ISSN 0142-6192

Hobby Electronics

May '79
40p

PARKING METER TIMER

Effects Unit
White noise wonders

AB Circuits
Multivibrators — how they work

Aerial Tuners
Matching aerials to receivers

Bench Power Supply
30V stabilised unit

555 Circuits
A chip to pass the time away

Varicap Diodes
The heart of the tuner

ambit® international

The PW Sandbanks Metal Locator: a kit based on this recently published design for this uniquely effective type of metal locator is available for only £35.00 + 8% VAT. The kit closely resembles the appearance as published, except that a close fitting injection molded housing replaces the vacuum molded electronics box - to improve the enviromental suitability of the construction. Carriage for complete kits £1.

The New Catalogue - "Tecknowledgey Part 2"
Part 2 of the catalogue: by the time this advert reaches the press, part 2 should be on sale. Sorry it's late, but it contains so many new and interesting things that we felt we had to hold up production to include them. Part three by the autumn -and already there are many new items to go in! Part one 45p, part 2 50p. (inc PP etc).

Radio ICs

TDA1062	HF/VHF tunerhead	1.95
TDA1083	One chip AM/FM rx	1.95
TDA1090	One chip HiFi am/fm	3.35
TDA1220	One chip am/fm rx	1.75
HA1197W	HiFi AM tuner IC	1.40
CA3123E	AM tuner IC	1.40
TBA651	AM tuner IC	1.81
CA3089E	Famous FM IF system	1.94
CA3189E	As 3089+ deviation mute AF preamp, adj, agc	2.75
HA1137W	Improved S/N 3089	2.20
TBA120	limiting amp+detector	0.75
TBA120S	high gain	1.00
MC1350P	agc'd IF preamp	1.20
MC1330P	synch AM/video detector	1.35
KB4406	Cascode IF preamp	0.65
uA753	limiting FM preamp	1.95

Communications circuits

SD6000	OMOS RF/Mixer pair	3.75
KB4412	Bal mixers, IF+agc	2.55
KB4413	AM/SSB det. squelch,agc	2.75
KB4417	mic processor	2.55
MC3357	best thing in NBFM yet	3.12
MC1496P	popular double bal mixer	1.25

Multiplex decoders + noise blanker

MC1310P	popular PLL decoder	2.20
uA758	buffered 1310	2.20
CA3090AQ	RCA PLL decoder	3.25
HA1196	improved PLL decoder with stereo preamps	3.95
HA11223	19kHz pilot cancel, low distortion, high S/N	4.35
KB4437	as HA11223 with remote VCO kill facility	4.55
KB4438	stereo MUTING preamp for post decoder mute	2.22
KB4423	impulse noise blanker	2.53

Discrete devices: more than ever:

BF960	800MHz/2.8dB nf mosfet	1.60*
BF961	200MHz/2.0dB nf ..	0.80*
40822	FM RF amp	0.43*
40823	FM mixer	0.51*
40673	Famous MOSFET	0,55*
2SJ49/2sK133	120v/100W MOSPOWER output devices	10.50*

LEDS: the best value today

	3mm	5mm	2.5x5mm
Red	0.14	0.14	0.17
Green	0.18	0.16	0.20
Yellow	0.18	0.15	0.20
Orange	0.22	0.29	0.24

100 off mix, 25% discount. All are AEG first grade types - absolutely no junk. 5mm clips for panel mounting 0.03 each

Misc. ICs for radio/audio applications

U237B	5 LED bargraph driver	0.80*
SAS6610	4 station touch tune IC	1.48*
SAS6710	adds 4 stations to 6610	1.48
MSM5523/4	LW,MW,SW and FM digital frequency readout plus clock, timers, stopwatch	£14*
MSM5526	LW/MW/FM DFM with direct drive for LCD	£11*
TCA730	DC volume control	3.50
TCA740	DC tone control	3.50
TDA1028	DC input switch	3.50
TDA1029	DC mode switch	3.50

Radio and Tuner modules
We cannot really list all the details we would like to here - but with advent of the new mark 3 tuner system, the Dorchester and matching AF units, Ambit offers you the widest choice ever, plus hardware and styling that matches the very high standards we have set in this new range.

At last, DIY HiFi which looks as if it isn't.

That's not to say it doesn't look like HiFi - just that it doesn't look like the usual sort of thing you have come to associate with DIY HiFi. The Mk3 outstrips and outperforms all British made HiFi tuners, and most imported ones too. Certainly at the price, there isn't one near it. But more than that, it looks superb . A small pic here would be an insult, so send an SAE for details on the kit that looks as if isn't. It's something else............

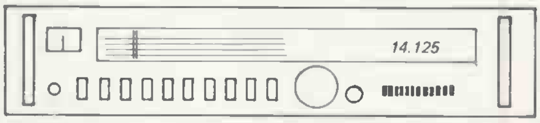
- Exceptionally high performance - exceptionally straightforward assembly
- Baseboard and plug-in construction. Future circuit developments will readily plug in, to keep the MkIII at the forefront of technical achievement
- Various options and module line-ups possible to enable an installment approach to the system

and now previewing the matching 60W/channel VMOS amplifier:

- Matching both the style and design concepts of the MkIII HiFi FM tuner
- Hitachi VMOS power fets - characterized especially for HiFi applications
- Power output readily multiplied by the addition of further MOSFETs
- VU meters on the preamp - not simply dancing according to vol level
- Backed with the usual Ambit expertise and technical capacity in audio

The PW Dorchester - LW, MW, SW, & FM stereo tuner

THE DIGITAL DORCHESTER ALL BAND TUNER



With styling and dimensions to fit in with the rest of AMBIT's new range of tuner & audio equipment.

When the new range of OKI digital frequency display ICs was announced, the original prototype of the Dorchester had been made - but since so many of you wanted to use the OKI frequency counterdisplay system with the Dorchester, we quickly designed a unit to incorporate the necessary facilities. The Digital Dorchester is designed in 19" inch form, and forms a perfect match for the other units in the range. If you don't want to go to the expense of the full Ambit DFM1 module, with AM/FM/Time/Timers, then the MA1023 clock module can be used instead -

The Dorchester has been described in PW Dec., Jan. and Feb. issues - but for those of you who may have missed it - it is an All Band broadcast tuner, covering LW/MW/SW and FM stereo in 6 switched ranges. Construction is very straightforward, with all the switching being PCB mounted - and the revolutionary TDA1090 IC used for AM/FM.

The electronics for the radio section of the Dorchester remain unchanged at £33.00, with 12.5% VAT. The hardware package, of case, meter, PSU now costs £33.00 + 8% with the MA1023 available for an extra £5 only.
For the fully digital version, with Ambit DFM1, the price is £56.50 + 8% VAT.

TERMS etc: CWO please, VAT on Ambit Items is generally 12½%, except where marked (*). Catalogue part 1:45p, part 2 50p all inclusive. Postage 25p per order, carriage on tuner kits £3. Phone Brentwood (0277) 216029/227050 9am-7pm. Callers welcome inc. Saturdays .

2 Gresham Road, Brentwood, Essex.

OSTS

Since AMBIT introduced the "One Stop Technology Shop" to our service, we have been pleased to see just how many users of electronic components appreciate our guarantee to supply goods only from BS9000 approved sources. More than ever, professional and amateur electronics engineers cannot afford to waste time on anything less than perfect pedigree products.

SEE THE AMBIT AD TOO!

CD4000 CMOS

4000	17p	4059	563p	4522	149p
4001	17p	4060	115p	4527	157p
4002	17p	4063	109p	4528	102p
4006	109p	4066	53p	4529	141p
4007	18p	4067	400p	4530	90p
4008	80p	4068	25p	4531	141p
4009	58p	4069	20p	4532	125p
4010	58p	4070	20p	4534	614p
4011	17p	4071	20p	4536	380p
4012	17p	4072	20p	4538	150p
4013	55p	4073	20p	4539	110p
4016	52p	4075	20p	4541	141p
4017	80p	4076	90p	4543	174p
4018	80p	4077	20p	4549	399p
4019	60p	4078	20p	4553	440p
4020	93p	4081	20p	4554	153p
4021	82p	4082	20p	4556	77p
4022	90p	4085	82p	4557	386p
4023	17p	4086	82p	4558	117p
4024	76p	4089	150p	4559	388p
4025	17p	4093	50p	4560	218p
4026	180p	4094	190p	4561	65p
4027	55p	4096	105p	4562	530p
4028	72p	4097	372p	4566	159p
4029	100p	4098	110p	4568	281p
4030	58p	4099	122p	4569	303p
4031	250p	4160	90p	4572	25p
4032	100p	4161	90p	4580	600p
4033	145p	4162	90p	4581	319p
4034	200p	4163	90p	4582	164p
4035	120p	4174	104p	4583	84p
4036	250p	4175	95p	4584	63p
4037	100p	4194	95p	4585	100p
4038	105p	4501	23p		
4039	250p	4502	91p		
4040	83p	4503	69p		
4041	90p	4506	51p		
4042	85p	4507	55p		
4043	85p	4508	248p		
4044	80p	4510	99p		
4045	150p	4511	149p		
4046	130p	4512	98p		
4047	99p	4513	206p		
4048	60p	4514	260p		
4049	55p	4515	300p		
4050	55p	4516	125p		
4051	65p	4517	382p		
4052	65p	4518	103p		
4053	65p	4519	57p		
4054	120p	4520	109p		
4055	135p	4521	236p		

Micromarket PRICES SLASHED

6800 series

6800P	6.50
6820P	£6
6850P	2.75
6810P	£4
6852	3.65

8080 series

8080	6.30
8212	2.30
8216	1.95
8224	3.50
8228	4.78
8251	6.25
8255	5.40

MEMORIES

2102	£1 70
2112	£3 40
2513	£7.54
4027	£5 78
2114	£10
2708	£10.55

Development

MEK6800	£220
TK80	£306

AMI, Signetics TI, Intersil, Harris etc OA

Voltage Regs

NEW LOW PRICES

7800 series UC TO220 package 1A	all 95p
7900 series UC TO220 package 1A	all £1
78MUC series TO220 package ½A	all 90p
78LCP series TO92 100mA	all 35p
L200 up to 3A/adjustable V&A	195p
78MGT2C ½amp adjustable volts	175p
79MGT2C ½amp adjustable volts	175p
723C precision controller	65p

MAINS FILTERS FOR NOISE/RFI etc

1 amp in IEC connector	£4.83
5 amp in 'wire in' case	£3.87
NE550A	73p

LINEARS non-consumer

BIMOS

CA3130E	84p
CA3130T	90p
CA3140E	35p
CA3140T	72p
CA3160E	90p
CA3160T	99p

Op amps

LM301AH	67p
LM301AN	30p
LM308H	121p
LM308N	97p
LM318H	279p
LM318N	224p
LM339N	66p
LM348N	186p
LM3900N	60p
709HC to5	64p
709PC dil	36p
710HC to5	65p
710PC dil	59p
723CN	65p
741CH to5	66p
741CN 8dil	27p
747CN	70p
748CN	36p
NE531T	12Cp
NE531N	105p

OPTO 7 seg displays

0.43" High Efficiency HP:

5082- 7650 red CA
5082- 7653 red CC
5082- 7660 yellow CA
5082- 7663 yellow CC
5082- 7670 green CA
5082- 7673 green CC
} 233p

0.3" Standard HP

5082- 7730 red CA
5082- 7740 red CC
} 147p

0.5" Fairchild

FND500 red CC	150p
FND507 red CA	150p

TTL : Standard AND LP SchottkY

	'N'	'LSN'		'N'	'LSN'		'N'	'LSN'		'N'	'LSN'		LSN
7400	13	20	7455	35	24	74126	57	44	74185	134		74377	124
7401	13	20	7460	17		74128	74		74188	275		74378	93
7402	14	20	7463			74132	73	78	74190	115	92	74379	130
7403	14	20	7470	28		74133		29	74191			74386	37
7404	14	24	7472	28		74136		40	74192	105	180	74390	140
7405	18	26	7473	32		74138		60	74193	105	180	74395	139
7406	38		7474	27	38	74139		60	74194	105	187	74396	133
7407	38		7475	38	40	74141	56		74195	95	137	74398	180
7408	17	24	7476	37		74142	265		74196	99	110	74399	150
7409	17	24	7478			74143	312		74197	85	110	74445	92
7410	15	24	7480	48		74144	312		74198	150		74447	90
7411	20	24	7481	86		74145	65		74199	160		74490	140
7412	17	24	7482	69		74147	175		74248		90	74668	110
7413	30	52	7483A			74148	109		74249		93	74670	249
7414	51	130	7484	97		74150	99		74251		90		
7415		24	7485	104	99	74151	64	84	74253		105		
7416	30		7486		40	74153	64	54	74257		108		
7417	30		7489	205		74154	96		74258		153		
7420	16	24	7490	33	90	74155	54	110	74259		420		
7421	29	24	7491	76	110	74156	80	110	74260		153		
7422	24	24	7492	38	78	74157	67	55	74261		353		
7423	27		7493	32	99	74158		60	74266		40		
7425	27		7494	78		74159	210		74273		124		
7426	36	27	7495A	65	99	74160	82	130	74275		312		
7427	27	29	7496	58	120	74161	92	78	74279		52		
7428	35	32	7497	185		74162	92	130	74283		120		
7430	17	24	74100	119		74163	92	78	74290		90		
7432	25	24	74104	63		74164	104		74293		95		
7433	40	32	74105	62		74165	105		74295		120		
7437	40	24	74107	32	38	74166			74298		100		
7438	33	24	74109	63	38	74167	20		74324		157		
7440	17	24	74110	54		74168			74325		242		
7441	74		74111	68		74169		200	74326		247		
7442	70	99	74112	88		74170	230	200	74327		237		
7443	115		74113		38	74172	625		74352		100		
7444	112		74114		38	74173	170		74353		100		
7445	94		74116	198		74174	87	120	74362		715		
7446	94		74118	83		74175	87	110	74365		49		
7447	82		74119	119		74176	75		74366		49		
7448	56	99	74120	115		74177	78		74367		43		
7449		99	74121	25		74180	85		74368		49		
7450	17		74122	46		74181	165	350	74373		77		
7451	17	24	74123	48		74182	160		74374		77		
7453	17		74124			74183		210	74375		60		
7454	17	24	74125	38	44	74184	135						

MISCELLENY

NE555 30p
NE556 78p
NE558 180p
ICM7217 950p
ICM7208 1495p
ICL7106CP - LCO DVM IC 955p
LCO DVM KIT 2480p
3½ digit LCD display 1150p
ICL7107 LED DVM kit 2065p
ICM7216 - 8 digit 10MHz DFM/ timer £19.82 (for LED C.Cath)

SCALAR ICs

8629 150MHz divide by 100 420p
95H90DC 780p
11C90DC 1400p
8618 new divide by 100 or 10 for 120/60MHz 450p

The ICL7216BIPI is still the cheapest way to make a full 8 digit/ 10MHz frequency counter/timer, and with 10 external components + display - it is also one of the simplest. For £19.82, it takes a lot of beating. The mains filters have been extended now to include a 6amp IEC version at £5.10, and with the amount of electronic noise on the average supply (next door's fridge, for instance) it is a really worthwhile addition to any sensitive equipment. LPSN TTL now includes many more of latest types, all - of course - are absolutely prime first quality types. And don t forget our range of OPTO displays includes Hewlett Package high efficiency 0.43" types in all colours - renowned as the finest quality in the market. For other types of component - discrete LEDs, radio and audio devices, tuner modules, kits etc., see our other advertisement for more details - or send for the AMBIT catalogue system. Part one (45p) includes details of our background 'standard' items, and the new part two includes all the latest introductions and developments, plus a rundown on OSTS.

TERMS: CWO pse., VAT to be added at 8% (inland), pp 25p per order. When ordering from the OSTS and Ambit - a single combined remittance and pp charge is sufficient. Account details OA.

2 Gresham Road, Brentwood, Essex.

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(A DIVISION OF GOTHIC ELECTRONIC COMPONENTS LTD)
PO Box 290
8 Hampton Street
Birmingham B19 3JR

TELEPHONE: 021-233-2400

MAIL ORDER ONLY

ALL PRICES IN PENCE EACH UNLESS OTHERWISE STATED

CAPACITORS

Electrolytic Axial Leads — Order Code
−10% to +50% Tol — Cap 015 + μF + V d.c.

μF \ V d.c.	16	25	40	63
1.0				8
1.5				8
2.2				8
3.3				8
4.7				8
6.8			8	9
10		7		9
15	7		8	10
22		7		12
33	7		8	
47		7	10	12
68	8			
100		8	12	
150	8	9		29
220	12		24	34
330			28	37
470		21	30	44
680	19	28	36	50
1000	23	28	55	
1500	32	36		
2200	39			

Electrolytic Can Type — Order Code
High Ripple, IEC Grade 1, Low E.S.R. — Cap HR + μF + Volts
Supplied complete with Vertical Fixing Clip

μF	V	Ripple 1A @ 85°C	1A @ 50°C	
2200 μF	16V	1A	1.4A	166
4700 μF	16V	2.8A	3.6A	184
10000 μF	16V	5.8A	8.1A	222
22000 μF	16V	9.8A	13.7A	346
2200 μF	25V	1.3A	1.8A	175
4700 μF	25V	4.6A	6.4A	201
10000 μF	25V	8.0A	11.2A	264
22000 μF	25V	12.8A	17.9A	438
1000 μF	40V	0.9A	1.2A	168
2200 μF	40V	2.4A	3.3A	188
4700 μF	40V	5.6A	7.8A	231
10000 μF	40V	9.2A	12.8A	367
1000 μF	70V	1.8A	2.5A	190
2200 μF	70V	4.0A	5.6A	235
4700 μF	70V	7.5A	10.5A	376
1000 μF	100V	4.0A	5.6A	222
2200 μF	100V	7.8A	10.9A	346

Miniature Low Value — Order Code
Polystyrene, Axial, ±1% Tol., ≥ 63V D.C. Wkg — Cap 424
Ceramic Plate, Radial, Low K, 1.8pF–8.2pF ±.25pF Tol, 10-330pF ±2% Tol, 100V D.C. Wkg — Cap 632
Ceramic Plate, Radial, Med K, ±10% Tol, 100V D.C. Wkg — Cap 630
Ceramic Plate, Radial, High K, −20% to +80% Tol, 63V D.C. Wkg — Cap 629
+ Value

pF	424	632	630	629
1				
1.2				
1.5				
1.8		5		
2.2		5		
2.7		5		
3.3		5		
3.9		5		
4.7		5		
5.6		5		
6.8		6		
8.2		5		
10		5		
12		5		
15		5		
18		5		
22		5		
27		5		
33		5		
39		5		
47		5		
56		6		
68		6		
82		6		

pF	424	632	630	629
100	16	6		
120	16	8		
150	16	8		
180	16	6		
220	16	6		
270	18	8		
330	18	8		
390	18		5	
470	18		5	
560	16		5	
680	16		5	
820	16		5	
1000	16		5	5
1200	16		5	
1500	18		6	
1800	18		6	
2200	18		6	6
2700	18		6	
3300	18		6	
3900	18		6	
4700	23		7	6
5600	23			
6800	23			
8200	23			

nF	424	632	630	629
10	25			6
12	26			
15	26			
18	27			
22	28			8
27	38			
33	41			
39	43			

Electrolytic Radial Leads — Order Code
−10% to +50% Tol. — Cap 034 + μF + Volts

μF \ V d.c.	6.3	10	16	25	35	40	50	63
.47								6
.68								6
1.0								6
1.5								6
2.2								6
3.3								6
4.7						6		7
6.8				6			7	8
10			6			7		8
15			6	7			8	10
22		6	7			8	10	
33			7	8		10		
47		7	8		10			
68			8	10				
100		8	10					
150		10						
220	10							

Tantalum Bead — Order Code
±20% Tol. — Cap PR + μF + Volts

μF \ V d.c.	3.15	6.3	10	16	25	35
0.1						9
0.15						9
0.22						9
0.33						9
0.47						9
0.68						9
1						9
1.5						10
2.2				9		11
3.3				9	11	14
4.7				10	14	15
6.8		9		11	15	16
10		10	11	14	16	20
15		11	14	15	20	
22	11	14		16		
33		15	16	20		
47		16	20			
68	16	20				
100	20					

Trimmers — Order Code

250V D.C. Wkg. Film Dielectric, Miniature

1.4 – 4.1pF	19	Cap 808 A
2 – 8pF	19	Cap 808 B
2 – 20pF	21	Cap 808 C
5.5 – 59.5pF	29	Cap 808 D

500V D.C. Wkg. C004 EA Tubular Type — Order Code

.8 – 3.8pF	46	Cap 802 3
.8 – 6.8pF	48	Cap 802 6
1 – 13pF	61	Cap 802 12
1.7 – 19.7	62	Cap 802 18

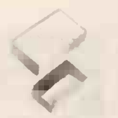
Polyester Radial Leads — Order Code
Dipped Type, ±20% Tol, ≥ 250V D.C. Wkg. C280/352 Style — Cap 352
Moulded Type, ±10% Tol, ≥100V D.C. Wkg. 10.2mm Pitch Centres — Cap 360
Moulded Type, ±10% Tol; ≥100V. D.C. Wkg. 7.6mm Pitch Centres — Cap PHE280
+ Value

μF	352	360	PHE280
.001		5	6
.0015		5	6
.0022	5	6	7
.0033	5	6	7
.0047	5	6	7
.0068	5	6	7
.01	5	6	7
.015	5	7	8
.022	5	7	8
.033	5	7	8
.047	5	7	8
.068	6	8	9

μF	352	360	PHE280
.1	6	8	9
.15	7	9	
.22	8	10	
.33	10		
.47	12		
.68	15		
1.0	19		
1.5	27		
2.2	32		

CASES

Small Desk Console — Boss Industrial Mouldings
Slope Front Console, Recessed Top
ABS Base, C/W Brass Bushes, In Orange
1mm Aluminium Top Panel Finished Grey

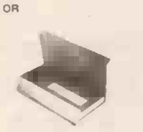


		Order Code
W161, D96, H39 (57)	186	Case BIM1005 OR
W215, D130, H47 (73)	268	Case BIM1006 OR

Plastic Boxes — Boss Industrial Mouldings
Moulded Box and Close Fitting Flanged Lid
ABS Box, C/W Brass Bushes, and Lid In Orange

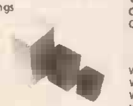
		Order Code
L112 W62 D31	87	Case BIM2003 OR
L150 W80 D50	115	Case BIM2005 OR
L190 W110 D60	195	Case BIM2006 OR

Instrument Case — Boss Industrial Mouldings
Covers Manufactured from 14SWG Aluminium
Chassis Manufactured from 18SWG Mild Steel
Covers Finished Orange
Chassis Finished Matt Black



		Order Code
W250 D167.5 H 68.5 (Chassis 153mm Deep)	1480	Case BIM3000 OR

Plastic Boxes with Metal Lids — Boss Industrial Mouldings
Recessed Top Box
ABS Base, C/W Brass Bushes, In Orange
1mm Aluminium Top Panel Finished Grey



		Order Code
L85 W56 D29	97	Case BIM4003 OR
L111 W71 D42	130	Case BIM4004 OR
L161 W96 D53	182	Case BIM4005 OR

Diecast Boxes — Boss Industrial Mouldings
Diecast Box and Flanged Lid
Aluminium Box and Lid In Natural Finish

		Order Code
L113 W63 D31	104	Case BIM5003 NA
L152 W82 D50	181	Case BIM5005 NA
L192 W113 D61	280	Case BIM5006 NA

VERO ELECTRONICS PRODUCTS

2.5" x 5" .1" pitch Veroboard	59	VERO 21069J
3.75" x 5" .1" pitch Veroboard	66	VERO 21072D
2.5" x 1" .1" pitch Veroboard (5)	70/Pack	VERO 21076C
3.75" x 5" .1" pitch Plain Board	56	VERO 21078E
5.82" x 2.9" .1" pitch V-Q DIP Board	111	VERO 21084E
Spot Face Cutter	89	VERO 21013A
Pin Insertion Tool for .040 type pin	122	VERO 21015F
DS Pins .040 (100)	38/Pack	VERO 21087G
SS Pins .040 (100)	38/Pack	VERO 21017B
6mm Board Standoff (100)	181/Pack	VERO 21321K
15mm Board Standoff (100)	215/Pack	VERO 21322G
19mm Board Standoff (100)	226/Pack	VERO 21323D
Verowire Kit (1-pen, 2-wire, 25-comb)	375/Kit	VERO 21341D
Verowire Combs (100)	407/Pack	VERO 21339F
Verowire Wire (4)	228/Pack	VERO 21340G
Flip Top Box, Small, Black	192	VERO 21317D
Flip Top Box, Large, Black	250	VERO 21319J

Small Desk Consoles — Boss Industrial Mouldings
Slope Front Console, Recessed Top
ABS Base, C/W Brass Bushes, In Orange
1mm Aluminium Top Panel Finished Grey
Ventilation Slots In Base

		Order Code
W105 D143 H32 (56)	206	Case BIM6005 OR
W170 D143 H32 (56)	271	Case BIM6006 OR
W170 D214 H32 (82)	375	Case BIM6007 OR

All Metal Desk Consoles — Boss Industrial Mouldings
Slope Front Console, Recessed Top
Two Piece All Aluminium Construction
Ventilation Slots In Rear and Base
Choice of 15° or 30° Sloping Front
Off White Top Panel, Blue Base

		Order Code
W102 D140 H28 (51) 15° slope	1018	Case BIM7151A
W165 D211 H33 (76) 15° slope	1350	Case BIM7154A
W254 D287 H33 (76) 15° slope	1572	Case BIM7156A
W356 D287 H33 (76) 15° slope	1823	Case BIM7158A
W102 D140 H28 (76) 30° slope	1018	Case BIM7301A
W165 D183 H28 (102) 30° slope	1202	Case BIM7303A
W254 D259 H28 (102) 30° slope	1572	Case BIM7306A
W356 D259 H28 (102) 30° slope	1823	Case BIM7308A

Eurocard Size Desk Console — Boss Industrial Mouldings
Slope Front Console
ABS Case, C/W Brass Bushes, In Orange
1mm Aluminium Top Panel, Finished Grey

		Order Code
W169 D127 H45 (70)	375	Case BIM8006 OR

HARDWARE — Order Code

D.I.L. Sockets

8 Pin Low Profile Socket Tin	11	DIL SKT 8
14 Pin Low Profile Socket Tin	13	DIL SKT 14
16 Pin Low Profile Socket Tin	14	DIL SKT 16
24 Pin Low Profile Socket Gold	66	DIL SKT 24
28 Pin Low Profile Socket Gold	78	DIL SKT 28
40 Pin Low Profile Socket Gold	127	DIL SKT 40

Heatsinks

Individual Type for 1 x T05 50°C/W	10	Sink 5F
Individual Type for 1 x T066 10.5°C/W	26	Sink TV2
Individual Type for 1 x T03 7.2°C/W	24	Sink TV3
Individual Type for 1 x T0126 17°C/W	23	Sink TV4
Individual Type for 1 x T0220 17°C/W	23	Sink TV5

P.C.B. Components

Dalo Pen, Blue Ink, Slow Drying	92	Pen 33PC

Fuseholders
Suit 20mm x 5mm fuses.

P.C.B. Mounting, Open Type	8	Fuse/H20B
Chassis Mounting, Open Type	17	Fuse/H20C
Panel Mounting, Screwdriver Slot	77	Fuse/H20PT
Panel Mounting, Finger Release	56	Fuse/H20P

Fuses
20mm x 5mm Glass

Quick Blow, Range 100mA–5A	8	Fuse 20
Slow Blow, Range 250mA–5A	22	A/S Fuse 20

+ Rating

Lampholders, Panel Mounting
Similar In Style to Fuse/H 20P
Low Voltage Type Suits LES and M/F Bulbs.

Low Voltage, Red, Amber or Green	75	Lamp LV
Internal Neon 200/240V Red or Amber	95	Lamp N

+ Colour

Bulbs, Low Voltage, L.E.S.

6V, 0.36W; 8.5V, 1W; 14V, 0.75W.	22	Bulb LES

+ Voltage

RESISTORS — Order Code

Carbon Film, Fixed

0.25W, E24 Values 1R0-10M, 5% Tol.	1.5 ea.	90p/100 (Mult 10/Value)	£7.90/1000 (Mult 100/Value)	Res RD¼
0.5W, E12 Values 1R0-4M7, 10% Tol.	2 ea.	1.25p/100 (Mult 10/Value)	£10.10/1000 (Mult 100/Value)	Res RD½

+ Value

Metal Film, Fixed

0.5W, E24 Values, 5R1-1M, 2% Tol.	6 ea.	3.80/100 (Mult 10/Value)	£32.40/1000 (Mult 100/Value)	Res MR30
2.5W, E12 Values 10R-27K, 5% Tol.	13 ea.	7.90/100 (Mult 10/Value)		Res PR52

+ Value

Metal Glaze, Fixed

0.5W, E24 Values, 1M-33M, 5% Tol.	10 ea.	5.40/100 (Mult 10/Value)	Res VR37

+ Value

Skeleton Presets, Miniature — Order Code

0.1W, E3 Values, 100R-1M, Lin. Vertical Mounting	7	Min Preset V
0.1W, E3 Values, 100R-1M, Lin. Horizontal Mounting	7	Min Preset H

+ Value

Skeleton Presets, Standard

0.3W, E3 Values, 100R-4M7, Lin. Vertical Mounting	10	Std Preset V
0.3W, E3 Values, 100R-4M7, Lin. Horizontal Mounting	10	Std Preset H

+ Value

Potentiometer, Rotary

0.5W, E3 Values, 1K-2M2 Lin.	34	Pot Lin
0.25W, E3 Values, 4K7-2M2 Log.	34	Pot Log

+ Value

Monitor

SIMON SAYS

1979 is fast shaping up as the year of the computer game. The latest addition to the range answers to the name of 'Simon'.

Simon, from the American side of the pond, was introduced to the great British public at an extravagant Press launch, featuring half of showbiz London.

We went along to what we thought would be just another Press reception and found ourselves rubbing shoulders with such household names as Russell Harty, John Craven and Richard O'Sullivan. The reception was hosted by Elaine Stritch and Donald Sinden, who demonstrated Simon to us.

The idea of the game is to repeat the ever-increasing random signals (flashing lights) generated by Simon without error. The sequence gets longer and longer. When you finally make a mistake, Simon blows a raspberry. There are three variations of the game and four skill levels, taking the light sequence to a staggering 31 flashes.

Simon's set program is stored in the ROM circuits and is permanently retained, even when the game is switched off. Information entered by the player is stored by the RAM circuits. In addition, there is a mini-chip incorporating a series of micro-switches to control lights and sound.

Simon costs £29 from Milton Bradley Ltd., Century House, 61-63 Uxbridge Road, Ealing, London, W5 5SA.

NO CHARGE

Plastic trays sometimes used to store microelectronic devices on the production line can pass on static charges of several thousand volts. That's rather inconvenient, since less than 100 volts can cause breakdown.

Standard trays are available, but KABI will mould special designs to customers' specifications. They also supply earthed Velostat wrist straps for production line workers. The range of velostat products is from KABI (Electrical and Plastics) Ltd., Cranborne Road, Potters Bar, Herts. EN6 3JP.

QUICK STRIP 'N' WRAP

This new tool from OK Machine and Tool (UK) is the size of a small screwdriver, but performs the complete wire-wrapping job. At one end it has a bit for making wire-wrapped terminal connections, in the middle a 'no nick' wire stripper and, at the other end, an unwrapping bit.

The connection, which takes only seconds to make, is considerably stronger than solder and has excellent conductivity characteristics. However, it can be undone quickly, if necessary.

The tool, designed to be used with AWG30 (0.25mm) wire and 0.025 inch (0.63mm) square terminal posts, is ideal for field service engineers, laboratories and hobbyists. Hobby Wrap costs £4.97 from OK Machine and Tool (UK) Ltd, 48a The Avenue, Southampton, Hants SO1 2SY.

IN CIRCUIT TESTING

Ever faced the problem of desoldering a dozen transistors from a board to find the one duff one? Of course, it's always the last one you try.

In-circuit testing saves a lot of time and trouble. The Lawtronics in-situ Transistor Tester is designed to test discrete semiconductors without removal from the board.

Red and green LEDs on the front panel show which of the non-polarised probes is on the cathode of a junction and whether the device is short circuit, open circuit or operational. Transistor polarity is also shown. The unit measures only 2½in x ¾in x 4¾in and is powered by a PP3.

The in-situ Transistor Tester is £19.95 from Lawtronics Limited, 139 High Street, Edenbridge, Kent TN8 5AX.

News from the Electronics World

LOW VOLTAGE IRONS

Tele-Production Tools' new Telpro TL range of low voltage soldering irons which are thermally self-limiting at about 325°C, 370°C or 410°C are ideal for use with many existing solder stations.

The 16-20 watt irons, available for 12, 24 or 48 volt operation, are supplied with a detachable, iron-clad bit. The high purity of the bit coating minimises copper migration, increasing the life of the bit.

Further details from Tele-Production Tools Ltd., Stiron House, Electric Avenue, Westcliff-on-Sea, Essex 5SO 9NW.

MINI DECK

The CM600 cassette deck from BFI Electronics is a completely self-contained unit measuring only 76 × 76 × 64mm.

Designed specifically for digital applications, all the necessary read/write amplifiers and control circuitry are included in the tiny ½lb package.

It has a two-track recording head, which will record 800 bits per inch (max.) at 2400 bits per second. A standard 100 feet miniature tape cassette will hold 1.6 million bits of information.

Further details of the CM600 from BFI Electronics Limited, 516 Walton Road, West Molesey, Surrey KT8 0QF.

HOLY MEMORY

IBM are developing a new data storage system for tuneable lasers. The system is based on a technique known as 'hole burning'.

A laser is fired at the memory substrate, which is then cooled within a few degrees of absolute zero. The resulting chemical change in the photoreactive material produces a hole in its optical absorption response at the frequency used for burning.

Reading and writing information over a range of frequencies is made possible by using a tuneable laser. Very dense storage is possible.

POCKET TRANSISTOR TESTER

Ampmace claim to have made the use of multimeters for in-circuit testing of transistors and diodes obsolete with their new tester.

They have overcome the swamping effect of parallel resistors by feeding a sufficiently large, but finely controlled, current into the junction under test.

The new pocket-sized unit with an automatic on/off circuit for long battery life and built-in protection up to 1,000V AC or DC is made by Ampmace Ltd, Unit 96, Somers Road, Rugby, Warwicks.

TRIPLE MEMORY AND TEACHER

Plustron's new cheque book calculator, the LC Memory 3, has three memories which *never* forget.

The three memories can hold separate figures, can be recalled separately or can be integrated to give a total figure for all three memories.

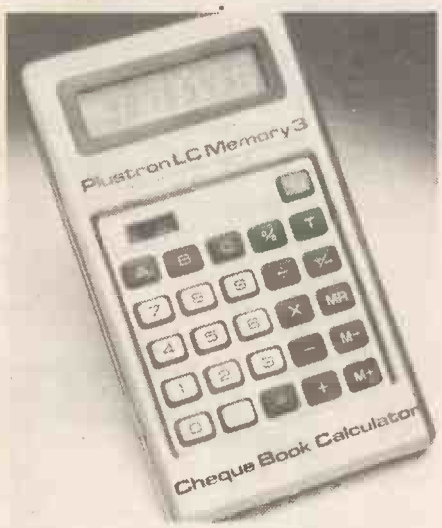
As a common or garden calculator, it offers four functions plus percent, chain and mixed, constant, reciprocals, sign change and power calculations. It has an eight digit LCD display with indicators for error (E), minus (—) and memory operation complete (M). The LC Memory 3 is around £19.88 from Plustronics.

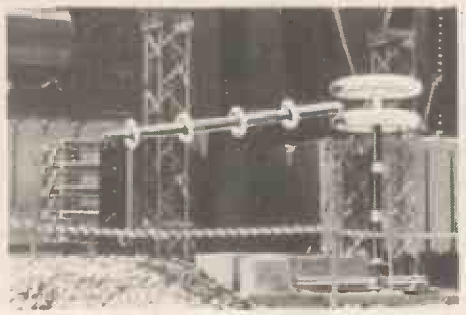
The Plustron Educational 1, also from Plustronics, doubles as a calculator *and* teaching aid.

Designed specifically for use by school children, the Educational 1 has large, clear and easy to use controls and buttons.

It can present programs in two levels of difficulty in addition, subtraction, division and multiplication. If the student's answer is wrong, the calculator shows an EE symbol and gives you another chance to get it right. When the program of ten problems is finished, your score comes up on the display. Multiplication tables can also be presented in question/answer form.

The Plustron Educational 1 is about £13.00 from Plustronics Ltd., Hempstall's Lane, Newcastle, Staffs. ST5 0SW.





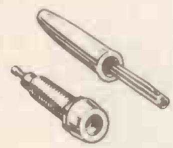
Is it the new Russian high energy beam weapon? Maybe it's a hush-hush nuclear installation snapped by our science correspondent in the wilds of the Highlands.

Frankly, we don't know exactly what it is. The press release which accompanied it was in German. The closest we got was — a high voltage something or other.

STEVENSON
Electronic Components

PLUGS AND SOCKETS

1mm plugs and sockets suitable for low voltage circuits. Available in red or black, Plugs 6p each. Sockets 7p each.



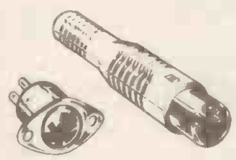
4mm plugs and sockets. Available in black, blue green, brown, red, white and yellow. Plugs 11p each. Sockets 12p each.

