ISSN 0142-6192

Hobby Electronics

September '79

45p

Electronic Timekeeping

The HE 'Tantrum'

A treat for jaded ears

Ultrasonic Remote Control

Do it at a distance

Radio Control World

High flyers

Lamp Dimmer

Save it

Starburst

A treat for jaded eyes

Thyristors

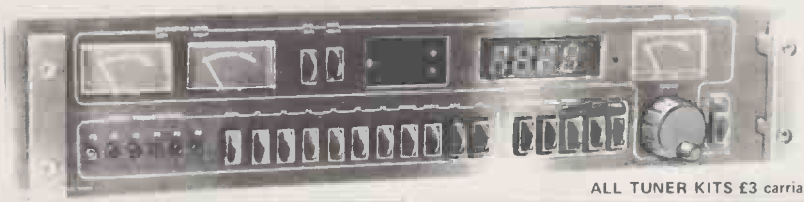
Power control

Tecknowledgey for sale.

The Mark III FM Tuner

DIY Hi-Fi will never seem the same again. Ambit's Mark III tuner system is electrically & visually superior to all others. Some options available, but the illustrated version with reference series modules: £149.00 + £18.62 VAT

With Hyperfi Series modules £185.00 + £23.12



ALL TUNER KITS £3 carriage

Features of the system:

- * Precision construction & design of all parts
- * Time frequency display
- * State of the art performance with facilities for updates, using modular plug in systems.
- * Deviation level calibrator for recording
- * All usual tuner features

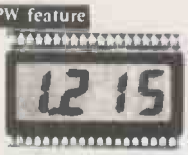
Digital Dorchester All Band Broadcast Tuner: LW/MW/SW/SW/SW/FM stereo

A multiband superhet tuner, constructed using a single IC for RF/IF processing · but with all features you would expect of designs of far greater complexity. The FM section uses a three section (air gang) tuned FET tunerhead, with ceramic IF filters and interstation mute; AM employs a double balanced mixer input stage, with mechanical IF filters · plus a BFO and MOSFET product detector for CW/SSB reception. Styled in a matching unit to the Mark III FM only tuner, employing the same degree of care in mechanical design to enable easy construction. MW/LW reception via a ferrite rod antenna.

Electronics only (PCB and all components thereon)	£33.00 + £4.12 VAT
Complete with digital frequency readout/clock-timer hardware	£99.00 + £12.37 VAT
Complete with MA1023 clock/timer module with dial scale	£66.00 + £8.25 VAT

Hardware packages are available separately if you wish to house your own designs in a professional case structure. Please deduct the cost of electronics from complete prices.

LW/MW/FM LCD Digital Frequency Display - July PW feature



Update your old radio, or build this into a new design. Or use it as a servicing aid · this low power unit with LCD display reads direct frequency in kHz/MHz, or with usual AM/FM IF offsets for received frequency. Low power LCD means no RFI · 15-20mA at 9v even with the divide by 100 prescalar. FM resolution is 100kHz, AM 1kHz. Sensitivities better than 10mV

Complete kit £19.50 +*£1.56 VAT. Built and tested version £24.00 +*£1.92 VAT

Various other DFM systems described in our catalogue part 2 · including a one chip solution to providing digital display of FRG7 kHz dial, combined with clock/timers etc.

PW SANDBANKS PI METAL LOCATOR

Maintaining our professional approach to home constructor kits, we offer the pulse induction 'Sandbanks'. Now with injection molded casing for greatly improved enviromental sealing. £37.00+ *£2.96vat.

VHF MONITOR RX WITH PLESSEY IC

4/9 channel version of the PW design · but using standard 3rd OT crystals, and TOYO 8 pole crystal filter with matching transformers. Coil sets from our standard range to cover bands from 40 to 200MHz. Complete module kit £31.25 +£3.90vat .

ETI · REMCON RADIO CONTROL

A tried and tested RC system with a full set of supporting hardware from a well known manufacturer. Please send for details · and watch our ads for further news of developments in RC products.

Radio and Audio Modules : The biggest range/ best specs:

EF5801/3/4 6 stage varicap tunerheads with LO feed and various levels of sophistication. New 5804 include pin AGC loop 'on board'. 5801:£17.45+£2.18vat · 5803:£19.75+£2.47vat 5804:£24.95 +£3.18vat. *Frequencies in 40-180MHz on appcn.*

EF5402 4 stage varicap with TDA1062, compound FET/Bipolar input stage, low noise, balanced mixer, pin agc, osc output. A worthy successor to the 5400. £10.75+£1.34vat

The 5402 is available centred on a wide range of frequencies from 30MHz to 180MHz. Non standard units £14.75+£1.84 · 3 weeks.

8319 4 stage varicap tunerhead from Larsholt using MOSFET RF and mixer stages. New temperature compensated oscillator for wide ranges of ambient temperature £13.45+£1.68vat

7252 Complete Larsholt FM tuner less stereo decoder. £26.50+£3.31vat

7253 Stereo FM tunerset from Larsholt with FET head. (as 7252)

944378 Hyperfi stereo decoder. The very best. £19.95+£2.49vat

911223 Pilot cancel stereo decoder, priced to make the MC1310 as obsolete as it now deserves to be.£12.50+£1.56vat

Inotec 1 A fully DC tuned and switched LW/MW/FM stereo tuner to interface with synthesiser control etc.A first! Details OA

COMPONENTS for Radio and Audio ICs, HMOS etc.

The list is too long to attempt here, but AMBIT specializes in all types of semiconductor for radio reception, including devices operating from DC to 5GHz. New low cost SBL1 diode ring mixers (equiv case MD108 etc) -first with HMOS fets, now with a PCB for DC amplifier, and offset sense and protection relay for speakers. See catalogue and updates for most info, pse send an SAE for information on anything you cannot find in catalogues.

Radio ICs	cost	+ vat	Stereo ICs	cost	+ vat	AF power ICs	cost	+ vat
CA3089E	1.94	24	MC1310P	1.50	19	LM380N	1.00	12
CA3189E	2.45	30	uA758	2.20	27	TBA810AS	1.09	14
HA1137W	2.20	27	CA3090A	2.75	34	TDA2002	1.95	24
SN76660	0.75	9	HA1196	3.95	49	TBA820M	0.75	9
TDA1090	3.35	42	HA11223	4.35	54			
TDA1083	1.95	24	KB4437	4.35	54			
TDA1220	1.40	17	KB2224	2.75	34			
SL6640	2.75	34	Preamp ICs/switches					
MC3357	3.12	39	TDA1028	3.50	44			
HA1197W	1.40	17	TDA1029	3.50	44			
MC1496	1.25	16	TDA1074	4.14	52			
LM373/4	3.75	49	KB4438	2.22	28			

from the general list:
LEDs:all colours and low prices
2SJ48/2SK134 HMOS 9.90 +£0.80 vat(Pair)
Signal fets/transistors and TOKO COILS & FILTERS!

OSTS: Remember all OSTS stocks are obtained from BS9000 approved sources · your assurance that all devices are very best first quality commercial types. Some LPSN TTL is presently in great demand, so please check by phone before ordering .

