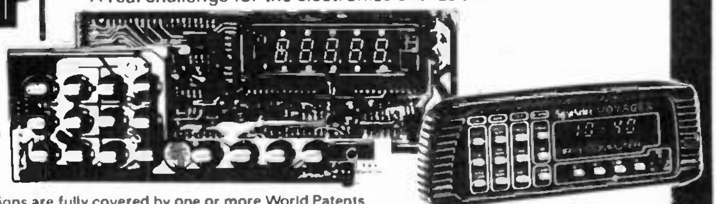

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To 'spin' the electronic 'coin' you press a button — when you release the button the 'coin' falls on one 'side' and the initial letter of that side is displayed.

No prizes for design complexity with this circuit. As you'll see in the diagram shown (**Figure 1**) it's so simple it's almost untrue!

NOR gates IC1a & b are coupled together, along with capacitor C1 and resistor R1, as an astable multivibrator, oscillating at about 700 Hz. The frequency of oscillation of the astable is controlled by the values of components C1 and R1. If either component is increased in value, the frequency of oscillation decreases: if either component value is decreased, the frequency increases. Chosen frequency (ie 700 Hz) is not critical, incidentally, so don't be afraid to insert other values if you don't have the exact values specified.

The squarewave output of the astable is applied, via push-button PB1, to a bistable multivibrator formed by NOR gates IC1c & d. The two bistable outputs are in antiphase ie one is on when the other is off, and they control LED segments c and d of the seven-segment display.

LED segments e,f and g are coupled together, through a 680R resistor to 0 V and are permanently on forming the letter 'b'; the seven-segment display will show the letters 't' or 'h' only when the push-button is operated.

Construction is simple. The project is built-up on a 10 strip by 24 hole piece of Veroboard (as shown in **Figure 2**) and is powered by a PP3-sized 9 V battery. It shouldn't take more than a couple of hours to build.

Once you've finished it, all you'll have to do, when faced with a seemingly impossible choice, is to pull it out of your pocket, press and release the push-button — and there's your answer: heads you accept that drink you've been offered; tails you don't refuse it!

Now, if you could only make up your mind whether you should build it or not . . . . .

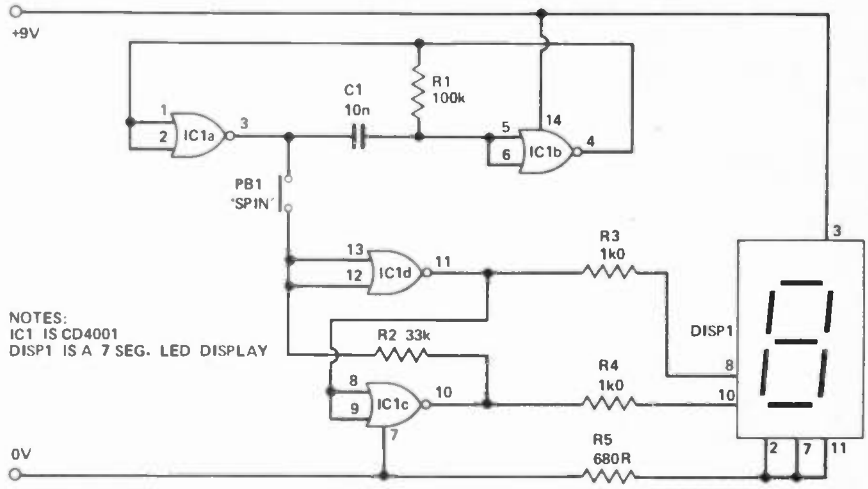

Figure 1. Circuit of the HE Heads and Tails Game

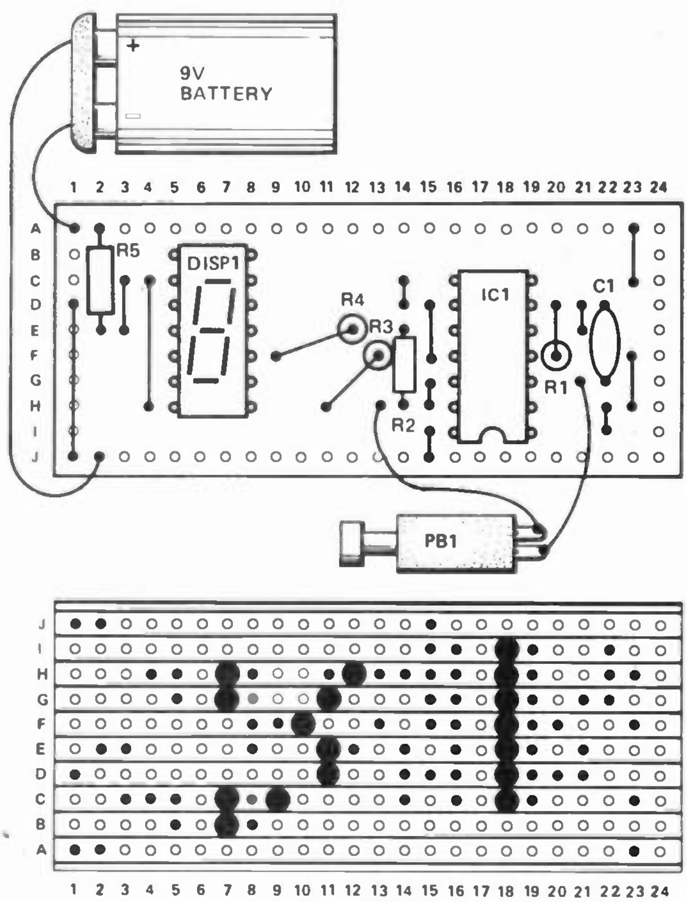

Figure 2. Veroboard layout of the project, showing component locations and track breaks underneath the board

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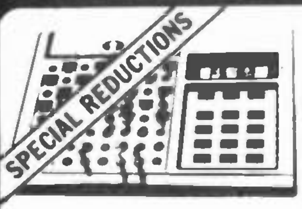

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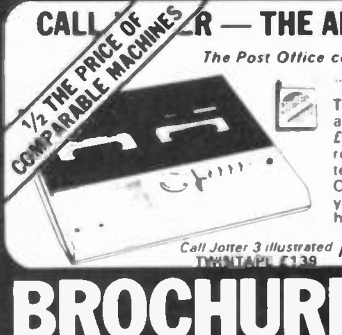

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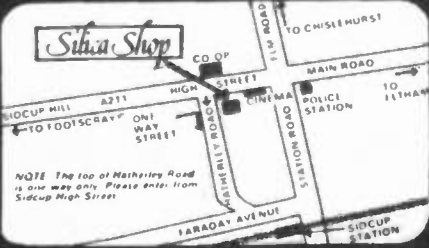

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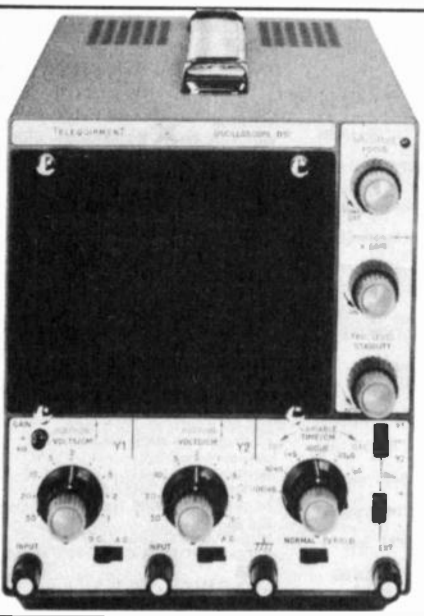
FAMOUS NAMES

Allen B. Du Mont — an American engineer who developed the first commercially available oscilloscopes.



A modern oscilloscope, such as this Telequipment D51, offers the kind of facilities Allen B. Du Mont must have dreamed of. The operation and use of 'scopes of this type is described in this month's feature article on page 39

Allen Balcon Du Mont was born in 1901, which makes him one of the first of our Famous Names to be wholly a product of the 20th Century. His engineering career started in 1924 when, as a freshly appointed graduate, he joined the Westinghouse Lamp Corporation in Bloomfield, New Jersey, as an engineer in the development laboratory. Since the invention of the triode valve (Audion) by Lee De Forest, many of the large electrical firms who had interests in both communications and in electric light had used their technical knowledge of lamp construction (particularly the use of tungsten filaments sealed into glass) to manufacture valves. The Westinghouse plant was one which had been partly converted to valve manufacture and in 1924, the great radio boom started when RCA pioneered the use of radio as an entertainment medium. Du Mont, like so many engineers in the field at that time, found himself in at the start of something big. He transferred to the radio valve division at Bloomfield and started to apply mass production techniques to valve manufacture. Mass production was only just beginning to make a mark on car production (thanks to the work of Henry Ford) and its use on articles which were thought of as delicate scientific instruments was unheard of. In parallel with this effort, he also started to develop the first large-scale test equipment for radio valves, the forerunners of our modern test rigs.

The results of this truly *engineering*, as distinct from *scientific* effort was felt all over the USA. An engineer, it is sometimes said, is one who can make for a penny what any fool could make for a pound. Du Mont's work raised the production of the Bloomfield works to a staggering 50 thousand valves of all types per day. This remarkable achievement established the young Du Mont as a production engineer of the first calibre and in 1928 he became Chief Engineer of the De Forest Radio Co. in Passmore, NJ, where his task was to modernise the plant and improve its productivity. This was no small job, because the Passmore plant was the 'oldest' radio valve manufacturing plant in the world; having been set up by Lee De Forest to manufacture the first ever triode radio valves — it was full of relatively old equipment.