Jack plugs and sockets

	unscreened plug	screened plug	socket
2.5mm	9p	13p	7p
3.5mm	9p	14p	8p
Standard	16p	30p	15p
Stereo	23p	36p	18p

Din plugs and sockets

	plug	socket
2 pin speaker	7p	7p
3 pin	11p	9p
5 pin 180°	11p	10p
5 pin 240°	13p	10p



CABLES

Connecting wire
Available in packs of eight metres (one metre of each colour) or packs of forty metres (five metres of each colour).

	single	standard
Eight metre pack	16p	16p
Forty metre pack	76p	70p

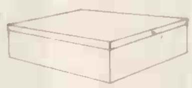
Screened Cable		Ribbon cable	
Single screened	8p	10 way	58p metre
twin individually screened	11p	20 way	100p metre

VEROBOARD

Size in.	0.1in.	0.15in.
2.5 x 1	14p	13p
2.5 x 3.75	42p	40p
2.5 x 5	52p	50p
3.75 x 5	60p	60p
3.75 x 17	195p	180p

Veropins – single sided per 100
0.1in 35p
0.15in 40p

ALUMINIUM BOXES



Boxes complete with lid and screws.

Model	Length	width	height	Price
AL1	3	2	1	48p
AL2	4	3	1½	58p
AL3	4	3	2	65p
AL4	6	4	2	70p
AL5	6	4	3	85p
AL6	8	6	2	116p

We now have an express telephone order service. We guarantee that all orders received before 5pm. are shipped first class on that day. Contact our Sales Office now! Telephone: 01-464 2951/5770.

ORDERS DESPATCHED BY RETURN POST

Quantity discounts on any mix TTL, CMOS, 74LS and Linear circuits: 25+ 10%. 100+ 15%. Prices VAT inc. Please add 30p for carriage. All prices valid to 30th April 1979. Official orders welcome.

BARCLAYCARD AND ACCESS WELCOME.

TRANSISTORS

AC127	17p	BCY71	14p	ZTX109	14p
AC128	16p	BCY72	14p	ZTX300	16p
AC176	18p	BD131	35p	2N697	12p
AD161	38p	BD132	35p	3N1302	38p
AD162	38p	BD135	38p	2N2905	22p
BC107	8p	BD139	35p	2N2907	22p
BC108	8p	BD140	35p	2N3053	18p
BC109	8p	BF244B	36p	2N3055	50p
BC147	7p	BFY50	15p	2N3442	135p
BC148	7p	BFY51	15p	2N3702	8p
BC149	8p	BFY52	15p	2N3704	8p
BC158	9p	MJ2955	98p	2N3705	9p
BC177	14p	MPSA06	20p	2N3706	9p
BC178	14p	MPSA56	20p	2N3707	9p
BC179	14p	TIP29C	60p	2N3708	8p
BC182	10p	TIP30C	70p	2N3819	22p
BC182L	10p	TIP31C	65p	2N3904	8p
BC184	10p	TIP32C	80p	2N3905	8p
BC184L	10p	ZTX107	14p	2N3906	8p
BC212	10p	ZTX108	14p	2N4058	12p
BC212L	10p			2N5457	32p
BC214	10p			2N5458	30p
BC214	10p			2N5459	32p
BC477	19p			2N5777	50p
BC478	19p				
BC479	19p				
BC548	10p				
BCY70	14p				

DIODES

1N914	4p	1N4148	3p
1N4001	4p	1N5401	13p
1N4002	4p	1N5402	15p
1N4004	5p	1N5404	16p
1N4006	6p	1N5406	18p

BZY88 series 2V7 to 33V 8p each.

74LS

		LS95	65p
		LS123	56p
		LS125	40p
		LS126	40p
LS00	16p	LS132	60p
LS01	16p	LS136	36p
LS02	16p	LS138	54p
LS03	16p	LS139	50p
LS04	16p	LS151	50p
LS08	16p	LS153	50p
LS10	16p	LS155	80p
LS13	30p	LS156	80p
LS14	70p	LS157	45p
LS20	16p	LS164	90p
LS30	16p	LS174	60p
LS32	24p	LS175	60p
LS37	26p	LS190	80p
LS40	22p	LS192	70p
LS42	53p	LS193	70p
LS47	70p	LS196	80p
LS48	48p	LS251	60p
LS54	16p	LS257	55p
LS73	29p	LS258	55p
LS74	29p	LS266	40p
LS75	44p	LS283	60p
LS76	35p	LS290	55p
LS78	35p	LS365	45p
LS83	60p	LS366	45p
LS85	70p	LS367	45p
LS86	33p	LS368	45p
LS90	45p	LS386	35p
LS93	45p	LS670	180p

LINEAR

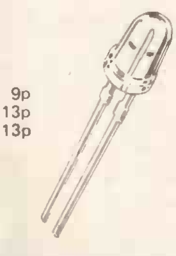
A SELECTION ONLY! DETAILS IN CATALOGUE.

709	25p	LM324	50p	NE556	60p
741	22p	LM339	50p	NE565	120p
747	50p	LM380	75p	NE567	170p
748	30p	LM382	120p	SN76003	200p
CA3046	55p	LM1830	150p	SN76013	140p
CA3080	70p	LM3900	50p	SN76023	140p
CA3130	90p	LM3909	60p	SN76033	200p
CA3140	70p	MC1496	60p	TBA800	70p
LM301AN	28p	MC1458	35p	TDA1022	650p
LM318N	125p	NE555	25p	ZN414	75p

TTL

		7493	34p
		7494	52p
		7495	52p
		7496	50p
7400	12p	74121	25p
7401	12p	74122	33p
7402	12p	74123	40p
7404	12p	74125	35p
7408	14p	74126	35p
7410	12p	74132	50p
7413	25p	74141	56p
7414	48p	74148	90p
7420	12p	74150	70p
7427	24p	74151	50p
7430	12p	74156	52p
7442	43p	74157	52p
7447	55p	74164	70p
7448	58p	74165	70p
7454	14p	74170	125p
7473	25p	74174	68p
7474	25p	74177	58p
7475	32p	74190	72p
7476	28p	74191	72p
7485	70p	74192	64p
7489	145p	74193	64p
7490	32p	74196	55p
7492	35p	74197	55p

OPTO



LEDs	0.125in.	0.2in.	
Red	TIL209	TIL220	9p
Green	TIL211	TIL221	13p
Yellow	TIL213	TIL223	13p
Clips	3p	3p	

DISPLAYS

DL704	0.3 in CC	130p
DL707	0.3 in CA	130p
FND500	0.5 in CC	100p

CMOS

FULL DETAILS IN CATALOGUE

		4029	60p
		4040	68p
4001	15p	4042	54p
4002	15p	4046	100p
4007	15p	4049	28p
4011	15p	4050	28p
4013	35p	4066	40p
4015	60p	4068	20p
4016	35p	4069	16p
4017	55p	4071	16p
4018	65p	4075	16p
4023	15p	4093	48p
4024	45p	4510	70p
4026	95p	4511	70p
4027	35p	4518	70p
4028	52p	4520	65p

RESISTORS

Carbon film resistors. High stability, low noise 5%.

E12 series. 4.7ohms to 10M. Any mix:

	each	100+	1000+
0.25W	1p	0.9p	0.8p
0.5W	1.5p	1.2p	1p

Special development packs consisting of 10 of each value from 4.7 ohms to 1 Megohm (650 res.) 0.5W £7.50. 0.25W £5.70

CAPACITORS

HERE ARE JUST A FEW OF THE CAPACITORS STOCKED

TANTALUM BEAD each

0.1, 0.15, 0.22, 0.33, 0.47, 0.68, 1 & 2.2uF @ 35V	9p
4.7, 6.8, 10uF @ 25V	13p
22 @ 16V, 47 @ 6V, 100 @ 3V	16p

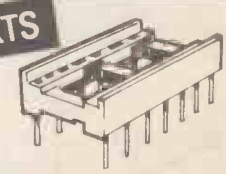
MYLAR FILM

0.001, 0.01, 0.022, 0.033, 0.047	3p
0.068, 0.1	4p

RADIAL LEAD ELECTROLYTIC

63V	0.47	1.0	2.2	4.7	10	5p
			22	33	47	7p
	100					13p
			220			20p
25V	10	22	33	47		5p
	100					8p
		220				10p
				470		15p
	1000					23p
10V		220				5p
				470		9p
	1000					13p
		2200				23p

SKTS



Low profile by Texas

8 pin	10p	24 pin	24p
14 pin	12p	28 pin	28p
16 pin	13p	40 pin	40p

Soldercon pins: 100: 50p
1000: 370p

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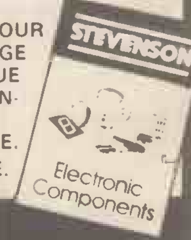

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Power Supply Unit

This low-cost stabilised power supply unit gives a 0-30 V, 1 amp output and features full overload protection. It makes an excellent addition to the home laboratory.

THIS SIMPLE BUT EFFICIENT bench power supply unit (PSU) produces a stabilised output that is fully variable over the range 0-30 volts, at currents up to 1 amp. The design features full overload protection, an overload LED indicator, and a DC output switch that gives instant connection/disconnection to an external load.

Our prototype PSU is fitted with a built-in 0-30 V meter, which can be regarded as an optional "luxury" extra. Whichever way you build the unit, it will make an excellent addition to your home laboratory or workshop.

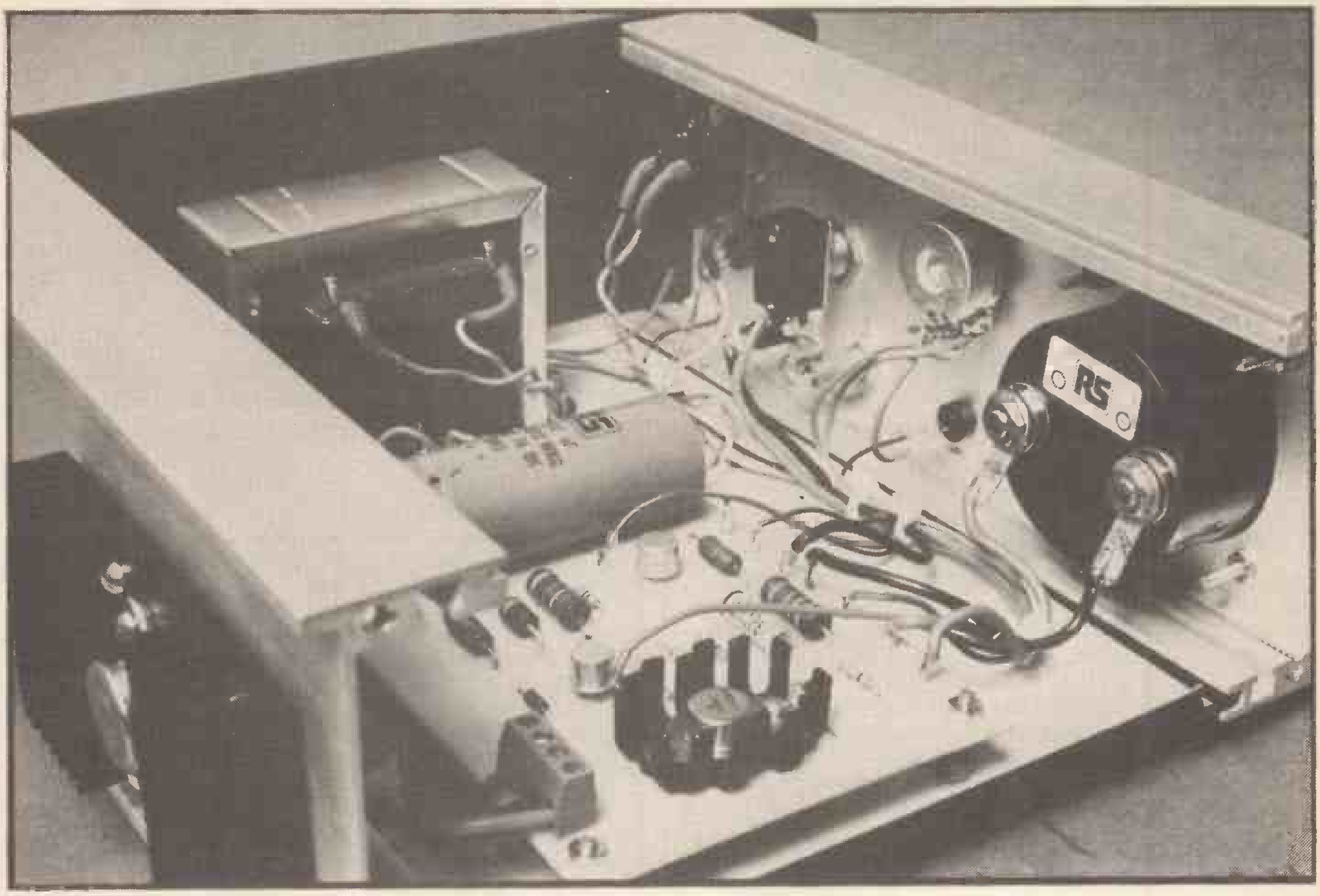
CONSTRUCTION

Construction on the PCB is quite straightforward, and should present no problems if care is taken to observe the polarities of all semiconductors and of the large electrolytic capacitor. Note that Q3 is mounted on a small heatsink.

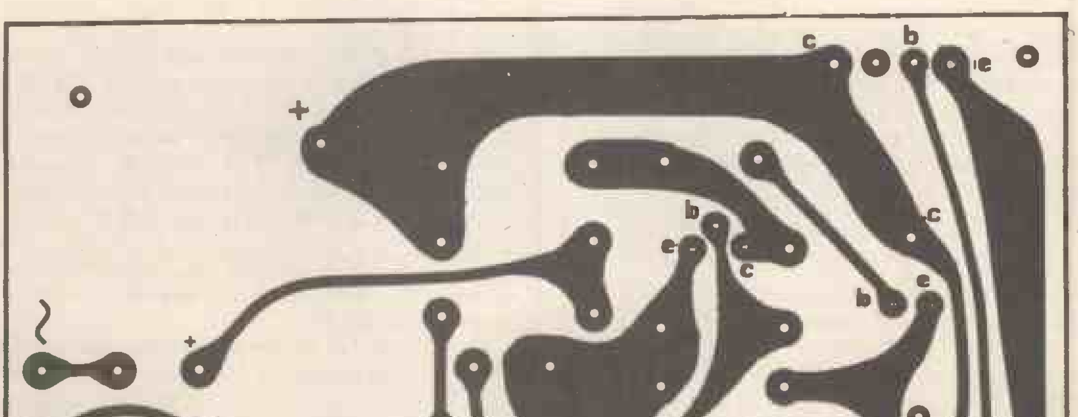
The most difficult part of the construction is the cutting of the metalwork, and the interwiring of the PCB. Note that power transistor Q4 has to dissipate up to 30 watts: it must be mounted on a fairly hefty heatsink and must be insulated from the chassis. Reasonably heavy-gauge wiring (we used 32/.2 mm) should be used on the interwiring from the mains transformer to the PCB, from the PCB to Q4, and from the PCB to the output switch and terminals.

On our prototype we fitted a 0-30 V meter to the front panel to monitor the output voltage. We made this from a 100 uA moving-coil meter and a 300k series resistor. This meter can be omitted if preferred, saving a few pounds.

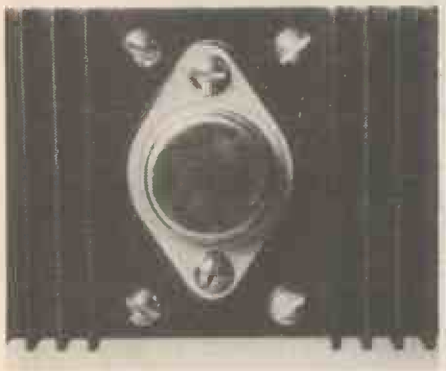
Holes should be drilled at the top and base of the case to provide adequate ventilation. When construction is complete, double-check all wiring, and then switch on.



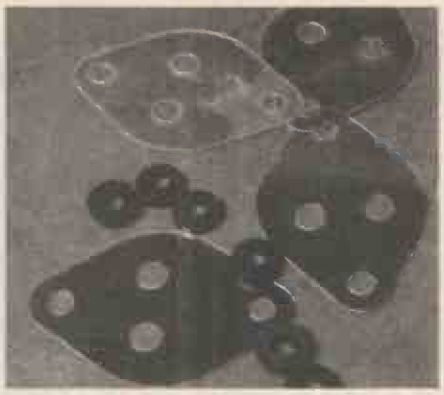
Internal view of the HE PSU.



PCB foil pattern.



Q4 mounted on its rear panel heatsink.



A transistor mounting kit — mica washers and insulating bushes.

Sleeved connections to Q4 through the rear panel.

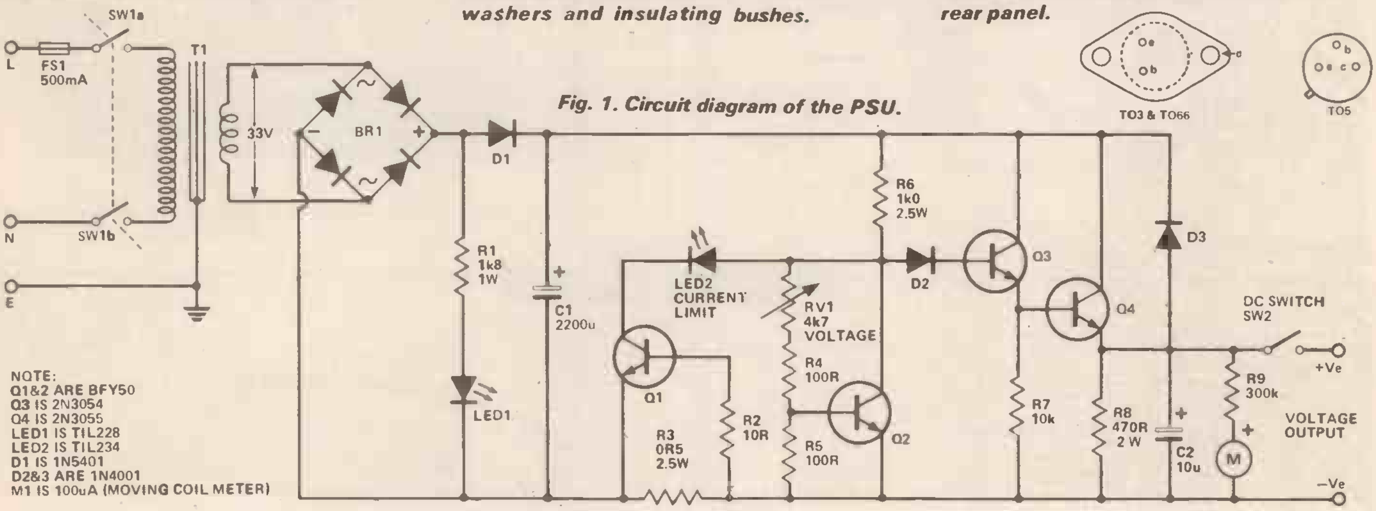


Fig. 1. Circuit diagram of the PSU.

How it Works

The operating theory of the PSU is fairly simple. The mains voltage is stepped down by 33 volts by transformer T1 and is full-wave rectified by bridge rectifier BR1. This full-wave rectified signal is fed, via R1, to LED 1, which indicates the on/off state of the unit. The full-wave rectified signal is fed on to the rest of the circuit via D1, and is converted to fairly smooth DC by electrolytic capacitor C1.

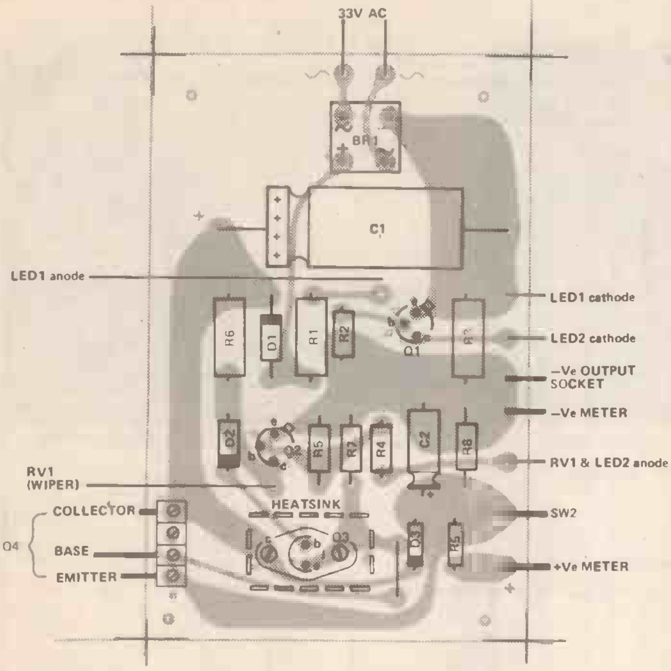
The main voltage regulating component of the PSU is transistor Q2 and its associated resistance network. The collector voltage of Q2 is controlled by the ratio of R5 to RV1 + R4 and by the value of the base-emitter voltage of the transistor (about 650 mV). The voltage is given by the equation:

$$Vce = Vbe\left(\frac{R5 + R4 + RV1}{R5}\right)$$

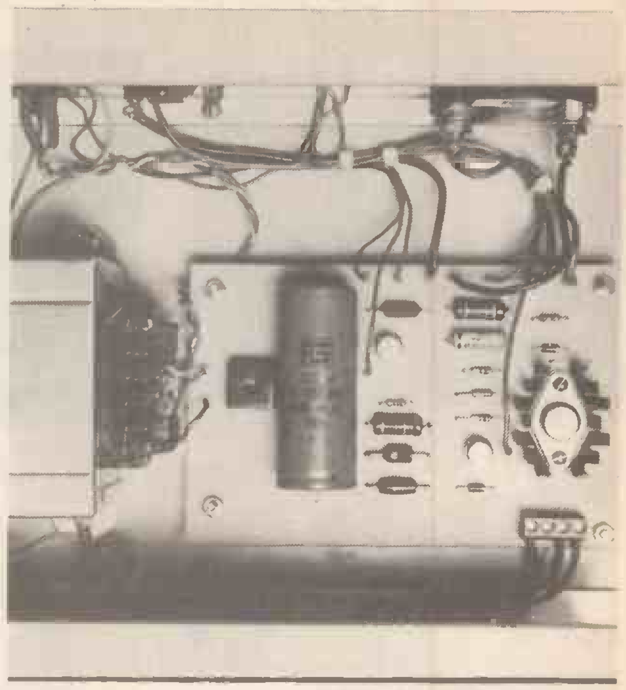
With the component values shown, this voltage is variable from about 1.3 volts to about 32 volts via RV1. This voltage is available at a low impedance level, and has a negative temperature coefficient of about 0.3%/°C. This coefficient is considered to be insignificant in this particular application.

The Q2-collector voltage is fed on to the output terminals of the unit via D2 and the Q3-Q4 Darlington or Super-Alpha emitter follower stage, which reduces the available output by one or two volts (to the 0-30 V range) but boosts the available output current to above 1 A. Capacitor C2 gives the circuit a low output impedance to high-frequency signals, and D3 protects the PSU against damage if high voltage transients are fed into its output terminals from an external load.

Transistor Q1 provides the circuit with overload protection. All of the output current of the PSU flows through R3, and generates a voltage across that resistor. Normally, this voltage is insufficient to bias Q1 on, so Q1 has no effect on the circuit. When the current through R3 exceeds 1.2 A, however, Q1 is biased on, and draws collector current via R6 and LED 2, thereby reducing the output voltage of the unit to a level that is just sufficient to drive 1.2 A through its external load, and at the same time turning LED 2 on to indicate the overload state. The output current of the circuit cannot significantly exceed 1.2 A, even under short circuit output conditions.



Component overlay.



Top view of the installed PCB.

Parts List

RESISTORS: All resistors are ¼W ±5% unless otherwise stated.

R1	1k8	1W
R2	10R	
R3	R47	2W5 wirewound
R4, 5	100R	
R6	1k	2W5
R7	10k	
R8	470R	2W
R9	300k	±2%

CAPACITORS
C1 2200 u 63V Electrolytic
C2 10 u 50V Electrolytic

POTENTIOMETERS
RV1 4k7

SEMICONDUCTORS

Q1, Q2	BFY50
Q3	2N3054
Q4	2N3055
BR1	200V 2A Bridge Rectifier
D1	1N5401
D2, D3	1N4001
LED1	TIL228
LED2	TIL234

MISCELLANEOUS

T1	0-33V @ 1A
M1	100 uA Moving Coil
SW1	DPDT Toggle (rated at 1A)
SW2	SPST Toggle (rated at 1A)
SK1, SK2	4mm Sockets

Heatsink to suit TO3 mounting
Heatsink to suit TO66 mounting
Insulating kits for above heatsinks
FS1 500 mA 20mm×5mm+suitable holder
PCB Terminal block if required
PCB to pattern
Case to suit

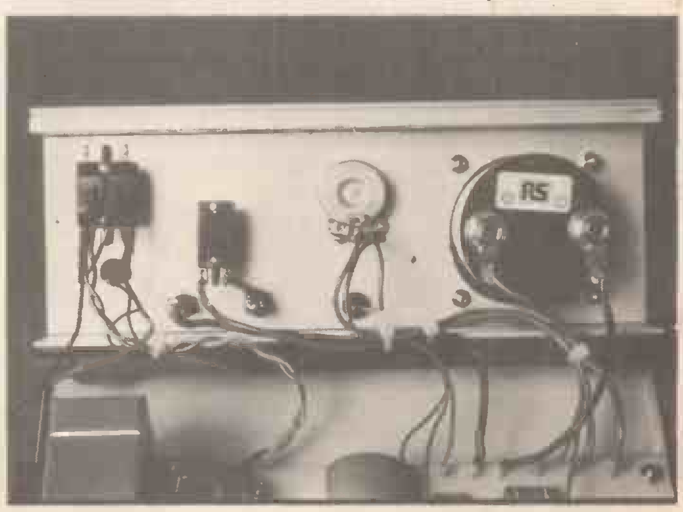
SETTING UP

The output voltage should be variable from zero up to about 30 volts via RV1: if the output won't reach 30 V, slightly reduce the value of R5 (by shunting it with another resistor) until the correct results are obtained. Under current overload conditions the output voltage should fall off and LED 2 should turn on. **HE**

Buylines

Our case for this project was obtained from West Hyde Developments Limited, Unit 9, Park Street Industrial Estate, Aylesbury, Bucks. HP20 1ET. The transformer is available from Stevenson, type D16.

Transformer and PCB connections to the front panel.



Feedback

Most amplifier users see it as a curse. Some amplifier designers see it as a cure-all. The truth is somewhere between the two. Ian Sinclair gives you the facts.

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 you've built just howls all the time, and you're told it's caused by feedback. Let's unwrap the mystery.

First of all, sort out what we mean by an amplifier. Whatever it's 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 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 amplitude that an amplifier amplifies; a few designs of amplifiers (called current amplifiers) are intended to amplify not the voltage amplitude but the current amplitude. The point is, though, that the amplifier doesn't miraculously cause the signal to get greater; it simply creates a new waveform whose amplitude is greater than the signal input, but 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 in not connecting the signal into a circuit with a low resistance, much lower than the output of the amplifier is designed to feed. If we stick to fairly high resistance circuits, though, we can make connections to the output of our amplifier without reducing the signal — no noticeable amount of signal is taken away from the amplifier.

INTRODUCING FEEDBACK

'now this is where feedback comes in. A feedback connection is a connection made through a resistor or through a set of resistors or 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 of just the input signal but a mixture of signals, the input signal and the feedback signal. What happens now depends on how the mix is arranged.

MIXING IT

One way of arranging the mix is to have the feedback signal in phase with the output. 'In phase' means that

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

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 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. (Fig 2)

If we use an attenuating network for the feedback loop (remembering that an attenuating 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.

If the gain of the amplified portion is greater than the attenuation of the feedback network, then the output signal will provide enough feedback signal at the input to produce the output signal by itself, with no other input needed. This arrangement is an oscillator — it continually generates an output signal with no need for an input. If an amplifier oscillates, it's because of positive feedback somewhere, perhaps from signals passed through stray capacitances if the oscillation is at a high frequency, or 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

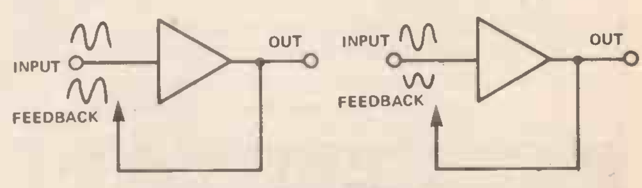


Fig. 2. Feedback. (a) In phase, adding to the signal at the input (positive feedback), (b) in antiphase, subtracting from the signal at the input (negative feedback).

oscillations if the amplifier has a large amount of gain.

Positive feedback is used therefore to make oscillator circuits, and to boost amplifier performance, 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 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. Antiphase 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 the same as that 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 we are applying to the amplifier. 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.

STABILIZING GAIN

At first sight, 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 disadvantages 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 figure of gain — 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 amplifier simply cannot be closely controlled when the IC is manufactured.

FIGURING OUT THE GAIN

How much gain can we expect from an amplifier 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 providing that the gain of the amplifier before the feedback was added was much more than 50 (perhaps 500 or more). This figure of gain should remain fixed throughout the life of the amplifier, even if transistors are replaced.

Being able to design for a definite figure at gain, then, is one good reason for using negative feedback, but it's certainly not the only reason. 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 in 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 the 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.

EXTENDING BANDWIDTH

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 20 kHz) is less than for 'mid-band'

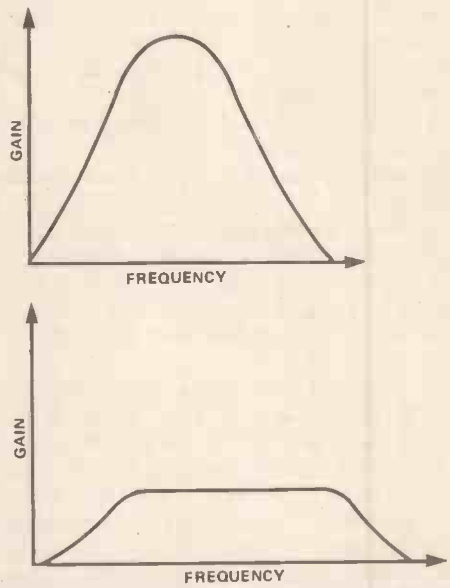


Fig. 3. Reducing frequency distortion by negative feedback. (a) Graph of gain plotted against frequency for an amplifier without feedback. (b) The effect of negative feedback is to reduce the gain, creating a flat portion of graph.

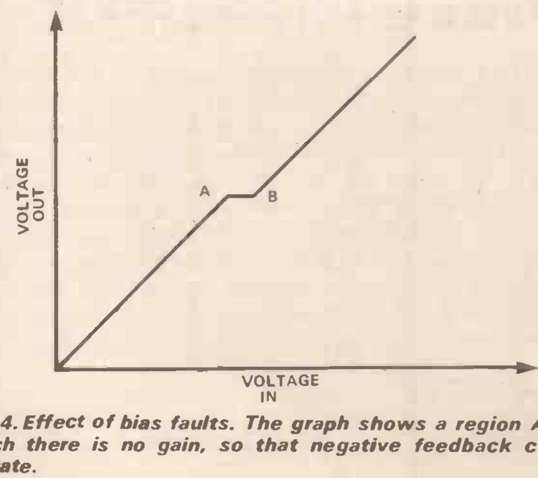


Fig. 4. Effect of bias faults. The graph shows a region A-B in which there is no gain, so that negative feedback cannot operate.

frequencies in the range 400 Hz-1 kHz. A negative feedback connection will reduce the gain, but 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 Fig. 3, the amplifier can cope with the low and the 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.

A CURE ALL?

Negative feedback is so useful that we fall into the habit of assuming that it can cure all sorts of nasty complaints that 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 when no feedback is being used. 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, Fig. 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 increase in output over a small range of input, so there is no gain. No gain means that negative feedback will not correct the distortion caused by this sort of shape 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**

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Electronic Music

If an electronic music synthesiser means a keyboard and a black box to you, make synthesisers simple with this article by Tim Orr.

Electronic music of one form or another has been around for almost as long as electronics. In fact, I have seen a complete music synthesiser built in 1926 which used only two valves. Fifteen years ago electronic music was produced by studios that contained lots of special purpose electronic processors, mixing discs, tape recorders, reverberation units, and then it all changed! Someone (several people claim that it was themselves), decided to pack most of the electronic processors into one unit, so that an integrated system for electronic music production in one box was obtained. This device, known as the synthesiser, took EM out of the studio and on to the stage, and since then things have just proliferated. The pioneers of EM were Moog and ARP in the States and EMS (Peter Zinovieff and David Cockerell) in England. Now there are very many companies throughout the world producing synthesisers although it is fair to say that very few of them are producing new and interesting ideas. In fact it is quite difficult to define what devices are in the EM area, because it has been merged with professional audio (studio) processors and musical (generally guitar) effects devices.

VOLTAGE CONTROL

The fundamental concept that makes synthesisers what they are is that of voltage control. Voltages that are generated control the pitch of the oscillators, they control the harmonic structure of the sound (enabling dynamic filtering), they control volume and many other parameters. A typical synthesiser system is shown in fig. 1. A conventional musical keyboard is used as the interface between the musician and the machine. When a note is pressed, two signals are generated, a pitch voltage and a gate voltage. The keyboard would generally be tuned so as to produce semitone tuning, that is twelve notes per octave, each note spaced at intervals of one twelfth of the square root of two!! What this means in terms of voltages is +1V per octave or 1/12V oer semitone. This voltage is used to control the pitch of VCO's, (voltage controlled oscillators), and the resonant frequency of VCF's (voltage controlled filters). The pitch voltage is stored in a device known as a sample and hold. This is an analogue memory that is controlled by the gate voltage. When the gate is high the unit 'samples' the pitch voltage and when it goes low the unit 'holds'. The gate merely tells the synthesiser that a note has been pressed, which in this case triggers off two waveform generators, the AD (Attack Decay) and the ADSR (Attack, Decay, Sustain, Release). The AD sweeps the VCF producing dynamic filtering and the ADSR generates an amplitude envelope.

The sound generation process is as follows. The musician selects a note. This tells the VCO what the pitch must be. The waveform from the VCO is filtered by the VCF, but the filtering is controlled by the AD waveform. This could make the sound go AH -OW-OO or even OO-OW-AH. The filtered sound then passes through the VCA which gives it an envelope that is controlled by the ADSR. Fast attacks give the sound a percussive quality, slow attacks a 'backward' quality. There is also a slow oscillator for generating vibrato and swept filtering effects and a noise generator for producing pitchless sounds, such as explosions. All the parameters are controllable via potentiometers (about 16 in this case) and so an enormous range of effects can be synthesised.

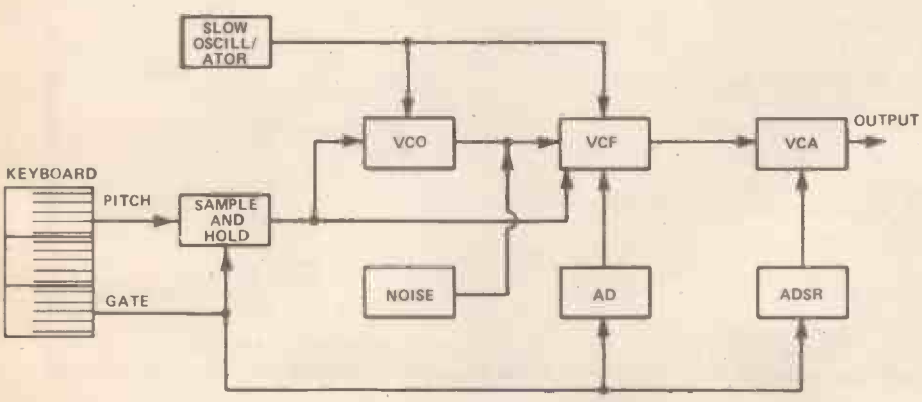
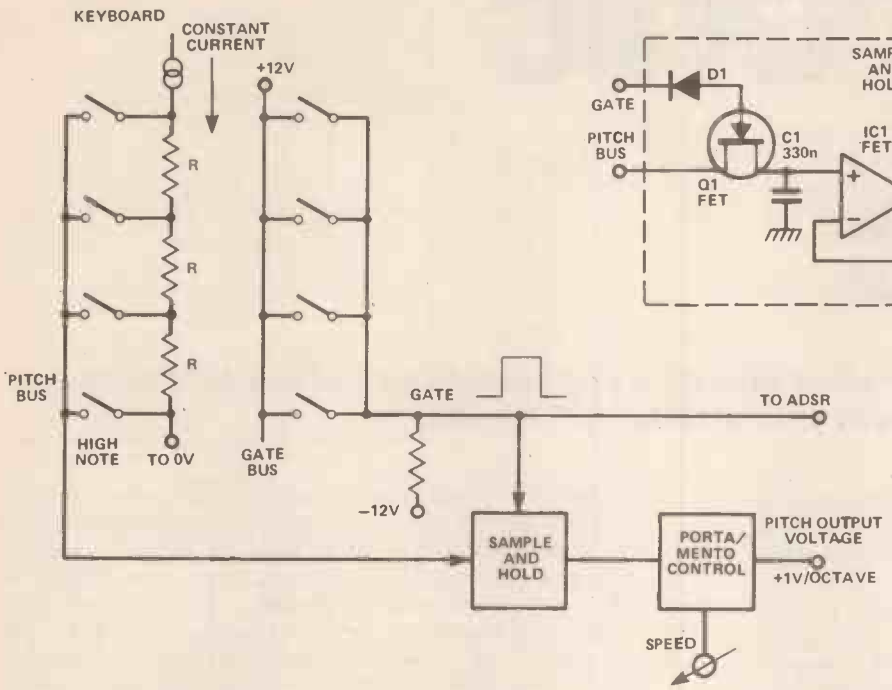


Fig. 1. Block diagram of a typical synthesiser.