TTL:Standard AND LP SchottkY

All prices listed in pence *

	'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		124	74132	73	78	74190	115	92	74379	130
7403	14	20	7470	28		74133		29	74191			74368	37
7404	14	24	7472	28		74136		40	74192	105	180	74390	140
7405	18	26	7473	32	38	74138		60	74193	105	180	74393	140
7406	38		7474	27	38	74139		60	74194	105	187	74395	139
7407	38		7475	38	40	74141	56		74195	95	137	74396	133
7408	17	24	7476	37	38	74142	265		74196	99	110	74398	180
7409	17	24	7478		38	74143	312		74197	85	110	74399	150
7410	15	24	7480	48		74144	312		74198	150		74445	92
7411	20	24	7481	86		74145	65	97	74199	160		74447	90
7412	17		7482	69		74147	175		74247		90	74490	140
7413	30		7483A		110	74148	109	191	74248		90	74668	110
7414	51		7484	97		74150	99		74249		93	74670	249
7415		24	7485	104	99	74151	64	84	74251		90		
7416	30		7486		40	74153	64	54	74253		105		
7417	30		7489	205		74154	96		74257		108		
7420	16	24	7490	33	90	74155	54	110	74258		153		
7421	29	24	7491	76	110	74156	80	110	74259		420		
7422	24	24	7492	38	78	74157	67	55	74260		153		
7423	27		7493	32	99	74158		60	74261		353		
7425	27		7494	78		74159	210		74266		40		
7426	36	27	7495A	65	99	74160	82	130	74273		124		
7427	27	29	7496	58	120	74161	92	78	74275		312		
7428	35	32	7497	185		74162	92	130	74279		52		
7430	17	24	74100	119		74163	92	78	74283		120		
7432	25	24	74104	63		74164	104	130	74290		90		
7433	40	32	74105	62		74165	105		74293		95		
7437	40	24	74107	32	38	74166			74295		120		
7438	33	24	74109	63	38	74167	20		74298		100		
7440	17	24	74110	54	54	74168			74324		157		
7441	74		74111	68		74169		200	74325		242		
7442	70	99	74112		38	74170	230	200	74326		247		
7443	115		74113		38	74172	625		74327		237		
7444	112		74114		38	74173	170		74352		100		
7445	94		74116	198		74174	87	120	74353		100		
7446	94		74118	83		74175	87	110	74362		715		
7447	82	89	74119	119		74176	75		74365		49		
7448	56	99	74120	115		74177	78		74366		49		
7449		99	74121	25		74180	85		74367		43		
7450	17		74122	46	57	74181	165	350	74368		49		
7451	17	24	74123	48	73	74182	160		74373		77		
7453	17		74124		137	74183		210	74374		77		
7454	17	24	74125	38	44	74184	135		74375		60		

ALL PRICES EXCLUSIVE OF VAT — VAT AT 15%

VOLTAGE /PSU REGULATORS

7800 series	95p
7900 series	£1
78M series (TO220 pack)	90p
78LCP series	35p
78MGT2C	175p
79MGT2C	175p
723C	65p
NE550A	73p
L200	195p

MAINS FILTERS

1Amp IEC	4.83
6Amp IEC	5.83
5A wirein	3.87

All BS approved

Requests for the next issue of the catalogue now being "booked" for despatch immediately it is ready (about November). Please send 50p to reserve a copy. (Part 3)

IMPORTANT: ALL OSTS PRICES EXCLUDE VAT · CURRENTLY 8% · BUT MAY BE CHANGED BY THE TIME YOU READ THIS. PLEASE REMEMBER TO ADD VAT, and 25p POSTAGE !!

CD4000 CMOS

4000	17p	4059	563p	4522	149p
4001	17p	4060	115p	4527	157p
4002	17p	4063	109p	4528	102p
4006	109p	4066	63p	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
4014	95p	4075	20p	4541	141p
4016	52p	4076	90p	4543	174p
4017	80p	4077	20p	4549	399p
4018	80p	4078	20p	4553	440p
4019	60p	4081	20p	4554	153p
4020	93p	4082	20p	4556	77p
4021	82p	4085	82p	4557	386p
4022	90p	4086	82p	4558	117p
4023	17p	4089	150p	4559	388p
4024	76p	4093	50p	4560	218p
4025	17p	4094	190p	4561	65p
4026	180p	4096	105p	4562	530p
4027	55p	4097	372p	4566	159p
4028	72p	4098	110p	4568	281p
4029	100p	4099	122p	4569	303p
4030	58p	4160	90p	4572	25p
4031	250p	4161	90p	4580	600p
4032	100p	4162	90p	4581	319p
4033	145p	4163	90p	4582	164p
4034	200p	4174	104p	4583	84p
4035	120p	4175	95p	4584	63p
4036	250p	4194	95p	4585	100p
4037	100p	4501	23p		
4038	105p	4502	91p		
4039	250p	4503	69p		
4040	83p	4506	51p		
4041	90p	4507	55p		
4042	85p	4508	248p		
4043	85p	4510	99p		
4044	80p	4511	149p		
4045	150p	4512	98p		
4046	130p	4513	206p		
4047	99p	4514	260p		
4048	60p	4515	300p		
4049	65p	4516	125p		
4050	55p	4517	382p		
4051	65p	4518	103p		
4052	65p	4519	57p		
4053	65p	4520	109p		
4054	120p	4521	236p		
4055	135p				

Micromarket

6800 series					
6800P	6.50	8216	1.95	2114	£10
6820P	£6	8224	3.50	2708	£[illegible]
6850P	2.75	8228	4.78	**Development**	
6810P	£4	8251	6.25	MEK6800	£220
6852	3.65	8255	5.40	TK80	£306
8080 series		**MEMORIES**		AMI, Supertics TI, Intersil, Harris etc	OA
8080	6.30	2102	£1 70		
8212	2.30	2112	£3 40		
		2513	£7.54		
		4027	£5 78		

MISC. LSI/Scalars/DVMs

NE555 30p NE556 78p NE558 180p
LM3909 72p 95H90DC /320MHz 7 80p
11C90DC /650MHz £14 00
ICM7216B1PI 8 decade 10MHz DFM/timer with direct LED drive and all counter features £19.82
ICM7217AIBI 4 decade programmable cntr £9.50
ICM7207 clock pulse generator IC £4.95
ICM7208 7 decade counter/display driver £14.95
ICM7106CP LCD DVM IC (3½ digit) £9 55
ICM7106CPK LCD DVM KIT £24 80
ICM7107CP LED DVM IC £9 55
ICM7107CPK LED DVM KIT £20 65
SP8629 divide by 100/200MHz scalar £4 20
MSL2318 divide by 100 to 175MHz min divide by 10 to 45MHz min £4.20

PLEASE REMEMBER TO AOD 8% VAT TO ITEMS LISTED UNDER OSTS

LINEARS non-consumer

BIMOS			
CA3130E	84p	LM324N	71p
CA3130T	90p	LM339N	66p
CA3140E		LM348N	186p
CA3140T	72p	LM3900N	60p
CA3160E	90p	709HC to5	64p
CA3160T	99p	709PC dil	36p
Op amps		710HC to5	65p
LM301AH	67p	710PC dil	59p
LM301AN	30p	723CN	65p
LM308H	121p	741CH to5	66p
LM308N	97p	741CN 8dil	27p
LM318H	279p	747CN	70p
LM318N	224p	748CN	36p
		NE531T	120p
		NE531N	105p

OPTO 7 seg displays

0.43" High Efficiency HP: 233p

5082 7650 red CA
5082 7653 red CC
5082 7660 yellow CA
5082 7663 yellow CC
5082 7670 green CA
5032 7673 green CC

0.3" Standard HP 147p

5082 7730 red CA
5082 7740 red CC

0.5" Fairchild

FND500 red CC 150p
FND507 red CA 150p

Current news: Work continues apace on our HMOS PA kit, and by the time this is published · we expect to be about to launch the product in a style that matches the Mark III system. The unit uses separate transformers and power supplies, and includes a DC offset sensing circuit combined with slow switch-on using a relay. We introduce the HyperFi FM IF with this advert · and a separate leaflet is available on request with an SAE. All new pricelist revision also available with an SAE. The Mullard DC controlled tone/volume and switch ICs with a 'more than HiFi' specification are in stock at last · together with reams of data (over 50 pages now). Also, RC enthusiasts will be interested to learn that we are supplying parts for various kits now.