Du Mont gave the De Forest plant the same thorough attention he had devoted to the Westinghouse factory but then turned his mind back to research, since he was convinced that the key to success in radio was continual research and development. He had been fascinated by the patents of Charles Jenkins, one of the US pioneers of TV in the '20s. Jenkins, like Nipkow in the 1870's and Baird in the '20s, used electro-mechanical methods (involving rotating mirror drums) which produced very low-definition pictures. Du Mont set up a sound and vision system in 1930 but came to the conclusion that such a system could not possibly provide pictures comparable to film movies. Unlike others at the time, he was convinced that nothing else but comparability with the movies would be good enough for public use and that only a fully-electronic system could provide the quality of picture needed. This remarkably logical conclusion led him to the most important step of his life.

In 1931, on his 30th birthday, Allen Du Mont set up his own business. It's never been difficult to set up business in the USA in boom years, because it tends to be a country more interested in starting things and seeing them through; compare this with our obsession with stopping things — for every Society for starting something, we have a hundred devoted to stopping something! The Allen B. Du Mont Laboratories existed to pursue a new technology — that of the Cathode-ray Tube — as far as was possible.

At the time, the cathode-ray tube was a fragile piece of experimental glassware, a curiousity with few applications. Its design, in fact, had hardly changed since it was invented by Braun at the turn of the century. It would be hard to imagine anyone better suited to convert this primitive piece of glass plumbing into a piece of modern mass-produced scientific equipment and Allen Du Mont flung himself into his self-appointed task with relish. He re-thought the design and construction of the cathode-ray tube with the same energy and thoroughness as he had shown in the Westinghouse plant. He not only improved the primitive design of the tube, he also devised methods of production which were still in use for making experimental storage tubes in 1956. Seeing that no-one else in the States was better equipped to make use of the new tubes, he went on to design his own oscilloscope, and built another production line for that.

The Du Mont oscilloscope was a landmark in the history of electronic instruments. It was the first truly commercially-available oscilloscope and was snapped up by laboratories all over the world. It had a good stable timebase, a Y-amplifier with a previously unheard of bandwidth of nearly 1 MHz and it was rugged and dependable. It was to prove, in fact, to be the most significant product of the Du Mont Laboratories, far outshining anything else, and in World War II the Du Mont oscilloscope was chosen by all three military services.

Meanwhile, however, Du Mont's work on the oscilloscope was financing TV receiver techniques. He was following closely the work of Zworykin at RCA, convinced that this line was going to result in the all-electronic TV system he had dreamed of. Zworykin, in the USA, and Schoenberg's team at EMI in England, both came up with the same answer — identical systems — in 1936 and Du Mont was able to manufacture TV receivers and offer them for sale to the public in 1937.

The glory was short-lived, however, because TV development was frozen by the outbreak of war. The Du Mont laboratories were turned over to the manufacture of radar tubes and other electronic equipment, while the production of oscilloscopes was trebled. The pioneering work on TV receivers was never resumed to any extent, despite Allen Du Mont's presence on the NTSC — the National Television Standards Committee — the body which, in the late '40s, came up with the famous specification for a colour TV system. By the time the Committee saw its recommendations emerging in the shape of the first RCA colour receiver, Du Mont was a sick man. He died in 1956.

Allen Du Mont never attained the fame and glamour of some of our other subjects, but he was one of the engineers whose work laid the foundations for much that we take for granted today. For two generations of enthusiasts in the USA, the Du Mont oscilloscope was one of the attainable dreams, an instrument which made an amateur into a near-professional. For that alone, his name will be remembered. **HE**

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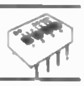

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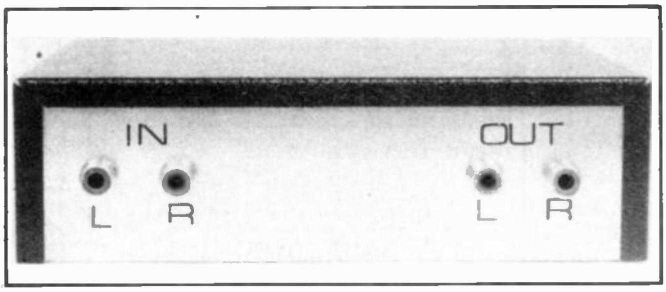
STEREO BASS BOOSTER

Explore the depths of your Hi-Fi system!

ONE OF the major drawbacks with budget speakers, compared to the higher priced systems, is their relatively poor performance at low frequencies.
This region of the audio spectrum is covered by the bass driver, which can be of inferior quality in cheaper designs. Also, the cabinet is usually constructed with a small internal volume that is sealed and filled with acoustically absorbent wadding — an infinite baffle enclosure. These factors raise the low frequency roll-off point which is the point at which the output level begins to fall as frequency is gradually decreased (see **Figure 1**).

Also, amplifiers within a similar price range tend to lack any form of equalisation apart from bass and treble controls; typically, these allow a boost/cut of around 10 dB at 100 Hz and 10 kHz but frequencies at a certain point below 100 Hz will be unaffected by the bass control and are therefore reproduced at a lower level. To compensate for this, some form of low frequency amplification is required — which is where the HE Stereo Bass Booster comes into play. It provides an increased output for signals at the bottom end of the bass range.

The boost is applied to signals within a frequency band that is variable between limits of 50-150 Hz. The amount of boost may also be varied (though not independently of frequency) up to a maximum of about 6 dB. These changes are achieved through the use of two special potentiometers that vary four resistance each, in a single control. These pots are shown on the circuit diagram of **Figure 2** as RV1a, RV1b, RV1c and RV1d.



Our prototype was enclosed in a small aluminium case with a black PVC covering. However, since nearly all of the components are built onto the PCB,any metal case of suitable dimensions may be used. Plastic boxes, though easier to adapt, are not desirable because the booster will be processing low level signals and screening is therefore necessary. Power for the unit is obtained from a PP3 battery supplying around 10 milliamps.

Construction

As mentioned earlier, the single PCB for this project takes most of the components, leaving only the on/off switch and phono sockets to be externally wired. This makes construction a fairly simple task, though special attention should be being given to the two ICs, which are mounted in 8-pin DIL sockets. Ensure all the polarised capacitors (eg electrolytic) are inserted the right way round and the link wires correctly positioned — just follow the overlay diagram of **Figure 3**.

The case may now be drilled to accept the switch, phono sockets and pot shafts. Also, four small holes are drilled in the base for the PCB fixing bolts (see **Figure 4**). The main board is then bolted into the case (after being checked for errors).

The remaining hardware is fitted and wired up to the board as shown in **Figure 3**, and the internal view of the prototype (**Figure 5**).

Finally, the top of the case is screwed into place and the booster is ready for use.

In Use

The Bass Booster is best placed between the pre- and power amp sections of the amplifier, if your amplifier has pre-out power in terminals. Alternatively, the tape monitor facilities provided on most hi-fi amplifiers can be used; the input for the Booster is taken from the 'Tape Out' ('Rec') socket and the Booster output is taken back to the 'Tape In' socket. The source — record player or tuner — is connected as usual; the Monitor/Source switch should be set to 'Monitor'.

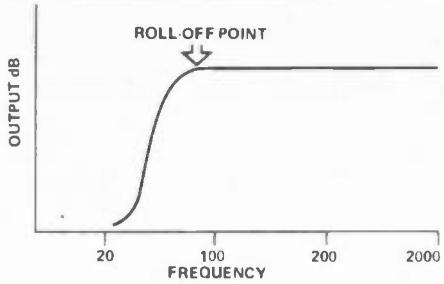
Amplifiers without these facilities are less satisfactory since the booster will have to be placed in between the signal source the pre-amplifier. This will result in a decreased signal-to-noise ratio and some loss of treble — but the effect may not be too noticeable.

Setting the controls is quite straightforward but takes a bit of time. The booster is switched on and both boost controls advanced until the amount of bass appears to balance the other frequencies present. This is made easier if a familiar source (a favourite record or tape) is used. If you are using the tape monitor set-up you can perform an 'A-B Test' by switching between 'Source' and 'Monitor'. In any case the controls should never be set so that 'booming' or distortion is produced.

How It Works

The design of this circuit is fairly simple to understand since the two FET op-amps are wired in cascade (one follows the other), with identical shaping (tonal response) and feedback circuitry (effecting the gain). Each amplifier is arranged to produce a non-inverted output. This output is determined by the feedback loop from pin 1 to pin 2 (for IC1a) and the series RC circuit of C3, R5 and RV1b. Varying RV1a and b alters the gain whilst simultaneously sweeping the roll-off frequency across a 100 Hz band, from 50 up to about 150 Hz. This results in a smooth transistion from no boost to the full 6 dB increase in output at the lower end of the sweep range.