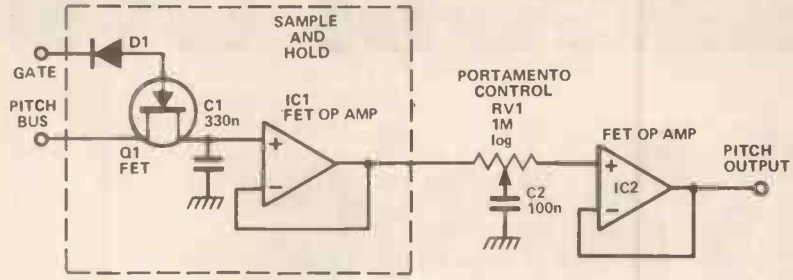


Fig. 2. Signal processing in a simple monophonic synthesiser.

CONTROLLING IT

Most synthesisers are monophonic, that is they produce only one note even if several are pressed. Generally the keyboard selects the highest note played. This is simply done by passing a constant current through a series resistor chain, (Fig. 2). A voltage is picked up on the pitch bus which is linearly proportional to the highest note pressed. This voltage then passes through an analogue switch (Q1) which is controlled by the gate signal. When a note is pressed, the gate is high and the switch is ON. The pitch voltage charges up C1. When the keyboard is released the gate voltage goes low, the switch turns OFF and the pitch voltage is held on C1. A voltage follower (IC1) is used to buffer this voltage to the rest of the synthesiser. A FET op amp is used because this doesn't discharge the capacitor C1. A portamento control (RV1) has also been included. This allows the player to glide rather than change instantly from one note to the other.

A musical keyboard is the most common control medium for the player, but conventional instruments have many other types of control. These include levers, valves, tension bars, dampers, percussive devices, string tensioners, elongatable resonators, air pressure sacks, etc. It is not practical to include all of these controls into one synthesiser, although some of them do appear in various machines. For instance there is a 'wind' synthi and several drum and guitar synthesisers.

Two common types of controls are the XY joystick and the pitch bend wheel. The performer can play keyboards with one hand and operate a control with the other. For instance the pitch bend wheel can be used to bend notes just like a guitar player does by stretching (bending) the string.

The primary sound generator in a synthesiser is the VCO. This produces the fundamental waveform which the synthesiser manipulates. It is usually controlled by a manual knob so that it can be tuned to other instruments

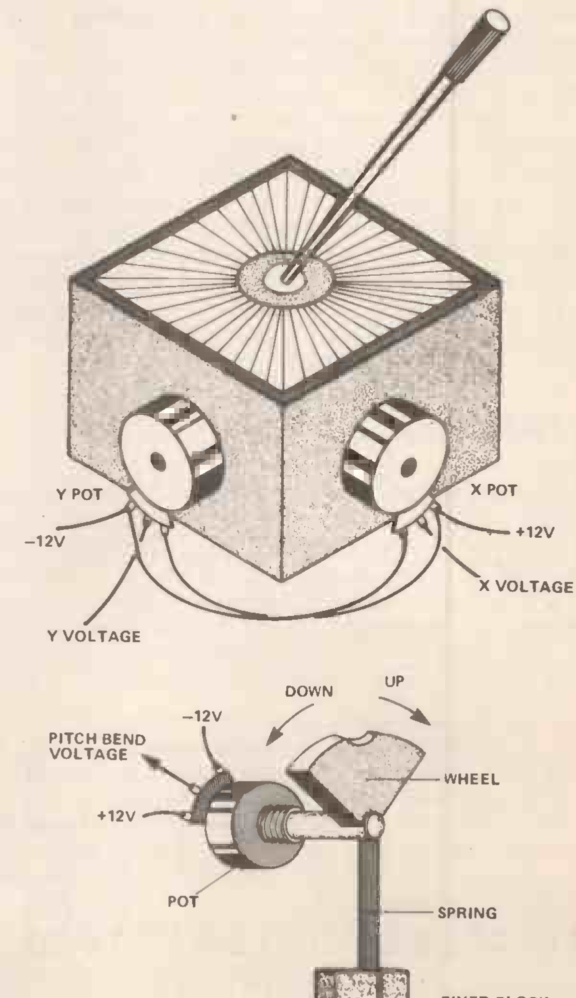


Fig. 3. Two common controls — the xy joystick and the pitch bend wheel.

by the keyboard voltage and a voltage control input. If a slow sinewave is injected then vibrato effects (frequency modulation) can be produced. Most VCO's are logarithmic in response. That is a control voltage increase of +1V will increase their frequency of operation by one octave (double). Thus a control voltage change of 4V will change the frequency by a factor of 2^4 which is 16. Generally most VCO's have a wide range of operation, often greater than 1000 to 1, although for musical purposes a range from 100 Hz to 1.6 kHz is sufficient. If the synthesiser has more than one VCO then they can be arranged to produce a musical chord. This chord can then be controlled by the pitch voltage from the keyboard, producing a very rich musical sound. It is, however, possible to produce interesting sounds from a single VCO.

The waveforms typically generated by a VCO are sawtooth, triangle, squarewave, (sometimes with a variable mark/space ratio) and sinusoidal. These all have different harmonic structures which characterise them, (Fig. 4.). A sawtooth can be constructed out of a sinewave at frequency fo, plus a smaller one at 2fo plus a smaller one at 3fo, plus a smaller one at 4fo etc. These are known as harmonics and a sawtooth has an infinite series of even and odd harmonics. The squarewave has only odd harmonics (fo, 3fo, 5fo, 7fo). A triangle waveform, which is, in fact, just an integrated squarewave has only odd harmonics, but they die away faster than those of the squarewave.

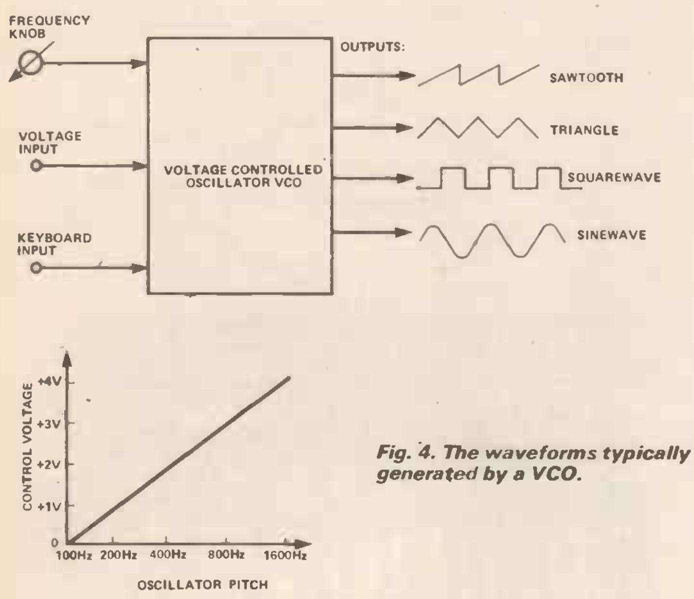
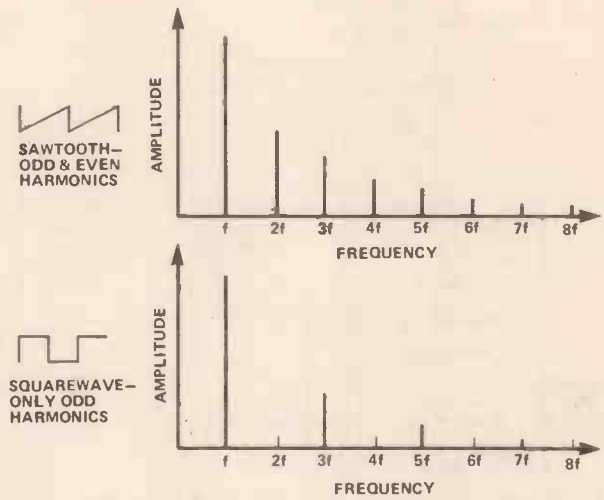


Fig. 4. The waveforms typically generated by a VCO.



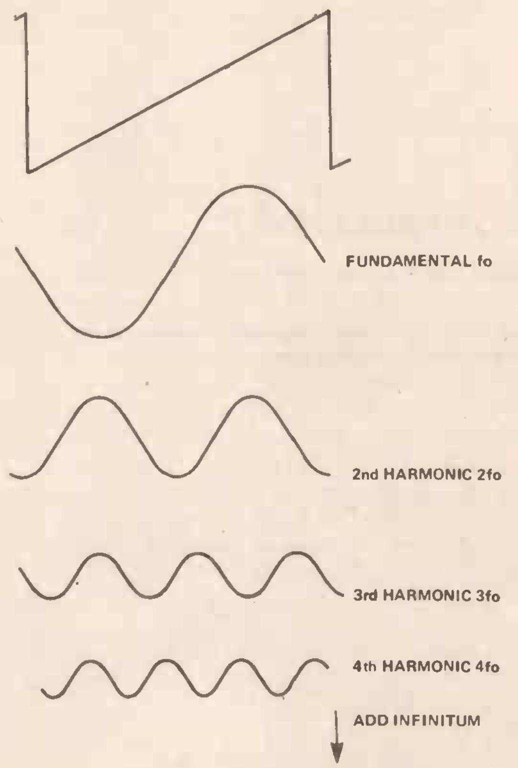


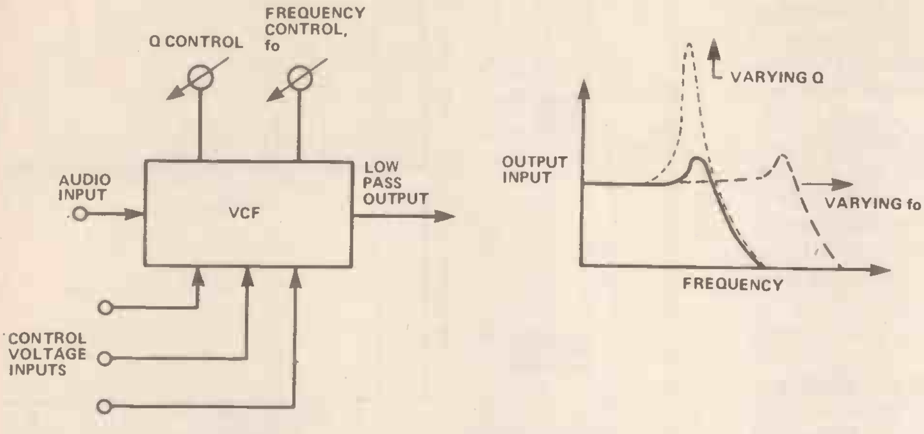
Fig. 5. Discriminating between harmonics.

A squarewave with an uneven mark/space ratio has a mixture of both odd and even harmonics. This can produce some very interesting sounds if the mark/space ratio is slowly modulated by a control voltage. The sinewave has no harmonics, it is a pure sound and is generally not very interesting.

VOLTAGE CONTROLLED FILTERS

VCF's are used to manipulate the harmonic structure of a signal. They can selectively enhance or reject a particular frequency. By changing their resonant frequency they produce dynamic filtering. Your mouth is also a dynamic filter and this is one of the reasons for the popularity of synthesisers, that is the pseudo human quality of many EM sounds.

A typical VCF is a lowpass filter. It has a signal input and an output. The VCF has a manually controlled Q factor (resonance) and break frequency. Also the break frequency can be voltage controlled. If the VCF with a high Q is used to filter a low frequency squarewave it is possible to discriminate the individual harmonics that were discussed earlier. As the resonant peak of the filter passes over the harmonics, they are selectively amplified. This process is known as ringing or chiming



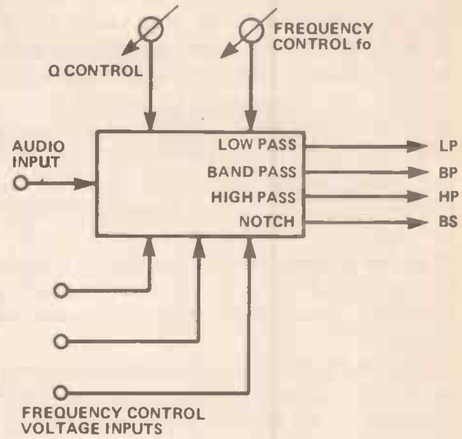


Fig. 6. (above) 'Chiming the harmonics' to produce a 'swept filter' sound.

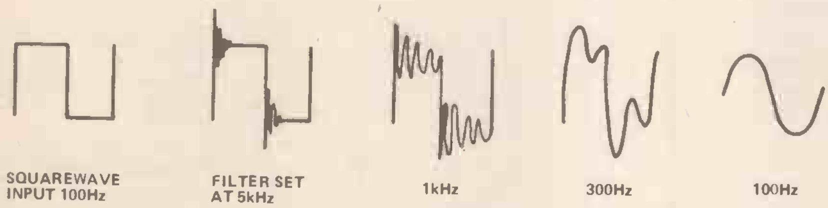


Fig. 7. Using a low pass filter, with a Q of 5 to "ring" the harmonics of a square wave.

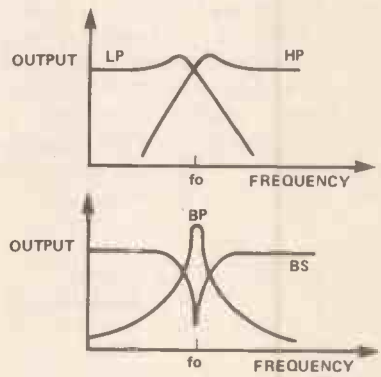


Fig. 8. The flanger — a recursive filter working on time delay.

the harmonics and produces the characteristic synthesiser 'swept filter' sound (fig. 6). If an Ad wave form is used to sweep the VCF then a wide range of filter sounds can be generated.

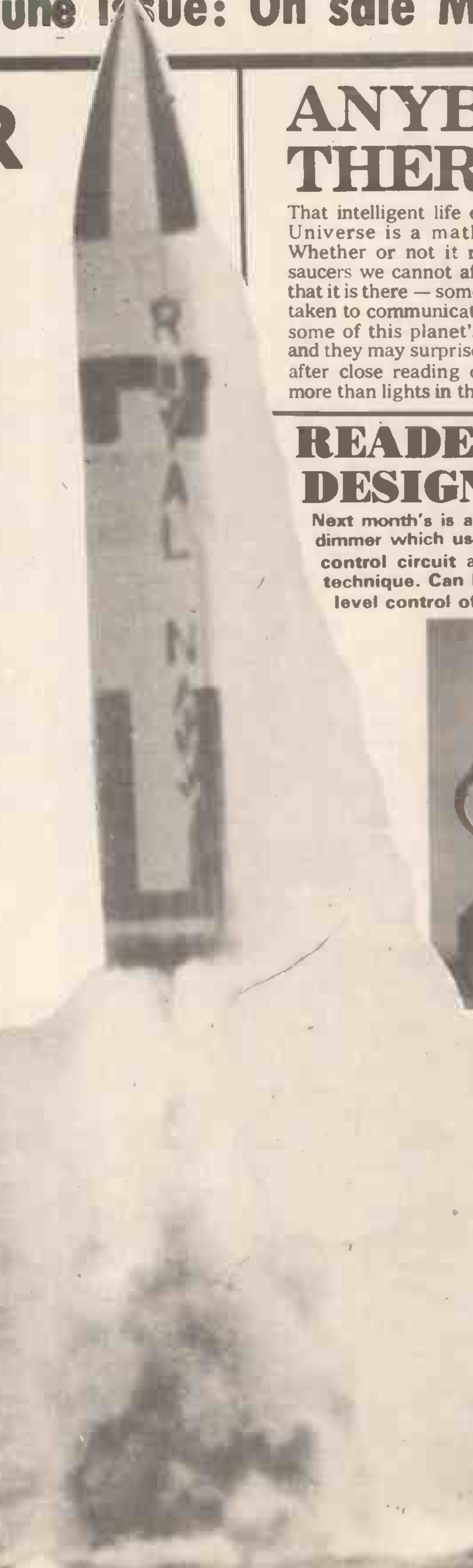
A more elaborate filter structure is shown in fig. 7. This is the universal filter and only appears in larger synthesiser systems. The controls are the same as before, but there are four outputs, lowpass, highpass, bandpass and bandstop (notch). These all have the same resonant frequency and can be used to further increase the range of filtered effects.

Another type of filter that has been recently introduced is the flanger, fig. 8. This is a recursive filter that works on the time delay rather than the phase delay principle. A bucket brigade delay line is used to delay the input signal. The original and delayed signals are then added together, their amplitudes being equal. Thus, when the two are in phase, they add up but when they are 180 out of phase they cancel out completely. This produces a notch, or rather a series of notches which is called a COMB filter response. These notches are equally spaced on a linear frequency scale, their spacing being controlled by the delay time. The shorter the delay time the fewer are the notches. There is also a feedback path around the unit. This makes the filter much more 'peaky' and the effect of the filtering greatly pronounced. Flanging is similar to the effect on jet engine noises that can be heard as they fly over head.

A typical electronic music synthesiser — the transcendent 2000.

electronics today international

What to look for in the June issue: On sale May 4th



HI-FI RECEIVER

A fifty watt stereo amplifier and a high quality tuner would make two excellent projects in themselves. With specifications such as these boast, we could be sure that the units would soon become widely accepted as the very best in DIY hi-fi. However we've gone one better to combine the two units to produce a receiver of outstanding merit. If you're about to buy, build or borrow a high-class hi-fi — stop it at once until you've read next months ETI.

ECM

ECM (Electronic Counter Measures). Without extensive capability in this field a modern fighter aircraft stands about as much chance against its opponents as would a bi-plane. Radar homing missiles can be jammed, locating radar foiled and laser targeting pick out a plane for ground-to-air attack in a fraction of a second. On the ground too, anti-tank missiles, remotely guided, can "take out" highly sophisticated (and expensive) tanks before they get time to retaliate. The principle behind the machinery are fascinating and their implications chilling. Read about them next month in our comprehensive article.

ANYBODY THERE?

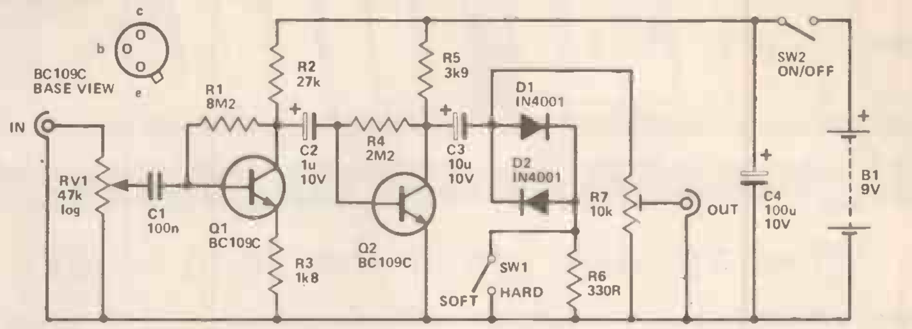
That intelligent life exists elsewhere in the Universe is a mathematical certainty. Whether or not it rides around in flying saucers we cannot afford to ignore the fact that it is there — somewhere. Steps are being taken to communicate with other worlds by some of this planet's largest observatories, and they may surprise you. Don't blame us if after close reading of this, you encounter more than lights in the sky!

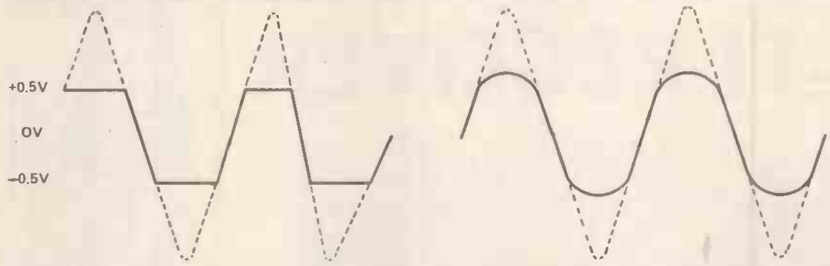
READERS' DESIGNS

Next month's is a remote controlled light dimmer which uses an ingenious voltage control circuit and ultrasonic transmission technique. Can be adapted to give remote level control of just about anything.

Short Circuits

CLIPPING AMPLIFIER





Probably the main use for clipping amplifiers these days is in musical effects units to produce the so called "fuzz" effect. This circuit uses two common emitter amplifiers based on Q1 and Q2 to drive a simple clipping circuit using D1 and D2. RV1 is the input attenuator and if this is adjusted for an output level of less than about 1 volt peak to peak at Q2 collector, neither D1 or D2 will be sufficiently forward biased to conduct significantly. These components then have no real effect on the circuit, which in consequence operates as an ordinary amplifier. Assuming SW1 is closed, if RV1 is adjusted for a signal level of more than 1 volt peak to peak at Q2 collector, during positive output excursions when the signal amplitude is greater than 0.5 V D1 will conduct and act like a low voltage zener, preventing the signal from exceeding 0.5 V in amplitude. Similarly, on negative output excursions D2 will limit the signal level to no more than —0.5 V. This causes the signal to be severely disctorted by the clipping action as shown in (a) the distortion products giving the desired "fuzz" effect.

A circuit of this type can be used to produce a form of sustain effect when employed with a guitar. Here RV1 is adjusted so that clipping occurs even when the signal from the guitar has decayed considerably. This results in the output signal remaining at a virtually constant 1 volt peak to peak level for the duration of each note, whereas a guitar signal normally hits a high initial peak and then rapidly decays. In this application the hard clipping produced by the unit will produce the fuzz distortion products whether they are required or not. This problem can be alleviated to some degree by switching SW1 to the "soft" position. R6 is then connected in series with D1 and D2, and this gives the smoother clipping action shown in (b) due to the voltage developed across R6 when D1 and D2 pass a current. This greatly reduces the high frequency distortion products which are the most noticeable and objectionable ones.

The circuit has an input impedance of about 47k and needs an input of less than 1 mV RMS to produce clipping. If the full 1 volt peak to peak output is not required. R7 can be used to attenuate the signal to the required level.

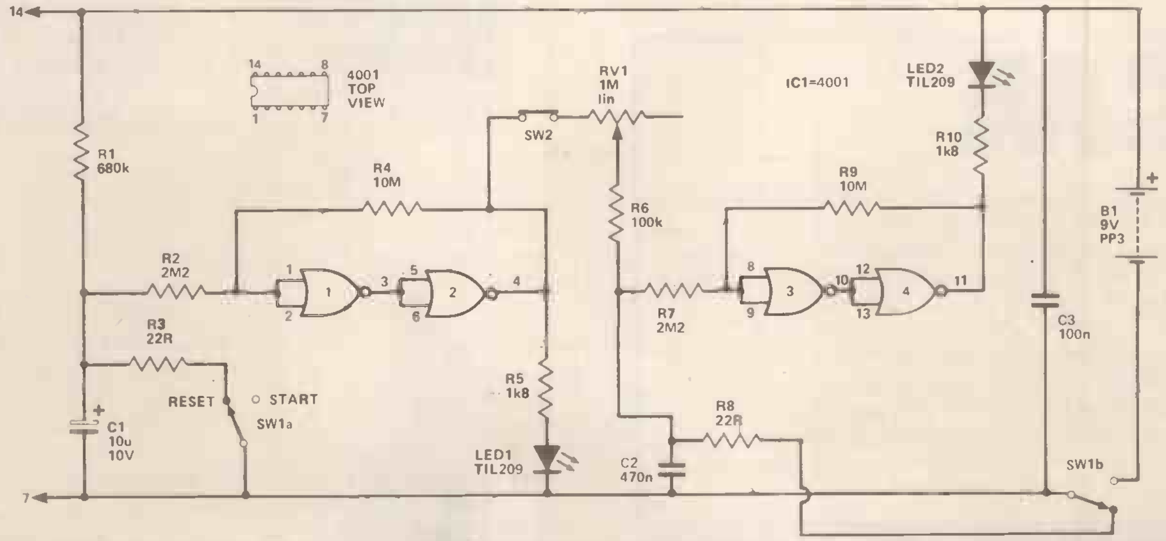
REACTION GAME

This is a simple reaction testing game for one player. The idea of the game is to end up with both LED indicators switched on, and initially only one lamp will come on, followed by the second one shortly afterwards. When this happens a switch must be operated as quickly as possible, and the first LED will switch off if the attempt is too slow.

The circuit uses the four 2 input NOR gates of a 4001 CMOS device, the gates being connected as simple inverters in this application. Gates 1 and 2 are connected to form a Schmitt trigger type circuit, and at switch on C1 will be discharged causing gate 1 input and gate 2 output to be low. After about seven seconds C1 will have charged through R1 to the transition voltage of gate 1, with the coupling between the two gates resulting in gate 2 output swinging positive quite rapidly. Coupling through R4 causes gate 1 input to be taken further positive, and a regnerative action occurs which results in gate 2 output jumping to the high state and switching on D1. This indicates that the player should operate the push button switch SW2.

Until this switch is opened, another trigger/timer circuit will be fed from gate 2 output. D2 is normally on but will be switched off at the end of the second timing period if SW2 is not used to halt the charging of C2 in time. The second delay can be adjusted using RV1, from more than 500mS at maximum resistance to only about 50mS at minimum resistance. This gives a difficulty factor varying from "easy" to "impossible" for anyone with normal reactions.

The circuit is reset using SW1 which disconnects power from the circuit, discharges C2 through current limit resistor R8, and similarly discharges C1 through R3. The unit is then ready to start operation again when SW1 is set back to the "start" position.



BUILD A PROJECT ON CSC

FREE

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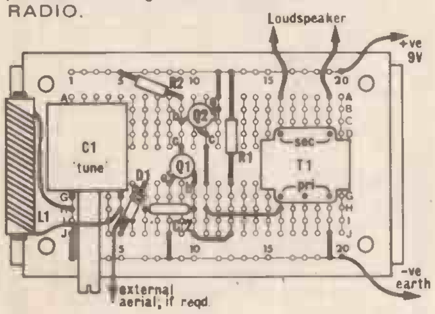
Now using Experimentor Breadboards and following the instructions in "Electronics by Numbers" ANYBODY can build electronic projects.
Simply look at the diagram — this has exactly the same type of layout of all EXPERIMENTOR boards. Look at the component list and select the component Q1, this is an NPN transistor type 2N3904, this plugs into holes C10, D11, and B12. Easy isn't it?
Now take C2, which is a .1 uf capacitor, this plugs into holes H7 and H10.
Do the same with all the components, connect a 9 volt battery and you have a perfect working TWO-TRANSISTOR RADIO.



YOU WILL NEED

B1—9 VDC battery
C1—365—pF variable capacitor
C2—.1—uF capacitor
D1—Diode, 1N914 or 4148 or equiv.
L1—Standard broadcast loopstick antenna
Q1—NPN transistor, 2N3904 or equiv.
Q2—PNP transistor, 2N3906 or equiv.
R1—100,000—ohm resistor, ¼ watt
R2—4700—ohm resistor, ¼ watt
S1—SPST switch
T1—500:8—ohm matching transformer
SPKR—8—ohm speaker

Building radios is lots of fun. Here's a loud-speaking crystal set. L1 and C1 form the circuit that tunes the radio. For better performance substitute a germanium diode such as IN34 or IN60.
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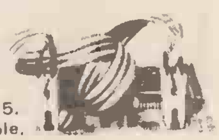

PC — 16 pin. £2.75.
PC — 16 pin with cable. £6.00.
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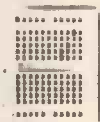

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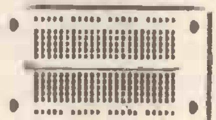
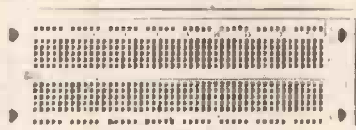
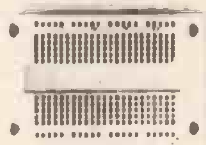


EXP. 300. £5.75.



EXP. 650 for Micro-processors. **£3.60.**



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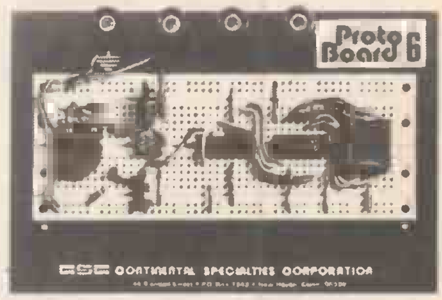
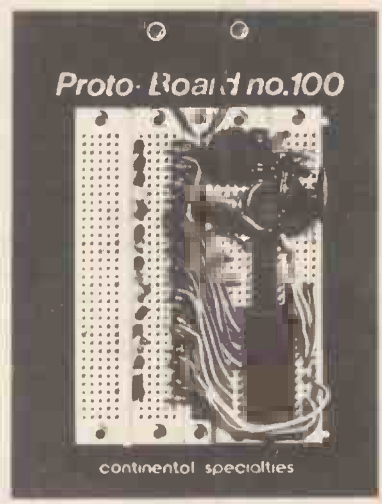


PB.6 Kit, 630 contacts, four 5-way binding posts accepts up to six 14-pin Dips.
PROTO-BOARD 6 KIT. £9.20.



PB.100 Kit complete with 760 contacts accepts up to ten 14-pin Dips, with two binding posts and sturdy base. Large capacity with Kit economy.
PROTO-BOARD 100 KIT £11.80.

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PROTO-BOARDS.			
PB. 6.	630	6	£11.01
PB. 100.	760	10	£13.82

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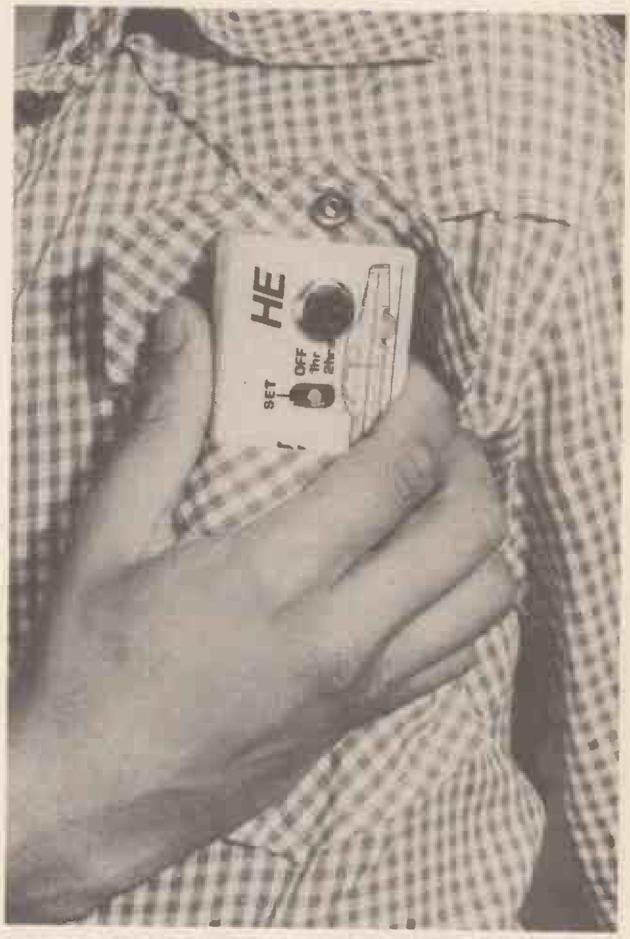
ADDRESS . . . .

HE . . . .

Parking Meter Timer



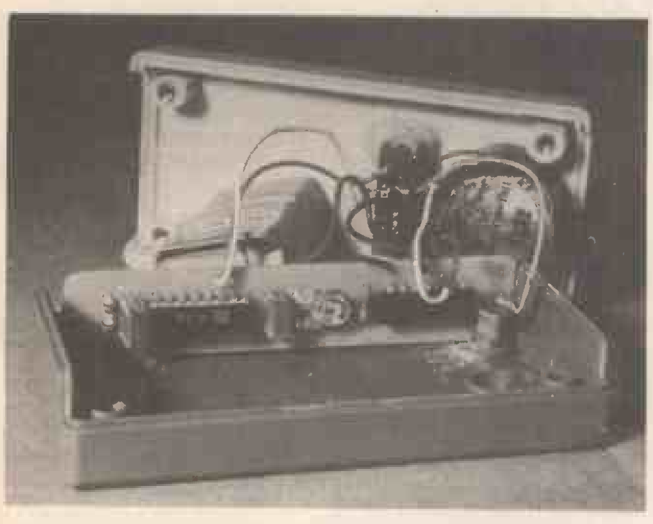
Steve Ramsahadeo who built the prototype of the parking meter timer is shown above (too shy to show his face) with the unit in his shirt pocket. The reminder bleeps will prevent the consequences shown below though the ticket being written out is real and the sufferer is an ETI staff member!

Avoid expensive parking fines with our pocket-sized warning bleeper

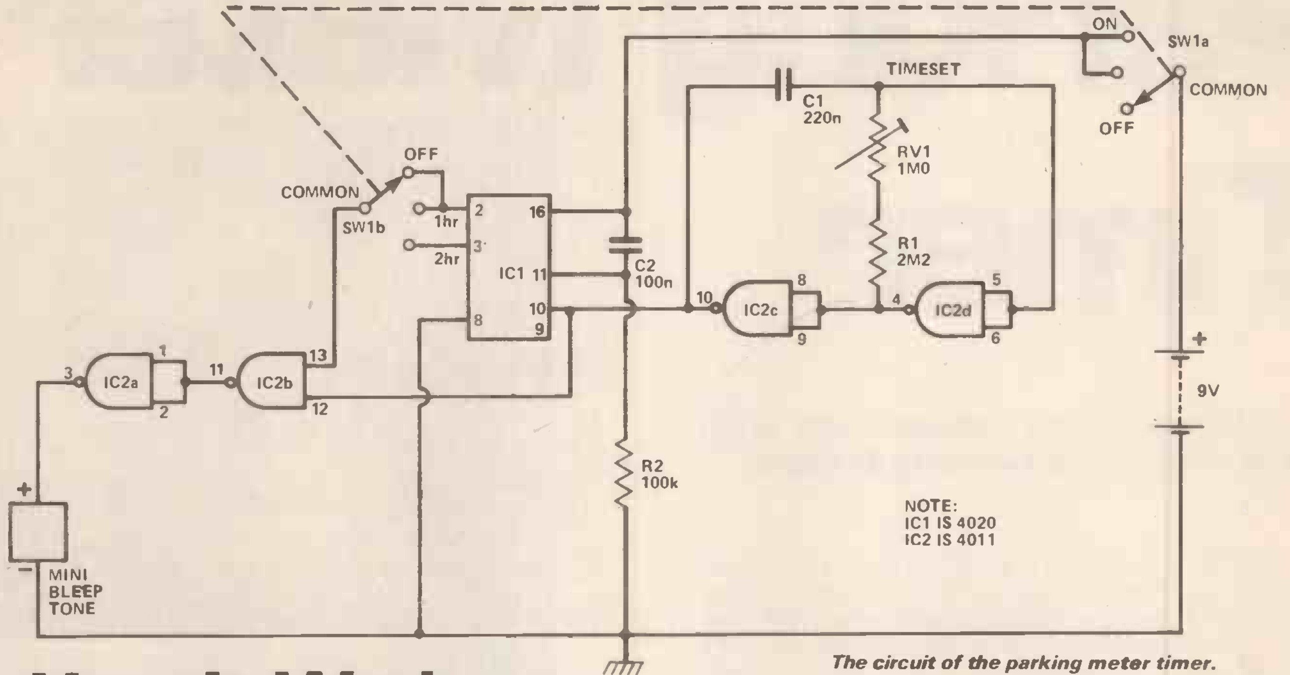
HAVE YOU EVER returned to a parking meter just in time to see a meter maid slap a ticket on your jallopy windshield? If so, our parking meter timer will help ensure that that experience never happens again. It does so by sounding a loud 'beeping' alarm signal several minutes before your parking time is up, thus giving you time to sprint back to the parking zone and feed another coin into the meter just before your 'legal' time expires.

The timer uses just two CMOS integrated circuits and half a dozen discrete components and is small enough to fit comfortably into a shirt pocket. To use the unit, you simply select either a one hour or two hour parking period via a slide switch when you first feed the meter after initially parking the car: this automatically switches the timer on. Then slip the timer unit into your pocket and forget about it.

A few minutes before the expiry of your selected parking time, the timer automatically emits a loud 'times-nearly-up' beeping alarm sound. This sound is loud enough to be heard in a noisy room, even when the unit is pushed into an inside pocket. Once the alarm has sounded, you can turn the unit off via its slider switch. The parking meter timer costs only a few pounds to build, but could save you a lot of money from parking fines.



Internal view of timer showing how the PCB is fitted.



The circuit of the parking meter timer.