Terms: CWO please. Account facilities for commercial customers OA. Postage 25p per order. Minimum credit invoice for account customers £10.00. Please follow instructions on VAT, which is usually shown as a separate amount. Overseas customers welcome · please allow for postage etc according to desired shipping method. Access facilities for credit purchases.

Catalogues: Ambit. Part 1 45p. Part 2 50p 90p pair. TOKO Euro shortform 20p. Micrometals toroid cores 40p. All inc PP etc. Full data service described in pricelist supplements.

Hours/phone: We are open from 9am -7pm for phone calls. Callers from 10am to 7pm. Administrative enquiries 9am to 4.30pm please (not Saturdays). Saturday service 10am to 6pm.

AMBIT catalogues are guaranteed to contain the most up-to-date and best informed comment on modern developments and advances in the field of radio and audio. There is no competetive publication that even approaches the broad range of parts/information on modern techniques.

ambit® international

2 Gresham Road, Brentwood, Essex.

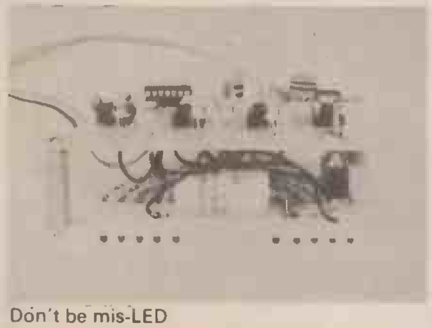
Hobby Electronics

Vol. 1. No. 11 September 1979

TANTRUM

We apologise to readers for the delay in publishing the Tantrum Stereo Amplifier, this was due to production difficulties and will be appearing next month.

The state of the gate

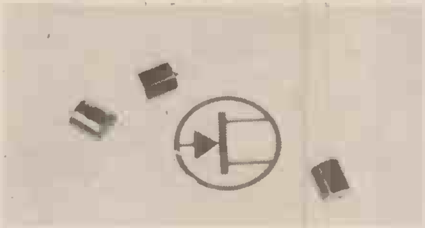


Don't be mis-LED

Get turned on

Plane and simple

Dog Whistle?



The source of the drain

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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

		Ripple 1A @ 85°C	1.4A @ 50°C	
2200 µF	16V	1A	1.4A	166
4700 µF	16V	2.6A	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		5		
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	8		
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			

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					

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							

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		

Trimmers — Order Code
250V D.C. Wkg. Film Dielectric, Miniature

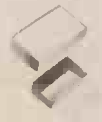
1.4 – 4.1pF	19	Cap 808 A
2 – 8pF	19	Cap 808 B
2 – 20pF	21	Cap 808 C
5.5 – 59.5pF	29	Cap 808 D

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

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

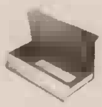


		Order Code
W161, D96, H39 (57)	186	Case BIM1005 OR
W215, D130, H47 (73)	268	Case BIM1006 OR

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

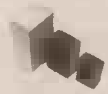
		Order Code
L112 W62 D31	87	Case BIM2003 OR
L150 W80 D50	115	Case BIM2005 OR
L190 W110 D60	195	Case BIM2006 OR

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.

F.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; 6.5V, 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 RO¼
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

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DIGITAL INTEGRATED CIRCUITS

4000 Buffered C-MOS — High Speed

5 -15V 'B' Series, Up to 20MHz

HEF4000	14	HEF4046	100	HEF4514	250
HEF4001	14	HEF4047	87	HEF4515	299
HEF4002	14	HEF4049	28	HEF4516	90
HEF4006	95	HEF4050	28	HEF4517	382
HEF4007	14	HEF4051	69	HEF4518	69
HEF4008	80	HEF4052	72	HEF4519	55
HEF4011	14	HEF4053	72	HEF4520	65
HEF4012	14	HEF4066	37	HEF4521	188
HEF4013	32	HEF4067	380	HEF4528	99
HEF4014	84	HEF4068	14	HEF4532	120
HEF4015	60	HEF4069	14	HEF4534	510
HEF4016	35	HEF4070	14	HEF4539	110
HEF4017	55	HEF4071	14	HEF4543	155
HEF4018	65	HEF4072	16	HEF4555	78
HEF4019	46	HEF4073	16	HEF4556	78
HEF4020	88	HEF4075	16	HEF4557	386
HEF4021	85	HEF4076	85	HEF4585	97
HEF4022	82	HEF4077	14	HEF4724	171
HEF4023	14	HEF4078	16	HEF40097	90
HEF4024	45	HEF4081	16	HEF40098	73
HEF4025	14	HEF4082	16	HEF40106	62
HEF4027	32	HEF4085	64	HEF40160	119
HEF4028	52	HEF4086	64	HEF40161	119
HEF4029	60	HEF4093	50	HEF40162	119
HEF4030	46	HEF4094	175	HEF40163	119
HEF4031	200	HEF4104	166	HEF40174	119
HEF4035	110	HEF4502	91	HEF40175	119
HEF4040	68	HEF4505	571	HEF40192	140
HEF4041	75	HEF4508	51	HEF40193	140
HEF4042	54	HEF4510	70	HEF40194	119
HEF4043	79	HEF4511	110	HEF40195	117
HEF4044	84	HEF4512	98		