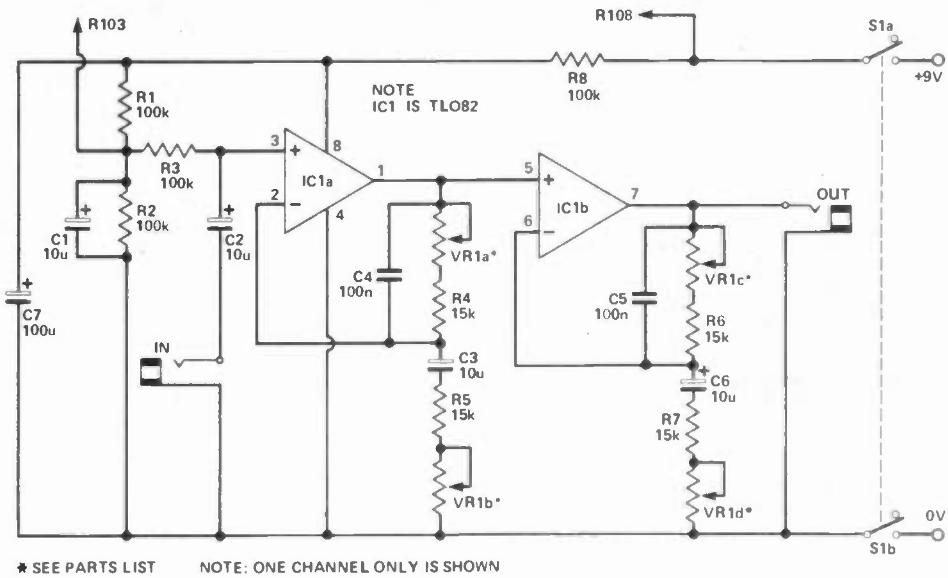
Bias for both halves of the circuit is set by R1, R2, and C1; these hold pin 3 of ICs 1 and 101 (not shown in the circuit) at half the supply voltage. R3 is included to minimise interference between channels (crosstalk). Supply decoupling is achieved by C7, across each op-amps supply pins,. Each input is coupled to pin 3 by a large capacitor.



▲ **Figure 1. Typical bass response of a speaker system.**

Buylines

A complete kit of parts for this project may be obtained from Bewbush Audio, 26 Hastings Road, Pound Hill, Crawley, Sussex. The cost, including postage, is £18.95. The pots may be ordered separately for £1.80 the pair and the PCB is available seperately for £1.85. Suitable cases can be had from West Hyde and other suppliers.



▲ **Figure 2. Circuit diagram of one-half of the Stereo Bass Booster.**

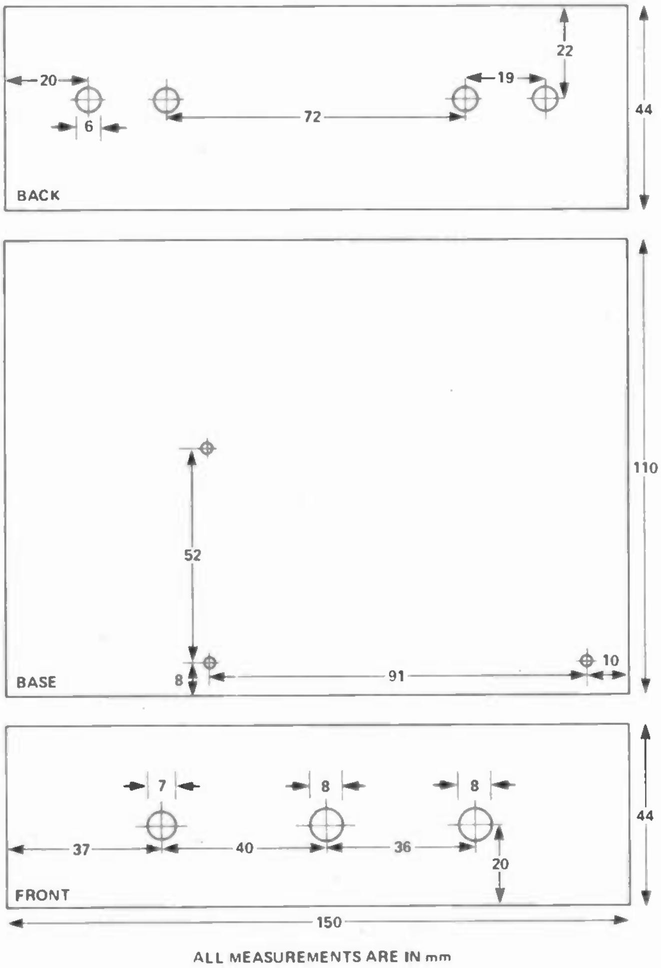


Figure 4. Layout dimensions for the case.

Parts List

RESISTORS (all ¼ W, 5%)

R1,R2,R3, R103	100 k
R4,R5,R6,R7, R104,R105, R106,R107	15 k
R8,R108	100 R

CAPACITORS

C1,C2,C3, C6,C102, C103,C106	10 uF 16 V radial electrolytic
C4,C5, C104,C105	100 nF C280 polyester
C7,C107	100 uF 16 V radial electrolytic

PONTENTIOMETERS

RV1,RV101	50 k linear quad ganged

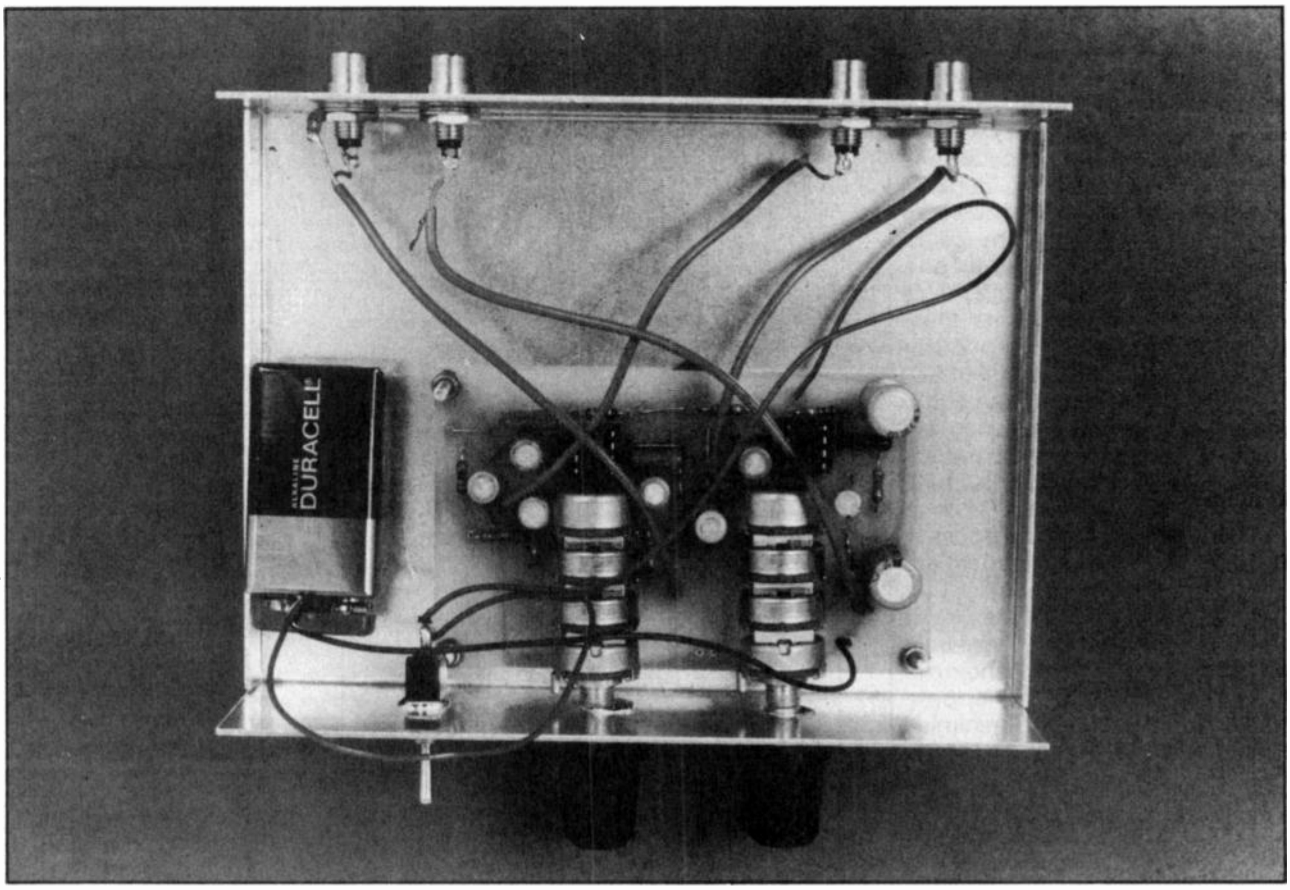
SEMICONDUCTORS

IC1,IC101	TL082 BIFET dual op-amp

MISCELLANEOUS

SK1,SK2, SK3,SK4	chassis mount phono socket
S1	sub-miniature on/off switch

PCB,PP3 battery, PP3 clips, knobs, case, nuts, bolts etc.