How It Works

The two integrated circuits used in the design are CMOS devices. IC1 is a 4020 14-stage ripple carry binary counter, and IC2 is a 4011 quad 2-input NAND gate. Two of the NAND gates (IC2a and IC2b) are interconnected as a low-frequency astable multivibrator, with its output feeding to the CLOCK (pin 10) input terminal of the 4020 and to one of the input terminals of the IC2c NAND gate: the second terminal of the IC2c NAND gate is fed from either the 14th (pin 3) counter stage of the 4020, which is normally low but goes high on the 4096th count of the clock, in the '2 hour' position of SW1, or from the 13th (pin 2) stage of the 4020, which goes high on the 2048th count of the clock, in the '1 hour' position of SW1. The output of the IC2c NAND gate is fed to a miniature tone generator module via IC2d, which is connected as a simple inverter. The complete operating sequence of the circuit is as follows:

The unit is switched on by moving SW1 to either the 1 Hour or 2 Hour position. At switch-on a brief reset pulse is fed to pin 11 of the 4020 via the C2-R2 network, and all outputs of this IC go low. The astable 'clock' generator starts to operate as soon as the unit is switched on, but the tone generator is held off because one of the inputs to the IC2c NAND gate is low. At the end of the 2048th clock cycle in the '1 Hour' position or the 4096th clock cycle in the '2 Hour' position, one of the inputs of the IC2c NAND gate is set high by the respective output of the 4020. The tone generator module is then switched on whenever the output of the clock generator goes high, and thus produces a 'bleep' signal.

In use, the timer can be set to produce either precise 1 and 2 hour periods, or periods that are a few minutes short of these times, by adjustment of the RV1 'set time' control.

CONSTRUCTION

The most important thing to remember about this project is that, to be of real practical value, it must be small enough to fit comfortably in a shirt pocket, so that you can use it even in the warmest weather. With this in mind, we've taken a lot of trouble over miniaturisation.

The housing that we've chosen for the project is a Type 65-2514F Verocase, which is just large enough to house all of the components. Even so, it is necessary to cut away part of the pillars along one side of the case, to accommodate the PCB and its components.

Slide switch SW1 should be recessed into the front of the case, so that it doesn't get accidentally switched off when the unit is in use. We achieved this by cutting a small slot in the front cover and fixing the switch into position from the rear by using layers of epoxy adhesive to set the switch at the correct height.

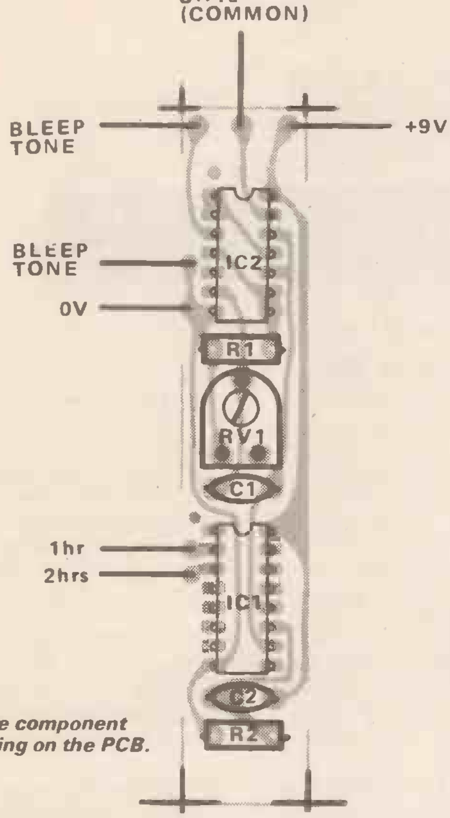
TAKE PRECAUTIONS

Note when assembling the PCB that miniature polycarbonate capacitors are used for C1 and C2, and also that sensible precautions must be taken when soldering the two CMOS IC's into place. The wiring of SW1 to the PCB should be done with special care. When construction of the timer unit is complete, it can be calibrated as follows:

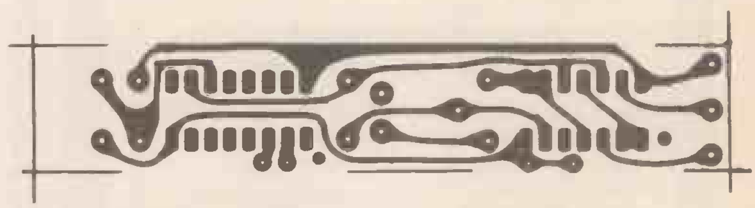
CALIBRATION

Temporarily disconnect the lead to the 'common' tag of SW1b and connect the lead to the positive supply rail. Switch the unit on. The unit should now produce the 'bleeping' tone. If you want the unit to give precise one hour and two hour timing periods, adjust RV1 to give 68.3 bleeps per minute. If, on the other hand, you want periods of 1 hour 50 minutes (to give you the 'times-nearly-up' warning), set RV1 to give 74.5 bleeps per minute. That completes the calibration, and you can now reconnect the lead to the common tag of SW1b, and put the unit to practical use.

As a final point, you may care to note that you can get timing periods of ½ hour or ¼ hour from the unit by connecting SW1b to pin 1 or pin 15 of IC1, if you so wish.

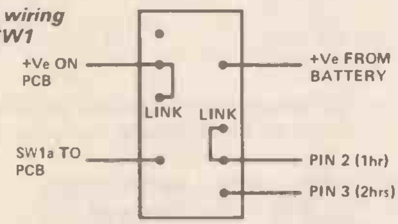


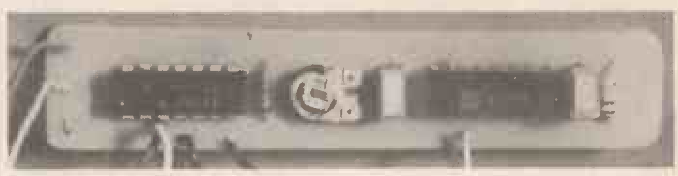
The component siting on the PCB.



The PCB pattern shown full size.

The wiring of SW1





Completed PCB

Parts List

RESISTORS. (all ¼w 5%)

R1 2M2 4
R2 100k 7

CAPACITORS

C1 220n polycarbonate 99
C2 100n polycarbonate 24

POTENTIOMETER

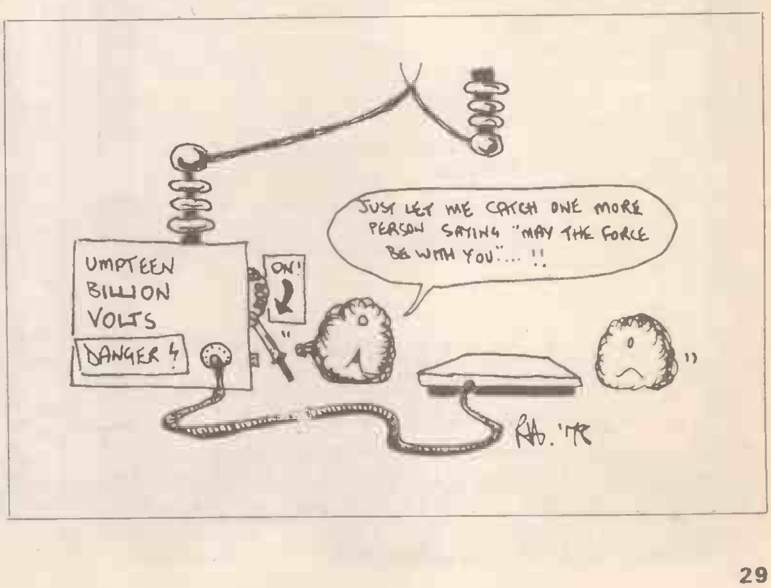
RV1 1MO preset 2

SEMICONDUCTORS

IC1 4020 3
IC2 4011 4

MISCELLANEOUS

Bleep tone
SW1 min, slide three position double pole.
Vero case to suit. PCB PP3 battery.



Marketplace

DIGITAL ALARM CLOCK

Size: 100mm x 130mm x 60mm.

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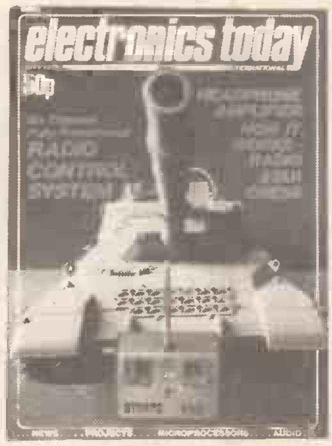

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AB Circuits

Do you know how a multivibrator works? Chances are you are like the rest of us, you can recognise it, but can't explain it, well there's no excuse now.

ACCORDING TO THE RECORDS, it was a Mr Abrahams and a Mr Bloch who invented in 1914, a circuit which has come in for a lot of use ever since. They might very well have called it an AB circuit, but they chose the name of multivibrator, and it stuck. The names astable, monostable and bistable to describe different varieties of multivibrators came a lot later.

One of the nice things about the MV circuit is that it's instantly recognisable. Mr A. and Mr B. would still be able to follow the action of modern transistor multivib, circuits, even though it's 65 years since their invention. Oddly enough, though, the action of the MV isn't so well known. Out of hundred exam. answers this year on the action of a MV, only a few indicated even the faintest idea of how the circuit worked. Perhaps, in honour of the memory of Messrs. A. and B. we should set the record straight!

To start with, a multivibrator circuit is a positive feedback circuit. Now positive feedback has several effects, but the most important one from the point of view of understanding the MV is that it can make the gain of an amplifier very great so great that a tiny change of voltage at an input will cause the output to whack right over from one voltage limit to the other.

The other important fact about the MV, and the one which doesn't seem to be well known, is that the resistors and capacitors are much more important than the transistors. It's the time needed for a capacitor to charge through a resistor that decides what the frequency of an MV will be, and most of the time of a cycle is spent in charging a capacitor, with the transistors playing no part in the action whatsoever. It's because of this that the circuit can work equally well using transistors, valves FET's and almost any other device which can be switched on and off.

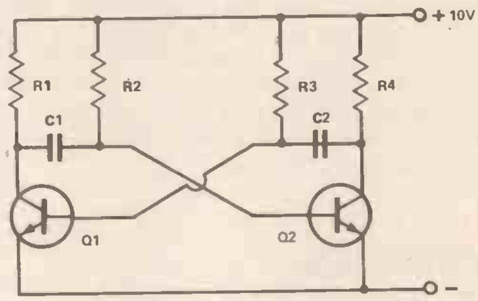


Fig. 1. The traditional MV circuit, with cross-coupled transistors.

BOTTOMS UP

Bearing all that in mind, lets take a careful look at an MV circuit in action, using the simple circuit of Fig. 1 as a guide. The action of the circuit repeats, so we pick it up when Q2 is cut off (Why? — well, we'll see later!) and Q1 is conducting. The collector voltage of Q1 is low because of the current flowing through R1, and the base voltage of Q2 is below 0 V and rising, as R2 pours current into C1.

As C1 fills up, or charges, the voltage at this side of it, connected to the base of Q2, rises. Now a silicon transistor doesn't start to conduct until its base voltage reaches about 0.5 V above its emitter voltage. The emitter voltage of Q1 and Q2 are both set at zero, so Q2 won't start to conduct until R2 has charged C1 up to a level of 0.5 V. In this state the transistors *aren't* amplifying. Q1 is bottomed, Q2 is cut off, so there's no gain from either of them.

Things change dramatically when the base voltage of Q2 reaches the turn-on voltage. Whenever Q2 starts to conduct, its collector voltage drops and that unsticks Q1, out of its bottomed state. What we have now is a two transistor amplifier with positive feedback, enormous gain; and a small positive going signal (the charging capacitor) at the base of Q2. The result is that the collector voltage of Q2 (the output of this amplifier) shoots down to about earth voltage (about 0.2 V in this example) in a time less than a millionth of a second and the collector voltage of Q1, rises also. That's as long as the transistors act as amplifiers this time round Q1 is cut off. With its collector voltage up at supply voltage. The base voltage of Q2 has been held high by this action, but won't rise much above 0.6 V because the base-to-emitter part of a transistor doesn't obey Ohm's Law — the voltage across it when it is conducting stays pretty constant. For example, if the voltage between base and emitter is 0.55 V at 1 mA current, it's only about 0.61 V when the current is 10 mA and 0.67 V when the current is 100 mA. Q2 is bottomed by all this, with its collector voltage down to about 0.2 V, which is about as low as collector voltage of a conducting transistor can go.

CAPACITOR ACTION

That's the changeover then but there's one important action we haven't mentioned. When Q2 switched on, with its collector voltage shooting down from +10 V to 0.2 V, the base voltage of Q1 must also have shot down by exactly the same amount. Why? Because of C2, that's why. The action of a capacitor is that a change of voltage at one plate causes exactly the same change of voltage at the other plate, until the capacitor has time to charge. The switch-over of a pair of transistors equipped with positive feedback doesn't give any time for capacitor charging, so that the 9.8 V drop (from 10 V down to 0.2 V) at the collector of Q2 will cause a 9.8 V drop at the base of Q1. Wait a minute, though, the base of Q1 started at a voltage of about 0.55 V — it doesn't ever rise much higher. So a 9.8 V drop lands it up at a voltage of 0.55-9.8 V (and I didn't use my calculator!) That's the part of the cycle which is important, because it starts off the next part of the timing.

The score now is amplification nil, capacitors charging, 1. No amplification because one transistor is cut off and the other one bottomed; C2 charging now with one plate at 0.2V (connected to the collector of Q2) and the other at —9.25 V. Things can't stay that way for long because R3 is connected to the + 10 V line. Current will flow through R3 to charge up C2 and let the base voltage of Q1 rise steadily. Eventually, the base voltage of Q1 will reach the magic figure around 0.5 V when Q1 starts to conduct. Once more, when this happens, the transistors are in the voltage gain business again, and the rise of voltage at the base of Q1 causes Q2 to cut off. This time its the base of Q2 which ends up at —9.25 V, and current starts flowing through R2 to charge C1. The transistors have, once more, acted as amplifiers for only a millionth of a second or less.

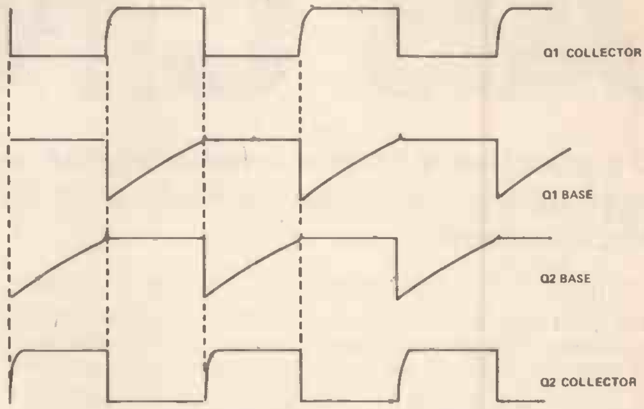


Fig. 2. Waveforms in the MV circuit of Fig. 1. Note that the collector waveforms are not perfect square waves, because of the slow rise-time.

WAVEFORMS

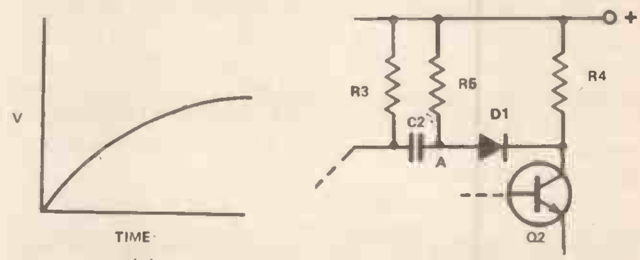
That's the basic circuit, then, and Fig. 2 shows the waveforms we see at the various points in the circuit. These waveforms have been drawn on the same timescale, as we would see them on a four-beam oscilloscope, so that you can see what's going on at all four test points.

The basic MV circuit works well, even with fairly grotty transistors, and produces a wave which is roughly square. A noticable feature of the waveform at either collector is that, though the drop of voltage is very rapid, the rise takes rather a long time, so that the circuit doesn't produce a really well-shaped square wave. We know how to cure this — we've known for about thirty years how to cure it — but it's one of these things that people keep re-inventing! What causes the slow rise of collector voltage is the capacitor which couples the collector to the other base. Take, for example, the collector of Q2 in Fig.1. When the base of Q2 is switched to —9.25 V, there is no current in Q2. If C2 were not connected, the collector voltage would rise to +10 V almost instantly. C2 *is* connected, though, and that's what delays things. You see, the plate of C2 that's connected to the base of Q1 is held at around 0.55 V — its that business of the base-emitter voltage being constant. As a result, C2 has to charge through R4 if the voltage of the plate connected to the collector of Q2 is to rise. Charging takes time, and follows the graph shape shown in Fig. 3a.

The rules for capacitor charging are well understood. The figure R × C (R in ohms, C in microfarods) is called time constant, measured in microseconds and in a time of one time constant the capacitor charges to 63% of its final voltage (10 V in our example). After two time constants, the voltage has reached 86% of its final value, after three time constants 95%, and after four time constants 98%. We usually assume that it's as good as all the way there after four time constants, so that's the time that's needed to charge C2 and allow the collector voltage of Q2 to reach 10 V.

SQUARED UP

Now we can smarten up this square wave no end if we disconnect C2 from R4 when Q2 switches off. How do we do it? By using a diode D1 connected as shown in



(a) (b)

Fig. 3. (a) Waveshape of voltage across a charging capacitor. (b) Using a diode to separate R4 from R5 when Q2 switches off. R5 is then used to charge C2.

Fig. 3b. A diode, remember, conducts only when its anode is more positive than its cathode. While Q2 conducts, D1 will also be conducting keeping point (a) down at a low voltage, a bit higher than the 0.2V of the collector of Q2 perhaps at about 0.7V or so. Now when Q2 cuts off and its collector voltage starts to rise, D1 simply stops conducting. Point A can't change voltage quickly because it's connected to C2, but the collector voltage can rise really quickly, with no C2 hanging on to it. The collector voltage rises smartly, then, and C2 is charged up at a more leisurely rate by R5. The result is a really sharp-edged square wave at the collector of Q2. We can, if we like, add the same bit of additional circuitry at the collector of Q1, to produce perfect square waves there as well; this wave will be the inverse of the wave at the collector of Q2.

The theory of charging capacitors tells us that a given capacitor-resistor combination always takes the same time to reach a given fraction of its final charging voltage. In the MV circuit shown the capacitor is forced to about —9.25 V, and charges until it reaches about +0.5 V, and the time taken for this is about 70% of the time constant, 0.7 CR; this value of 0.7 CR holds good whatever the supply voltage happens to be, provided the capacitor is fixed to a negative voltage equal to the drop in collector voltage. The result is that the frequency of an MV shouldn't change when the supply voltage is raised. When we try it, we find that the frequency increases — but there's nothing wrong with the theory. What's happening is that the base of a silicon transistor won't

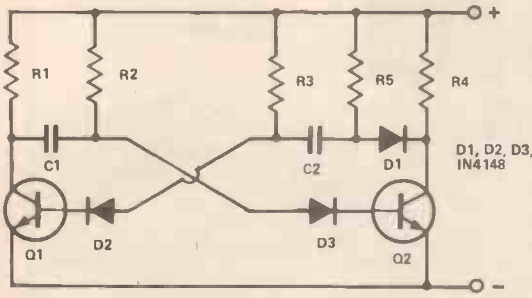


Fig. 4. An improved MV circuit. D1 permits the waveform at R4 to be a good square wave, which will be better still if the output is taken through an emitter-follower. D2 and D3 prevent breakdown of the base-emitter junctions of the transistors.

stand for large negative voltages, and the base-emitter junction starts to behave like a zener diode, conducting at a large reverse voltage. This mucks up our theory, which assumes that the negative voltage at the base would be about equal to the drop of collector voltage. To get around this, so that the MV can be relied on to give the same frequency output at idfferent supply voltages, we add silicon diodes in series with the base leads, as shown in Fig. 4.

Silicon diodes are not made by the same process as transistors, and will stand much greater negative voltages, so that the diode, not the base, takes the battering. The diode, incidentally, can alternatively be connected in series with the emitter leads.

All in all, it's a remarkable circuit that can still be extensively used so many years after its invention. What makes it even more remarkable is that it's survived the change from valves to transistor almost unchanged. When I try to imagine electronics fifty years from now, I can see the MV circuit unchanged — but I'm not sure what devices will be amplifying for that odd microsecond in each cycle! **HE**

Short Circuit

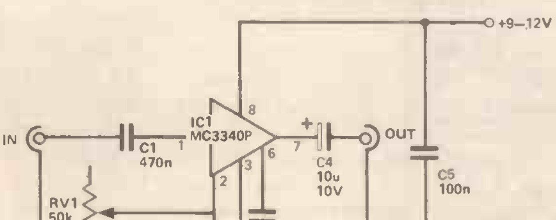
REMOTE AND TOUCH VOLUME CONTROLS

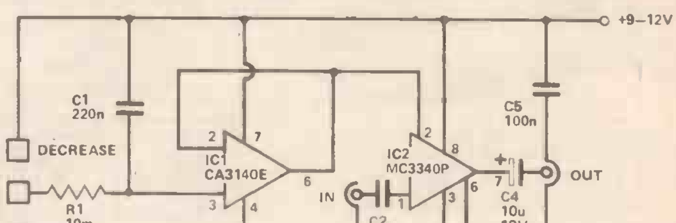
An electronic attenuator such as the MC3340P IC can be used as the basis of a remote volume control, as shown in the first circuit. RV1 controls the voltage gain of, the MC3340P, which varies from typically 13 dB at minimum resistance to about −80 dB at maximum resistance. Since only a DC level is controlled by RV1, any AC pick-up in the connecting cable can be filtered out, which is the purpose of C2. The cable only needs to have two conductors, it can be many metres long, and does not have to be a screened type. C1 and C4 are merely input and output DC blocking capacitors respectively. C3 rolls off the RF response of the circuit so as to aid stability and prevent RF breakthrough.

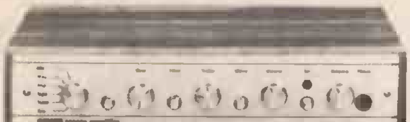
The MC3340P can be used as the basis of a novel touch operated volume control, as shown in the second circuit. This has the advantage over a conventional volume control of having no moving parts to wear out. The device is controlled by a voltage rather than a resistance and gives the same attenuation range as the previous circuit.

The control voltage is obtained from a charged capacitor (C1) via an op amp unity gain buffer stage utilizing IC1. IC1 has a PMOS input stage which produces a typical input resistance of 1.5 million Meg ohms. This ensures the charge on C1 is not significantly affected by the amplifier of attenuator circuit, so that once set it remains virtually unaltered for a long period of time.

The charge voltage on C1 is set by the operator who, by touching the lower two contacts, can charge C1 via R1 and his or her skin resistance. This decreases the control voltage fed to IC2, and increases the volume. Touching the upper two contacts causes C1 to gradually discharge; increasing the control voltage and decreasing the volume. When the unit is switched off, C1 gradually discharges. At switch on it is necessary to bring the volume up to the required level, rather like using an ordinary combined on/off switch and volume control. Both circuits will handle input levels of up to 500 mV RMS, with a THD figure of only about 0.6% at high volume settings, rising to about 2% or so at low settings.







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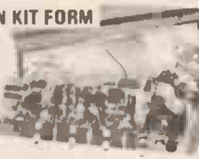

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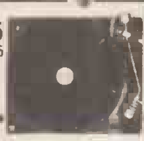

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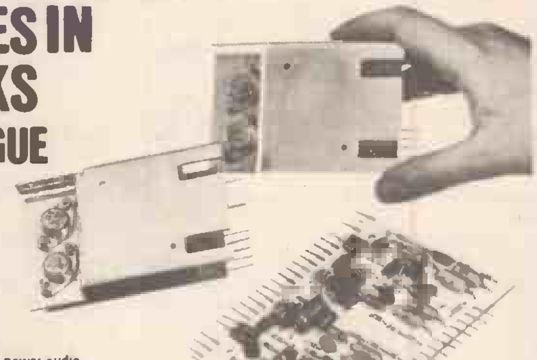

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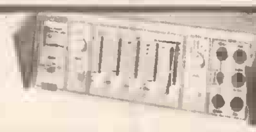

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Hobby Electronics

Next Month

CB

Open almost any American magazine and you'll see adverts for Citizen's Band (CB) transceivers. Although we don't have CB in Britain (yet) we though you'd like to know more about it. In the States it has a language all its own, but if you want it in plain English, look out for CB next month.

Drill Speed Controller

This unit regulates the speed of your trusty single-speed machine for those jobs, like masonry, when it's simply too fast.

Meters and Multimeters

We published an introduction to test gear in the March issue. Next month Ray Marston explores the subject of meters and multimeters. He explains what is important in the spec., how they work and looks at the circuit of a current (no pun intended) design.

Into Electronics

We conclude this very popular series with goggle boxes, fighter finders and number crunchers. Ian Sinclair goes into TV, radar and computers.

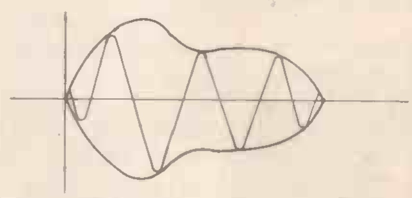
GSR Monitor

When you're under stress you sweat. When you sweat your skin resistance changes. Our GSR Monitor shows you (and everyone else) how you're feeling. Build it for fun or for more serious biofeedback experiments.

Kit Review

Would you like to hear your plants sing? Yes, sing. This kit combines a biological amplifier, to give more oomph to natural potentials produced by the plant, and a music synthesizer, controlled by the boosted plant power.

Envelope Generator



Built around the Motorola MC3340P attenuator chip, this unit gives you full Attack, Decay, Sustain and Release (ADSR) control.

Display Techniques

In this article Tim Orr looks at a variety of displays, including the familiar LED and LCD types. He explains how they work and what they're used for.

The June issue will be on sale on May 11th

The items mentioned here are those planned but circumstances may affect the actual contents.

555 Projects

EVERY SO OFTEN a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device.

It was first introduced by Signetics, but is now manufactured by almost every semiconductor manufacturer. It is cheap and probably one of the most versatile devices we have described.

The device can be made to operate as a monstable or as an oscillator (multivibrator) with times from micro seconds to several hours.

It can operate on power supplies from 5 V to 18 V and can thus be used with TTL, model railways or motor car circuits with ease.

Finally, and not least, the device can source or sink up to 200 mA (0.2 A) allowing it to drive relays, lamps and other large loads directly.

The 555 itself takes about 10 mA from the supply when the output is high (timed period) and 1 mA in the reset state (output low). To this must be added the load current.

BASIC CIRCUITS

This section describes the basic circuits that can be built around the 555 timer. These will be used in specific applications in later sections.

MONOSTABLE

The basic 555 is usually obtained in an 8 lead DIL pack with connections and internal circuit as shown in Fig. 1.

Vcc (the supply) and ground (Ov) are obvious. The output is true (high going) and the trigger input is low going. The device is DC coupled, hence the output stays up if the trigger input is longer than the timed period. The device is not re-triggerable in its basic form.

To construct a monostable we add a resistor and capacitor Rt and Ct as shown in Fig. 2.

Referring to Fig 1 and 2 the operation is as follows. The trigger input sets the flip flop and the output goes high. The discharge transistor turns off, and Ct starts to charge via Rt. When the voltage on Ct reaches the control voltage defined by the three resistor chain, comparator 1 resets the flip flop, the output goes low and the discharge transistor turns on again to discharge Ct. The circuit can now be triggered again by another input.

The timed period is therefore the time that it takes Rt to charge Ct to the control voltage from OV. As the three resistors are equal, the control voltage is ⅔ Vcc, and since Rt is also connected to Vcc the timed period is independent of Vcc.

Waveforms for the operation are shown also on Fig. 2.

For mathematically minded people, the timed period is given by:—

$T = 1.1\ Rt \times Ct$ where Rt is in ohms and Ct in Farads.

For non mathematically minded people, a table of values for various periods is given in section 5.

It can be seen from Fig. 1 that the control voltage is brought out to pin 5. With this facility the control voltage can be de-coupled to improve the noise immunity of the device, or changed to give a control voltage other than ⅔ Vcc.

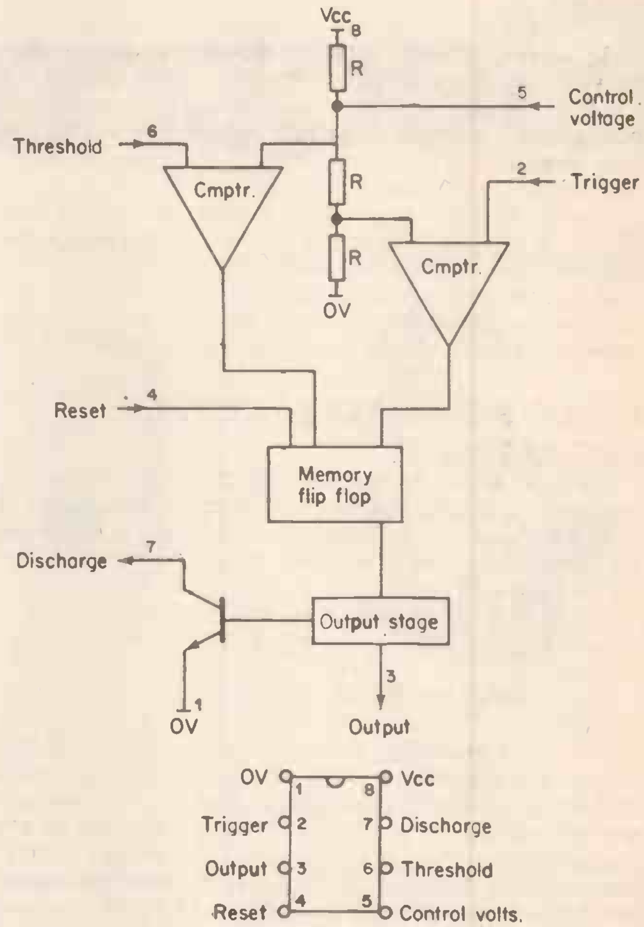


Fig. 1. 555 Connections.

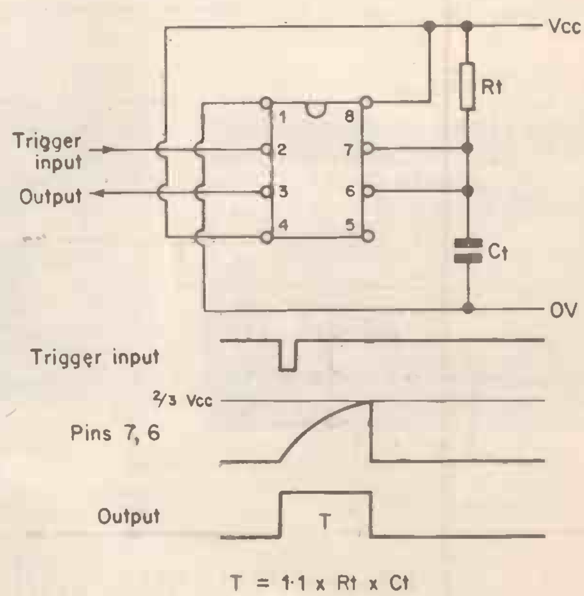


Fig. 2. Monostable.

This article was taken from 'IC555 Projects' by E. A. Parr, published by Bernard Babaria at £1.45. It describes several practical circuits using IC timer.

By varying Rt and Ct the timed period can be controlled from about 5 μS to about an hour. Above 5 minutes, though, accuracy and reliability start to fall because of the large value components necessary. In long time applications the ZN1034 (manufactured by Ferranti) is a better device.

The minimum value of Rt is determined by the discharge transistor, and IKO is normally the minimum allowed. The maximum value of Rt is determined by the leakage current of comparator 1. The data sheets recommend 20 M, but accuracy suffers above IMO. For most purposes Rt should be kept between IKO and IMO.

MULTIVIBRATOR (ASTABLE OPERATION)

If we look at Fig. 1 we see that the trigger input is connected to the flip flop via comparator 2. To set the flip flop the input has to fall below ⅓ Vcc. Apart from providing noise immunity, this allows us to make the 555 into an oscillator.

To do this we connect two resistors Ra, Rb and a capacitor Ct as shown in Fig. 3. The operation is as follows.

Assume that the flip flop has just been set and the voltage on Ct is about ½ Vcc. Capacitor Ct will be charging via (Ra+Rb). When the voltage on Ct reaches ⅔ Vcc, comparator 1 will switch, the flip flop will reset and the discharge transistor will turn on. Ct now discharges via Rb. Note that Ct is also connected to the trigger input. When the voltage on Ct reaches ⅓ Vcc, comparator 2 will switch. This sets the flip flop again, turns the discharge transistor off and Ct starts charging again via (Ra+Rb). We are now back to where we started. This astable operation will continue indefinitely.

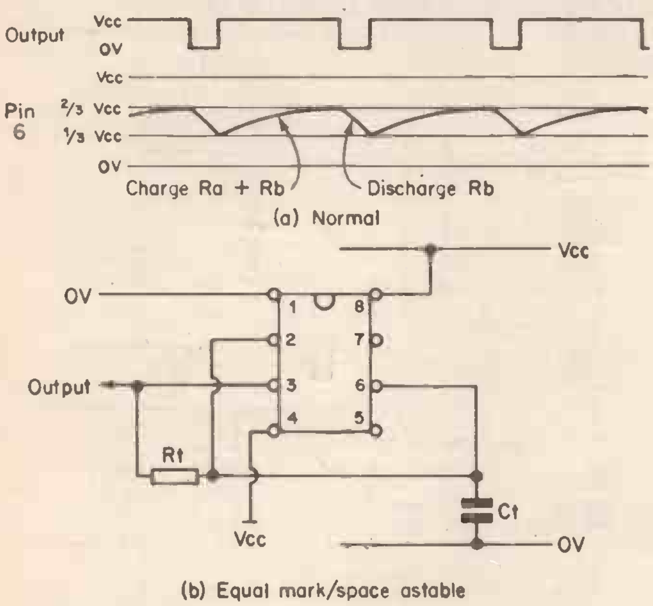
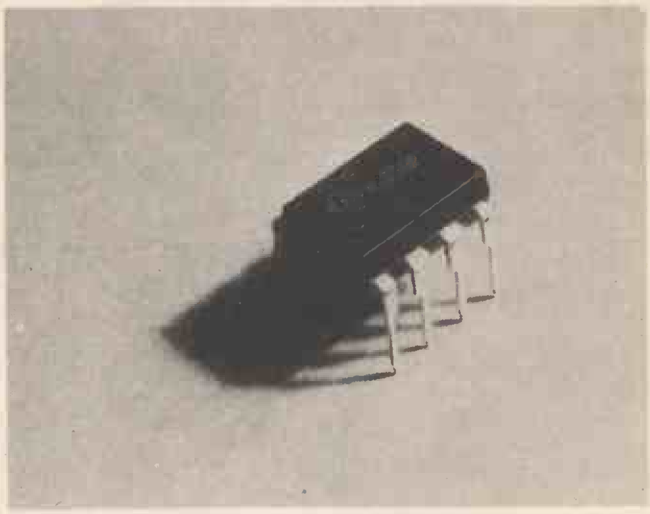


Fig. 3. Astable Operation.



A 555 without its clothes on. Note the small dot, this denoted pin 1.

The voltage on Ct thus varies between ⅓ and ⅔ Vcc, although this can be changed by external manipulations of the control voltage. The voltage waveforms are shown on Fig. 3a.

The time of the high period is given by

$$T1 = 0.7\,(Ra+Rb)Ct$$

this is sometimes called the charge period for obvious reasons.

The time of the low period is given by

$$T2 = 0.7 \times Rb \times Ct$$

this is tometimes called the discharge period.

The total period is thus:—

$$T = 0.7\,(RA+2Rb)Ct$$

and the frequency is:—

$$f = \frac{1.45}{(Ra+2Rb)Ct}$$

If Rb is much larger than Ra (eg, 100k and 1kO) we get nearly equal mark/space ratio and the frequency is approximately given by:—

$$f = \frac{0.72}{Rb \times Ct}$$

Note that in the basic multivibrator circuit it is not possible to get the low period longer than the higher period.

Tables of values for various frequencies are given in section 8.

If an oscillator for a particular frequency and mark/space ratio is being designed, Rb and Ct should first be chosen to give T2, then Ra selected to give T1 from the formula above.

If an oscillator of exactly equal mark space ratio is required, this can be given by ignoring pin 7 connecting a resistor direct from the output to charge and discharge the capacitor (see Fig. 3).

Both charge and discharge periods are given by

$$T = 0.7\,C\,R$$

hence the total period is

$$T = 1.4\,C\,R$$

TOUCH SWITCH

The 555 needs about 0.5 μA at the input to trigger, this means that it can easily by made to function as a touch switch. The circuit described here senses mains hum (Fig. 4). The human body, except in the middle of a desert, has several volts of 50 to 60 Hz mains enclosed in it. This voltage can be used to trigger a 555 direct.

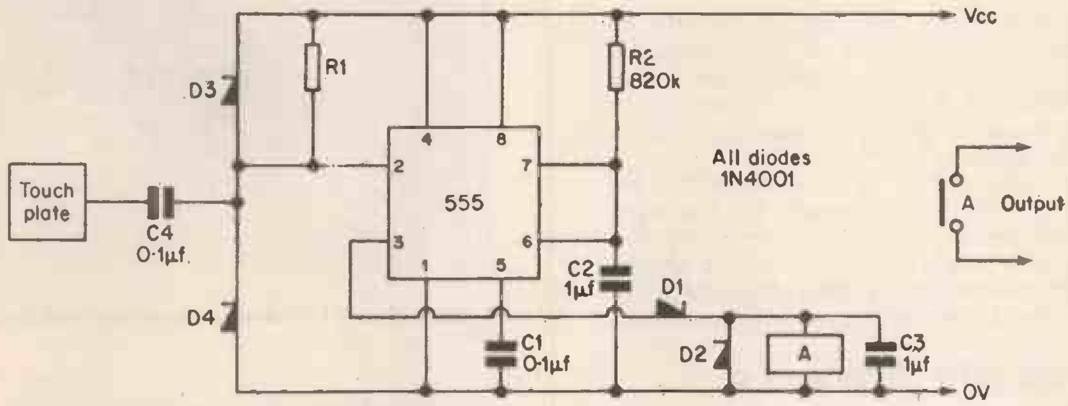


Fig. 4. Mains-Hum touch switch.