7400 T.T.L.

N7400N	9	N7444N	83	N74122N	39	N74190N	60	N74LS28N	32	N74LS138N	85	N74LS253N	105
N7401N	11	N7445N	65	N74123N	37	N74194N	80	N74LS30N	16	N74LS139N	85	N74LS257N	104
N7402N	11	N7446AN	62	N74125N	32	N74195N	79	N74LS32N	24	N74LS153N	76	N74LS258N	107
N7403N	11	N7447AN	51	N74126N	32	N74198N	120	N74LS33N	32	N74LS154N	122	N74LS260N	26
N7404N	12	N7448AN	44	N74128N	74	N74199N	139	N74LS37N	24	N74LS155N	80	N74LS261N	300
N7405N	12	N7450N	13	N74132N	46	N74221N	160	N74LS38N	24	N74LS156N	80	N74LS266N	40
N7406N	25	N7451N	13	N74145N	60	N74279N	116	N74LS40N	22	N74LS157N	54	N74LS273N	130
N7407N	27	N7453N	15	N74147N	125	N74298N	200	N74LS42N	53	N74LS158N	60	N74LS283N	116
N7408N	13	N7454N	13	N74148N	83	N74365N	150	N74LS51N	22	N74LS160N	120	N74LS290N	90
N7409N	13	N7460N	13	N74150N	65	N74366N	150	N74LS54N	16	N74LS161N	78	N74LS293N	100
N7410N	11	N7470N	26	N74151N	46	N74367N	120	N74LS55N	22	N74LS162N	130	N74LS298N	100
N7411N	18	N7472N	22	N74153N	55	N74368N	150	N74LS73N	29	N74LS163N	78	N74LS324N	170
N7412N	17	N7473N	23	N74154N	96			N74LS75N	40	N74LS164N	90	N74LS365N	105
N7413N	23	N7474N	23	N74155N	53	**74LS**		N74LS76N	33	N74LS170N	200	N74LS366N	105
N7414N	46	N7475N	28	N74156N	48			N74LS78N	33	N74LS173N	100	N74LS367N	105
N7416N	22	N7476N	26	N74157N	49	N74LS00N	15	N74LS83AN	97	N74LS174N	100	N74LS368N	105
N7417N	23	N7480N	43	N74158N	54	N74LS01N	16	N74LS85N	70	N74LS175N	100	N74LS373N	150
N7420N	11	N7483N	63	N74160N	74	N74LS02N	16	N74LS86N	33	N74LS181N	320	N74LS374N	150
N7421N	26	N7485N	65	N74161N	74	N74LS03N	16	N74LS90N	45	N74LS190N	91	N74LS375N	100
N7425N	27	N7486N	23	N74162N	74	N74LS04N	16	N74LS92N	70	N74LS191N	95	N74LS378N	160
N7426N	22	N7490N	30	N74163N	74	N74LS05N	23	N74LS93N	45	N74LS192N	128	N74LS386N	35
N7427N	22	N7491AN	60	N74164N	85	N74LS08N	16	N74LS95BN	65	N74LS193N	130	N74LS390N	170
N7428N	30	N7492N	33	N74165N	65	N74LS09N	22	N74LS96N	116	N74LS194N	150	N74LS393N	170
N7430N	11	N7493N	31	N74166N	93	N74LS10N	16	N74LS107N	38	N74LS195AN	120	N74LS395N	180
N7432N	21	N7494N	74	N74170N	134	N74LS11N	22	N74LS109N	38	N74LS196N	80	N74LS490N	130
N7433N	30	N7495AN	48	N74173N	111	N74LS12N	23	N74LS112N	40	N74LS197N	110	N74LS670N	170
N7437N	21	N7496N	46	N74174N	63	N74LS13N	38	N74LS113N	38	N74LS240N	160		
N7438N	21	N74100N	88	N74175N	62	N74LS14N	74	N74LS114N	38	N74LS241N	160		
N7439N	60	N74107N	25	N74180N	80	N74LS15N	24	N74LS125N	40	N74LS242N	160		
N7440N	12	N74109N	42	N74181N	165	N74LS20N	16	N74LS126N	40	N74LS243N	160		
N7442N	40	N74116N	148	N74182N	69	N74LS21N	22	N74LS132N	60	N74LS244N	160		
N7443N	79	N74121N	23	N74192N	65	N74LS22N	24	N74LS136N	37	N74LS251N	90		

LINEAR INTEGRATED CIRCUITS

CA3011	92
CA3018	75
CA3020	191
CA3028A	86
CA3046	76
CA3048	245
CA3080E	70
CA3089E	253
CA3130E	90
CA3140E	38
CA3189E	266
LM301AN	30
LM308N	95
LM318N	200
LM319N	216
LM324N	70
LM339N	71
LM381N	110
LM381AN	180
LM382	120
MC1458N	35
MC1496N	97
NE531	119
NE536T	216
NE540	225
NE555N	25
NE556N	60
NE560N	351
NE561N	427
NE562N	461
NE565N	120
NE566N	155
NE567N	170
NE570N	405
NE571N	459

NE592K	162
RC4136	130
TBA120S	79
TCA580	346
TCA730	450
TCA740	450
TDA1008	326
TDA1022	648
TDA1028	338
TDA1029	338
TDA1034B	217
TDA2581	266
TDA2640	292
TL081CP	75
TL084CN	140
UA709CT	46
UA709CN	40
UA710CN	41
UA711CN	65
UA741CT	42
UA741CN	18
UA747CN	50
UA748CN	35

Voltage Regulators

LM309DA (K)	108
UA723CN	38
UA7805CU	65
UA7812CU	65
UA7815CU	65
UA7905CU	86
UA7912CU	86
UA7915CU	86
UA78L05CS	32
UA78L06CS	32
UA78L12CS	32
UA78L15CS	32

OPTO ELECTRONICS

Light Emitting Diodes, Individual

			Order Code
.125" (3mm)	Red	14	CQY54
	Green	17	CQY95
	Yellow	19	CQY97
Panel Mounting Clip to suit.		3	LED3 Clip
.2" (5mm)	Red	15	CQY24A
	Green	17	CQY94
	Yellow	19	CQY96
Panel Mounting Clip to suit.		5	LED5 Clip

Light Emitting Diodes — 7 Segment Display

.3" (7.6mm)	C. Anode R.H. Decimal Pt. Red	160	XAN3061
	C. Anode R.H. Decimal Pt. Green	199	XAN3051
	C. Cathode R.H. Decimal Pt. Red, Low current drain	160	XAN3074
.6" (15.2mm)	C. Anode L.H. Decimal Pt. Red	230	XAN6620
	C. Anode L.H. Decimal Pt. Green	230	XAN6520
	C. Cathode L.H. Decimal Pt. Red	230	XAN6640

Photoresistors

ORP12	90	ORP12
ORP61	90	ORP61

Phototransistors

OCP71	180	OCP71
BPX25	175	BPX25
BPX29	175	BPX29

Photocoupler

FCD820	150	FCD820

SWITCHES

Miniature Toggle — Honeywell

				Order Code
SPDT		2A/250V A.C., 5A/28V D.C.	58	SW 8A1011
SPDT	C/Off		67	SW 8A1021
SPDT	Double Bias To Centre		75	SW 8A1041
SPDT	Single Bias To Centre		75	SW 8A1051
SPDT	Bias		70	SW 8A1061
DPDT			86	SW 8A2011
DPDT	C/Off		92	SW 8A2021
DPDT	Double Bias To Centre		102	SW 8A2041
DPDT	Single Bias To Centre		102	SW 8A2051
DPDT	Bias		96	SW 8A2061

Miniature Push — C & K

SP	Push To Make, Momentary	0.5A/250V A.C., 1A/28V D.C.	54	SW 8531
SP	Push To Break, Momentary		54	SW 8533

Slide — Switchcraft

DPDT	Standard Actuator	36	SW 46206
DPDT	Slot Actuator, Voltage Change, Marked 110/240	43	SW 46206F

SEMICONOUCTORS

Diodes

IN827	193	IN4006	7	BB110G	61	OA202	9
IN914	4	IN4007	8	BY127	15		
IN916	5	IN4148	3	BY206	34		
IN4001	4	IN5402	15	BYX10	19	**Microwave**	
IN4002	4	IN5404	16	OA47	10		
IN4003	6	9AX13	5	OA90	7	BAW95D	1091
IN4004	6	BAY38	27	OA91	7	CL8960	2592
IN4005	7	BB106(4)	172	OA200	9	CXY11C	1280