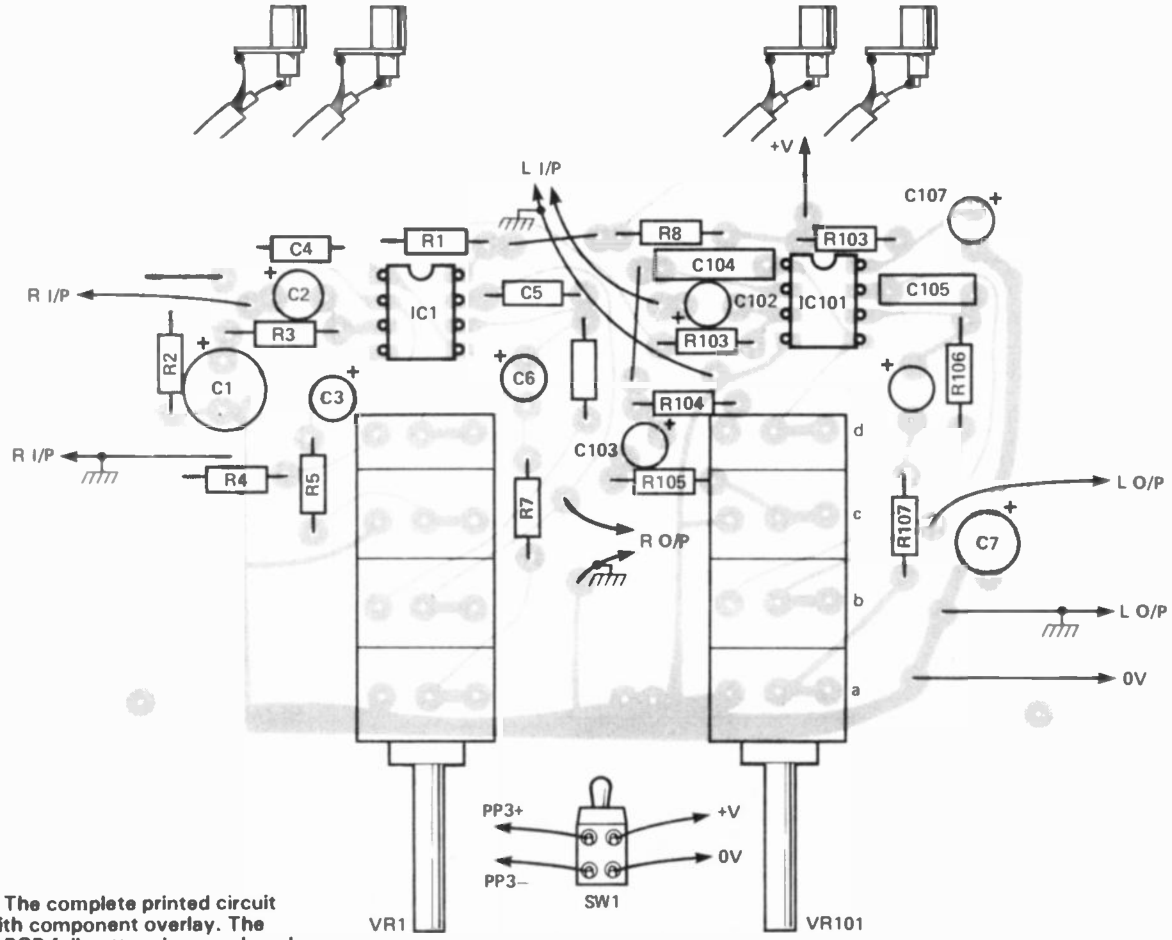


Figure 3. The complete printed circuit board, with component overlay. The full-sized PCB foil pattern is reproduced on page 65.

HE

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Clever Dick

This month's collection includes a variety of clever puns, pithy comment and witty sayings — plus, of course, the usual grovelling and boot-licking.

This is "Corrections Month", in which Our Esteemed Editor has asked me to reply to the backlog of enquiries concerning projects which, for many curious reasons, have failed to work as they should. Here's a typical example.

Dear CD,
I have just built the Quick Project "Simple Stylus Organ" from the November issue. I built it carefully and checked the circuit serveral times but when I connected it to the battery, nothing came out of the speaker. I found (if the circuit diagram is right) three mistakes in the Veroboard layout. I made some corrections but — still nothing. I would be most grateful if you could tell me what is wrong.
J.E. Hunt,
Bury, Lancs.

What were you expecting — bug-eyed monsters? As sometimes happens, there were errors in both the circuit diagram and the component layout for this project. You can find them listed, in a reply to another enquiry in "Your Letters"
Did someone mention puns?

Dear CD (Circuit Designer),
I have come up against some snags relating to the Metronome in HE, November '81. After having fitted all the links and most of the resistors I was prompted, for some reason, to check the circuit. Judging from the number of errors, IC someone has been LED astray.
Please come to my rescue! I wish to finish this project in "time" and fit it into a conventional case which I am making in walnut. This in itself presents enough problems without mistakes in the component diagram. I have already angled-off two corners of the Veroboard to make it fit — I'll have a fit myself if it doesn't!
Just one other thing; in the illustration of the case I would appreciate it if the young lady would remove her left thumb and forefinger from the control knob, so that I can see the notation.
In spite of a rum do, I trust you will take this in good spirit.
R.P. Dawe
Bedford.
PS If I don't finish this project I'll have to face the music with my wife.
PPS I see that the lady's pretty little hand is clear of the illustration on page 3, but I prefer to see her looking on the SUNny side of things.

They say that a good pun has to hurt — well, you can believe that I'm in pain. I understand the Editor has already covered this project so, Mr. Dawe, if you'd like to refer to "Your Letters" you should find the solution to your problems with the Metronome. You'll have to see a doctor about your puns, though perhaps with the advances in medical science, you can have them surgically removed?
Ray Penn of Enfield and W.A. Burnell of St. Austell, down in Cornwall, will also find their answers in the Letter pages.
The next letter is quite alarming (that's one of the worst things about puns — they're infectious).

Dear CD,
While I was flicking through the October '81 HE I noticed that no track breaks were shown in the Baby Alarm project. As I've only been doing electronics for a year, could you please tell me where the track breaks go?
Also, all my HEs, all four of them, are grotty and creased. GROVEL GROVEL. Please can I have a binder?
Yours binderly,
D. Belfield,
Cheadle, Cheshire.
PS Where do you get the SAB0600 and how much?
PPS My sister likes chocolate digestives.
PPS Binder . . .

This one comes under the heading "cryptic comment". What (or who) is an SAB0600? I will happily award next, month's binder to anyone (exluding Mr. Belfield, naturally) who can explain, politely and in one sentence, what his sister or chocolate digestives have to do with me?
As to the track breaks, they are only needed if the board is mounted using screws or bolts; in that case the track should be cut at A22, B22, C22 and at H22, I22 and J22.
It's amazing the lengths some people will go to just to get their greasy paws on one of my sparkling new binders . . .

Dear Intelligent "Superbrain '81" Richard (the most intelligent electronics expert ever known to we inferior human life-forms),
Wishing to construct the Fire Detector project from the November 1981 issue Supplement, I have found difficulty in obtaining the VA1056S Thermistors. Please, please can you help?
A.J. Hilton,
Guildford, Surrey.
PS How about a project for an infra-red beam burgular alarm?
PPS Keep up the super mag and read my comments on the survey!
PPPS A BINDER would be usefull!!!??

All true, of course — but naturally I'm too modest to say so myself. You'll also be happy to learn that type VA1056S Thermistors are listed in the Maplin catalogue and that a circuit for an Infra-Red Intruder Alarm appeared in the latest issue of Electronics Digest, which should still be available from your local newsagent. I've read your comments, thank you very much, and I quite agree. There's far too much of it going on.

I realise that not everyone out there has a typewriter (or could use one) but please, at least try to write clearly!

Dear CD,
I wonder if you could tell me where I could obtain a 25A715 transistor or an equivalent. I've tried my local stockist and all the companies advertising in HE but none of them stock it.
I enjoy the features in the mag but I wondered whether there might possibly be more variation in the projects?
Yours Desperately,
F. Smieja,
Cheltenham

This letter presented a second-class puzzle — a guessing game with no prizes. After some considerable time spent checking all the catalogues, I came to the conclusion that there was no such animal as a "25A715". There is, however, a transistor designated 2SA715, made by Hitachi, and the European equivalent is a BD436. Another hour spent checking the catalogues failed to turn up a supplier for the device, though, so the puzzle is back in your hands, Mr Smeija (I think that's the name). Finally, the word "variation" took a while to de-code; the answer to the question (if that's what it was) is that you'll find plenty of variation in the months to come.
If Mr Smieja's(?) writing was somewhat less than legible, the following, was, at lease, plain enough.

Dear CD,
I have never owned a copy of HE nor ever will.
Can I have a binder please?
Yours Sarcastically,
C. Bicky,
Walthamstow.

That's sarcasm? Sorry, I missed it. I would have thought an old salt like you could have done better than that.
He certainly doesn't get a binder, either. My complaint in the January pages about nobody writing just to say "hello" prompted a flood of letters (well, two or three) from kind readers . . .

Dear Clever Dick,
HELLO.
P.A. Langley,
Stafford

Dear Clever Dick,
Hello.
N. Churchill,
Romford, Essex.

Some, however, couldn't resist a good grovel.

Dear clever, Clever Dick,
I'd like to say "hello". Well, you did ask, in the January issue — now isn't that obedient of me (grovel, grovel, lick, lick).
Please can you tell me how you mount your speakers (I see you don't use any ugly nuts and bolts).
Also, can you please tell me when you are going to publish the article on large scale model aircraft, mentioned in the December '81 edition?
Lastly, where do I get transfers for HE projects?
L. Arden,
Bracknell, Berks.
PS You must be fed up with grovellers so why don't you give in?
PPS Your mag is brilliant . . great . . fabulous (crawl, crawl).
PPS You have probably guessed by now . . can I have one? Yes, yes a binder that's it. PLEASE. I can't buy one because I have spent all my money on Hobby Electronics Projects. (Here follows more abject grovelling)

No, I never get fed up with grovelling and crawling. I like to see how far you can go. I assume the reference to speakers is in connection with a Monitor item from the January '82 issue. Actually, my speakers are "mounted" on the floor! I am informed by our Esteemed Editor (EE, for short) that, regrettable as it might seem to some, John Greenfield's article will not be appearing. Hobby Transfers have also been discontinued but the PCBs for most projects are available from our PCB service — see page 38.
The Clever Dick Fan Club continues to grow — they even like me in Yugoslavia.

Dear CD,
I am in a very unpleasant position. I've lost my copy of HE with the Touch Switch project in it. Now that I want to make that project for my new stereo system, I'm "blind" 'cause I don't have the article.
Please, can you help me? I enclose a postal note and SAE for a photocopy. I'm sure you can help, 'cause you're clever! I need that project urgently!
A. Karakasevic,
Zemun, Yugoslavia.