R1 sets sensitivity. Typical values in range 47k–10M.
In extremely low noise areas, remove D3–D4, and connect R1 to 0V.
Adjust value of R1 so 555 does not trigger permanently. (R1 ~ 10M)

The monostable period is set for about 1 sec. The induced mains comes via C2, giving a continuous string of trigger pulses. The output will go low for about 10 mS every second as the monostable times out and retriggers. Diode D1 and capacitor C3 slug the relay so it does not "chatter", on these 10 mS pulses. Resistor R2 sets the sensitivity.

The relay energises when the plate is touched, and de-energises up to 1 sec after the finger is removed, the delay depending on when the monostable last retriggered.

These circuits should NOT be connected direct to mains, relay coupling should be used. Under no circumstances should SCR and Triac drive be combined directly with a touch switch.

The current drain is minimal, and the unit will run for months on a 9 V battery.

The maximum load current of the 555 is 0.2 A and the 556 is 0.15 A. This means that the devices can be coupled to small high impedance loudsp,eakers without the need of a further driver stage.

For a 9 V supply, these currents correspond to 45 ohms for the 555 and 60 ohms for the 556. Many 75 ohm loudspeakers are available and these give more than adequate noise.

If lower impedance speakers are used, a series resistor should be inserted to bring the impedance up to the required value.

SIGNAL INJECTOR

This unit is a signal injector for use in testing audio and other amplifiers. It gives a square wave out which is rich in harmonics, the frequency of which can be varied from 50 Hz to 15 KHz.

The circuit is shown in Fig. 5. It is a 555 astable connected in its equal mark/space mode. The frequency is set by VR1, R1 and C1 in the above mentioned range.

VR2 controls the output level, the output being AC coupled by C3.

To prevent stray radiation into the circuit under test, the circuit should be constructed in a die-cast box with the output being taken via co-ax cable.

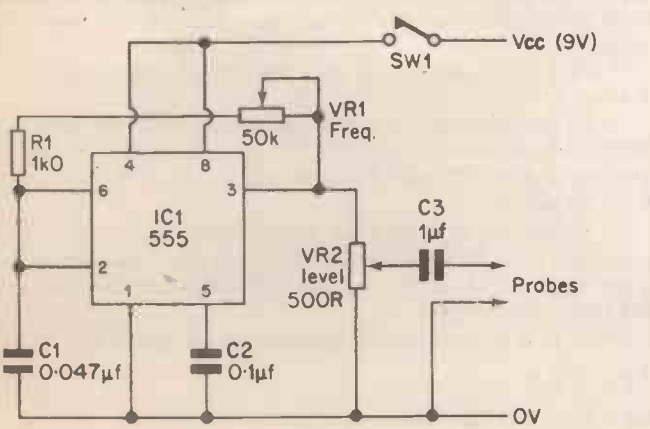


Fig. 5. Signal Injector.

SIMPLE ALARM CIRCUIT

To simply use a 555 as a tone generator we connect the loudspeaker to the device as shown in Fig. 6. It will be

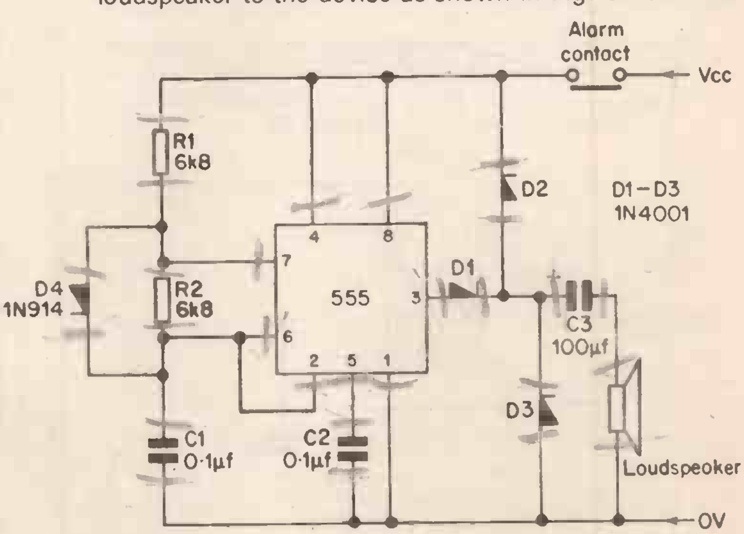


Fig. 6. Simple Alarm Circuit.

noticed that the speaker is AC coupled by C3. It is possible to direct couple the speaker to the output, but unless the return side of the speaker is returned to the mid rail point there is standing mean DC current through the speaker coil which some speakers object to.

Diodes D1 to D3 are for the protection of the 555 from any inductive spikes caused by energising and de-energising the speaker coil. In the author's experience they are not necessary except in the case of unusually highly inductive speakers. They are omitted on all subsequent speaker driving circuits. Diode D4 is added if equal mark space is required.

MULTI ALARM CIRCUIT

The cost of a simple 555 tone generator compares very favourably with the commercial audible warning devices, with the added advantage that the pitch can be varied where more than one alarm is required. If two alarms cannot occur together, considerable cost saving can be made by using the circuit of Fig. 7. Different timing resistors are connected to the alarm contacts and the 555 itself gets its current through D1 etc.

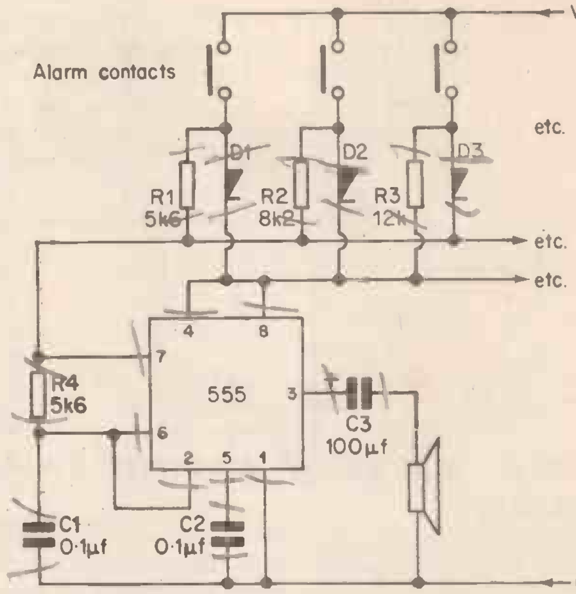


Fig. 7. Multi-Alarm Circuit.

SIREN

If a rising and falling exponential ramp is applied to the control voltage pin of an oscillator we get a siren output. The circuit for this is shown in Fig. 8.

The output of IC2 is used to charge C1 via R7, giving an exponential rise and fall. Because of the long times required, R1 is a high value and is unable to drive the control voltage pin directly. An emitter follower, TR1, is used to buffer the voltage on C1. This can be either an NPN or PNP emitter follower to suit what the constructer has available.

The emitter follower output is taken to the control voltage pin by R6. Again, the value of R6 determines the frequency shift of the siren.

If the component values used are the same as those in the diagram Fig. 8, the "warbler siren" used by police cars in American TV series is produced. This has the same make up as a normal siren, but the frequency shifting is much faster.

COIN TOSSER

This circuit uses an additional TTL IC with a 555 to provide a random "heads/tails" indication. The circuit is built into a box which has two lights labelled "heads" and "tails" and a push button labelled "toss". When the toss button is pressed and released one or other light will come on, the result being purely random.

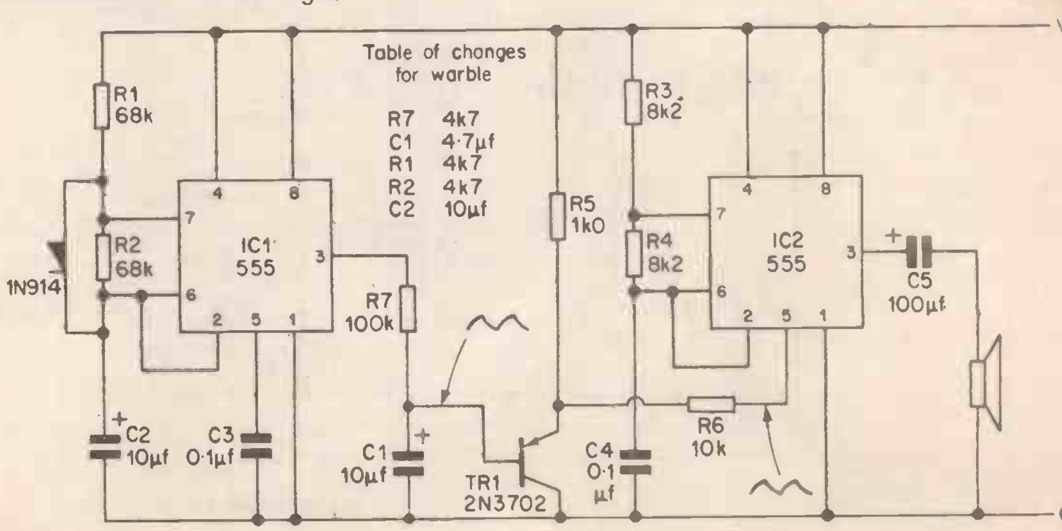
The circuit is shown on Fig. 9. IC1 is a 555 connected as an oscillator, which is allowed or inhibited by PB1, the toss push button, connected to the reset pin. The frequency is set for about 100 KHz, so in the 0.5 sec that the button will probably be pressed for, some 50000 pulses will be produced.

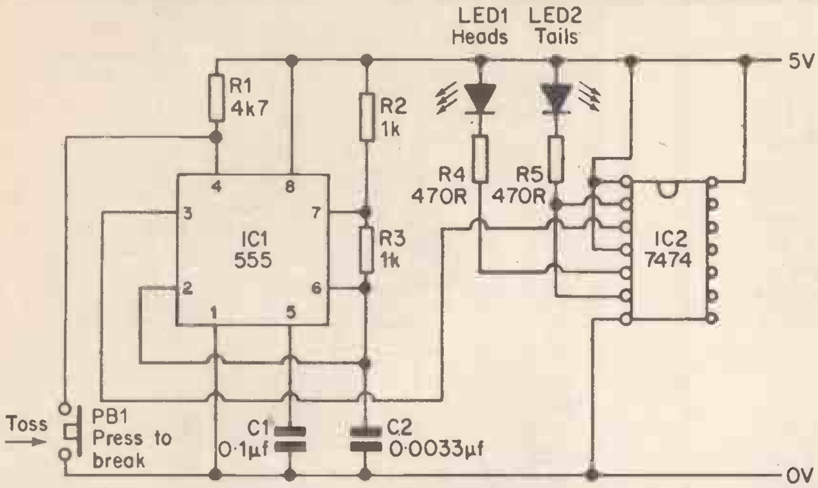
These pulses go to IC2, a TTL 7474 D type flip flop. When this device is connected as shown, it becomes a divide by two counter, so one, and only one, of its two outputs will be at a binary 1, the other being at a binary 0. Which output is at a binary 1 will be determined by the number of pulses from IC1 being odd or even. This will be to all intents and purposes random.

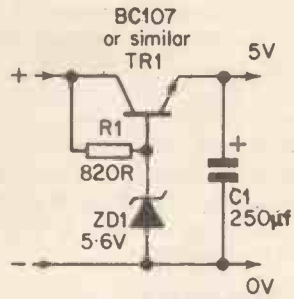
The two outputs heads and tails are LEDs, driven directly off the ouputs of IC2. The LEDs are lit when the corresponding output is low, ie at binary 0.

The circuit is most useful if battery powered. The TTL requires a 5 V rail. There are two possibilities. Firstly three 1.5 V cells will provide a 4.5 V supply which will just work TTL. Secondly a simple series regulator as shown in the insert on Fig. 9 will give 5 V from a 6 V or 9 V battery.

Fig. 8. American Police Siren.







Simple 5V regulator

Fig. 9. Coin Tosser.

S.C.R. DRIVE (PHOTOGRAPHIC TIMER)

WARNING. Circuits using 240 V are potentially lethal. These should be constructed in an earthed case, and great care taken when working on them. Where the circuit 0 V is connected to the line neutral, plugs must be correctly wired or the entire circuit will be at 240 V.

This simple circuit shown in Fig. 10 gives control of a photographic enlarger. The 555 is connected as a simple monostable, but the output controls the load via the diac and the triac.

The delay period is controlled from 1 to 100 secs by RV1. For ease of setting RV1 should be made a ten turn pot with analogue dial. Because of the proximity of the mains voltage RV1 should have an insulated spindle.

Variable resistor RV2 calibrates the timer for variations in Ct by adjusting the control voltage.

The triac is effectively burst fired. When the 555 output is high, the triac is conducting. The turn on is not synchronised to the supply and if the load is, heavy spikes may be induced onto the mains. Filtering should then be placed in series with load (RS components TV chokes).

The supply Vcc can be obtained from a simple transformer/bridge/rectifier/smoothing capacitor circuit.

For maximum safety, the control logic could be connected to the triac by an opto isolator and zero voltage switch.

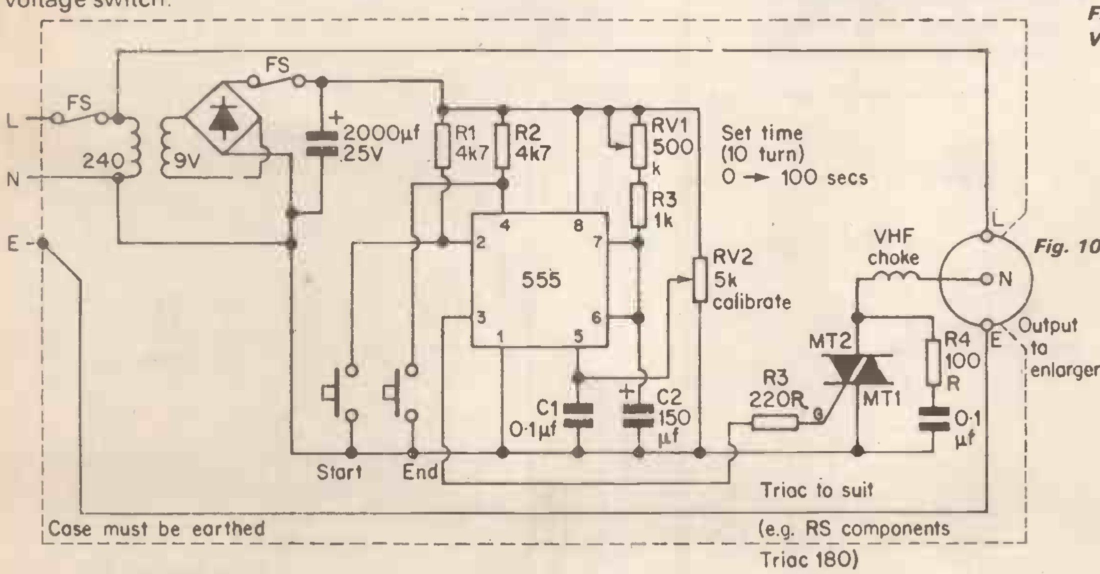


Fig. 10. Photographic Enlarger Timer.

COMPUTER VOICE

This is one of the author's favourite circuits as it combines two of the most useful ICs, the 555 and the 741.

The circuit was originally designed to give a Dalek type speech for a computer in an amateur dramatics play.

The circuit works by quickly varying the amplitude of the speech. The circuit is shown in Fig. 11.

IC1 is a 741 connected as an inverting amplifier with gain normally determined by R2 and R5. Across R5 is a relay contact and when the contacts close RV1 and R6 is

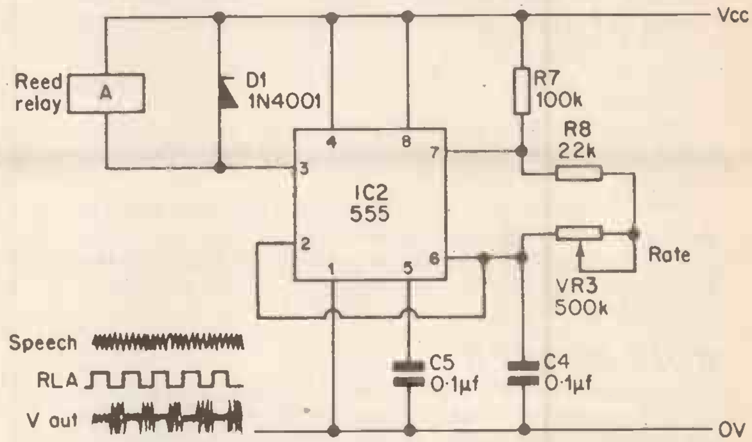


Fig. 11(a). Above, Computer Voice Synthesiser

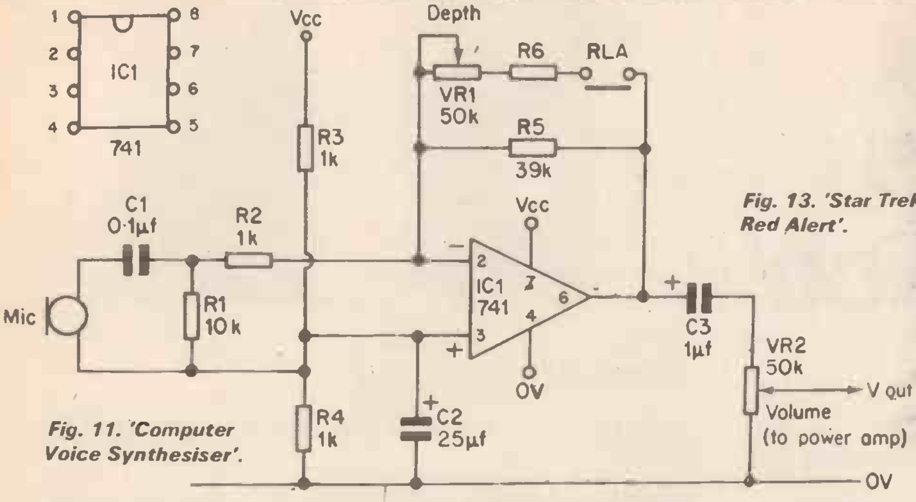
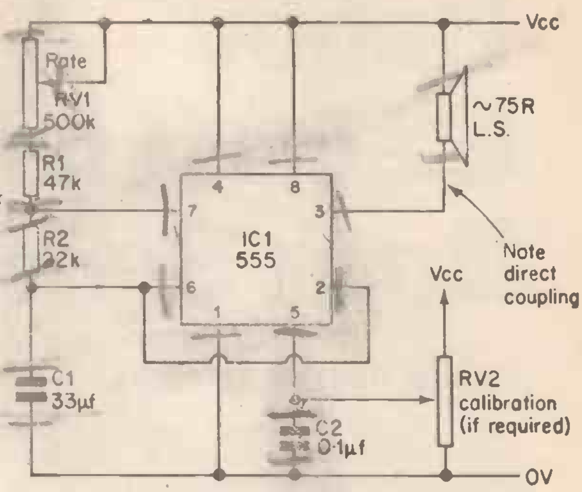


Fig. 11. 'Computer Voice Synthesiser'.

Fig. 13. 'Star Trek Red Alert'.



put in parallel with R5 and the gain is reduced by an amount determined by RV1.

The speech from the microphone thus varies in amplitude at a rate determined by the relay contacts and the magnitude of the variations by RV1.

RLA is buzzed by IC2, a 555 timer, the rate being set by RV3. A frequency in the range 20-60 Hz was found to give the best results.

With the values shown a typical moving coil microphone wil give 500 mV out of the circuit which will drive the AUX inputs on most power amplifiers, or any of the many available IC power amps.

STAR TREK RED ALERT

The Red Alert sound on Star Trek is a sawtooth modulated tone. It starts low, rises slowly to a high value then drops suddenly and starts again.

The circuit is shown on Fig. 13. IC1 and IC2 are connected as before, except that the period of IC1 is set to give a charge time (output high) of about 0.5 sec and a discharge time (output low) of about 0.1 sec.

The ramp is produced by C1, which is charged by a crude constant current source provided by Q2 and its associated components. A simple resistor charging could be used, but the exponential charge does not give an authentic sound.

C1 is discharged by Q1, which is turned on by the brief discharge time (output low) of IC1.

The resulting sawtooth is applied to the control voltage input of IC2 to give the required sound. As before, the value of R9 determines the range of the sound.

When the control voltage input is used to control an oscillator, an increasing voltage gives a decreasing tone. The input to give us our Red Alert sound should therefore be an inverted sawtooth.

METRONOME

To give sound effects with a 555 it is not necessary to use high frequencies. The sound of a metronome, a simple click, can be produced with a single 555.

The circuit is shown on Fig. 12. The 555 is connected as an oscillator and RV1 gives a range of 10-140 beats per minute. The notes regarding the choice of a speaker for the previous circuits also apply here.

If the cone of the speaker is accessible, the tone of the metronome can be made indistinguishable from a clockwork metronome by doping the cone with polyurethane varnish. Care should be taken not to allow the varnish to jam up the coil movement. **HE**

This article is reproduced by kind permission of Bernard Babani (Publishing) Ltd, The Grampians, Shepherds Bush Road, London W6 7NF, and taken from 'IC 555 Projects' by E. A. Parr. The book contains sections on motor car, model railway and alarm circuits together with basic information, general circuits and variations on the basic IC. The book (Bernard Babani No. BP44) is available from most component stores and good book shops for £1.45. It is also available from the HE Book Service.

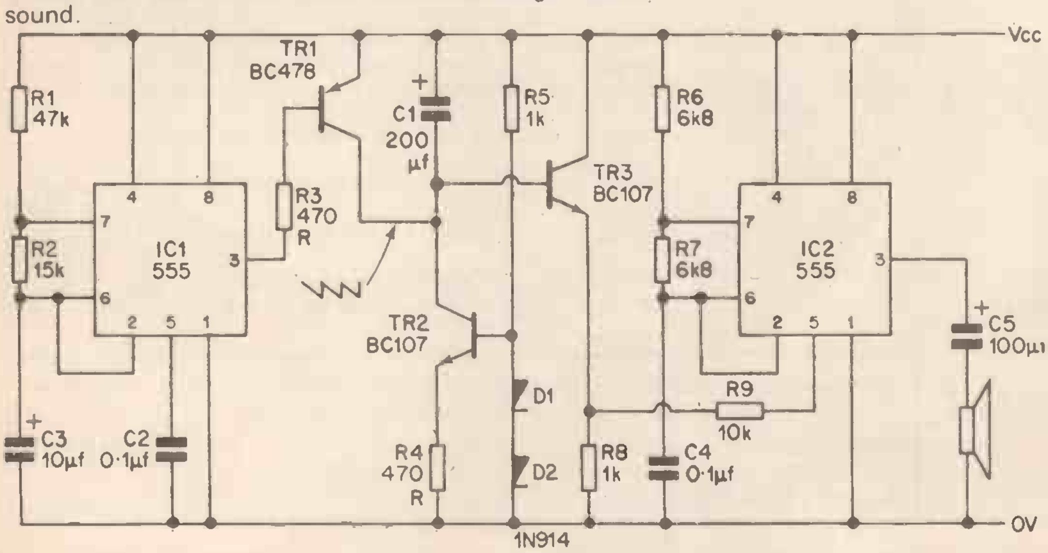


Fig. 12. Metronome.

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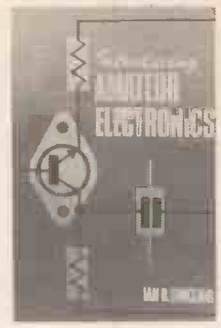

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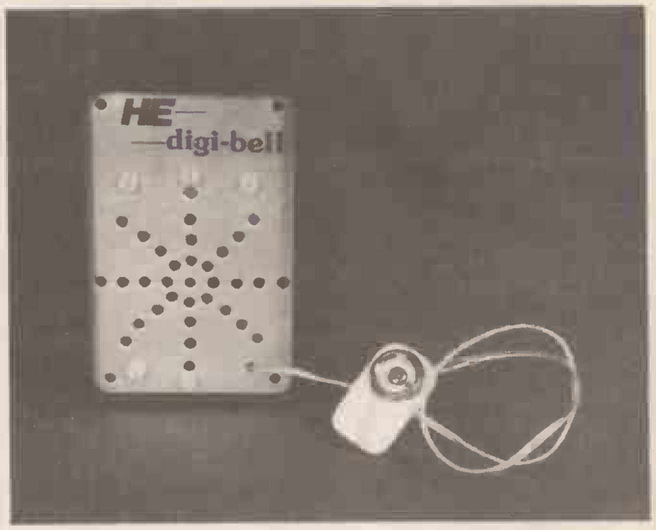
Digibell Project

No more pressing door bells with the HE Digi-Bell, it's just touch and go, the 'chime' will never be ignored.

UNTIL RECENTLY doorbells have all relied upon a mechanical action to strike a bell or chime. With the advent of reliable ICs the electronics industry has been attemptimg to innundate us with microprocessor based song-boxes. Any type of doorbell must fulfill one basic function, however, that is to attract the householder's attention to the fact that someone is at the door. It doesn't matter how many tunes it may play, if it can't be heard or even worse, is ignored altogether it's use as a doorbell is somewhat suspect.

There are two distinct methods of attracting someones attention (audibly that is) the most obvious is volume, nothing wrong with the theory but it does rather lack elegance. Hopefully HE will never be accused of that. The second method involves the peculiarities of the human ear. We are more sensitive to certain frequencies or combinations of frequencies than others.

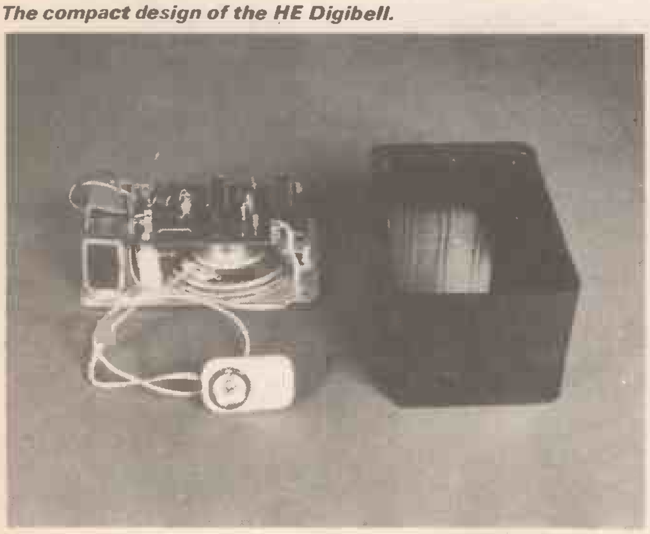


NOTICEABLE NOTES

A great deal of research was done in the sixties by the Post Office into what makes a sound noticeable. The result of this research is with us today in the shape of the Trimphone Warbler. The sounds made by these instruments are very distinct and the Digi-Bell works in a similar manner.

The Digi-Bell has one more unusual feature, the inclusion of a touch-switch as opposed to the normal mechanical push-button. The sensor uses the resistance of the skin to activate a short time delay which sounds the 'Bell' for a short time after the finger is removed.

The compact design of the HE Digibell.



CONSTRUCTION

All the electronics are mounted on a single PCB. The usual precautions must be taken when handling CMOS devices. Ensure all the polarised components are fitted the right way round. In the prototype the PCB was mounted above the speaker on pillars. The touch-plate was made from a small piece of Perspex. The outer contact was an old knurled nut from a standard toggle switch, (use a plated type to avoid corrosion). The centre contact was made from a plated dome-headed 6BA screw. Both contacts were filed and the connecting wires soldered directly. The knurled nut can then be fixed to the Perspex plate by an epoxy adhesive.

OPERATION

Because the Digi-Bell uses CMOS IC's, the stand-by current is extremely low, around 2-5 uA, so an on-off switch is unnecessary. It's a good idea to use a mercury or alkaline battery, so the unit will function for several months.

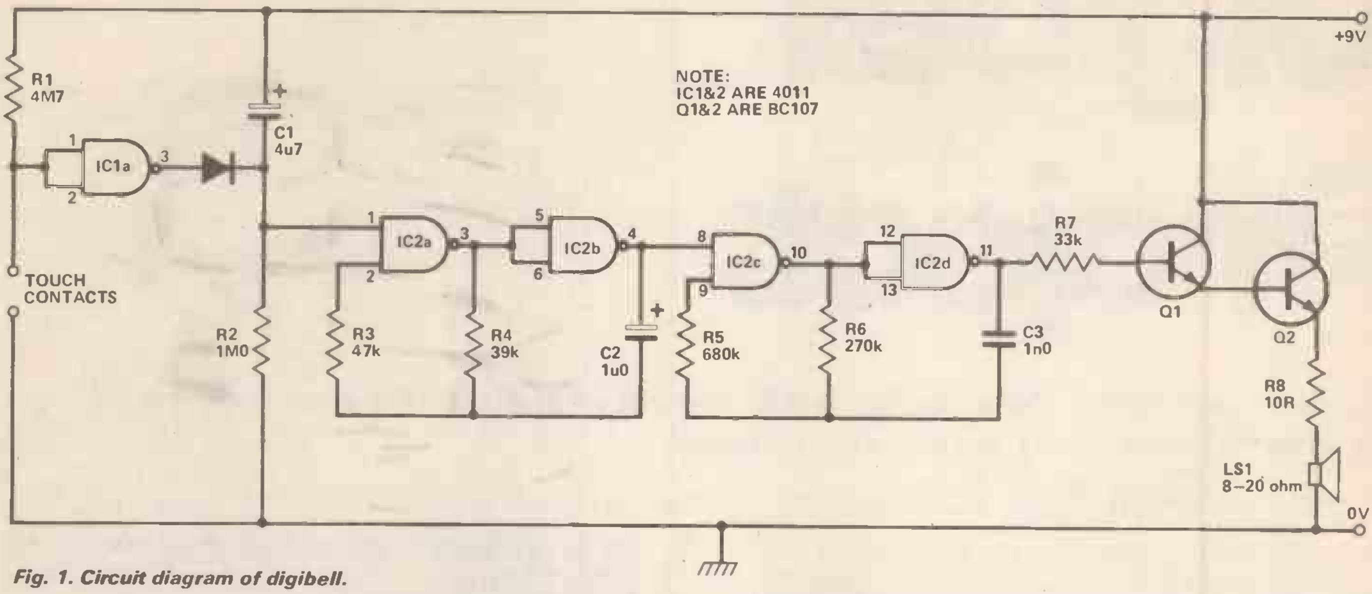


Fig. 1. Circuit diagram of digibell.

How It Works

The circuit of the Digi-Bell can be broken down into three distinct sections.

TOUCH SWITCH

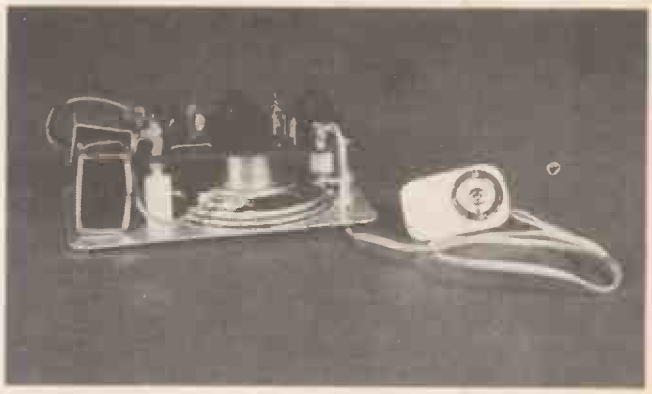
The touch switch uses skin-resistance to trigger the 'bell'. IC1 (quad, dual input NAND gate) has both inputs of gate (a) tied together. This now becomes a NOT gate. (If logic 1 (+9V) is preset at the input, logic 0 (0V) will appear at the output and vice-versa, therefore it is an inverter). The input pins 1 and 2 are connected to the +9V line (logic 1) via R1, so there will be logic 0 on the output (pin 3). If a resistance less than R1 (eg a finger, typically 10-50 k ohms) is connected between the input pins and the 0 V line, the logic stage will change and the output will rise to +9V. A CR network C1, R2 holds the output high for a short period (about 1 second per microfad of C1). The output from the CR network is taken to the first in a pair of astables.

THE OSCILLATORS

The output from the touch switch 'enables' the first astable (free running square-wave generator, see Jan HE for operation) which has a frequency of around 10 Hz. This in turn enables the second astable, with a frequency of 5 kHz, so the resulting output will be a 5 kHz square-wave, gated at 10 Hz.

AUDIO OUTPUT

The output from IC2 (c+d) pin 11 is fed to a Darlington Pair (current amplifier) comprising Q1, Q2, they drive a low impedence loudspeaker LSI. A 20 ohm speaker was found to give the greatest volume, although a lower impedance speaker will work but below 8 ohms damage to the output stage might occur.



A loudspeaker sandwich. The PCB is bolted to the front panel, with the loudspeaker between the two.

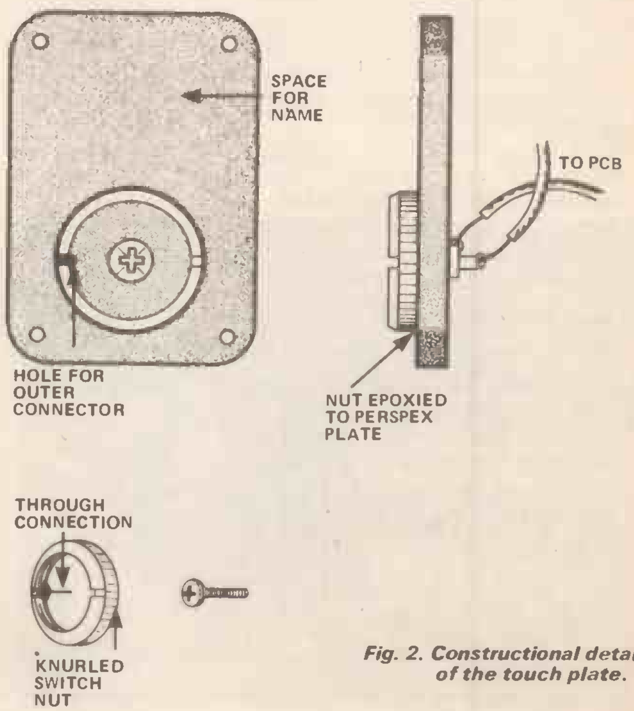


Fig. 2. Constructional details of the touch plate.

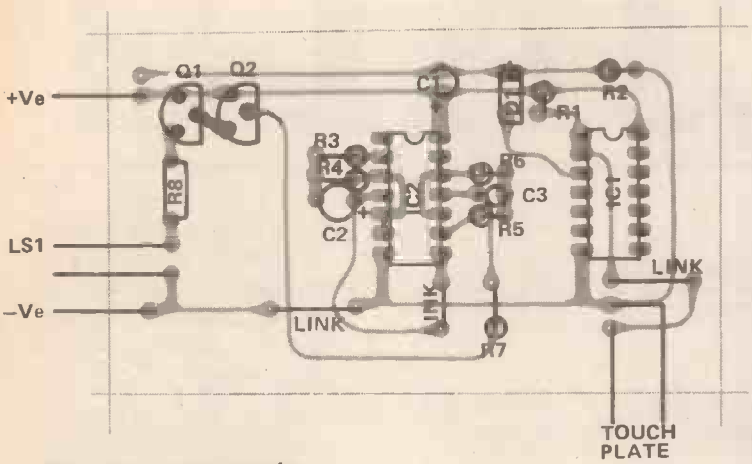
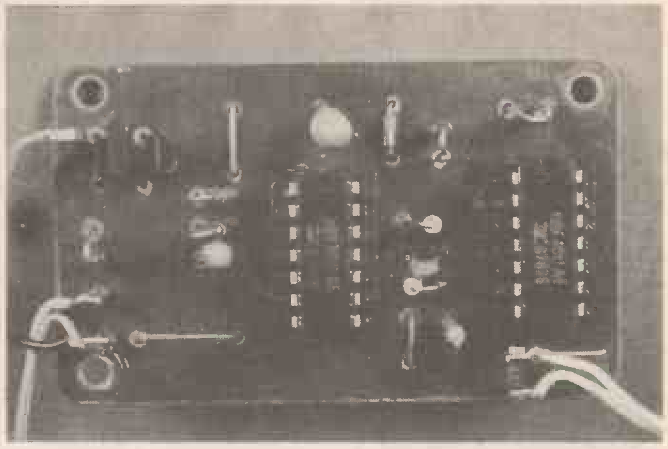


Fig. 3. Component overlay.



Top view of the PCB. Note that resistors are mounted vertically to save space.

Parts List

RESISTORS (All ¼W, 5%)

R1	4M7
R2	1M0
R3	47k
R4	39k
R5	680k
R6	270k
R7	33k
R8	10R

16 24 32 36 72 92 97

CAPACITORS

C1	elec	4u7 (See How It Works)
C2	"	1u0
C3	cer	1n0

SEMICONDUCTORS

IC1, 2	CD4001
Q1, Q2	BC107
D1	IN4001

MISCELLANEOUS
~~PCB to suit, Small piece of perspex, knurled nut, 6BA screw, Battery,~~ 9V PP3 (Mallory etc), loudspeaker.

None of the components are difficult to obtain, the semiconductors are all available from Watford, Maplin, Stevenson etc, the case can be chosen to suit the particular application.
Approxoimate cost £4.50.