Zener Diodes

400mW C4V7-C33
BZY88/BZX79 + Voltage 8

1.3W C7V5-C75
BZX61 + Voltage 16

Transistors

2N929	37	2N4427	206	BC478	24	BSX88	18
2N1893	30	2N4856	158	BC547	12	MJE340	48
2N2218A	28	2N4858	134	BC548	10	MPF102	32
2N2222	21	2N4860	122	BC548B	15	OC28	107
2N2369	19	2N5294	43	BC549	12	OC35	95
2N2369A	20	2N5416	108	BC549B	20	OC45	82
2N2646	42	2N5457	35	BC557	14	OCP71	180
2N2894	49	2N5458	30	BC558	14	TIP29A	41
2N2895	28	2N5459	32	BC559	17	TIP29C	53
2N2904	24	2N6258	432	BCY34	97	TIP30A	44
2N2904A	24	40673	80	BCY70	14	TIP30C	57
2N2905	22	AC188	22	BCY71	14	TIP31A	43
2N2905A	24	AD161	38	BCY72	15	TIP31C	58
2N2906	19	AD162	38	BD131	35	TIP32A	49
2N2907	22	BC107	10	BD132	35	TIP32C	63
2N2907A	25	BC107B	14	BD135	38	TIP41A	59
2N2918	330	BC108	10	BD136	37	TIP41C	69
2N2926G	11	BC108B	14	BD137	38	TIP42A	59
2N3053	17	BC108C	16	BD138	39	TIP42C	69
2N3054	50	BC109	10	BD139	35	TIP2955	68
		BC109B	17	BD140	35	TIP3055	54
2N3055	50	BC109C	18	BF115	28	TIS43	32
2N3055		BC147	7	BF180	37	ZTX109C	14
Full ISB Test	86	BC148	9	BF181	37		
2N3340	30	BC149	8	BF257	35		
2N3442	141	BC157	10	BF258	32		
2N3702	8	BC158	9	BF259	36		
2N3703	11	BC159	11	BFR90	303		
2N3704	8	BC177	15	BFS21	428		
2N3705	9	BC178	15	BFX13	23		
2N3706	9	BC179	18	BFX84	26		
2N3707	9	BC182	10	BFX85	26		
2N3708	9	BC182L	11	BFX86	30		
2N3709	11	BC183	10	BFX87	22		
2N3773	270	BC183L	11	BFX88	26		
2N3819	20	BC184	10	BFY50	15		
2N3820	39	BC184L	11	BFY51	15		
2N3866	97	BC212	10	BFY52	18		
2N3903	20	BC212L	11	BFY90	97		
2N3904	8	BC213	10	BLX65	238		
2N3905	12	BC213L	11	BLY35	1889		
2N3906	12	BC214	10	BLY93A	2706		
2N3962	95	BC214L	11	BPX25	175		
2N4347	227	BC327	17	BPX29	175		
2N4401	20	BC328	15	BRY39	45		
2N4403	20	BC337	16	BSW69	33		
2N4416	86	BC338	14	BSX20	19		

SEMICONOUCTORS

Rectifier Bridges		Order Code
1A 400V S.I.L.	93	BY179
1 4A 60V S.I.L.	84	BY164
1.5A 100V D.I.L.	33	VM18
1.5A 400V D.I.L.	35	VM48
1.5A 100V	45	W01
1.5A 400V	52	W04
2A 100V	89	VS148
2A 400V	109	VS448
6A 100V	143	VH148
6A 400V	183	VH448
10A 100V	172	VJ148
10A 400V	201	VJ448
15A 100V	215	VL148
15A 400V	226	VL448
30A 100V	242	VK148
30A 400V	260	VK448

S.C.R.'s

4A 400V	54	C106D
12A 400V	108	TIC126D

Triacs

10A 500V	124	BT138-500
15A 500V	177	BT139-500
23A 500V	492	BTW41-500

MAINS TRANSFORMERS

Secondaries may be connected in series or parallel to give wide voltage range
Primaries 0-220, 240V

6VA — Clamp Type Construction

Approx. 18% Regulation. F.C. 54, H36, W35

		Order Code
0-4.5V, 0-4.5V Secondaries	220	Trans 6VA 45
0-6V, 0-6V		60
0-12V, 0-12V		120
0-15V, 0-15V		150
0-20V, 0-20V		200

20VA — Clamp Type Construction

Approx. 16% Regulation F.C. 70, H48, W46

0-4.5V, 0-4.5V Secondaries	335	Trans 20VA 45
0-6V, 0-6V		60
0-12V, 0-12V		120
0-15V, 0-15V		150
0-17.5V, 0-17.5V		175
0-20V, 0-20V		200

55VA — Clamp Type Construction

Approx. 10% Regulation F.C. 92, H64, W57

0-6V, 0-6V Secondaries	540	Trans 55VA 60
0-12V, 0-12V		120
0-15V, 0-15V		150
0-20V, 0-20V		200
0-30V, 0-30V		300

100VA — Frame Type Construction

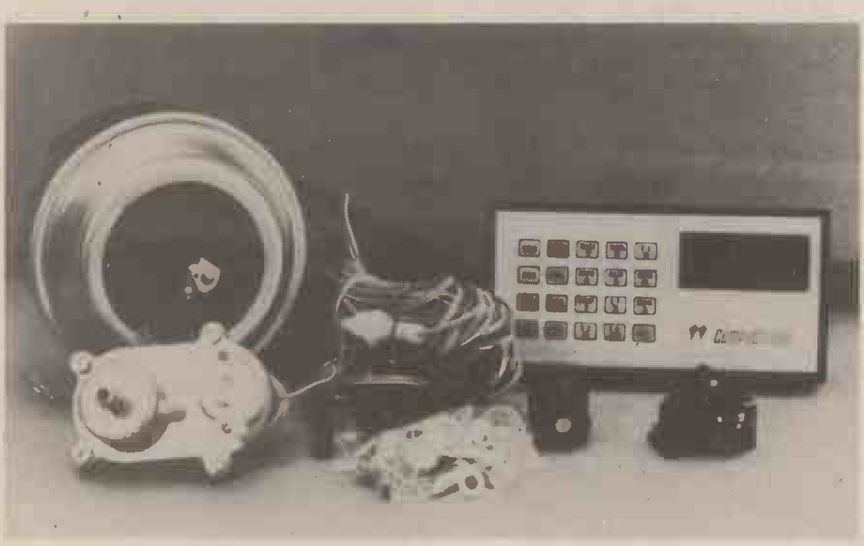
Approx. 8% Regulation H87, W74, D64

0-25V, 0-25V Secondaries	825	Trans 100VA 250
0-40V, 0-40V		400

COMMUNICATIONS INTEGRATED CIRCUITS — PLESSEY

SL360C	242	SL641C	384								
SL362C	302	SL650C	865								
SL610	230	SL651C	786								
SL611C	230	SL652C	329								
SL612C	230	SL680C	230								
SL613C	394	SL701C	220								
SL620C	347										
SL621C	347	SL1610C	166	SL1623C	251	SL1680C	170	SP8629	446	SP8690	907
SL622C	854	SL1611C	166	SL1625C	225	SL6600C	890	SP8630B	1361	SP8760B	680
SL623C	629	SL1612C	166	SL1626C	251	SL6640C	401	SP8655B	1058	SP8790B	454
SL624C	321	SL1613C	193	SL1630C	166	SL6650C	378	SP8657B	1058	SP8794B	454
SL630C	218	SL1620C	225	SL1640C	193			SP8659B	907		
SL640C	384	SL1621C	225	SL1641C	193			SP8660B	907		

Monitor

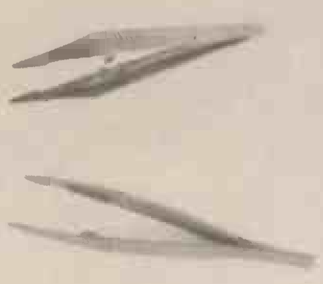


IT TELLS THE TIME TOO

Without devoting the whole of Monitor to this new device it would be impossible to describe it fully. Anyway we'll have a go at outlining some of its more unusual functions. It's called the "Compucrise—On Board Electronic Computer!" It has 26 different functions, so many in fact that we wonder if things haven't got a little bit out of hand. The main feature is the Cruise control, this will establish and maintain a pre-selected speed, it has a memory that will recall the last setting should the accelerator or brake pedals be used. The next bit comes under the heading Fuel Management, it will inform the driver his or her most efficient driving speed, the best brand of petrol to use and the effects of different types of tyres, pressures etc. would you believe? If that little lot isn't enough it also incorporates a highly accurate Quartz digital clock/stopwatch/alarm/calendar.