Apparently we published not one but two Touch Switches, back in March and September, 1980 — variations on a theme — so, the Back Number Department have been instructed to send both to far off Yugoslavia, with our best wishes.
Some errors are more embrassing than others.

Dear Sirs,
In the February issue of Hobby Electronics you recommend the fitting of a radio/cassette to a positive-earth motor vehicle using a piece of wood.
This is a potential fire hazard as the aerial is connected to the radio chassis, which is negative, and the car chassis, which is positive.
A. Bell,
London.

PS Now that I've saved all them cars, do I get a binder?

Who does he think I am ? Twins?

Our resident expert on these matters has had his wrists slapped and been demoted to Part-Time Handyman. I'm not feeling too well myself, either.
The method recommended is perfectly satisfactory for car stereo cassette players, of course, but could have nasty results if used with a car RADIO, which has an aerial earth-braid connected to the car chassis.

A safe method was suggested by Mr. L.E. Thomas, who works for Halfords, the High Street automotive experts.

Dear Clever Dick,
I write with reference to your reply to A.M. Lawrence in February's issue. Should he fit anything like a decent aerial he will immediately short his chassis to 12V positive and, if lucky, only blow his fuse; if unlucky — goodbye car stereo.
There is only one safe way out of A.M. Lawrence's problem and the attached information is supplied for your future reference.
Yours Sincerely,
L.E. Thomas,
Plymouth, Devon.

The information kindly supplied by Mr. Thomas is too long to reprint here, but a copy has been sent to Mr. Lawrence, with our apologies. Briefly, though, the method applies to cars fitted with a dynamo and involves re-magnetising the pole-pieces. It cannot be used on cars fitted with an alternator or where existing electrical accessories such as a clock, tachometer, radio or tape player are already fitted. I will be happy to supply a copy of the method to anyone who cares to send in a stamped SAE.
Alternatively, there is a somewhat simpler method; connect a 1000 picofarad capacitor between the aerial earth braid and the car chassis. The drawback of this is that it may result in slightly increased interference on the radio.

One thing is certain about CB'ers — they're not only dedicated, they're one-eyed.

Dear CD,
Note my disgust when I noticed a mistake in the January issue. The CB rig is a Fidelity 2000, not a 1000 as stated (tut tut!). The price is even wrong — £89 instead of £69.
After putting you right, let me congratulate you on a great mag. 10-10
R. Neil,
Kent.

PS Keep up the good work.
PPS -.-. .--. .. ... .- ...- . .- -... .. -. -.. . .-.

For those who missed it, this complaint is yet another referring to a news item in January's Monitor which featured two rather stunning girls holding a CB rig. When informed, The Person Who Writes Monitor was, indeed, suitably disgusted. "These CB nuts", he said (I have censored some of his more colourful expressions). "Who else would look at the rig!"
And for those not familiar with Morse Code, the PPS reads: "Can I Have a Binder". -. --- .-- .- -.--

Right, that's it for this month.
Clever Dick will now return to his cage. If you're all very good and write lots of letters, the EE will let me out again next month.
What's that? Who gets this month's binder? Oh.
No-one, that's who. Grovelling isn't everything you know. **HE**

INTO ELECTRONIC COMPONENTS

Part 8 is biased towards transistors.

BIPOLAR TANSISTORS can be regarded simply as devices that control the flow of current; a small amount of current passing between the base and the emitter will cause a much larger amount of current to flow between the collector and the emitter, provided that there is enough voltage present. Many circuits make use of just that simple idea. For example, **Figure 8.1** shows a transistor used as a switch. Unless some base current flows, no current will flow between the collector and the emitter and the circuit controlled by this transistor is not switched on. Another very important feature of a transistor, however, is that it simply does not obey Ohm's law. This it true both of the voltage between, and the current through, emitter and base *and* of the voltage across and current through collector and emitter.

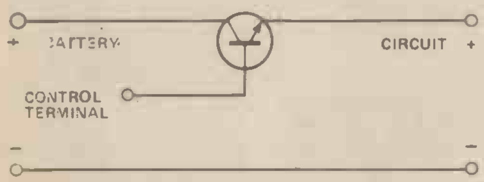

Figure 8.1 A transistor used to switch a circuit on or off.

If we pass a small amount of current through the base and the emitter of a transistor and then measure the current flowing between the collector and the emitter as we slowly raise the collector voltage (**Figure 8.2**), we find that the current shoots up but then remains almost unchanged, no matter how high we raise the collector voltage. This certainly isn't like the straight-line graph we get from current through and voltage across a resistor so we can be sure that Ohm's law is not being obeyed here, which is why transistors, like diodes, are sometimes called "non-linear devices". What actually happens is that, provided there is enough voltage to keep current flowing between the collector and the emitter, the amount of this current is completely controlled by the amount of base current rather than by the amount of collector-emitter voltage.

We can show this even more clearly by plotting a whole set of graphs of collector current against collector voltage (**Figure 8.3**). The difference between the curves is that each one has been drawn for a different amount of base current. You can see that, apart from the steep change of current at the very lowest values of collector voltage, the collector current is affected much more by the base current value than by the collector voltage.

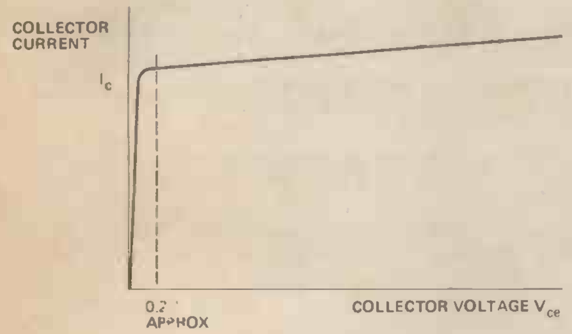

Figure 8.2 The effect of collector voltage on the collector current when the amount of base current is fixed. This graph is called a "characteristic curve" becuase it is peculiar to (ie characteristic of) a particular transistor.

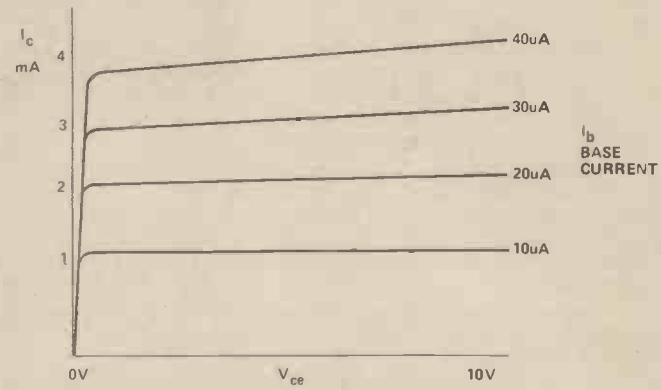

Figure 8.3 The family of graphs which is obtained when collector current is plotted against collector voltage for several different values of base current.

All this, as you might expect, is leading up to something important. Suppose we connect a resistor into the collector circuit of a transistor, as shown in **Figure 8.4**. The current through this resistor will be controlled not by the voltage to which it is connected, but by the base current of the transistor. When current does flow through the resistor, though, there will be a voltage across it and this voltage and the current, together, obey Ohm's law.

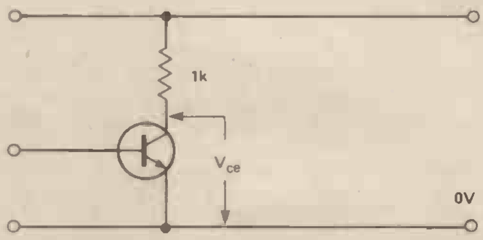

Figure 8.4 A resistor (the load resistor) connected into the collector circuit of a transistor.

Let's investigate this further, with the aid of **Figure 8.5**. If no base current flows then no collector current flows, so, with no current flowing through the 1k resistor there is (by Ohm's law) no voltage drop across it. That, in turn, means that we must have the same voltage at each end of the resistor. With no base current flowing through the transistor, therefore, the collector voltage is the same as the supply voltage, 9 V.

Suppose, now, that some base current is allowed to flow; perhaps because a large-value resistor had been connected between the base and the supply. Imagine that enough base current flows to cause a 1 mA current to flow between the collector ▶

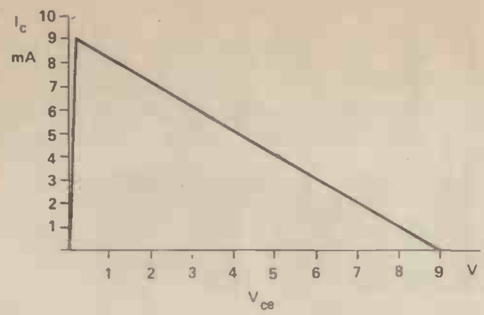

Figure 8.5 A graph of collector voltage plotted against collector current for a transistor with a load resistor, when the base current is varied.

and the emitter. A current of 1mA through a resistance of 1k produces a voltage drop of 1 V so that the collector end of the 1k resistor must be at 1 V less than the power supply end, making the collector voltage 8 V. What happens if we increase the base current? Increasing the base current so that the collector current rises to 2 mA will cause the voltage drop across the resistor to rise to 2 V and the voltage at the collector of the transistor must now be 7 V.

A pattern is beginning to emerge; as the base current is increased, the voltage at the collector decreases. It can't continue like this forever though, because when the base current reaches a value such that the collector current is about 9 mA, there will be 9 V dropped across the 1k resistor — there is nothing left across the transistor, so its collector voltage is zero! In practice, it never gets quite as low as zero but it comes to within a whisker of it, falling to about 0V2. If we attempt to increase the current still further, only the base current will increase; the collector current cannot increase as it is limited by the resistor.