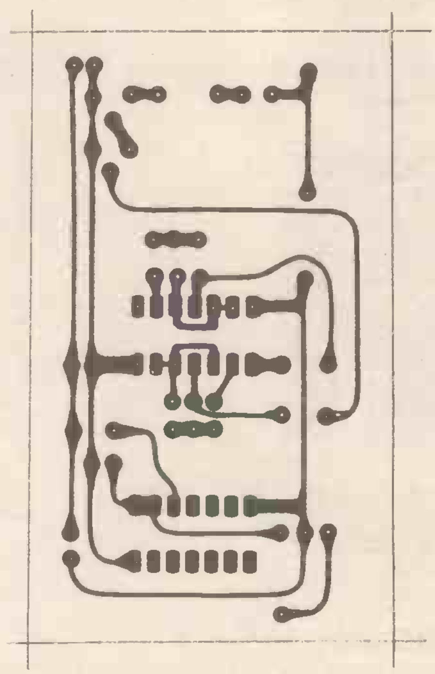
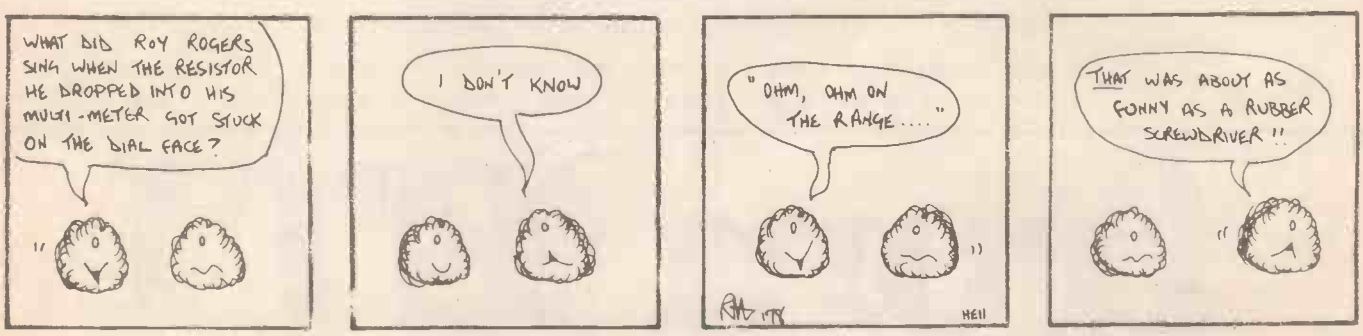


Fig. 4. PCB foil pattern.



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Into Electronics

by Ian Sinclair Part 7

This month Ian Sinclair looks at the electronic systems we all know and love — radio, disc and tape.

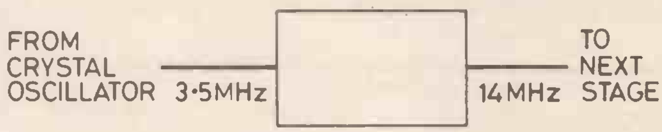
WE'VE COVERED A LOT of ground in these previous six issues, looking at the components and the circuits that make up the building-blocks of electronics systems. Now it's time to look at what we build with these circuits, the electronics systems which we make so much use of these days. We'll start with one of the oldest of electronics systems, radio.

The history of radio started when Heinrich Hertz in 1888 showed that electromagnetic waves, which had been predicted by Maxwell some twenty years earlier, actually existed, and could be transmitted from one place to another. The waves that his apparatus generated had quite a short wavelength, and the distance of his first transmission was comically short, a few metres, but he had demonstrated the first principles of radio, that a high-frequency (short wavelength) signal will leave a wire and travel through space. Another wire placed in the path of this signal will have signal voltages induced by the wave, so that the signals can be received.

FLASHERS — OLD HAT

The early transmitters generated radio waves by making use of the oscillations caused by sparks. These spark transmitters worked, but they generated a huge mixture of waves of different frequencies — fine when only a few transmitters existed, but useless now. Nowadays we need to generate a high-frequency radio wave which is of a single selected frequency, and to avoid interference with the thousands of other transmissions, we need to be able to keep the frequency constant to within a few Hertz (Hz). Every radio transmitter, then, apart from some low-power or mobile types, starts with a crystal-controlled oscillator.

This is only a starting point, though. The frequency which is to be used for transmission may be much higher than the frequency of the crystal. To obtain the higher carrier frequency from the lower crystal oscillator frequency, distorting amplifiers called frequency multipliers are used. A frequency multiplier stage is simply an amplifier with deliberate under- or over-biasing. The input is tuned to the (low) frequency of the crystal oscillator, which then switches the current in the multiplier on and off at the crystal frequency. This causes



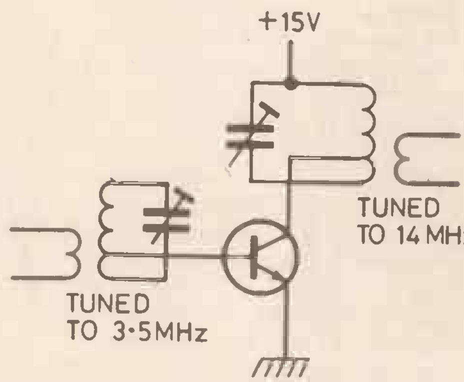


Fig. 7.1 Frequency multiplication using tuned circuits.

pulses of current in the collector circuit, whose load is a tuned circuit, tuned, that is, to an exact multiple of the oscillator frequency (such as twice, three times, etc). Each pulse of current through this load sets the tuned circuit into oscillation, and the oscillation will not have died away too much before the next pulse of current sets it off again. The point about having the load tuned to an exact multiple of the oscillator frequency is that each pulse of current will then arrive in just the right phase to keep the oscillation going in the tuned load. If the load is not correctly tuned, there will not be a continuous steady signal at the collector. The output from this lot is therefore a high frequency signal which is a sinewave, whose frequency is controlled by the crystal oscillator.

DAH, DAH DIT . . .

So far, so good. We have a high frequency signal which will radiate from a wire, an aerial (antenna in the U.S.A.). How do we use it? In the early days, the only way we

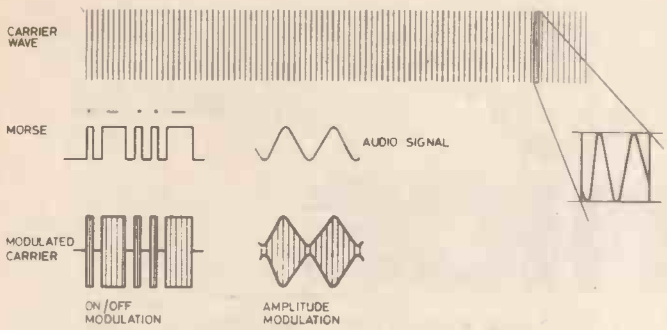


Fig. 7.2. Amplitude modulation of a carrier wave.

knew to use a radio wave was the way we used the current in a telegraph wire — we started and stopped it in the pattern called Morse code. Now the Morse code is a fairly simple code, but the idea behind it is important. You can't convey much of a message with a steady signal of any kind, telegraph or radio. To make your radio signal useful, you have to change it, modulate it, either in the form of a stop-start code like Morse code, or in some other way.

A Morse message takes a long time to send, even when automatic transmitters and receivers are used. What was needed was a way of coding an audio signal on to the radio wave, and one of the most frequently used methods is called amplitude modulation. Remember what we mean by amplitude. It's the size of the wave, measured to the peak, in volts. Amplitude modulation means changing the amplitude of the high frequency carrier wave, the one that can be transmitted from an aerial, in a way which allows the carrier to take the information of a low frequency signal along it.

Take a look at Fig. 7.2. This shows a high frequency wave; the frequency is so high that individual cycles cannot be distinguished in this scale. Along with this carrier wave is shown an audio wave, the type of signal we get, after amplification, from a microphone. Amplitude modulation means making the amplitude of the carrier wave vary at the same rate and with the same voltage changes as the signal wave, and the result of such amplitude modulation is shown in Fig. 7.2. This modulated wave is still a high frequency wave, it can still be radiated from an aerial, but its amplitude now varies in a way that carries all the information on the amplitude and frequency of the audio signal that we want to transmit.

The final stages of an AM transmitter therefore consist of amplitude modulation and power amplification, very often carried out together. One well-established method of amplitude modulation consists of feeding the carrier signal to a power amplifying stage whose collector voltage is then modulated by an emitter-follower (Fig. 7.3). Large transmitters, of course, use valves (vacuum tubes) rather than transistors, but the types of circuits that are used are similar. Fig. 7.4 shows a block diagram for a complete fixed-frequency AM transmitter.

So far, so good, but there's not much point in having transmitters sending out modulated carrier waves unless we can receive them. Receiving the carrier wave is one thing, a piece of wire will do that, though some design work and cunning is needed if we want to make the best use of the modulated wave. The problem now is what to do with the modulated carrier. The trouble is that it's still

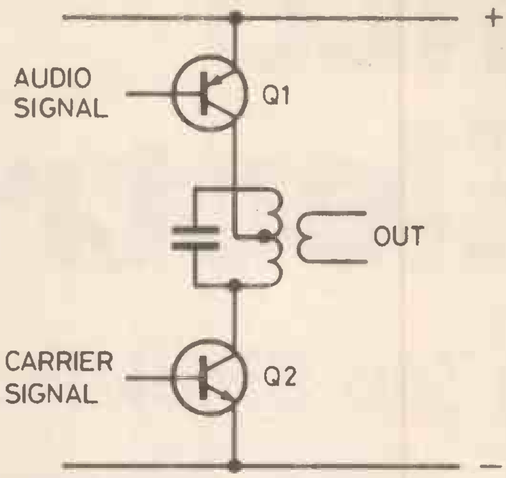


Fig. 7.3. AM by means of an emitter follower.

a radio frequency wave, even though it's modulated. No matter how much we amplify this wave, no loudspeaker or earphone will vibrate at the frequency of the carrier wave, large amplitude or small. The modulation cannot do anything because the modulation waveform of the opposite peaks of the carrier is in antiphase — one part of the modulation cancels out the other. What we need is some method of recovering the original audio signal from the modulated carrier wave.

DETECTIVE WORK

The process of recovery, called detection or demodulation, is practically always carried out by a diode, making use of the principle that a diode conducts in one direction only. A modulated carrier fed to a diode will cause the diode to conduct for only half of each cycle of the carrier wave, and so the waveform at the other side of the diode looks very different (Fig. 7.5). We can then use this waveform to charge a capacitor which is allowed to discharge through a resistor. If we choose the time constant of the capacitor and resistor well, the capacitor will not discharge noticeably during the time from one carrier peak to the next, but will discharge fast enough to follow the changes in the audio waveform. The effect of the capacitor also ensures that there's hardly any carrier wave left, and the small amount that remains can be filtered off, leaving the audio signal. O.K.?

Wait a minute, though. We've been assuming that we have a signal of large enough amplitude to pass through a diode. We don't in fact get that much signal from an aerial unless the transmitter is very close or very powerful, and we still need to make sure that we have selected the correct carrier wave from the thousands that are around. How do we do that?

TUNING IN

Selecting a frequency, of course, is the job of a tuned circuit, and the obvious way to construct a radio is to have several stages of amplification each using a tuned circuit as load. Obvious, yes, and this was the method that was once used. It's called TRF — tuned radio frequency (Fig. 7.6), but it isn't suited to modern needs, and here's why. To start with we need to be able to

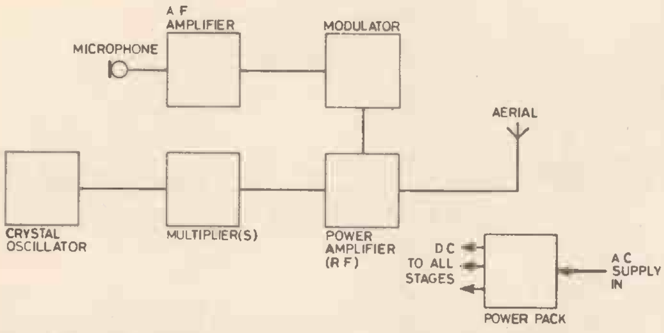


Fig. 7.4. Block diagram of a complete fixed frequency AM transmitter.

change the tuning of each tuned circuit if we want to be able to tune from one carrier frequency to another.

At the same time, if we want the radio to be selective enough to pick out one carrier wave from others whose frequencies are very close, we need a lot of tuned circuits. It's not entirely impossible, because we can make *ganged* tuning capacitors, variable capacitors with one shaft operating several capacitors, but it's difficult. In addition, and just to make a difficult job almost impossible, we have our old friend positive feedback lurking around. We may have to amplify the radio signal by quite a bit using perhaps a gain of one thousand or so. With so much amplification of a carrier that can launch itself off a piece of wire so easily, it's very hard to stop some of the amplified signal from getting back to the input. Working on the 'butter-side-down' principle, such feedback is always positive at some frequency or other, so that the whole amplifier oscillates.

The fact that an oscillating receiver is useless as a receiver is bad enough, what makes it worse is that it radiates the oscillating signal back into the aerial and so to any other receivers that are around. When your receiver oscillates, no one listens to the show. We don't like TRF receivers, folks.

SUPERSONIC CHANGES

All is not lost, though, because a brilliant invention of more than fifty years ago lets us have lots of tuned circuits, along with easy changes of frequency and less chance of feedback. It started with the name of supersonic heterodyne but not surprisingly lost a few letters and ended up being called the superhet receiver. How does it work? Pin your eyelids up and read on.

At the input of a superhet receiver, the signal is tuned in the usual way, using a variable capacitor which is part of a two-gang capacitor set. Instead of amplifying this tuned signal, though, its frequency is changed in a mixer stage. Two frequencies are fed into the mixer stage — the carrier signal that has been selected by the tuning, and a sinewave generated by an oscillator (called the *local* oscillator) which is part of the receiver. Most small receivers do not use a separate oscillator stage, the mixer is connected so that it will oscillate. Now we've mentioned the idea of signal mixing before (beat-frequency oscillator, remember?) but let's run over it again. When we feed two radio signals into an amplifier which is not biased for linear amplification, the output signal will consist of the sum and difference frequencies as well as the frequencies we put into the mixer. More remarkable and useful is the fact that if one of the input frequencies is modulated, then the sum and difference frequencies

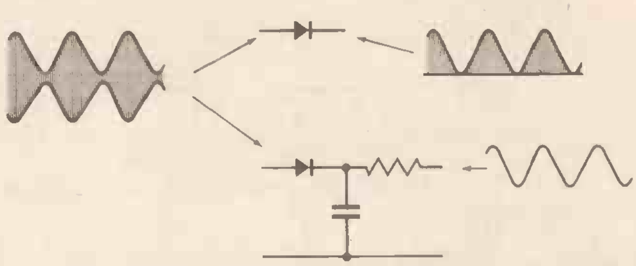


Fig. 7.5. Using a diode and CR network for detection and demodulation.

will also carry the identical modulation. We choose the difference frequency, called the intermediate frequency (IF) and use as the load of the mixer a tuned circuit which will resonate at this intermediate frequency.

TRACKING DOWN THE IF

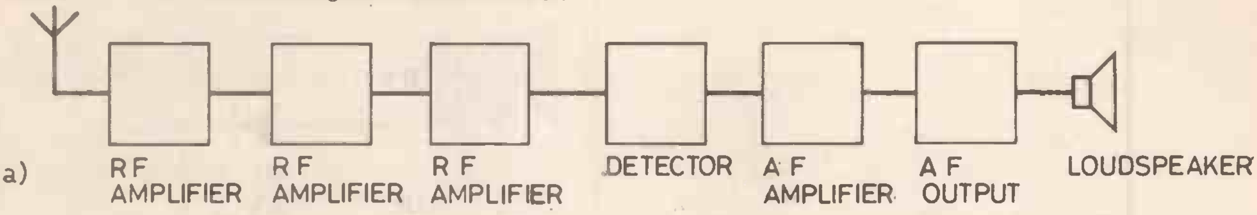
What's so smart about changing the frequency? Well, it's not just that we change the frequency, but that we change *any* input carrier frequency into the same IF frequency. The frequency of the local oscillator is controlled by a variable capacitor, the other half of the ganged pair whose first half is used to tune the carrier. Now with a bit of cunning we can arrange it so that these two tuned circuits, the input and the oscillator, will 'track' together, meaning that when we change the tuning of the carrier by 50 kHz, then the tuning of the oscillator will also change by 50 kHz. If this tracking is accurate, then the difference between oscillator frequency and carrier frequency stays constant, so that when we tune from one carrier to another the frequency at the output of the mixer, the IF, stays constant.

We now have the easy job of amplifying a signal which is at a fixed frequency. The tuned circuits for this lot can be kept inside metal cans to reduce radiation of IF signal, so that positive feedback can almost be eliminated. Any feedback to the input of the mixer is not particularly important, because it's at a different frequency from the carrier frequency and will be rejected by the tuned circuit at the input. A few high-class receivers use an additional IF trap at the input, just to make sure. Very cunning, very useful.

AUTOMATION

Summing it all up so far, Fig. 7.7 shows a block diagram of a superhet receiver up to the detector stage, and Fig. 7.8 shows the actual circuit diagram of a typical pocket transistor radio. There's one little bit of cunning that we haven't mentioned yet — it's called the AGC circuit, meaning Automatic Gain Control. This AGC is needed because of the way in which radio waves reach us. Radio waves are electromagnetic waves, like light, and they travel through space in the same way, at the same speed of 300 million metres per second, obeying the same laws. Apart from the effects of diffraction, the only way a radio wave can reach us from a distant transmitter (because of the curvature of the Earth) is by reflecting from the Heaviside or Appleton layers. These are belts of ionised gas that surround the atmosphere, with lots of loose electrons floating about, and they reflect radio

Fig. 7.6a Block diagram of a TRF receiver.



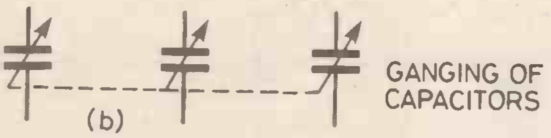


Fig. 7.6b Using ganged capacitors to tune several stages simultaneously.

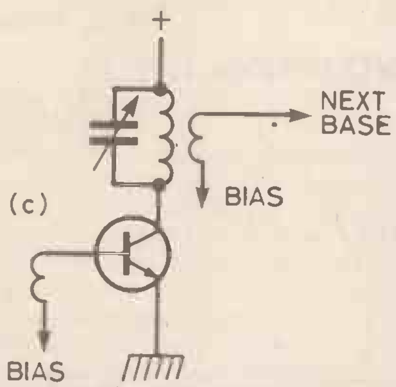


Fig. 7.6c A single RF stage and connections to the next stage.

waves at most of the lower frequencies. Any radio signal of up to around 30 MHz can then reach us by several paths, a direct path if the transmitter is not too far away, and various reflected paths (Fig. 7.9) depending on the height of the reflecting layers, which is generally around 30 to 50 miles.

TO BE OR NOT TO BE . . . IN PHASE

At the receiver, then, signals arrive from several different directions having travelled by different path lengths, and there is no chance that they will always arrive perfectly in step. At 1 MHz for example, the wavelength of a carrier

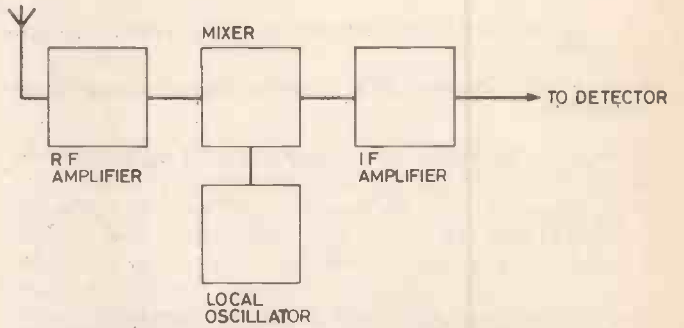


Fig. 7.7. Block diagram of a superhet receiver up to the detector stage.

is 300 metres. A path difference of only 150 m at this frequency will cause one wave to be inverted relative to the other, and any odd multiple of 150 m difference in path length will also cause the waves to be in antiphase.

The reflecting layers are constantly on the move, so that reflected waves have to cover different distances from one minute to the next. At one instant, the waves reaching the receiver may reinforce each other, at the next instant they are just as likely to cancel. The result is that the signal received at the aerial varies greatly in amplitude from one moment to the next.

We could, of course, sit with one hand on the receiver volume control turning up the wick each time the signal became faint and turning it down again when the signals were strong, but it's easier to use a form of negative feedback to do the job. AGC makes use of the fact that the detector diode rectifies the carrier signal, so that there's a steady (DC) voltage at the detector. The amplitude of this steady voltage is equal to the peak amplitude of the carrier, and we can filter out the audio signal changes which go along with it (Fig. 7.11). We can separate this DC signal out and use it to control the

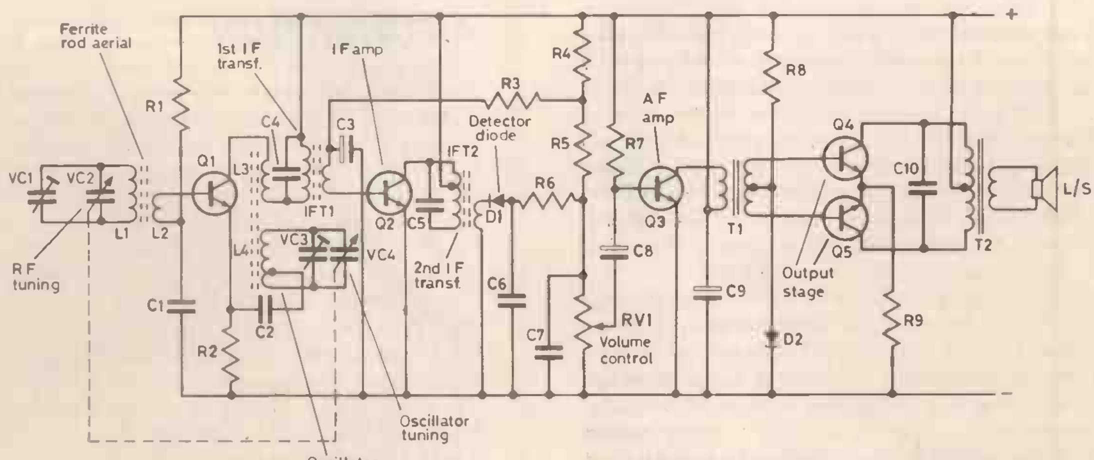


Fig. 7.8. Circuit diagrams of a typical pocket transistor radio.

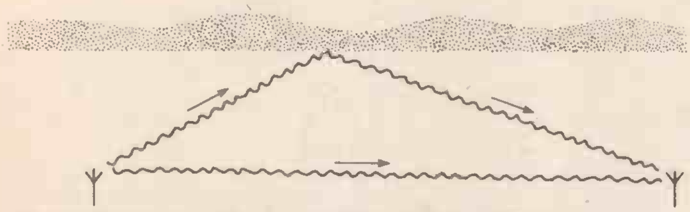


Fig. 7.9. Direct and reflected paths by which a signal can reach an aerial.

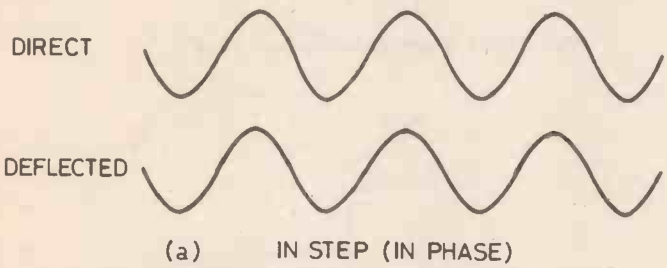


Fig. 7.10a Constructive interference (waves in step).

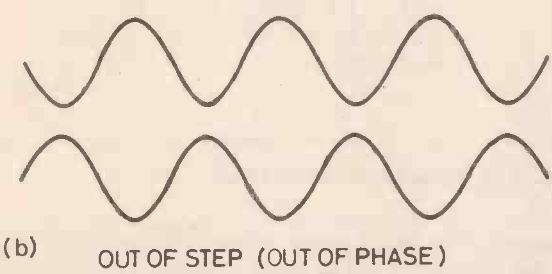


Fig. 7.10b Destructive interference (waves out of step).

gain of the receiver, usually by feeding it to an IF amplifier stage, sometimes to the mixer as well. Now when the carrier is strong there's a large DC signal at the detector, and this is used to bias the IF amplifier so that its gain is low. When the signal fades, the DC voltage at the detecttor drops, the IF amplifier bias changes, allowing more gain so that there is more amplification of the signal. All getting clear?

FM

Modulating the amplitude of a carrier isn't the only way of getting a high frequency carrier to take a low frequency signal for a ride. Another of the many types of modulation is FM, frequency modulation. In this type of modulation, the carrier amplitude does not change, but the audio signal causes changes in the frequency of the carrier. The greater the amplitude of the audio signal the greater the frequency change (deviation) of the carrier. The higher the frequency of the audio signal the more rapid are the frequency changes of the carrier.

Frequency modulation is easy to carry out, though demodulation needs rather more than the simple diode circuit that is used for AM receivers. The main advantage of FM is the freedom from noise and interference which can be achieved when well-designed equipment is used. For this reason, FM is used for all high quality sound broadcasting, and exclusively for stereo broadcasts, of which more later.

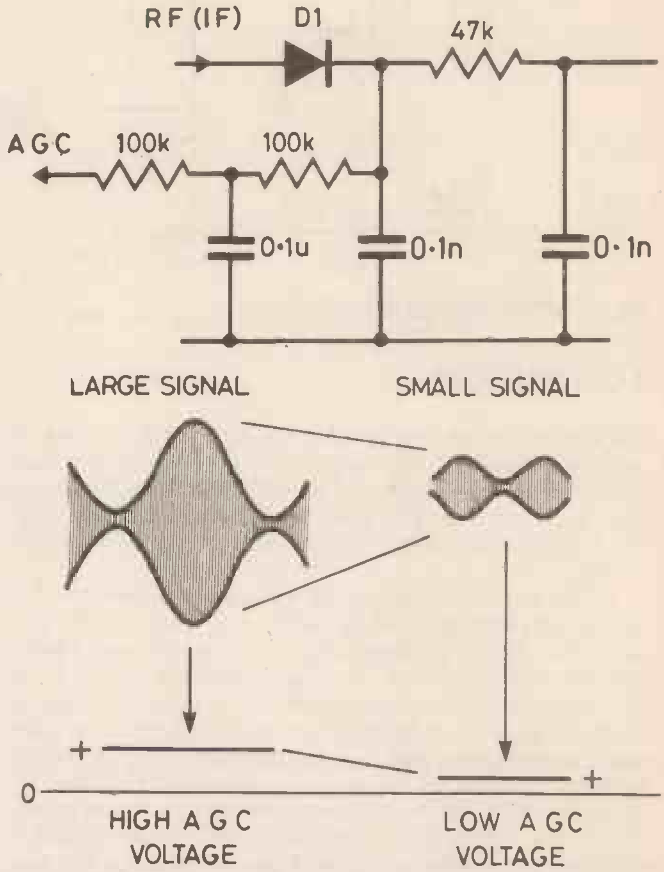


Fig. 7.11. Using the carrier amplitude to control the receiver gain (AGC).

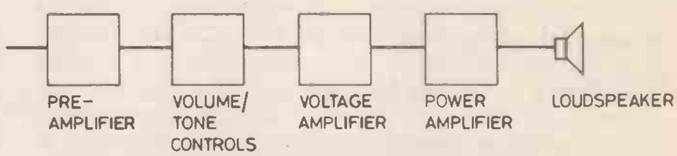


Fig. 7.12 Block diagram of a typical audio system.

AUDIO SYSTEMS

The one part of a radio system we haven't dealt with yet is the audio section — the circuit that handles the audio frequencies all the way from the detector to the loudspeaker. We've left this section so far not because of any difficulty but because the circuits are so similar to those used in other audio systems, such as disc and tape recorders. The range of fequencies that we're talking about, the audio range, is from around 30 Hz to about 20 kHz which is the range of frequencies of sound that can be detected by a human ear in good condition. These sound frequencies, converted into electrical signals by a microphone constitute the audio frequency signals which have to be amplified and converted back into sound. The circuits of any audio system must carry out voltage amplification, the control of gain (volume control), the control of the shape of the gain/frequency graph (tone control to you), and power amplification so that a loudspeaker can be driven. A block diagram of the sytem looks as in Fig 7.12.

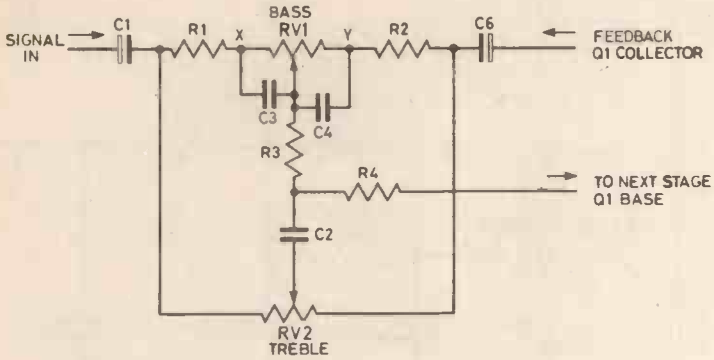


Fig. 7.13 Baxandall tone control circuit.

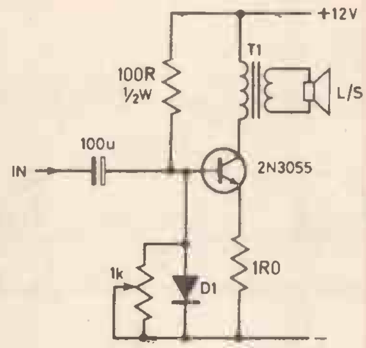


Fig. 7.14. A single-ended output stage.

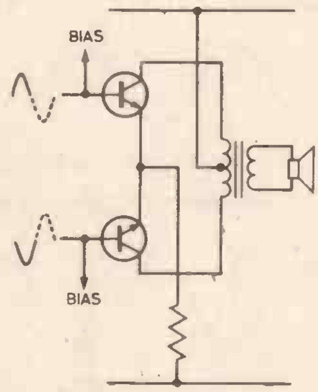


Fig. 7.15. A. push-pull output stage.

TONING UP

Voltage amplifiers are familiar by now, and the idea of amplitude control (using a potentiometer) is simple, but the tone control stages of a Hi-Fi amplifier are a bit daunting if you've never seen similar circuits before. Fig. 7.13 shows one very popular type called a Baxandall circuit.

In this circuit, a network of resistors and capacitors is connected so that it feeds two lots of signals into the base of a transistor. One signal is the audio signal from the previous stage, the other is a feedback signal from the collector of the transistor. Now this is negative feedback which will have the effect of reducing the gain of the amplifying stage, but the amount of signal that is fed back depends on the settings of RV1 and RV2 as well as on the values of the resistors and the capacitors in the circuit. For example, if the slider of RV1 is nearer end X of the potentiometer, then the signal in through C1 and R1 can reach the base of Q1 much more easily than the signal (feedback) through C6, R2 and most of the resistance of RV1. Because of this, the easier feedback path is through C4 rather than through RV1. C4 has a rather small value, so that it will pass high and middle frequencies more easily than very low frequencies, causing bass boost. The bass is boosted because more of the higher frequencies are being fed back, so the gain of the transistor for high frequencies is less than it is for low frequencies. With the slider of RV1 at end Y, only the higher frequencies of the signal can easily reach the base of the transistor without passing all the way through RV1, so that this now acts to cut bass. RV2 has a similar action on the high (treble) frequencies, so that separate control of the two ends of the audio range can be achieved. Such elaborate control is used only for high quality sound equipment. Your three quid Hong-Kong tranny makes do with a 0.1u capacitor wired across the speaker.

CHURNING OUT THE POWER, AND SINKING IT

One part of an audio system that we haven't spent much time on is the power output stage. Power output is needed because loudspeakers convert electrical power into audio (sound) power, so that electrical power in the form of a signal with enough voltage and current amplitude must be supplied. Loudspeakers are inefficient devices, converting less than 1% of the electrical power into sound, so that a fair amount of electrical power is needed. A power output transistor therefore has much larger current passing through it than we ever use in a voltage amplifier transistor, and because loudspeakers are damaged by direct current flowing through them, we have to couple the signals to the loudspeaker by a transformer or a capacitor. One exception to that last rule is that the DC can be balanced out in a type of output circuit called a bridge circuit, but these are rare.

Fig. 7.14 shows a single-ended output stage which uses one transistor with a transformer as its collector load. The term single-ended just means that the signal is not shared with any other transistors — you'll see circuits later which do share the signal and are not single-ended. The bias of the transistor is set so that a current of about 0.5 A flows when no signal is applied, and the full amplitude of signal at the input will cause the collector current to swing between 1.0 A and zero current at the peaks. The voltage at the collector is about supply voltage (12 V) with no signal, and the *average* voltage does not change when a signal is applied, so that with a full-amplitude signal the voltage swings down to zero volts (at the peak of current) and up to 24 V (at zero current). The peak voltage signal is therefore 12 V, the peak current signal is 0.5 A, the peak power is 12 x 0.5 = 6 W, and the average power is half of this, 3 W.

This type of single-ended output stage (a Class A stage) is wasteful of power and is used mainly in the type of mains operated equipment where high quality sound is not important (the telly, lad, the telly. If they're gawping at the picture, they're not listening to the sound). Most output stages make use of the push-pull, or double-ended principle, in which two transistors share the output signal between them. These push-pull circuits can also be operated with a large steady current (Class

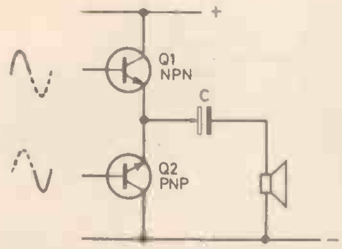


Fig. 7.16. A fully complementary output stage.

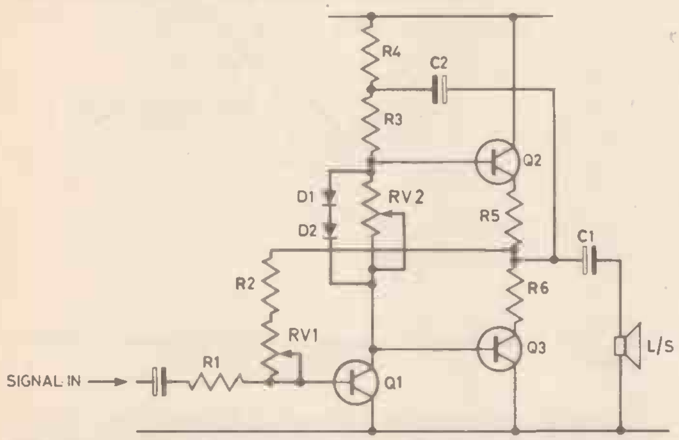


Fig. 7.17. A more complete version of the 'totem pole' output stage, given in Part 4.

A), but most designs make good use of both transistors by running each transistor with very little bias current, so saving power. The most popular circuit of this type is the totem-pole circuit, briefly referred to in Part 4 (Fig. 4.11). Let's look over that circuit again. In its simplest (and best) form, it uses one PNP and one NPN transistor connected as a pair of emitter followers, feeding the loudspeaker through a capacitor. With no signal input, the circuit is biased so that the voltage at the emitters is equal to half of the supply voltage. When the same signal input is taken to the bases of the two transistors, the positive half of the signal will cause Q1 to conduct (with Q2 biased off because Q2 is a PNP type). The voltage at the emitters will follow the shape of the positive half of the signal waveform, since Q1 is an emitter follower. The negative half of the waveform will shut off Q1 and make Q2 (PNP, remember) conduct so that the voltage at the emitters now follows the waveshape of the negative half of the wave. At the loudspeaker, the complete waveform is used. Because of the coupling capacitor, the waveform at the loudspeaker has an average value of zero; there is no DC level.

Fig. 7.17 shows a more complete output stage of this type. RV2 along with the diodes D1 and D2 provides some bias, so that the base of Q2 is at a higher voltage than the base of Q3. If both bases were at the same steady bias voltage, then signal voltages between V/2 −0.5 and V/2 + 0.5 would not produce any output, because a transistor does not conduct until its base voltage is about 0.5 V higher than its emitter voltage (negative to emitter voltage for the PNP type). Even when some bias is applied, the waveform output for very small signals is never quite perfect because the two transistors never match each other perfectly enough. This type of distortion is called 'cross-over distortion.' RV2 acts to adjust the bias current flowing in the output transistors, and can be set so that the cross-over distortion is as low as it can be for a given pair of transistors. RV1, along with R2 provides negative feedback of bias voltage and of signal. Because the output stage (which we can think of as a single emitter follower) is directly coupled, adjusting RV1 sets the voltage at the emitters of the output transistors. In use, RV1 is set to make the DC voltage at the join of R5, R6 equal to about half supply voltage. A more accurate method of setting is to connect in a signal whose amplitude is large enough to cause each peak of the output signal to appear flattened. RV1 is then adjusted so that both peaks are flattened symmetrically (Fig. 7.18). The amplifier is now set so that it can handle the maximum amplitude of input signal.

C2 is a 'bootstrapping' capacitor whose job is to assist Q1 to drive the bases of the two output transistors. When a signal of near maximum amplitude is being handled, there would not be enough voltage across R3 (which has a small value) to pass base current into Q2 unless we could increase the voltage of the supply. The

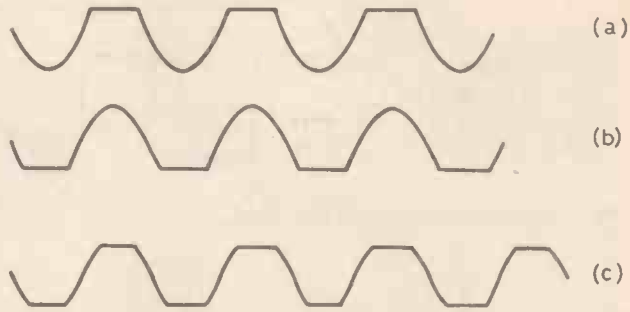


Fig. 7.18. Using a large amplitude wave to set an amplifier for maximum input signal.