Now for the mundane features, temperature gauge, inside, outside or engine temperature. Battery voltage indicator, generator voltage etc. Time to tank empty, current speed, average speed, it goes on, you'll just have to take our word it does about a million other things too.

All this information is updated once a second from a variety of remote sensors. The "Command Module," measuring 3 inches by 6 inches will sit quite happily on the dashboard of most cars. It can be fitted to nearly any car in about 3 hours (not diesel or fuel injection engines though) requiring the minimum of calibration. Cost, well you wouldn't expect to get much change from a fiver would you? It's actually not as bad as you would think, £173 plus VAT and fitting. Compucruise is currently available from Macpro Ltd, The Coach House, Birdingbury Road, Frankton, Warwickshire CV23 9QR. Who said motoring was getting boring?



TOOL TIME

Plastic tweezers have never been given the publicity they deserve so we at HE are beginning a campaign to highlight the usefulness of plastic tweezers to the electronic hobbyist. We're starting our campaign by introducing you to the new range of plastic tweezers from Tele-Production Tools Ltd, their range includes three different jaw sizes, coarse, medium and fine serrations. The in-built guides ensure that the faces mate correctly. The tweezers are available in small quantities for about 60 pence, they are particularly useful for handling components that are liable to damage from static discharge.

To obtain your tweezers write to Tele-Production Tools Ltd, Stiron House, Electric Avenue, Westcliff-on-Sea, Essex SS0 9NW.

COVER STORY

Our thanks to Relcy Antiques of Nelson Road, Greenwich, for being so patient when we took the cover shot. We would also like to point out that they do not sell Grandfather clocks with LED displays. Mind you their shop is well worth a visit if you are interested in "scientific" antiques.

COMMODORE CALCS

New book from Commodore on how to choose your Calculator, one of theirs of course. Nevertheless it makes very interesting reading. Your nearest Commodore stockist should be able to furnish you with a copy. The book covers all of the new range of Commodores machines and there should be something for everyone.

CASIO'S COMEBACK

We must admit, we were slightly worried about the lack of calculators in the past few months, particularly from our friends Casio, who could be relied to bring out at least two new specimens per month.

We need not have worried, the reason for Casio's disappearance was because they were busily beavering away developing the FX-501P and FX-502P programmables. (Wonder what the bloke who thinks up these names does with the other 23¾ hours of his day?)

Starting with the 501, we have 5 levels of parenthesis, 11 memories and 128 programme steps. The 502 is twice the calc. with 10 parenthesis levels, 22 memories and 256 programme steps. Both live in cases 140x76x16mm, 1300 hours continuous use, auto switch-off, full scientific functions . . . yawn . . . etc., etc.

You guessed it, the cassette recorder connects up to both models via a low cost adaptor. Within the calculators lurks a musical IC that enables a programme to be written and read on to and off of standard cassette tape. Now for the price list. As usual there are recommended retail prices, totally unrealistic as they're always sold cheaper somewhere or other. From the top we have the 501 at £64.95 and the 502 £84.95. The adaptor (FA-1) can be yours for a miserable £24.95. Casio can now be found at 28 Scrutton Street, London, EC2A 4TL and will be only too happy to relieve you of any surplus money you may have.

News from the Electronics World

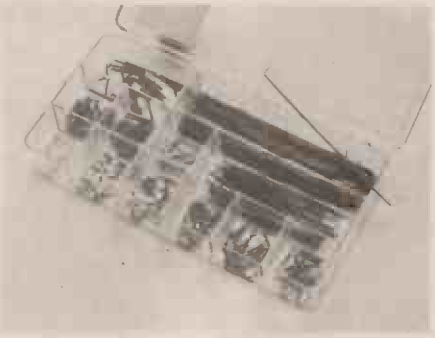
SIX DIGIT HAND HELD

Just about everything these days is available in hand-held version, frequency counters are the latest to succumb. This model, called the Max-550, will handle up to 550 MHz on a 6 digit display. The counter is crystal controlled (of course) giving an accuracy of 3 parts in 10^6 on signals down to 250 mV. (That means it's very accurate to the likes of you and me.)

Typical applications include audio, video and RF in-circuit testing, checking clock frequencies in digital systems, ultrasonic equipment in fact anywhere something electrical is happening many times a second. A full range of accessories includes a miniature aerial for direct radio reception, input cable carrying case, AC charger and an adaptor for use with a car battery. The Max-550 can be yours for £93.00 plus VAT. Available from Continental Specialities Corp, Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ.

WIRELESS?

For any of you following Ian Sinclair's new series "Into Linear ICs" you'll have noticed he's using a "Eurobreadboard" to explain much of the theory. This kit of jumper wires might just come in handy. It's intended for use with the Letrokit breadboard. The kit contains 350 wires and comes in a neat plastic box with individual compartments. 14 different lengths are supplied in the kit, the smaller ones conform to the almost standard 0.1 inch matrix. The longer lengths extend up to 5 inches. All the different lengths are colour coded, and each length has stripped ends, bent to 90° for instant insertion. For further details contact: Letrokit Ltd, Sutton Industrial Park, London Road, Earley, Reading, Berks.



MEETINGS IN MARGATE

Electronics is usually considered to be a solitary pursuit, it needn't be, especially if you happen to live in the Margate area. Dr Ken Smith of the University of Kent has written to tell us about a new club called the Thanet Electronics Club that he's involved with. They meet every Thursday evening at 7.30 pm at the Quarter Deck. Girls are very welcome too he assures us. And so they should be too, just wish a few more would write to us at HE. This sounds like an excellent opportunity for anyone in the Margate area to meet up with a few soulmates, so why not go along one evening? We would like to hear from any other clubs too, how about it?

FREE RADIO

Supporters of Free Radio 'Jackie, Invicta, Caroline et al might be interested in a convention on either the 13th or 20th (write for confirmation) of October. Both days are Saturdays, the venue will be in Wellington, Telford. The tickets will cost £6.00 and will include food etc. There will be talks, discussions, and slide shows from the people in the know and the possibility of a disco later in the evening. The meeting place will be the Wellington YMCA, we're told its within respectable distance of the local watering holes so there should be something for everybody. The address to write to is: Caroline News Sheet (CNS) POB, 35 Wellington, Telford, Salop. And please enclose a SAE.