The resistor used in this example is called a "load resistor" and it has the effect of converting changes in current into changes of voltage. This brings us to the two most useful applications of transistors — voltage switching and voltage amplification. The key to understanding both is that base current (and therefore collector current) can be changed by a large amount by a very small change of base voltage.

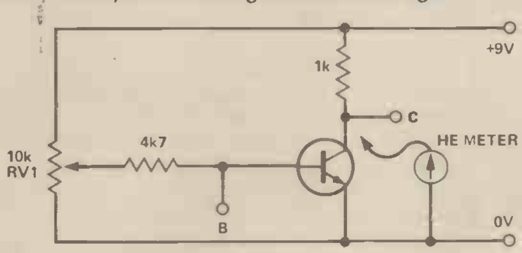

Figure 8.6 A circuit for checking the effect of a load resistor.

Try it out by setting up the circuit of **Figure 8.6** on the Eurobreadboard. The HE meter will have to be switched between ranges while you are taking measurements because it's going to be used to measure both base voltage (on the 2V5 scale) and collector voltage (on the 10 V scale). Make sure that potentiometer RV1 is set so that the base voltage will be zero when the circuit is first switched on. Connect the positive lead of the HE meter (switched to the 10 V scale) to the collector of the transistor and connect the battery. If the reading is 9 V then all is well; if not, check your connections and the potentiometer setting. If all looks correct then you probably have a leaky transistor — replace it!

With the HE meter reading 9 V on the collector, gradually alter the potentiometer setting until the collector voltage just starts to drop. Now unclip the HE meter's positive lead from the collector, switch to the 1 V range and connect it to the base. Don't alter the potentiometer setting, just change over the leads and the meter switch. Take a reading of base voltage as precisely as you can (remember to use the mirror on the scale of the HE meter to ensure that you are looking straight down) and note it down, entering it into a table which has headings of BASE VOLTAGE and COLLECTOR VOLTAGE. This first entry will be the base voltage for a collector voltage of 9 V.

Now disconnect the HE meter from the base, switch back to the 10 V range and connect to the collector again: adjust the potentiometer so that the collector voltage reads 8 V. Disconnect the meter's positive lead, switch back to the 1 V range and measure the base voltage again, as precisely as you can. Note the value (it won't have changed much) of the base voltage for a collector voltage of 8 V.

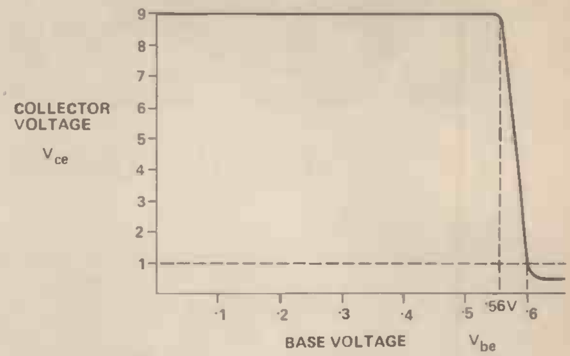

Figure 8.7 Typical results from the circuit of Figure 8.6

Repeat this procedure for collector voltages of 7 V, 6 V and so on all the way down to 1 V. You will then have an idea of how small a change in the base voltage is needed to change the collector voltage by quite a large amount! The results of your table can be plotted on a graph, which looks something like the one in **Figure 8.7**. This shows that the collector voltage drops from 9 V to 1 V for a base voltage change, in this example, of 0V56 to 0V6. Now that's a very small change (0V4), but it causes the collector voltage to change by 8 V. It's this principle of a small change of base voltage causing a large collector voltage change which is behind switching and amplification. For switching, we need a circuit like that of **Figure 8.8**. Switching the input voltage between 0 V and 9 V (the 4k7 resistor is included to limit the base current) will switch the collector voltage between the same voltages but in the opposite direction, so that when the input voltage is zero, the output (collector) voltage is 9 V and when the input voltage is 9 V, the collector voltage is almost zero. It is like a relay; a change of voltage at the input causes a switchover at the output.

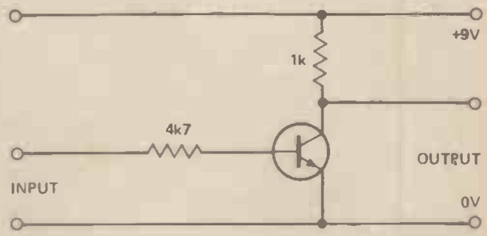

Figure 8.8 A switching circuit. The resistor in series with the base is essential to prevent excessive base current.

Making an amplifier is not quite as simple. Suppose that the voltage change from 9 V to 1 V at the collector is caused by a change from 0V55 to 0V71 at the base. The collector voltage 'swing' is 8 V for a change in base voltage of 0V16. The quantity which we call voltage gain is defined as:

$$\frac{\text{change of voltage at output}}{\text{change of voltage at input}}$$

and in this example will be 8/0.16, which is 50 times. What this means is that if we had an AC signal at the base, we could expect to get a signal of fifty times the amplitude at the collector.

It sounds good, but there are snags. One is that the signal at the base can't be the usual sort of AC signal centred around zero (**Figure 8.9a**); it must be a signal that will take the base voltage (using the figures in our example) between the limits of 0V56 and 0V71. If the base voltage exceeds these limits, even for an instant, it will no longer affect the collector voltage.

These voltages, 0V56 to 0V71 in our example, are the limits of what is called a "linear region" because it is within the range of these voltages that the graph of **Figure 8.7** is a sloping *straight* line. The transistor of our example will amplify, with a voltage gain of 50, only if the input voltage stays within the limits of 0V71 and 0V56. Now an AC signal like this is not true AC; it is a mixture of AC and DC as **Figure 8.9** shows. In this case, it's a 0V63 DC voltage with an AC voltage of 0V08 peak added to it. We can easily create such a wave by setting the base voltage at 0V63 DC, and adding in the AC through a capacitor. The voltage at the base will then be the sum of the AC and the DC voltages; just the type of wave we need. We can use AC voltages of less than 0V08 peak if we want but we can't use more because the limits of base voltage (0V56 and 0V71) would then be exceeded.

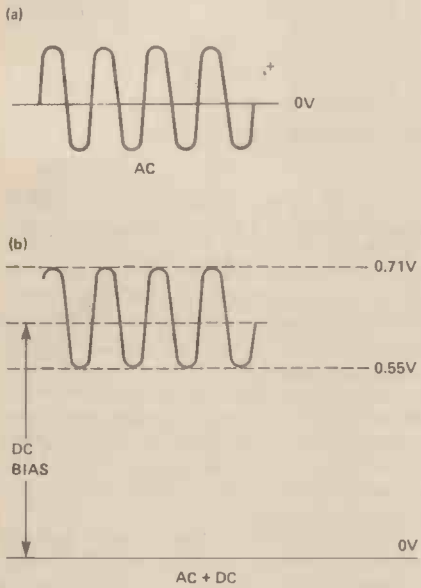

Figure 8.9 AC (a) compared to the mixture of AC and DC (b) which is needed at the input of a transistor amplifier.

Putting a DC voltage on to a base so that we can add AC to it is called "biasing". A correctly biased transistor will act as an amplifier for AC signals at the input (the base), and the shape of the wave at the output (the collector) will be a perfect copy of the input wave but with greater amplitide — unless the input voltage is allowed to go outside the limits of 0V56 and 0V71. Notice, though, that the signal at the collector is inverted — as the input wave reaches its peak of positive voltage, the output wave reaches its lowest voltage. This is because of the load resistor; as the base voltage is increased, the base current and the collector current both increase so that the voltage drop across the load resistor increases and the collector voltage drops — then rises as the base voltage decreases.

This inversion does not alter the shape of the wave, any more than a flat mirror alters the shape of your face, but if the voltage at the input goes outside the limits shown on the graph, then the output wave will be distorted. This type of distortion is called 'clipping' — either the top of the wave or the bottom or both become flattened (**Figure 8.10**). Distortion of this type can be avoided only by a combination of correct biasing (correct DC voltage level) and correct AC voltage input (not exceeding the limits).

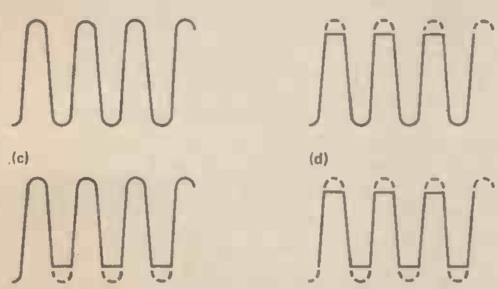

Figure 8.10 Distortion of a sinewave caused by incorrect bias or excessive signal ampliftude: (a) perfect sinewave; (b) clipped at the top (faulty bias — DC base current too low); (c) clipped at the bottom (faulty bias — DC base current too high); (d) clipped top and bottom (bias correct but signal ampliftude too high).

A Biased View

Measuring voltages at the base of a transistor is a tricky business (as you may have noticed) because the voltages are so small. A much simpler way of deciding whether bias is correct is to measure the voltage at the collector of the transistor. The 'rule-of-thumb' here is that the no-signal voltage at the collector (the DC voltage when there is no AC signal at the base) should be about half of the supply voltage. This is a useful rule only when the load is resistor, but since this applies to so many transistor voltage amplifiers, it's very useful indeed.