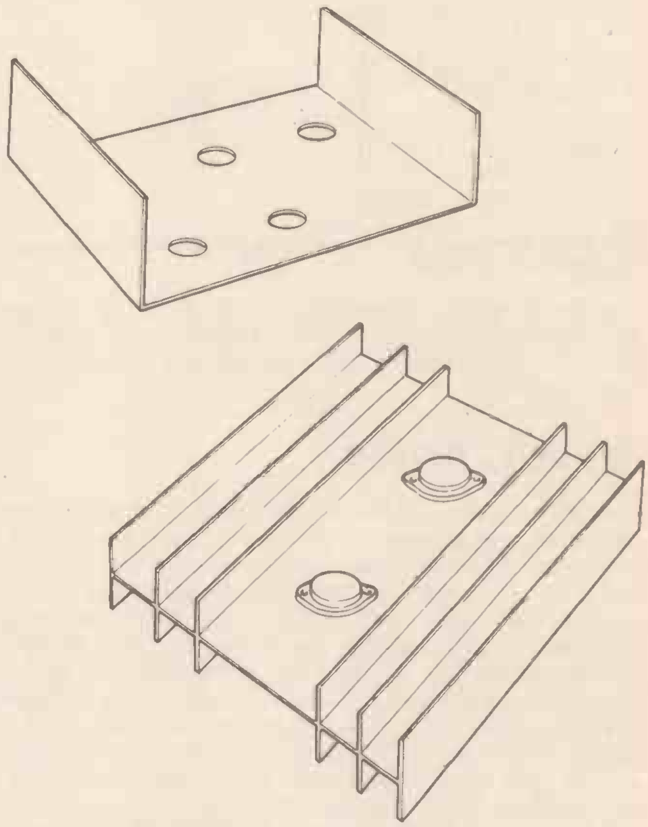


Fig. 7.19. Typical transistor heat sinks.

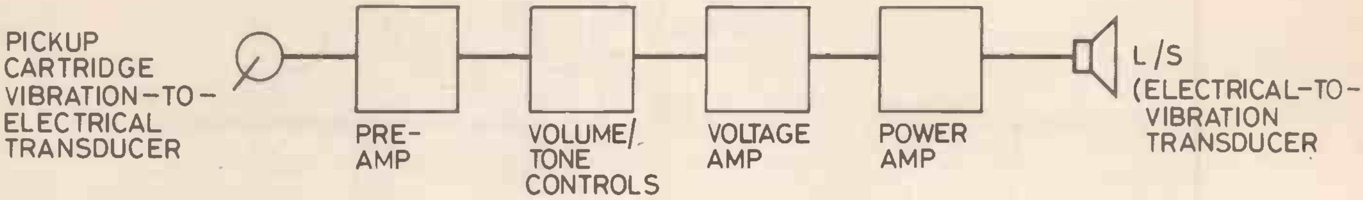


Fig. 7.20. Block diagram of a record player.

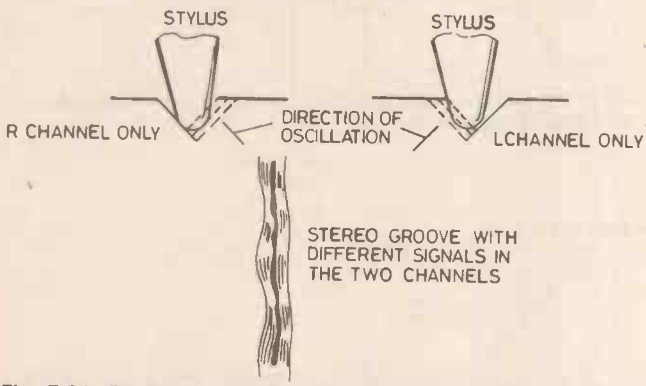


Fig. 7.21. Recovery of left and right channels from a single groove in a stereo disc.

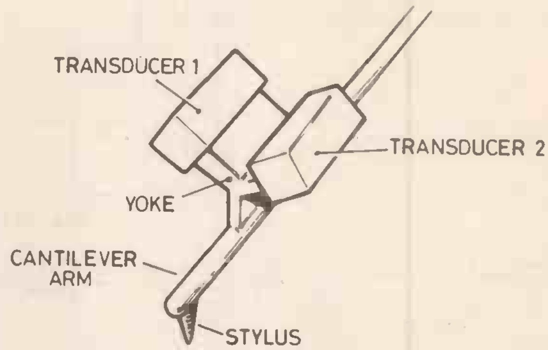


Fig. 7.22. Transferring stylus movement to transducers using a 'yoke.'

positive feedback signal through C2 does just that at each peak, and also helps to avoid signal losses. There's no risk of oscillation, because the voltage gain of Q2 is less than unity.

FRYING TONIGHT

Before we leave output stages, though, there's one important point about all of them. Output stages use transistors which can pass quite large currents at fairly high voltages, compared to most voltage amplifiers. The result is that power is dissipated in the transistors, and inevitably this means that the transistors will get hot. Unless we can pass on this heat, the temperature of the output transistors will increase until the collector-base junction, which is the part that has to dissipate the power, fails. There aren't many water-cooled transistors around (yet), so that the heat has to be passed on to the air, using convecting fins called heatsinks. These heatsinks (Fig. 7.19) are chunks of metal, finned and blackened, to which power transistors are tightly bolted, usually with a layer of heat-conducting silicone grease to help make good contact. The metal chassis of an amplifier is often used as the heatsink, and because the cases of power transistors are connected to their collectors electrically, mica washers have to be used as electrical insulators between the transistors and the metal chassis. This prevents the transistor collectors from shorting to the chassis or to each other.

DISC

The block diagram of a record player is shown in Fig. 7.20. All of the transistor stages should now be familiar to you, but the transducer is not and a brief look at it is worthwhile. Most discs nowadays are stereo, meaning that two separate recordings are made on the same track. We could, if we liked, record quite different sounds on the two channels, as they are called, but we use stereo recordings mainly for the pleasing effect of having sound appear to be coming from a larger source than one small loudspeaker. Stereo recording uses two microphones, and inevitably the sounds reaching these microphones will not be identical. The aim of stereo recording is to preserve these differences until the sound is finally played back through two loudspeakers. The channels are labelled L (left) and R (guess).

On a disc, a cycle of sound wave is recorded as a wave pattern cut into the plastic material of the disc. When stereo recording is used, the waves on one side of the groove, which has a V-shape, will not be the same as the waves on the other side, because each side of the groove carries the recording of one of the stereo channels. The groove angle is 90°, so that the pickup cartridge must include two transducers set at 90° if it is to convert the shape of the disc groove into two separate electrical signals. The use of a 90° angle makes it easy to keep the channels separate (to avoid cross-talk, as they say). Earnest students of Mechanics will tell you that a force has no components at 90° to its line of motion. Well, it works, anyhow.

The movement of the stylus has to be transferred to the transducers by using a yoke (Fig. 7.22) and for high quality replay, the mass of each of these moving parts must be very low. The stylus has to be able to return to its normal central position after each wave, so that some sort of return spring is needed, but for good reproduction this 'spring-back' must be as low as possible. In the language of the cartridge designer, the compliance must be high. The rms signal from most cartridges of the Hi-Fi type is around 2 mV at full belt.

TAPE

The disc player as we know it just evolved out of the primitive gramophones of the last century, and has changed from being a purely mechanical gadget into a mainly electronic system. Magnetic recording (tape or cassette) is just as ancient, and has adapted more readily to electronic methods, because it needed electronic

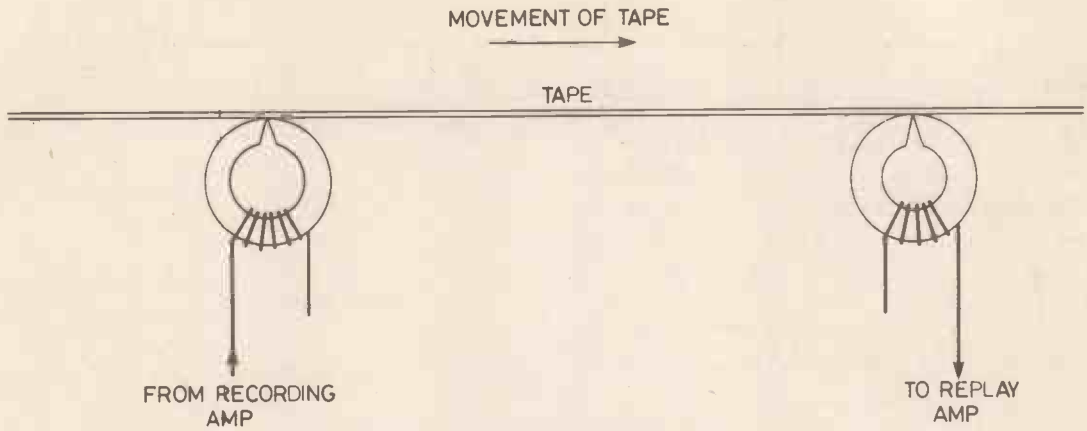


Fig. 7.23. The principle of tape recording.

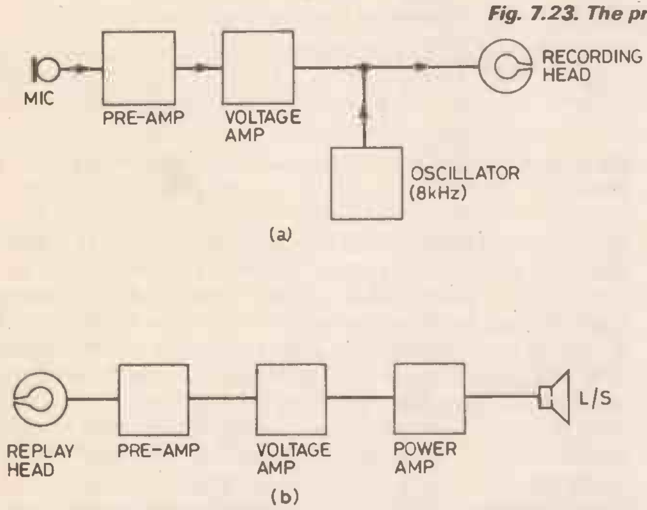


Fig. 7.24. Block diagram of a record/replay tape recorder system.

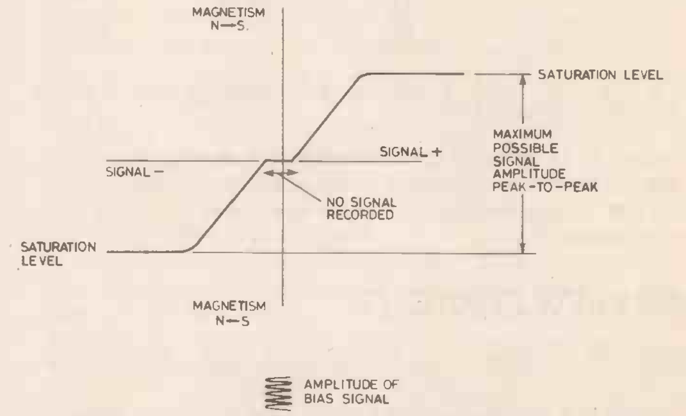


Fig. 7.25. The use of a bias signal to overcome the small-signal problem.

methods from the start. Stereo is easier to provide on tape, because we can record several tracks on one tape using as a transducer for each channel a tiny electromagnet, the recording head.

The principles of magnetic recording are shown in Fig. 7.23. A signal current passes through the electromagnet, so that a varying magnetic field exists at the gap in the head. The magnetic material, nowadays always a plastic tape coated with iron or chromium oxides, is pulled past the gap at a steady speed. Each piece of tape is left magnetised, and the amount of magnetisation is proportional to the amplitude of the signal current in the head at the instant when the tape was in the gap. When the same tape is run at the same speed past another head (or the same head with different connections to the coil) the changing magnetism at the head (caused by the combination of the magnetisation *and* the movement) induces voltage signals in the coil of the replay head. These signals, a millivolt or so in amplitude, can then be amplified. Block diagrams of a tape recorder system, both for recording and for replay, are shown in Fig. 7.24.

One awkward complication is the way that magnetic material behaves. Small current signals through a recording head leave no magnetic signal on the tape, large signals can cause the magnetic material to 'saturate' so that the waveform is clipped (Fig. 7.25). To overcome the small-signal problem, we add, while recording, a small signal at a high frequency, around 80 to 100 kHz, which is much too high to hear on replay. This is called the bias signal, and it is the bias signal which ensures that the tape always has some signal being recorded. To avoid saturation problems, the amplitude of signals must be controlled so as not to reach the level at which the tape saturates, so that meters or AGC circuits are used to keep the recording level below the saturation point.

What makes tape so difficult to use satisfactorily is that the amount of bias and the saturation level is different for each tape, and the amount of bias that is needed for any particular machine varies from one brand of tape to another. Adjustments to recorders can be made only if very specialised instruments are available, and very few laboratories have these instruments, so that the type of tape recommended by the maker of a tape recorder should be adhered to unless a review (in Hi-Fi news, for example) says otherwise. For more details of this tape recording business, try thumbing through 'Beginner's Guide to Tape Recording' (from the Book Service).

TWO-HEADED RADIO

One final problem — how do we transmit stereo signals by radio? One answer would be to use two different frequencies for the two channels, but that isn't very satisfactory — it uses up too many frequencies, and the unfortunate listener with a mono radio will hear only the

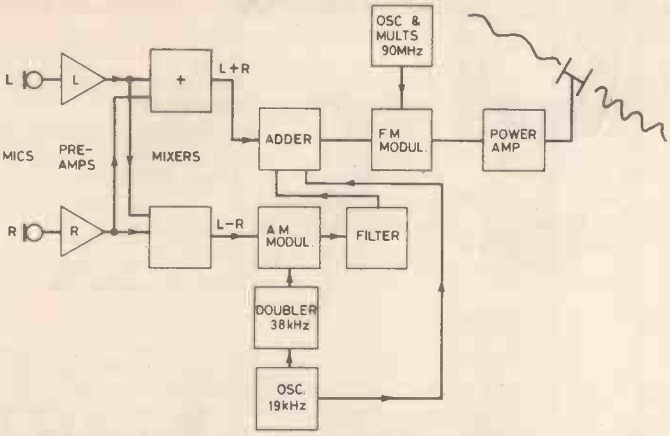


Fig. 7.26. Block diagram of a stereo radio transmitter.

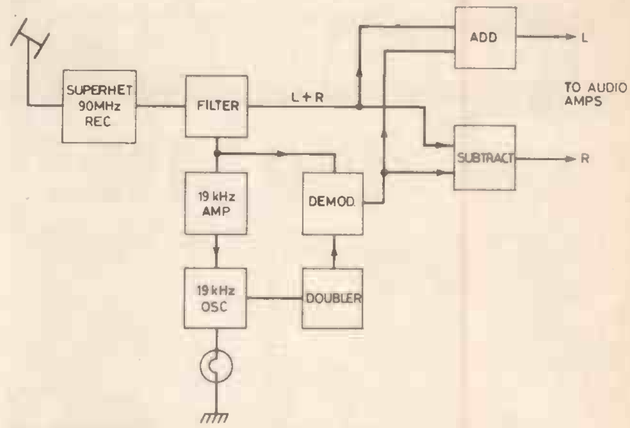


Fig. 7.27. Block diagram of a stereo radio receiver.

left channel *or* the right channel. The way out of this problem, is to mix the L and R signals to form L+R and L—R. Now the L+R signal is the normal mono signal which listeners with no stereo equipment will normally receive, and the L—R signal, the difference signal will allow a stereo receiver to recover the two separate R and L signals. How do we transmit them? Well, the (L—R) signal is amplitude modulated on to a low frequency carrier (called a subcarrier) at 38 kHz, and most of the carrier signal is then filtered out, leaving only the modulated sidebands (for more on sidebands, see the next Part). The (L+R) signal, with frequencies up to about 14 kHz is added in, and a small-amplitude 19 kHz sine wave added. We now have a signal which consists of three parts at quite different frequencies, easy to separate, and the whole of this signal is now frequency modulated on to a carrier at around 90 MHz.

A mono receiver will demodulate the signal, but will filter out all the parts whose frequencies are above 14 kHz, so that only the (L+R) signal is received. A stereo receiver (Fig. 7.27) is much more complicated. The mono (L—R) signal is filtered off in one circuit, the 19 kHz sine wave in another, and the sidebands of the (L—R) modulation in a third. The 19 kHz sinewave is used to generate a 38 kHz carrier (using a frequency multiplier circuit) which is then added to the (L—R) modulation. This lot can now be demodulated using a simple diode detector, so that we have the L—R signal. Now the signals are combined. If we add the signals: (L+R)+(L—R), we get 2L, a left channel signal. If we invert one signal and then add: (L+R)—(L—R), the result is 2R, a right channel signal. This operation, called matricing, recovers the original L and R signals which can then be separately amplified. A set of filter circuits is used to remove traces of the 19 kHz and 38 kHz signals which would otherwise cause bother with tape recorders, since they can beat (remember) with the tape bias sinewave.

Next month we conclude Into Electronics by looking at TV, Radar and Computing, no less. HE

Short Circuit

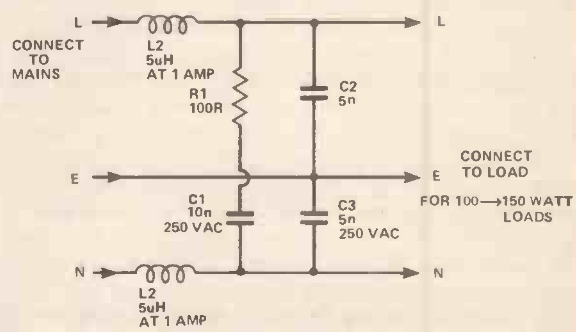
MAINS INTERFERENCE SUPPRESSION

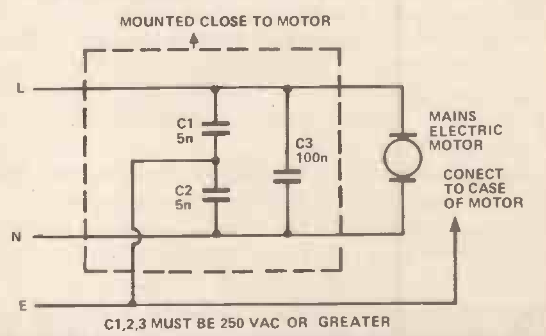
If you were to take a look at the mains voltage on an oscilloscope, you might expect to find a 250 V RMS sinewave. If you see a pure sine wave then you are quite lucky and you need not read any further. However, most mains supplies are composed of the sinusoidal generated by the electricity company plus various forms of interference generated by local users. When light bulbs, electric ovens and various electric motors are turned on they usually generate a sharp change in the load upon the mains supply which cause clicks and spikes to be generated. The worst offenders are large brush electric motors, thyristor dimmers and motor controls, spot welding units in fact anything that grabs large chunks of current abruptly from the mains supply.

The clicks and spikes often make their way into pieces of electronic equipment, producing audible clicks on loudspeakers and generating errors in digital equipment. Faced with this problem there are two things that can be done. Filter out the mains borne interference and try to prevent it being generated. Circuit A shows a typical mains filter.

The mains has to pass through a passive lowpass filter made out of an inductor and a capacitor. This causes the high frequency parts of the interference to be attenuated. The inductor must have a high current rating (1 amp in this case), and the capacitors a high voltage rating (250 V AC at least). This type of mains filter can be brought as a module for a few pounds, but it can also be made out of discrete components. In the latter case, use rubber sleeves on the connections, you only get killed once.

Circuit B shows how to suppress motor generated interference. This also reduces electro-magnetic radiation. Again, the capacitors need to have a sufficiently large voltage rating and take care to insulate all connections.





Aerial Tuners

Is your aerial 30 metres of wire connected directly to your short wave receiver? The aerial tuners described here enable you to match the aerial, whatever type, to the receiver.

TWO BASIC TYPES of aerial tuner are really all that are necessary for most short wave listening applications: the unbalanced type for long-wire aerials and the balanced type for balanced-to-unbalanced conversion as well as tuning the aerial feedline system.

Circuit and construction details for a long wire aerial system are illustrated in Fig. 1.

L1 in Figs. 1 and 2 is an air-cored coil, 32 mm dia. (1¼in), 8 turns per inch, 102 mm long.

A portion of every second turn is depressed, using the blade of a small screwdriver and moderate pressure, so that the remaining turns stand proud and allow a standard crocodile clip to be attached forming a tapping point on the coil (Fig. 1b).

The tuning capacitor, C1, can be anything suitable, providing it has a maximum capacitance greater than 0.2n.

The receiver tap is generally best at a point only several turns from the grounded end of the coil. Tune in a signal near or in the frequency band of interest and commence with the aerial tapped about ¼ to ⅓ the way up the coil from the grounded end. Tune C1 for maximum signal strength.

Move the tap higher and retune for maximum signal. If it increases, you're headed in the right direction. If it decreases move the tap the other way.

A balanced tuner is illustrated in Fig. 2. Coil taps are made in the same fashion as illustrated in Fig. 1. The tuning capacitor is a double-gang broadcast type which must have identical gangs. This item can be salvaged from old valve radios.

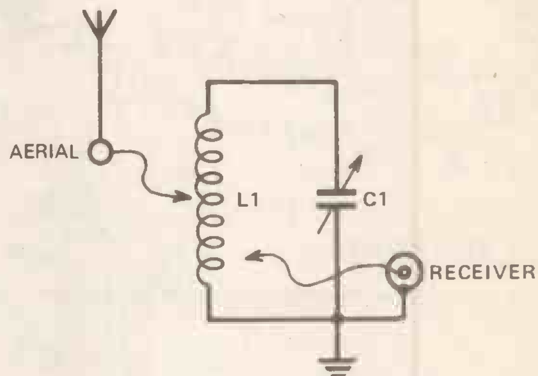
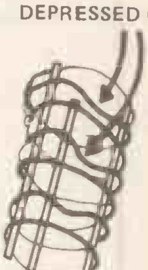
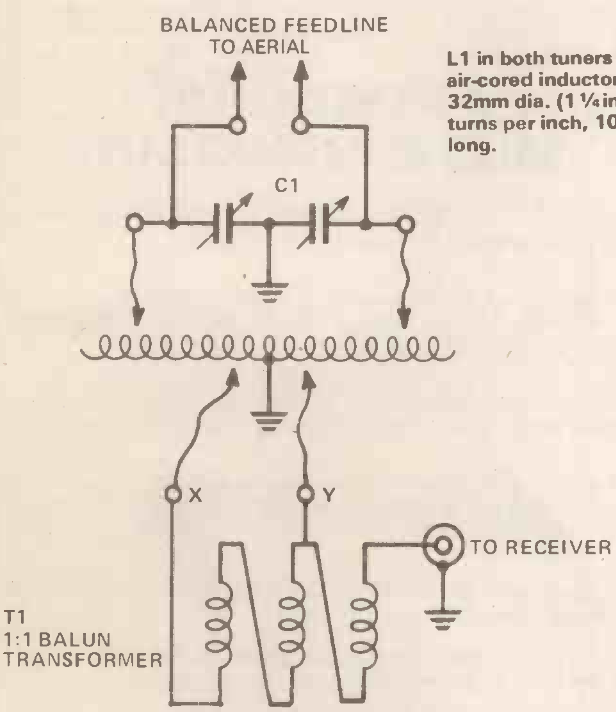


Fig. 1. (a) Circuit of a tuner for a long wire aerial.



(b) Construction of the coil.



L1 in both tuners is an air-cored inductor 32mm dia. (1¼in), 8 turns per inch, 102mm long.

Fig. 2. A balanced aerial tuner.

BALUN

The balun, T1, is a wideband type and is constructed as follows: A dual-hole ferrite core is required.

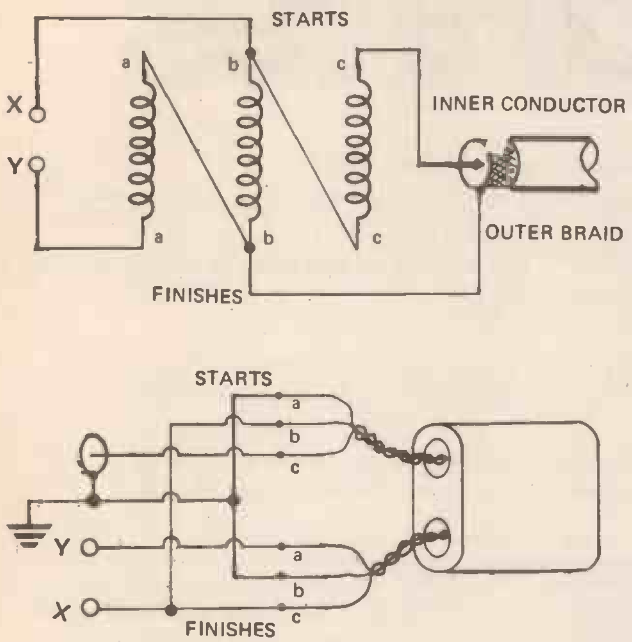


Fig. 3. Construction of the 1:1 balun transformer.

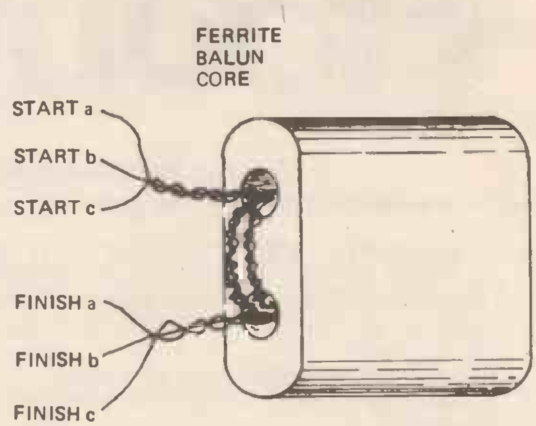


Fig. 4. Connections for 1:1 wideband balun transformer.

Take three 180 mm lengths of light gauge hookup wire or 26 gauge enamelled copper wire and twist them together at about two twists per 10 mm. Wind three turns of the twisted strands through the holes of the core as illustrated in Fig. 3. Identify and mark the three separate wires. Having done this, connect them as shown in Fig. 4. Use a small tagstrip or terminal block to support the joints.

When using the tuner, taps are made symmetrically about the centre-tap of the coil, L1.

The aerial tuners can be constructed in any suitable metal or plastic box. However, if using a metal box, choose one of such a size that the air-cored coil can be mounted at least its own diameter away from any side.

HE

Short Circuit

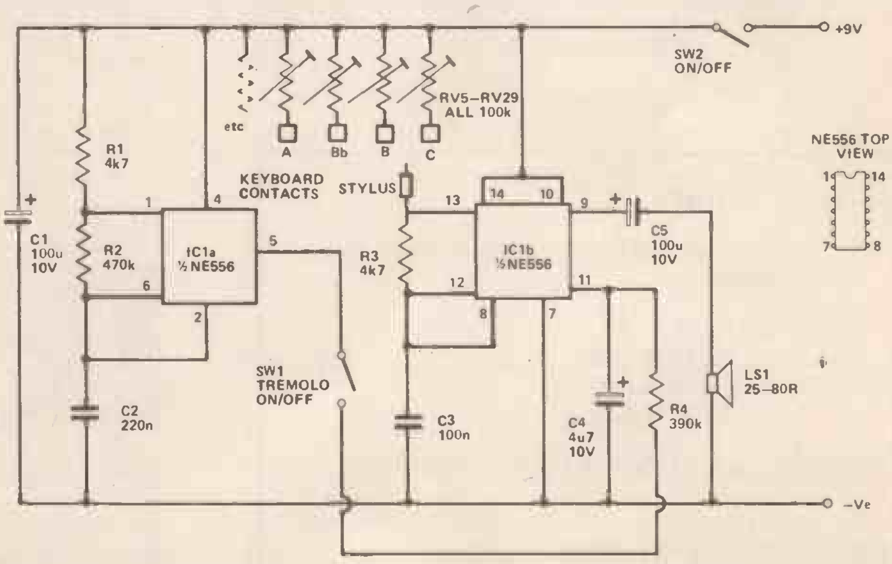
SINGLE IC ORGAN

This single monophonic organ (ie it can only produce one note at a time) is intended to be used with a stylus operated keyboard. This can be made using printed circuit techniques, or it can be made from stripboard etc. if preferred. In fact anything that will provide the necessary 25 connection points will do. The organ covers two octaves including semitones; one either side of middle C. It utilises a 556 dual timer IC which contains two 555 type timer circuits, both of which are used in the astable (oscillator) mode in this circuit.

The right hand section of the circuit is the actual tone generator, and its output feeds a miniature speaker via DC blocking capacitor C5. The frequency of operation is determined by C3, R3 and whichever of the 25 presets (RV5 to RV29) is selected using the stylus and keyboard.

Each preset is tuned to a different note ranging from the C below middle C (130.81 Hz) at RV5 to the C above middle C (523.25 Hz) at RV29. The presets are adjusted to the correct notes by aural means using pitch pipes or a tuned musical instrument to provide the reference notes. When the stylus is not connected to the keyboard the oscillator circuit is not complete and no output is produced.

The tone generator produces a straightforward rectangular waveform which is not particularly musical. Results can be considerably enhanced by slightly frequency modulating the tone generator to produce a tremolo effect and a richer sounding output. It is an easy matter to do this and it is merely necessary to couple a control signal to IC1 pin 11. The low frequency modulating signal (about 4Hz or so) is generated by the other section of the 556. This has its output loosely coupled to the tone generator via R4 and tremolo on/off switch SW1. The squarewave output of IC1a would give a rather abrupt tremelo effect and so C4 is used filter out the high frequency harmonics on the signal so as to give a much smoother and pleasant tremolo effect.



Hobbyprints

An easy, patented method of making PCBs for HE projects.

For some time it has been possible to buy acid resist rub-down pads and track — in fact we use them in the HE workshops and they work very well. HOBBYPRINTS take this idea a stage further — the complete PCB pattern is already on the sheet and can be rubbed down in seconds — and the patterns are nice and crisp, made from the original artwork, used for the prototype.

If you have the facilities for ultraviolet exposure, HOBBYPRINTS make excellent masters — being solid black on a translucent film. With this method you can use the HOBBYPRINTS time and time again!

HOBBYPRINTS are produced exclusively for HE, and the whole system is protected by patents 1445171 and 1445172. Each month we will be bringing out a new HOBBYPRINT, containing the patterns for each issue's projects.

HOBBYPRINT A (November HE)
5 Watt stereo amplifer, Waa-Waa pedal, Bedside radio.
HOBBYPRINT B (December HE)
Digital dice, Photon (2 copies), Metronome, Audio mixer.
HOBBYPRINTS C (January HE)
Graphic Equiliser, Touch switch, Vari-Wiper, Flash Trigger.
HOBBYPRINT D (February HE)
Short Wave Radio, Sine/Square generator, Scratch/Rumble filter, Car Alarm.
HOBBYPRINT E (March HE)
Light Chaser, Photo Timer, Casanova's Candle, (2 copies), Tone Control (2 copies).
HOBBYPRINT F (April HE)
Train controller, Cistern Alarm, Transistor Tester
HOBBYPRINT G (May HE)
Parking meter timer, Digibell, Power supply, Sound effects unit

How to use HOBBYPRINTS.

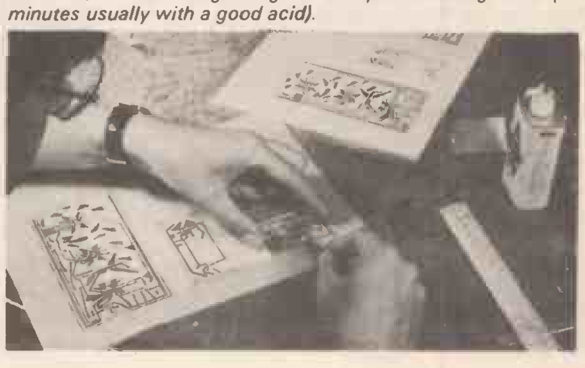
1. Clean the PCB as you would for any work giving it a rub down with fine sandpaper (we even supply this in the kit). A quick wipe over with lighter fuel will help to remove any grease marks.

2. Lay down the HOBBYPRINT and rub over with a soft pencil until the pattern is transferred to the board. Peel off the backing sheet carefully making sure that the resist has transferred. If you've been a bit careless there's even a 'repair kit' on the sheet to correct any breaks!

3. Cut the board to size and put it in the Ferric Chloride.

4. When etching is completed, wash the board and use the sandpaper or a scouring powder to remove the resist. The resist pattern is pretty hardy but is easily removed at the final stage.

5. All you've got to do now is drill the board. Time? Only about ten minutes from beginning to end plus etching time (15 minutes usually with a good acid).



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White Noise Effects Unit

Simulate the soothing sounds of wind, waves and surf on the beach, or the roar of jet aircraft and steam trains, with this HE White Noise Effects Unit.

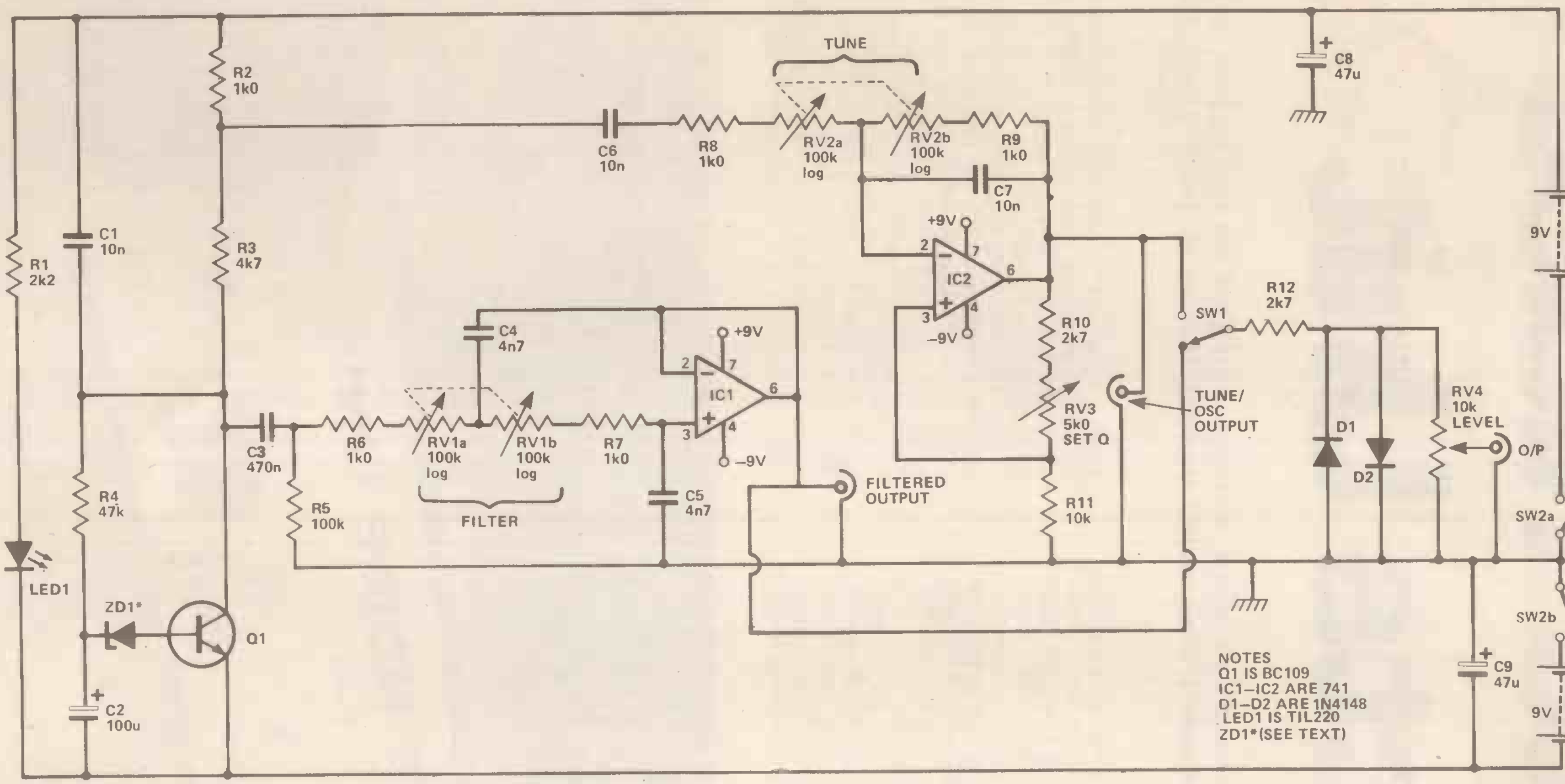
THIS COMPREHENSIVE little unit gives an excellent introduction to special sound effects. It contains a white noise generator, a variable-frequency low-pass filter and a variable-frequency tuned amplifier. This combination enables you to use the HE unit to generate a whole range of interesting sound effects, including those of wind, waves, surf, waterfalls, jumbo jets and 'steam' sounds, etc. As an added bonus, you can also use the unit as a variable-frequency 'tone' generator.