HOME COMPUTING

We must apologise for the lack of Home Computing this month, believe it or not there just wasn't room. The situation has become quite serious lately, we might just start thinking about a few extra pages soon in order to get everything in. It's interesting to compare HE with the competition, do you realise what good value we are? Just count up how many editorial pages some of the other magazines have, most of them cost an extra 5 pence! We would be very surprised if any of them have as many as us.

CATALOGUE CORNER

Chromasonics have sent us a supplement to their '79 catalogue, it contains all their updated prices, no they are not all increases you'll be surprised to learn. A quick glance revealed the ZN414 radio chip from Ferranti going at 2 for £1, can't be bad. For your copy contact Chromasonic at: 56 Fortis Green Road, Muswell Hill, London N10 3HN.

COMPETITION

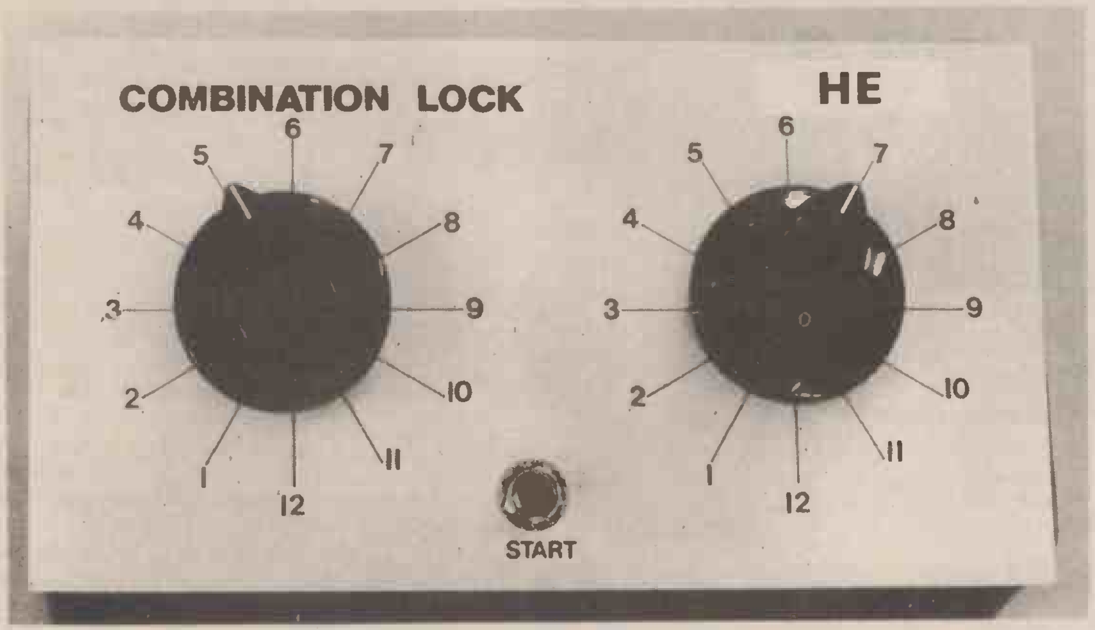
The entries are flooding in now for our picture competition, the closing date for entries is the 20th August so get them to us as soon as possible as we're still having difficulties with the post.

ERRATA

A gremlin crept into the Injector/Tracer project last month, the overlay diagram Fig. 2 was show 180° out of registration. The shaded PCB foil pattern is in fact the wrong way up. Hope this has not caused too many problems.

Combination Lock

Mechanical combination locks abound — as do ideas for electronic ones. Unfortunately, electronic designs we've seen are either too simple (and of limited use) or too complex — and beyond the average hobbyist. Here's something that's in between these two extremes.



DIGGING THROUGH THE files produced a wealth of ideas for locks — most of them impractical for the constraints imposed on the project application. Tossing ideas around the office threw up some fascinating techniques . . . But we had to get a simple project together.

The simplest method is to connect several rotary switches in series to apply power to a solenoid-operated door lock when you dial up the right switch position on each. This has the advantage of extreme simplicity and a reasonable number of possible combinations. Problem is, if you leave that combination set on the switches then security is compromised because somebody, less trustworthy than your good self, may just take notice, Tch, tch.

What was needed was some technique that was self-cancelling or did not reveal the combination once it was 'dialled up.'

It occurred to us that the rotary numerical combination lock, such as on safes (you know — spin the dial, 13 left, 37 right, 21 left), did not reveal the complete combination once the lock was opened.

Having digested that little principle the next thing was to work out how to do it electronically — and in a simple way.

The rotary numerical combination locks operate by successively unlatching a mechanical 'circuit'. When the last combination is dialled the bolt is released. How to do this electronically?

LATCHING CIRCUITS

A number of 'latches' connected in series and operated in sequence such that power is applied to a solenoid lock when the last latch is selected will be an electronic equivalent to the mechanical combination lock. Next problem — the electronic latch. This can be made up in a number of ways. Relays can be connected to latch on when energised. But they're relatively expensive. Digital logic gates can also be connected to make a latch.

When a silicon controlled rectifier (SCR) has a voltage applied to the gate it will conduct and remain 'on' until the anode-cathode voltage falls to zero. That's a latching operation. SCR's are cheap and readily available and will handle the current required to operate a solenoid lock and for these reasons were chosen for the latches in this project.

To dial a sequence of numbers, providing the required combination, we first considered a multi-bank, multi-position switch. That turned out to be mechanically awkward and expensive. Suitable switches are also difficult for the average hobbyist to obtain. Two, 12-position, single-pole rotary switches were eventually chosen. They are an 'off-the-shelf' item obtainable from many component outlets.

Dialling three pairs of numbers in sequence on the switches simulates the operation of a rotary numerical combination lock — almost. This provides over 1.7 million combinations!

RESETTING

That solves the combination problem and the latch problem, but how do you reset the SCRs once you've operated the lock? Simple — turn off the power source. A switch could be used to momentarily disconnect the supply, 'unlatching' the SCRs, resetting the solenoid lock to await its next use.

What if you forget to push the button? Tch, tch, tsc . .

It seems a peculiarity of human nature that it is easy to memorise a sequence of numbers but very difficult to remember to reset a button or lock.

A simple timer operating a relay can do the job for you. Accordingly, the project has a timer incorporated.

The project is designed to operate from a battery. No current is drawn until the START button is operated. Current will only be drawn from the supply for the 25 seconds duration of the timer.

Mains operation, from a small transformer and rectifier is possible but a battery standby circuit should be included in case of mains power failure.

SOLENOID LOCKS

There are two basic types: solenoid operated striker plates (i.e.: that are fixed in the door jamb) and solenoid operated bolts (attach to the door itself). We recommend you use a solenoid operated striker plate. Firstly, as they are fixed in the door jamb it is an easy matter to conceal all wiring. Secondly they may be used with existing dead-latching mortice locks. Solenoid operated bolt locks are made to fix on the door itself and require a flexible lead run across the door at the hinged side.

Solenoid operated striker plates or bolt locks are available from specialist locksmiths.