How, then, do we get the collector voltage to half of the supply voltage? Well, **Figure 8.11** shows one method; a resistor is simply connected between the base and the positive supply voltage. The snag is the value of the resistor — it has to be a large and precise value. For example, if we use a 1k load resistor and a 9 V supply, the ideal collector voltage will be 4V5, with another 4V5 dropped across the load, That means a collector current of 4.5 mA (4V5 across 1k, by Ohm's law) and if the transistor has a current gain value of 100 then the base current is just one hundredth of this, which is 45 uA. Now the base voltage will be somewhere around 0V56 — we cannot be sure of the exact value — and the supply voltage is 9 V so the voltage drop across the resistor in **Figure 8.11** will be 8V4, approximately. A resistor which passes 45 uA with 8V4 across it has a value (Ohm's law again) of around 186k. You can't actually *get* a 186k resistor but its close enough to 180k, which you can get, and it's odds on that 180k might be near enough.

Trouble is, it doesn't really work out so nicely all the time. The resistor value usually has to be one which simply isn't obtainable except by using series or parallel combinations of resistors to make up the precise value that the circuit needs. We've also assumed that we know the exact value of current gain and we've made no allowance for the tolerance of the resistors.

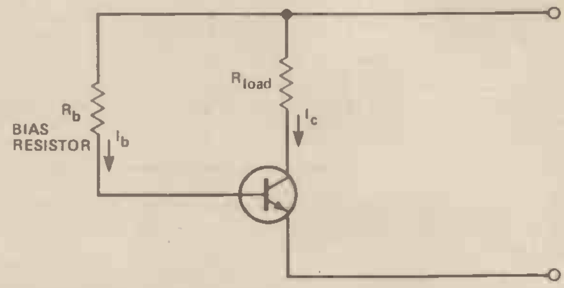

Figure 8.11 A single-resistor bias circuit.

Try it for yourself and see if you can find a value (start with 100k) which will give you a reading of 4V5 on the HE meter at the collector, using the circuit in **Figure 8.12**. If the collector voltage is low, you need a higher value; if the collector voltage is high, you need a lower value. Then, even if you do find a value that is suitable it's not likely to stay that way for long, because the heating of either the transistor or the resistor (but especially the transistor) will cause changes! Even old age (the components, not you) will cause the value of the resistor to 'drift', making this method unsuitable for all but a very few circuits.

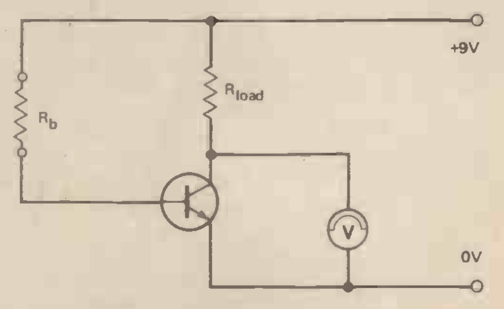

Figure 8.12 Trying out a single-resistor bias circuit. Set the HE Meter to its 10V range and try different values for Rb, starting with 100k.

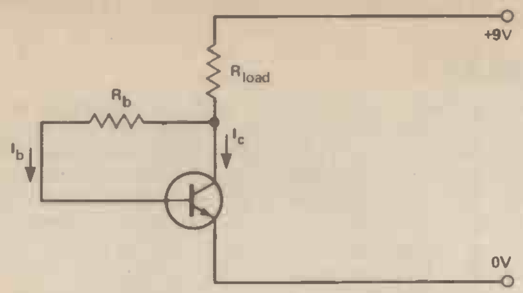

Figure 8.13 The negative-feedback bias system.

A much better bias system is shown in Figure 8.13. It doesn't look so very different — all that has been done is to move one end of the resistor from the positive supply to the collector — but it *behaves very* differently.

This circuit is an example of feedback, by which we mean that, while the base voltage affects the collector voltage, the collector voltage also affects the base current. If the collector voltage rises there will be more current flowing through the resistor R1, but more current flowing through R1 means more base current and this causes more collector current which in turn causes the collector voltage to be reduced!

The argument looks daft — a rise of collector voltage causes a fall of collector voltage — but what it means is that the circuit will oppose any change and that just the sort of thing that we need for a good bias circuit; we want to be able to set it and then leave it, relying on it not to change the bias voltage even if the current gain of the transistor changes or if the value of the resistor changes.

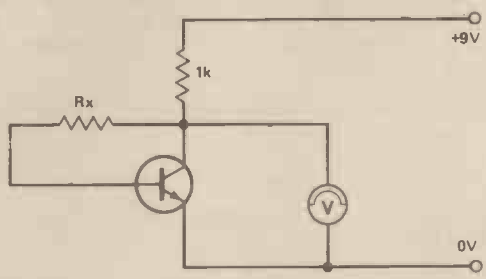

Figure 8.14 The negative feedback bias system in action; the HE Meter is set to its 10 V range. Suitable values for Rx lie between 68k and 100k.

Another benefit is that the resistor value we need for this type of bias circuit is smaller and we can take "next best" without upsetting the bias voltage too much. Suppose, for example, that we are using the usual 9 V supply and 1k load (Figure 8.14). When the collector voltage is at 4V5 (the ideal setting) then the voltage across R1 must be about 4.5 minus 0V6, (0V56 rounded up) which is 3V9, which means we need a collector current of 3.9 mA. Now if we assume, once again, that the base current needs to be 45 uA for this amount of collector current then the value of R1 is, by Ohm's law, 3.9/.045k, which is 86k6. In fact we could probably get away with as little as 68k or as much as 100k, but if we wanted to be fussy the 10% preferred value of 82k would do very nicely.

Try it for yourself; with the HE meter used to measure the collector voltage, plug resistors into the R1 position on the Eurobreadboard until you have got a collector voltage of about 4V5. Try the next preferred value up or down; certainly it'll shift the collector voltage, but the shift is nothing like as great as if we use, for bias, a resistor connected directly to the positive supply.

The ultimate bias system, used when we really need to keep things under tight control, is shown in Figure 8.15. Beginners often feel shy about using this system because they think it is more difficult to calculate the values. It's not so, but you do have to know what it's about!

As usual, it helps if we take an example and, since the 9 V supply 1k load idea has served us well so far, we might as well continue to use it. To start, we need to connect the base to a potential divider which will supply about one volt. *About?* Yes, because we don't have to be precise! All we need is a potential divider will pass about 1 mA (not precisely, so long as the current is a lot larger than the base current of the transistor) and keep the base at about 1 V. Suppose we make R2 = 1k and R1 = 8k2 — that should do nicely. What's that? You don't have an 8k2? Doesn't matter, we'll use a 6k8 — didn't I tell you that this circuit wasn't fussy?

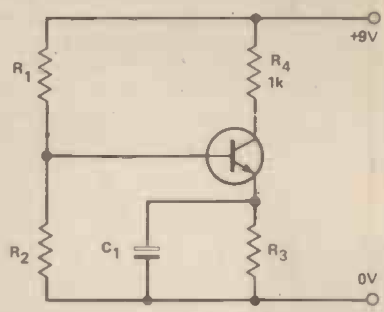

Figure 8.15 The potential divider bias system; C1 is short circuit for AC signals.

The combination of 1k and 6k8 in the potential divider circuit with a 9 V supply leads to a base voltage, using the potential divider rule (Figure 8.16 if you've forgotten) of 9 x 1 ÷ 7V8, which is 1V15. That's close enough for this calculation; in fact you could call it 1 V 1 and still be close enough. Now if the base voltage is 1V15, the emitter voltage must be about 0V6 or so lower than this when the transistor is passing current, which makes the emitter voltage somewhere around 0V55. How do we get this emitter voltage? Simple; we pass the emitter current through a resistor, R3. The collector current has to be 4.5 mA to give a 4V5 drop across R1 (1k) so, by Ohm-sweet-Ohm, the value of R3 has to be 0.55 ÷ 4.5, which is 0k12 or 120 ohms. And yes, we could probably get away with 100R or 150R without anything drastic happening.

Now try it. Whatever you're using as a transistor, use these value of resistors and see what the collector voltage is, using the HE meter. The value should not be far from 4V5 if you've used 120R for R3. To increase the collector voltage, use a larger value of R3; to decrease the collector voltage, use a smaller value of R3. That's all! You don't even have to make any assumptions about the value of the current-gain!

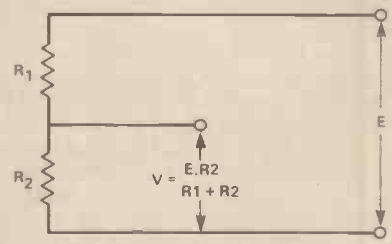

Figure 8.16 Recalling the potential-divider law.

Gain Some, Lose Some

Once we have biased a transistor correctly, we can use the transistor for amplification. To do this we feed a signal, through a capacitor, into the base circuit of the transistor and take the amplified signal from the collector circuit, also through a capacitor. The use of capacitors (coupling capacitors) avoids the problems we would have to face if we connected directly to the base or collector circuits. Other circuits would, if connected to the base, upset our bias arrangements and if connected to the collector, would upset the collector DC voltage.

How much gain can we expect to get from a transistor? Old textbooks are full of fearsome formulae but the universal use of silicon transistors has made the calculations very much simpler. Just measure the voltage drop across the load resistor and multiply this figure by 40! It's as easy as that. For example, if we have 4V5 across the load resistor, then the *maximum* gain that you can expect is 40 x 4.5 = 220 times.

Let's be quite clear what this figure is; it's the maximum possible voltage gain of conventional common-emitter amplifier circuit such as that shown in Figure 8.17 — and it's an 'ideal' figure which can never be reached in a practical amplifier. The ideal figure assumes that the amplifier is connected to an ideal voltage source, at the input, and to an ideal load at the output.