White noise can be simply described as a signal containing a full spectrum of quite randomly generated frequencies or 'tones', all with randomly determined amplitudes, but which have equal mean power when averaged over a reasonable unit of time. The basic sound of white noise resembles that of hissing steam, but this sound can be greatly modified, to give very interesting effects, by passing it through the types of filters that we have used in the HE design.

The HE white noise effects unit is battery powered, and has a panel-mounted LED (light-emitting diode) to indicate the ON state. Variable front-panel controls are provided for the control of the low-pass FILTER frequency, the tuned-amplifier TUNE frequency, the tuned-amplifier SET Q or 'tuning sharpness' adjustment (which also gives the 'tone' generation facility), and for the control of volume or LEVEL.

The unit is provided with three output sockets. The main output is via a mode selector (FILTERED or

White Noise Unit



TUNE/OSCILLATE) switch and the LEVEL control and a pair of amplitude-limiting diodes. Direct outputs are also provided from the two filters for feeding into auxiliary circuits such as mixers, modulators, or envelope generators, to produce more elaborate special effects.

CONSTRUCTION

Most of the circuit is wired up on a single PCB. Follow the overlay carefully, taking special note of the polarities of all semiconductors and electrolytic capacitors. The most important component in the whole unit is the noise generator diode, ZD1. This can either be a selected 'noisy' 5V6 to 10 V zener diode (ones from 'bargain'

How it Works

The heart of the unit is the white noise generator, which is designed around transistor Q1 and zener diode ZD1. This zener diode can either be a specially selected 'noisy' type, with a zener voltage in the range 5V6 to 10 V, or can be a special type-Z5J noise diode. In either case, the device is connected in series with the base of Q1 and is biased into its breakdown region at a low current from a low-impedance source via R4 and C2. Q1 is wired as a common emitter amplifier, with high-frequency roll-off provided by C1. When a reasonably noise component is fitted in the ZD1 position, a noise signal of a few hundred junction of R2 and R3, and is fed on to the variable-frequency tuned amplifier formed by IC2 and its associated components. This amplifier makes use of a Wien tuning network (C6-R8-RV2a and C7-R9-RV2b), and can be tuned over the approximate range 150 Hz to 15 kHz via RV2. The Q or tuning sharpness of the circuit is variable via RV3, and can be varied from 'very low' to 'almost infinite'. When RV3 is set above the 'almost infinite' level IC2 acts as an unregulated tuned oscillator, and generates a rectangular output waveform that is variable from 150 Hz to 15 kHz via RV2: a certain degree packs seem to have a particularly high yield of noisy types), or can be a special type-Z5J noise diode, available from Watford Electronics. When a suitably noisy component is used, the noise signal at the collector of Q1 will have a mean amplitude of a few hundred millivolts RMS.

When construction of the PCB is complete, fit it into a suitable box and complete all interwiring. Then connect the main output of the unit to an audio amplifier, switch on, and listen to the fascinating effects that the unit can generate.

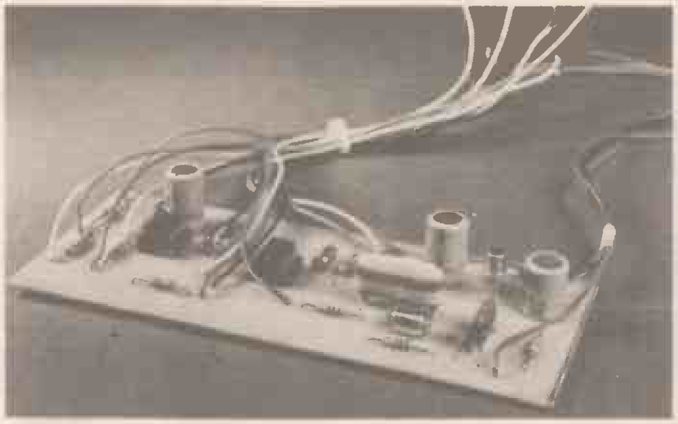
HE

millivolts RMS appears at the collector of Q1.

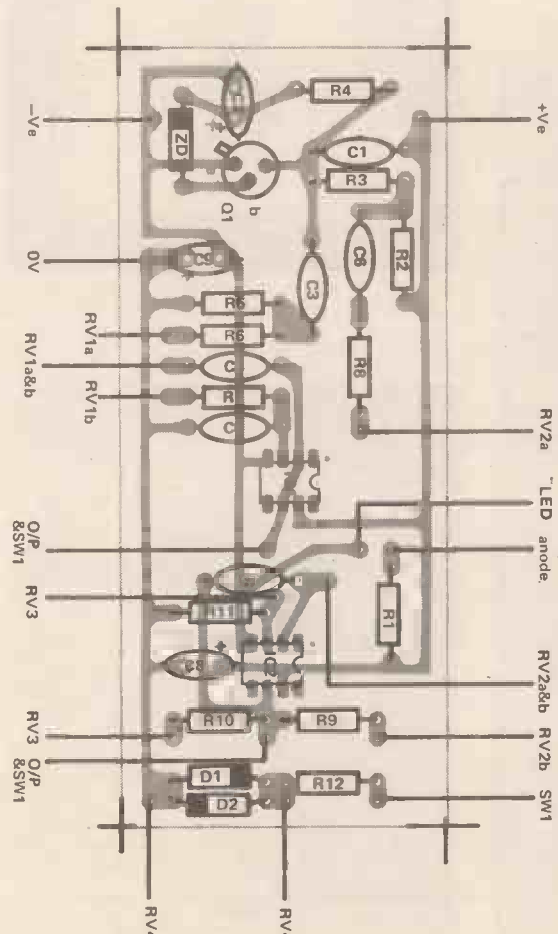
The noise signal from Q1 collector is fed into the variable-frequency low-pass filter formed by IC1 and its associated components. This filter passes all signals below a certain turn-over frequency, but rejects signals above that frequency. The filter is a second-order type, and rejects signals at a rate of 12 dB/octave. The turn-over frequency is variable over the approximate range 220 Hz to 24 kHz via RV1.

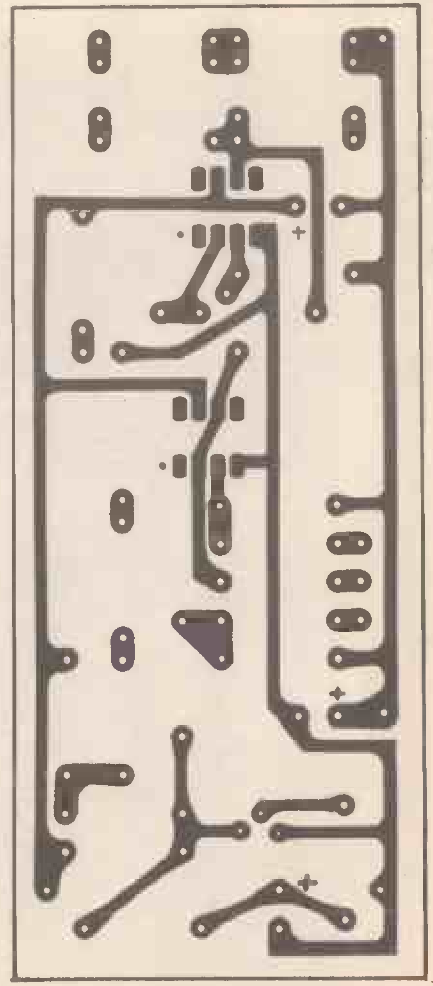
A second noise output is taken from Q1 at the point of interaction occurs between RV2 and RV3.

The outputs of the filter and the tuned amplifier/oscillator are taken directly to their own output sockets, and are taken to a master output socket via selector switch SW1 and LEVEL control RV4. Silicon diodes D1 and D2 are wired across RV4 to limit the peak-to-peak output signal level to about 600 mV, and ensure that cones will not suddenly be blown from their speakers if RV3 is inadvertently set to the 'oscillate' mode.



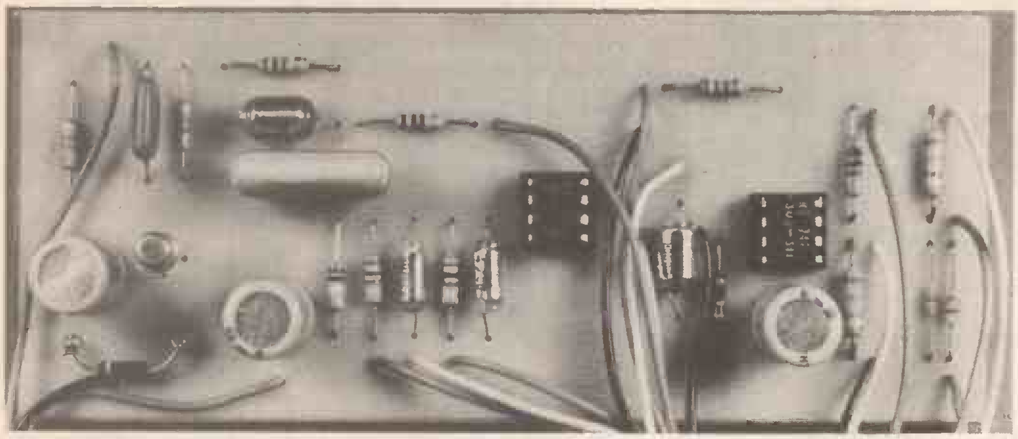
PCB with flying leads, ready for installation.





Parts List

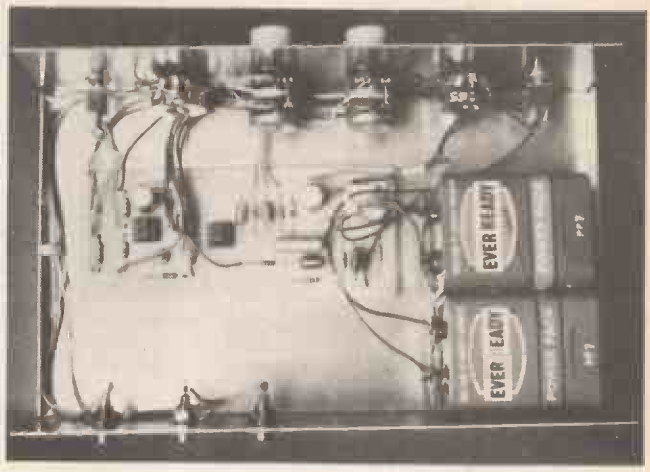
R1	2k2	C3	470n polyester
R2, 6, 7, 8, 9	1k0	C4, 5	4n7 polystyrene
R3	4k7	C6, C7	10n polystyrene
R4	47k	C8, C9	47u electrolytic
R5	100k		
R10, 12	2k7	SEMICONDUCTORS	
R11	10k		
		Q1	BC109
POTENTIOMETERS		D1, D2	IN4148
RV1, 2	Dual Ganged 100k log Carbon,	ZD1	see text
		IC1, IC2	741
RV3	5k0 Lin Carbon	LED	TIL 220
RV4	10k Log Carbon		
		MISCELLANEOUS	
CAPACITORS		3 phone-sockets	
C1	10n polyester	2 PP3 batteries and clips	
C2	100u electrolytic	case to suit	



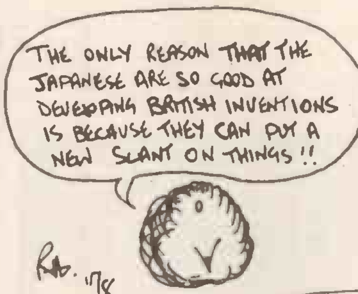
(left) Top view of completed PCB.

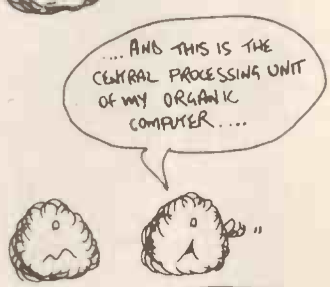
(below right) Internal view of the unit, ready to switch on.

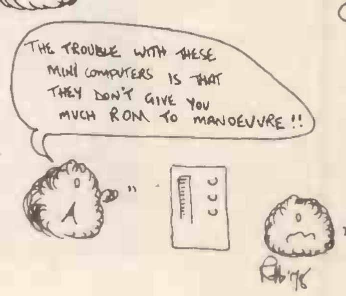
(below left) The front panel lay-out we used on our unit.



HE-HE!







Varicap Diodes

The Varicap Diode is now found in countless pieces of domestic equipment, yet it is probably the most underestimated component on the amateur market, and for no good reason as you will find out.

ONE OF THE VERY satisfying things about the physical sciences is that when a need arises there's very often a device somewhere that's just been discovered and which is the ideal solution to the need. The Varicap Diode is one such device—and its story is rather an interesting one.

Tuning a superhet radio receiver is a fairly simple business, when the frequencies that are being received are in the medium waveband. Frequencies of around 1-2 MHz don't leap easily off each little piece of wire, feeding back to other bits of wire, so that we can afford to be reasonably sloppy with the mechanical design of the tuning stages. The actual tuning can be done either by using ganged variable capacitors, with trimmers to keep the variables in step, or by using ganged variable inductors.

When designers had to cope with the much higher frequencies of Band 1 TV, of 45 MHz upwards, they soon found that the familiar techniques still worked very well. Given a bit more care in arranging the circuit, using a PCB and avoiding long runs of metal carrying signal frequencies, acceptable tuning could be achieved. Even the change to VHF radio at 90 MHz did not require a very great re-think of tuner design.

FREQUENTLY ENCOUNTERED PROBLEMS

Things started to get a bit difficult when Band III at around 200 MHz came into use. At this frequency, the inductance which is needed to resonate with the sort of stray capacity you find in a tuner is rather small and inductance consisting of small pieces of straight wire started to appear. The universal method of tuning was now the turret tuner, in which the 'coils' were carried on a cylinder fitted with contacts so as to act as a larger wafer switch. The contacts on the rotating turret, as this was called, made contact to corresponding studs on a printed circuit board underneath and with careful design, and effective shielding between sections, good results were obtained.

The coming of colour on Bands IV and V signalled the end of this type of construction because stray capacitance simply couldn't be reduced any further except by a fairly radical redesign. The first UHF tuners used conventional continuous tuning, either by ganged variable capacitors or by ganged variable inductors. Performance was generally adequate in strong signal areas, but for several reasons, the conventional methods of tuning fell short of what was expected.

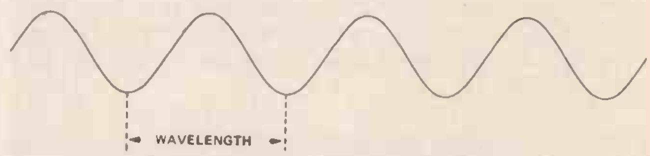


Fig. 1. The wavelength is the distance between neighbouring peaks of the same kind.

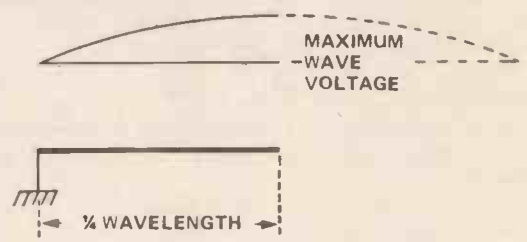


Fig. 2. A conductor earthed at one and will have a maximum signal voltage one quarter of a wavelength from that end.

One of the main problems was interaction. Whenever several tuned circuits are ganged, whether by ganged capacitors or inductors, there must be shafts or other moving parts joining them together. These shafts are usually metal, so that there are conductors which pass through from one section of the tuner to the next. Signals can pass along these shafts even if they are earthed, coupling one piece of the tuner to the next. Signals along earthed metal rods? Yes, because we're talking about signals which have a very short wavelength. For example, the wavelength of a 800 MHz signal in air is 375 mm (Fig. 1). Now if we use a metal bar, earthed at one end, then it is possible to have a signal wave on the bar with the zero voltage part of the wave at the earthed end, but a higher voltage signal at the other. This effect *(a standing wave)* will be particularly serious if the bar length is exactly one quarter wavelength. Quarter of a wave of 800 MHz in air is 93.75 mm, but it's less in a metal rod.

Now we can generally manage to avoid having rods of exactly 93.75 mm long, but there's going to be a part of wave signal on any piece of metal that isn't actually earthed and on any wire that goes to earth, and so on.

There will even be some standing waves in the capacitor plates and in the space inside each compartment of the tuner. The effects on the receiver are dead spots, failure to oscillate at some frequencies, perhaps even unwanted oscillations at some frequencies. What we would like to have is some method of tuning circuits which didn't require any moving parts, as it happened, by the time we really needed it, such a device was available—it's the Varicap Diode.

AN UN-BIASED ANSWER?

A Varicap Diode is, as the name suggests, a diode. When it's connected into a circuit and reverse biased, it has a very high resistance, but there is a capacitance between the anode and the cathode. This capacitance is not a constant—it can be changed by altering the amount of reverse bias. More reverse bias causes less capacitance, and a small reverse bias causes a large capacitance. Typically we get the values of capacitance and bias shown in Fig. 3.

To see why this happens, we need to brush up our knowledge a bit on the junction diode. Junction diodes are formed by growing a piece of P-type silicon over a piece of N-type, or the other way round. P-type silicon conducts because its structure has haps, called holes, which act like positively charged particles. N-type silicon has a crystal in which there are spare electrons, negatively charged, free to move. The names, P-type and N-type, remind us that the particles (carriers) which are free to move are ,respectively, positive holes and negative electrons.

Now we can illustrate what's happening by some simple diagrams in which we indicate only the type of carriers by + or — signs. Using this idea, a junction diode looks something like the diagram of Fig. 4. If we now make connections to the P and N materials, some distance away from the junction, we can connect a battery or some other voltage supply to the diode. This voltage is called a bias voltage, and its effect will be to cause a force on all the carriers. The N carriers are forced along the— to + direction, and the P carriers along the + to — direction by the bias voltage.

Looking at Fig. 5 we can see that if the positive pole of a battery is connected to the N-type material of the junction diode and the negative pole of the battery to the P-type material, the effect of the voltage is to pull the carriers away from the junction where the N-type meets the P-type. This is a reverse-bias, and with this voltage applied, the diode is almost an insulator, with no carriers at the junction. Conversely, if we connect the battery so that the positive pole is on the P-type material and the negative pole on the N-type material, carriers will be pulled across the junction by the voltage and so the diode will conduct. It's the reverse bias that interests us here, though.

It just so happens, any bias voltage less than about 0.5 V doesn't attract carriers across the junction, so that the diode is still slightly reverse biased. As the reverse bias is increased, the N and P carriers each move away from the junction and, of course, from each other. This is the action that we make use of in the varicap diode. It occurs in any junction diode, but the varicap diode has been deliberately designed to make the most of the effect.

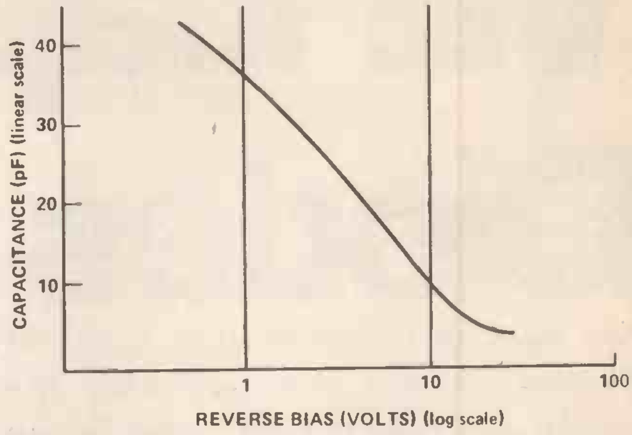


Fig. 3. Typical graph of capacitance against bias voltage for a varicap diode.

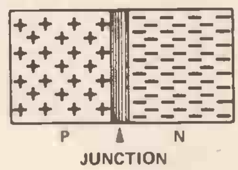


Fig. 4. Representing a junction.

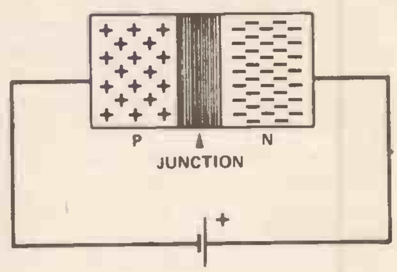


Fig. 5. Reverse-biased junction — the carriers have been pulled away from the junction.

We've known variable capacitors for years. The familiar variable capacitors have plates that slide into mesh with each other (Fig. 6a), but we also use compression trimmers (Fig 6b) in which the capacitance is increased by pressing the conducting plates of the capacitor towards each other. It's this action which is at the heart of the varicap diode. The N and the P-type carriers in a heavily doped semiconductor make the material a good conductor, almost as good as a metal. When a junction is formed, the P-type carriers on one side of the junction behave like a metal plate; the N-type carriers on the other side of the junction behave like another metal plate. What's in between? A piece of silicon with no carriers present, so that it acts as an insulator.

Now two conducting plates separated by an insulator are what we need to form a capacitor, and the size of the capacitance is decided by the area of the junction and the spacing between the two lots of carriers (Fig. 7).

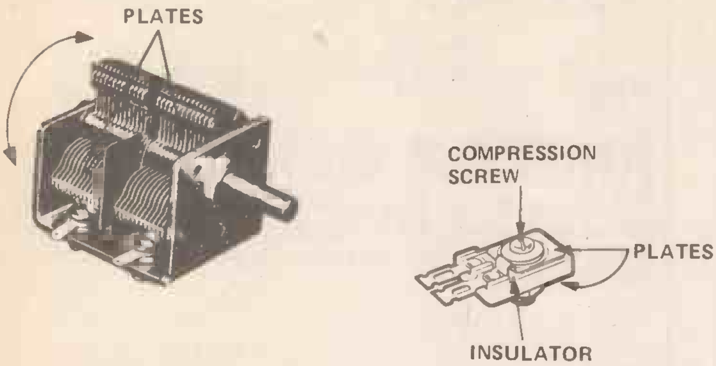


Fig. 6. Variable capacitors — (a) sliding-plate type, (b) compression type.

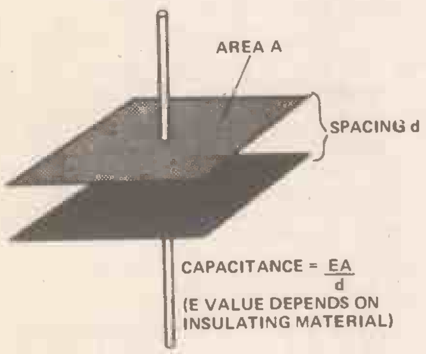


Fig. 7. How capacitance depends on area and spacing.

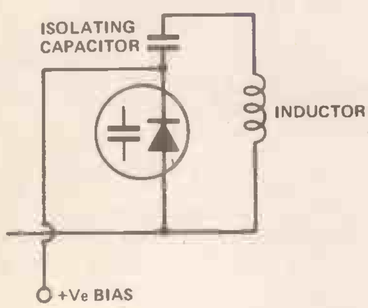


Fig. 8. Using a varicap diode in a circuit.

Once a diode has been formed, the area of the junction is fixed, but the distance between the two sets of carriers is something that we can alter—by changing the amount of reverse bias. At a low figure of reverse bias (0 to +0.4V), the layers of carriers are close to each other, so the capacitance between them is comparatively large. At a high figure of reverse bias (normally up to 30V), the layers of carriers are farther apart, making the capacitance between them much less. This is how the diode can act as a variable capacitance.

APPLICATIONS

How do we use it? The usual way is to use the varicap diode in series with a fixed value of capacitance. This way, we can connect up the bias voltage with no risk of upsetting the DC voltage of any other circuits. The bias supply can be taken through a resistor with decoupling capacitors used to make sure that no signals can pass from one section to another. The really big advantage of the varicap diode is that there's no mechanical movement. Only a DC voltage is needed for changing the capacitance and this can be supplied along a wire (Fig. 8) which can be kept free of signal voltages by using decoupling resistors and capacitors. Once outside the tuner casing, the wire can be of any length, and can be supplied from a potentiometer. We can also make use of automatic tuning, using other circuits to generate the tuning voltages to the varicap diodes.

Most impressive of all, though, is the improvement in tuner performance. We can gang many more circuits together, obtaining sharper tuning, and yet make smaller and more compact tuners. We can also isolate sections of the tuner more efficiently due to the lack of mechanical connections. Construction becomes much simpler, a tuner design which would have been practically impossible using the older techniques is comparatively straightforward when varicaps are used. Wonder what we'll use when TV starts to be broadcast direct from satellites on a one centimetre wavelength?

HE

Model Train Controller:

Improved Overload Trip

HERE'S an interesting follow up to last month's model train speed controller. It's not a constructional project, but the story of how we came to develop a new electronic transformer overload trip for use in possible future projects.

WE PUBLISHED the circuit of a model train speed controller in the April issue of HE. This project used a special type of 'thermal trip' thermistor in the primary leads of its transformer to give full overload protection to the 15 volts AC and the uncontrolled 12 volts DC outputs of the unit.

After that project was published we played with the train controller a little more, and finally decided that we weren't too happy with the action of the trip, mainly because it tended to come on at a lower overload current than we had expected, and because, once it had been tripped, the whole unit had to be switched off for about half a minute to allow the trip to reset itself again. Also, the trip took several milliseconds to activate in the event of a short circuit, and we didn't think that was particularly good.

Our first step in trying to improve the performance of the unit was to wire two of the special trip thermistors in parallel in the primary of the transformer. That raised the overload 'trip' current of the controller to a more satisfactory level, but didn't help with the other two problems. We then took a close look at a commercial model train controller, the Hornby 900, to see how it achieved its overload protection.

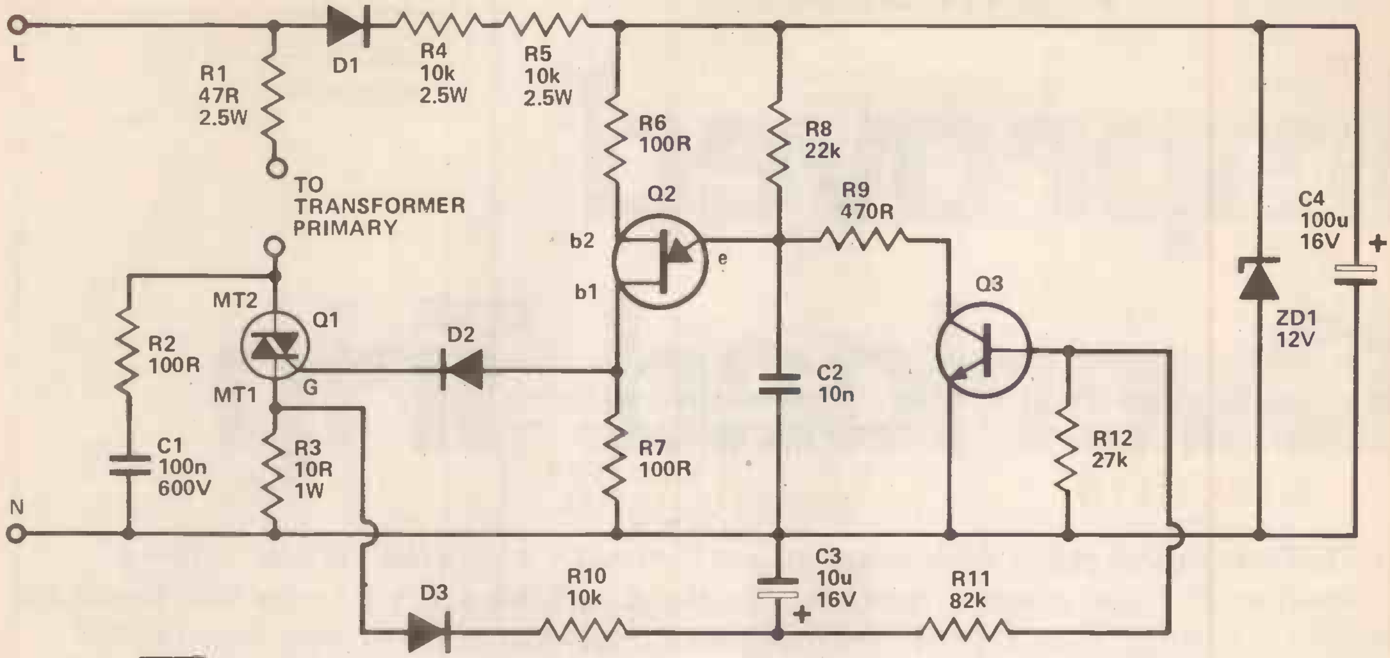
The Hornby system uses two electro-mechanical trips for overload protection. One of these is wired directly in series with the secondary of its transformer and protects the AC output and the other is in series with the output of the rectifiers and protects the two DC outputs. Output currents flow through each trip via a pair of contacts on a bimental strip and via a length of resistance wire that is looped around the bimetal strip. In the event of an overload the resistance wire heats up the bimetal strip, which bends and opens its contacts, thus cutting off the current flow: the bimetal strip then cools down and the contacts close again, reconnecting the output current. The cycle then repeats ad infinitum until the overload is removed.

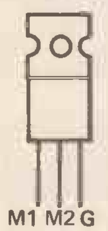
What we don't like about this system is its action in the event of a short-circuited output. The cut-out takes about four seconds to trip in the event of a short. The output in this period is limited only by the losses of the transformer and, on the DC side, by the rectifier. We measured short-circuit AC currents of 10 amps and DC currents of 8 amps on our Hornby unit. Once the Hornby cut-out had tripped, it takes 20 to 30 seconds to reset.

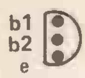
Having looked at the Hornby system, we decided to design an entirely electronic transformer overload protection system that suffered from none of the disadvantages of the two cut-out systems that we had just looked at, with a view to using this new trip in possible future projects in HE and our sister magazine, ETI. This trip was designed to connect to the primary winding of a transformer, and to activate when the secondary load exceeded a VA rating that could be pre-set by a single resistor. Our final design works very well. It activates within less than 10 mS, gives excellent short-circuit current limiting and reconnects power automatically within a few seconds of the overload being removed.

The full circuit of our electronic Transformer Overload Trip is shown in the diagram. We are not presenting this circuit as a constructional project, but as a circuit that is of technical interest and real practical value. If you want to add the unit to your own train controller, you'll have to devise your own constuctional methods. Note, however, that this circuit is connected directly to the mains supply line, which carries potentially (no pun intended) lethal voltages. You have been warned.

Improved Trip







NOTE:
Q1 IS TIC206D
Q2 IS TIS43
Q3 IS BC109C
D1–3 ARE 1N4007

Fig. 1. Circuit for the improved overload trip. This circuit will almost certainly be used in future mains-driven equipment as it offers a high degree of protection against overcurrent and overload conditions.

How It Works

Q1 is a triac or self-latching solid-state bilateral switch. It is wired in series with the transformer (the load) primary, and acts as a closed switch when it is on and as an open switch when it is off. It turns off automatically at the end of each half-cycle of mains voltage, and can be turned on at the startof each half-cycle via unijunction transistor Q2. Resistor R1 is also wired in series with the primary, to limit switch-on surge currents of the transformer to an acceptable level and R3 is used as a current-sensing component for the trip circuitry. The R2-C1 network damps any fast transients that try to appear across the triac.

Unijunction transistor Q2 is powered from a 12 volt DC supply that is derived from the mains line via D1 and R4-R5, and acts as a free-running oscillator that applies a series of 4 kHz trigger pulses to the triac gate via protection diode D2. The unijunction trigger-pulse generator can be turned off by driving Q3 on via its D3-R10-C3-R11-R12 base network. Q3 turns on automatically if the mean 'peak' voltage (ignoring momentary transients) across R3 exceeds approximately 3 volts, e.g. if a peak current of 300 mA or greater flows through R3 when R3 has a value of 10 R. This figure corresponds to a typical primary power rating of about 500 VA, which allowing for transformer losses, corresponds to a secondary power rating of about 30 VA.

Thus, Q1 is normally switched on via Q2 at the start of each half-cycle and acts just like a closed switch that applies power to the transformer primary. In the event of an overload, however, a voltage proportional to the overload current is 'stored' in C3 via R3-D3 and R10 within 2 half-cycles (10 mS) of the overload occuring, and this voltage turns Q2 off via Q3 and prevents Q1 from turning on in following half cycles, thus removing the power connection from the transformer primary. The stored voltage of C3 then leaks away until Q3 turns off and Q2 turns on again, at which point the triac is triggered on again during a half-cycle: if the overload condition is still present the above 'overload' cycle then repeats and the triac acts as an open switch: if the overload has been removed the triac remains on and normal operation resumes.

The circuit thus acts as a precision overload trip that automatically resets itself after a short period of the overload condition being removed.

AD INDEX

Reader's Letters

Please send submissions for the letters page to: Hobby Electronics, 25-27 Oxford Street, London W1. Mark the envelope "Letters Page." Letters which are too long for publication will be suitably edited.

Son Of Cartoons

R. V. Aldridge's comments in the March issue of HE has stimulated quite a response. You may remember he suggested that we 'omit the stupid cartoons and use the space for circuits and more circuits.' Here is just a small sample of the replies we've had. You may think they're a little biased: We would have printed some replies supporting Mr Aldridge, but so far we haven't received any.

Dear Sir,
After reading the letter from R. V. Aldridge in your March issue, I felt compelled to write to disagree with his comments about the cartoons.
I personally enjoy the cartoons enormously and consider that they help make electronics an enjoyable hobby.

D. R. Falkner
Middlesex.

Dear Sir,
I've just read with horror R. V. Aldridge's letter in your March issue. It's the fascinating and informative articles on many subjects plus the spirit of good humour they're written in that makes your magazine so enjoyable.
I would recommend Mr Aldridge to get the book 'A Million Electronic Projects for Morons' by D.R.I. Joint and spend the rest of his life doing them — we won't miss him.

Fred Pearson,
West Yorks.

Dear Sir,
In the March HE R. V. Aldridge suggested that you stop the cartoons in your mag. I for one hope you don't. I enjoy such as the Beasties and think they are well placed at strategic points around your mag.
As for Mr Aldridge's other comments, if he wants 'circuits and more circuits' and no other features, there are plenty of books he can get from the HE Book Service full of them. I myself get the magazines for that special touch.

A. Coverdale,
Cleveland.

Dear Sir,
I am presently taking a degree in electronic engineering and I find the information given in your magazine pleasantly refreshing. In my opinion HE is well presented and the articles are well varied. I don't believe that there is another electronic magazine on the market that includes articles on communications, computers and projects of general interest at such an easily readable level. I find that the theoretical articles are also easily read and aren't so obscure as to be neglected by the average reader.
One criticism — cartoon strips could be used more effectively to break up articles by being larger and better drawn.

Brian Harris,
Chesterfield.

Dear Sir,
I have just bought the April issue of HE specially to read '555 Circuits — This IC timer explored,' as stated on the front cover.
There was no such article inside. Have I been conned? What about the Trades Descriptions Act?

A. Bamber,
Kent.

Mr Bamber's letter is typical of several we've had pointing out our bloomer. Yes, we did advertise "555 Circuits' on the front cover. No, it didn't appear inside. First of all, we apologise to any of you who, like Mr Bamber, weren't able to read this superb feature last month. There seems to have been a breakdown in communication somewhere along the line. All concerned are now tea boys. We hope we've made up for it this month.

Dear Sir,
I have noticed that most of your circuits use the PCB method.
I have constantly tried to make my own circuit boards without success. So could I suggest an article on the construction of PCBs, with the emphasis on the cleaning and marking of the board before etching and also the strength of the ferric chloride solution.
I am sure this would be of interest to many other beginners.

A. Hall,
Renfrewshire.

We couldn't agree more with you. That's why we published a feature entitled 'Make Your Own Printed Circuits' in the December issue of HE. If you want to learn how to make your own PCBs and you missed the December issue (shame on you), a 60p postal order will bring it winging your way.

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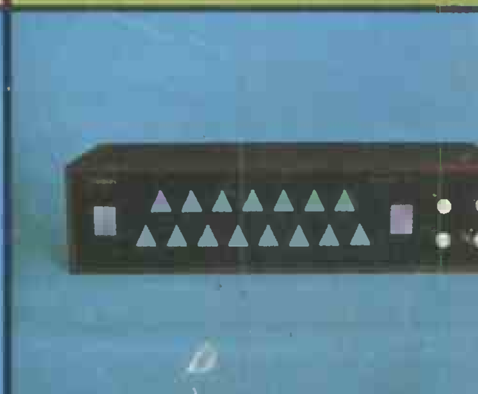

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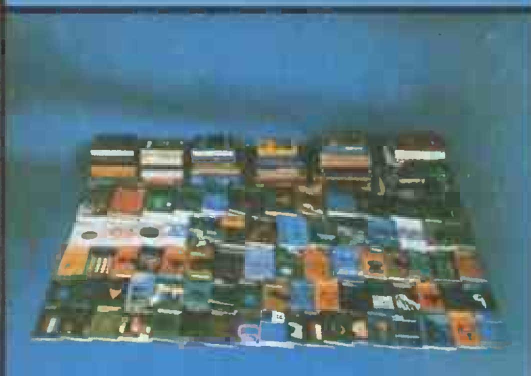

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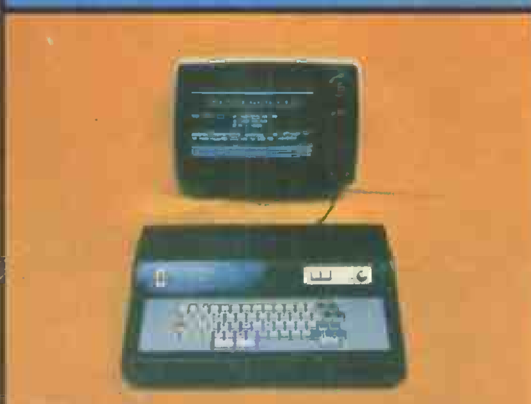

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