Unfortunately, this is not an ideal world! The effect of connecting less-than-ideal sources and loads to an amplifier is to reduce the gain of any amplifier below the maximum, because of what are called ''loading'' effects. These result because the transistor, the device itself, has built-in input and output resistances. The input resistance is typically small, around 1k or so, while the output resistance is usually around 30k, but both these figures can vary by as much as a factor of 5.

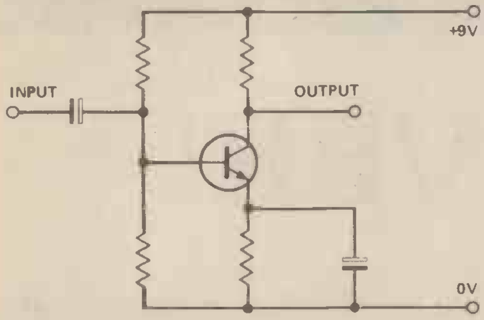

Figure 8.17 The common-emitter amplifier circuit, complete.

By connecting a source, such as a microphone with an internal resistance of about 200 R, to the input of the amplifier of **Figure 8.17**, we are setting up a potential divider circuit (**Figure 8.18**) which reduces the effective voltage supplied to the base; in fact, the base voltage will only be equal to the voltage supplied by the microphone when the microphone resistance is zero — which, of course, is impossible. Similarly at the output, the internal resistance of the transistor and the resistance of a load, such as a pair of headphones, set up another voltage divider which reduces the voltage avialable to the headphones. As a result, the effective gain of an amplifier from source (microphone) to load (headphones) is somewhat less than the maximum that the 'rule-of-thumb' calculation produces. Just how much less depends on how closely the source and load resistances 'match' the input and output resistances. The rule-of-thumb, here is that if the amplifier's input resistance is low, the source resistance should also be low. Similarly, the load resistance (this is not the same as the load resistor!) should 'match' the amplifier's output resistance.

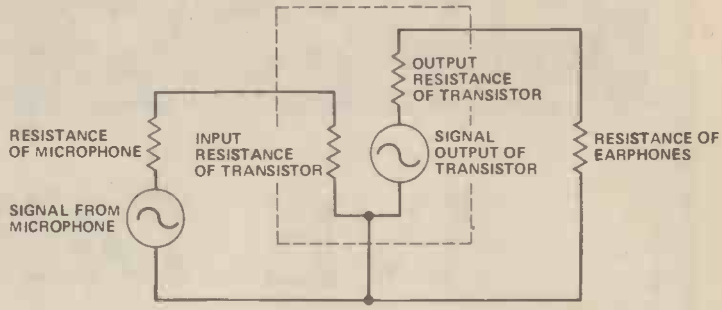

Figure 8.18 Equivalent circuit of a common-emitter amplifier 'gain block' (shown within dotted lines) with a source (microphone) and a load (headphones) connected. The total gain is reduced below that of the gain block itself because the voltage delivered by the microphone is 'loaded' by the input resistance of the amplifier. Similarly, the voltage delivered to the load is reduced because of the output resistance of the amplifier.

Note that for most amplifier circuits which use a load resistor, we can take the output resistance as being equal to the load resistor; also, these comments apply only to the common-emitter type of amplifier. A common-collector amplifier (more often called an emitter-follower), for example, can have a high input resistance and a low output resistance and will always have a voltage gain of slightly less than one (unity gain); for this reason, an emitter-follower is often used as a 'buffer' amplifier matching a high resistance source to the low resistance input of a voltage amplifier.

In the next installment we'll move on to the new hot-shots of electronics — integrated circuits. **HE**

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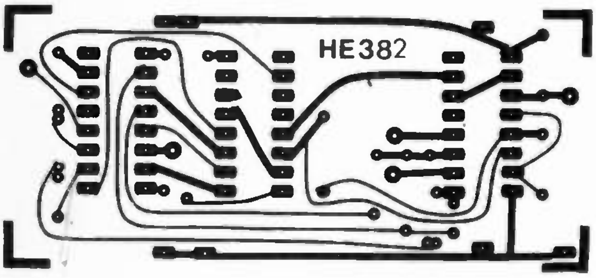

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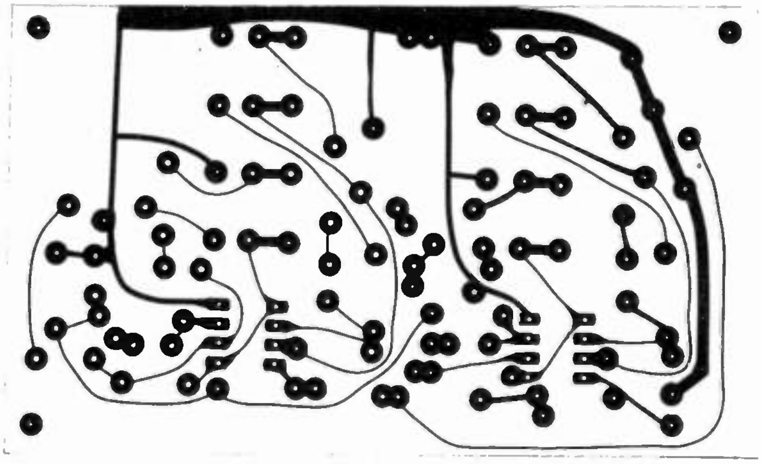

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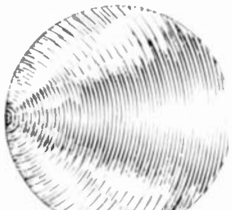

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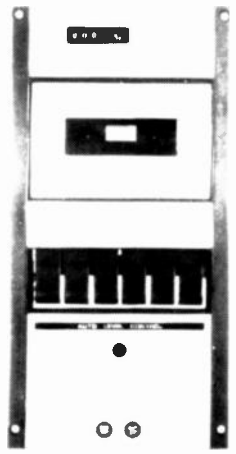

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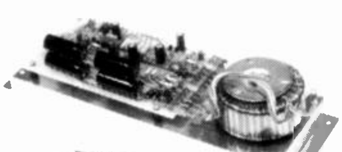

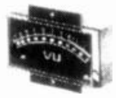

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Frequency Response 20Hz 25KHz + 3dB
Sensitivity for 100 watts 500mV at 10K
150 watts 500mV at 10K
T.H.D. 00.1%
Size 360 · 115 · 80mm

Prices			P&P
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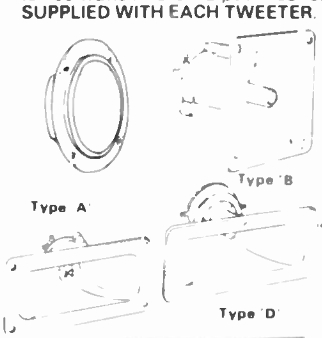

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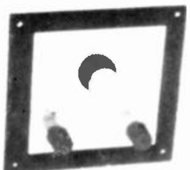

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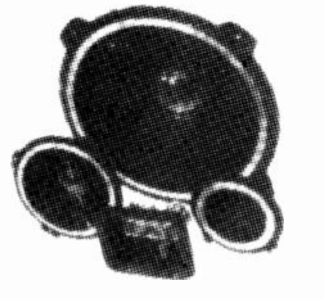

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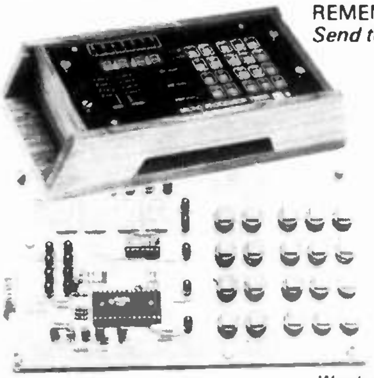

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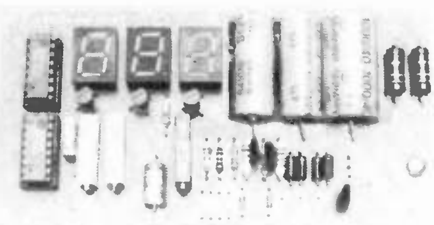

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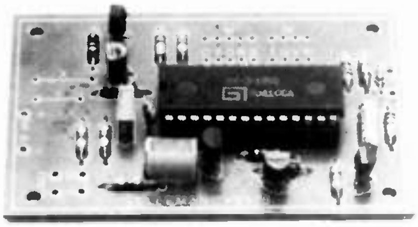

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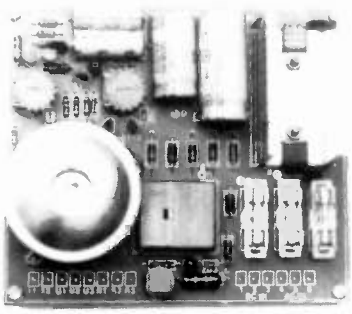

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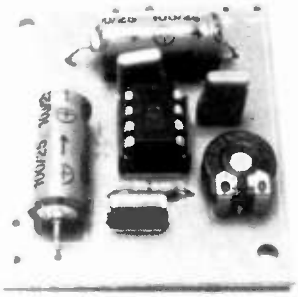

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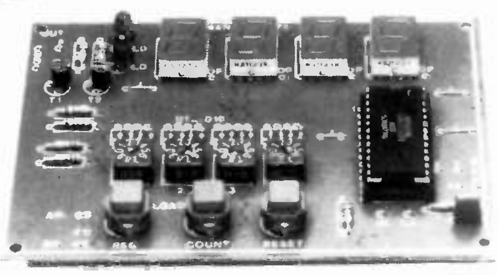

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