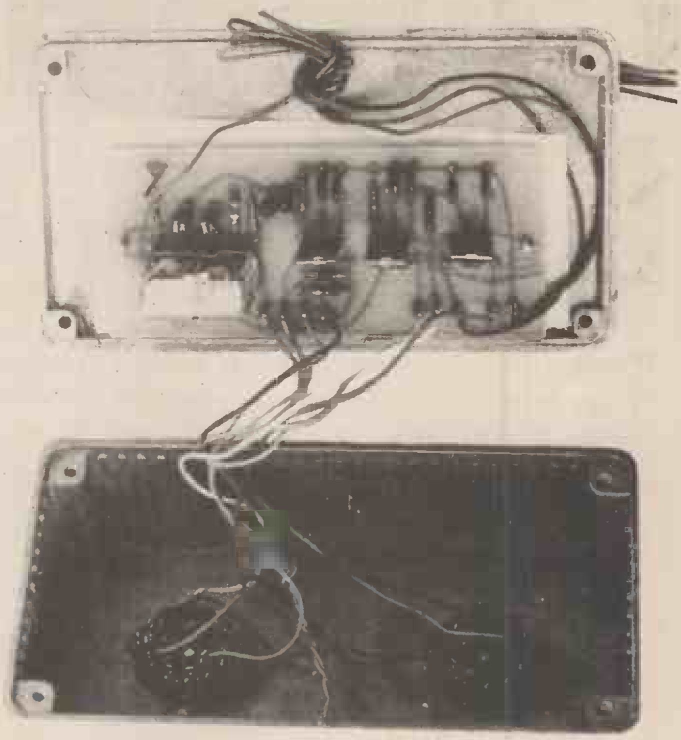
As the project operates from a 12 volt supply, a 12 volt version was used.

For new installations the key barrel of a lock may be dispensed with. In existing locks, the key mechanism may be disabled if you wish.

CONSTRUCTION

The relay and all minor components are mounted on a printed circuit board. For convenience, and to avoid wiring errors, this method of construction is recommended.

Commence by putting all the resistors and capacitors on the board. Take note of the orientation of the tantalum capacitors. Next mount the transistors, diodes and SCRs — take note of lead orientation, carefully follow the component overlay diagram. Mount the relay last.



Interior of the lock. A diecast box provides a rugged and safe housing.

All external connections are made via pc pins inserted in the appropriate holes on the board. To avoid wiring errors, follow a sequence of wiring the connection from each pin, step by step.

Wiring a 'code' on the switches is a fairly simple process. Using the table below, allocate switch position

This shows how the connection of wires A to C and A' to C' determine the combination of the lock. The above table shows the connection pattern for the combination 4-1, 1-11, 8-4 which can be seen by looking at the switch contact numbers corresponding to A, A', B, B', C and C'.

TABLE 1

SW1 pos no	pc pin	SW2 pos no	pc pin
1	B	1	A'
2		2	
3		3	
4	A	4	C'
5		5	
6		6	
7		7	
8	C	8	
9		9	
10		10	
11		11	B'
12		12	

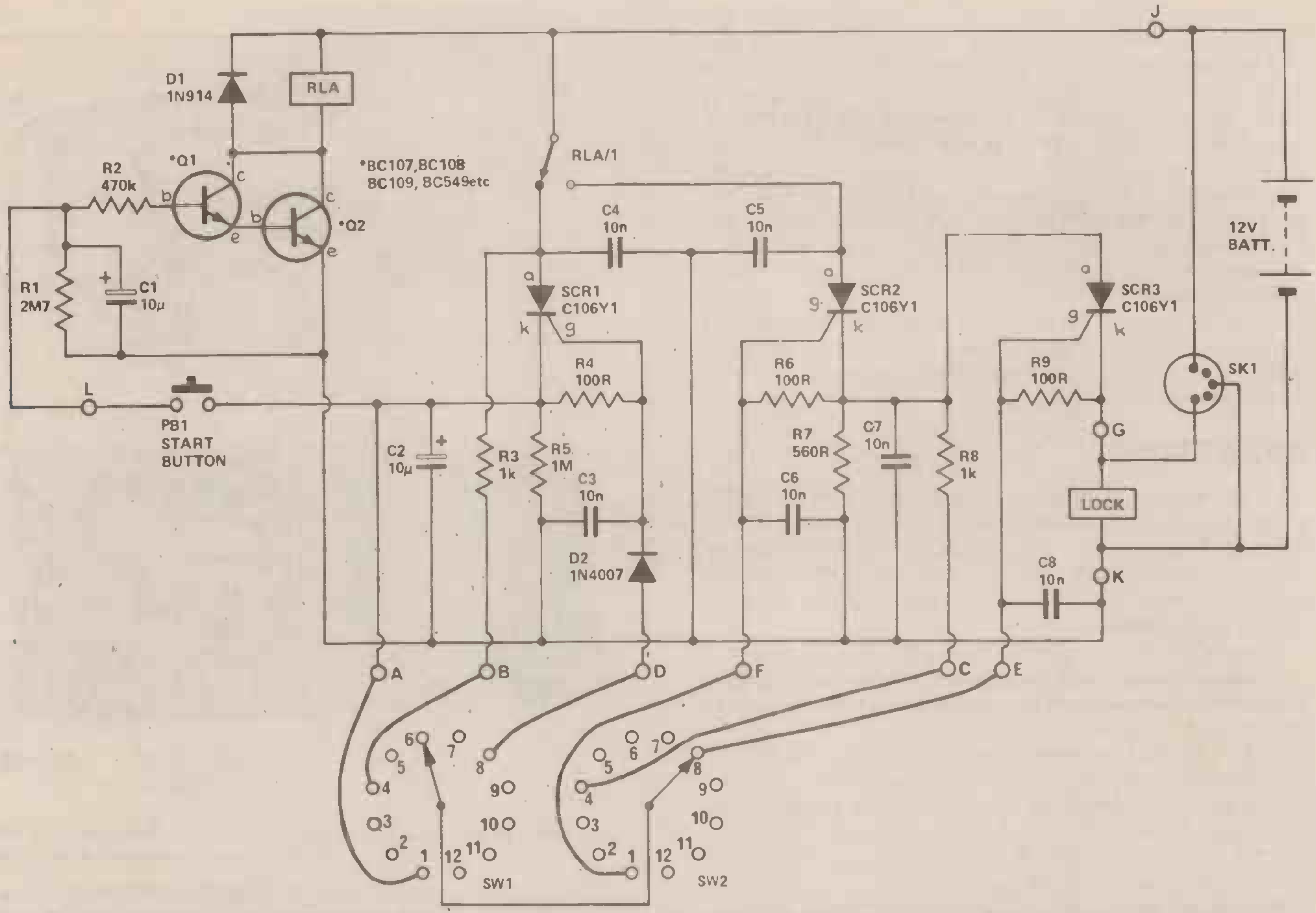


Fig. 1 The circuit diagram, SW1, SW2 and PB1 have to be operated in the correct sequence before the lock will open. Any deviation in sequence will result in the lock remaining secure

How It Works

An 'initial' code is dialled on SW-1 and SW-2, 4 and 1 in this case. The gate of SCR1 will be forward biased via R5, SW-1, SW-2 and D2, SCR1 turns on, charging C2 to 12 volts.

The push-button PB1 is then pressed. This applies 12 volts from the cathode of SCR1 to the junction of R1/R2. Capacitor C1 will quickly charge to 12 V Q1 and Q2 will turn on, operating the relay RLA. The circuit involving Q1, Q2, R1, R2, C1 and the relay is a 25-second timer. The relay will drop out after about 25 seconds as C1 will slowly discharge via R1, R2 and the input impedance of Q1, Q2, which is very high. The rest of the sequence must be completed within 25 seconds to operate the lock for when RLA drops out, the circuit is 'reset'.

When PB1 is pressed and RLA operates, the relay contacts, RLA1, will then transfer the 12 V supply from the anode of SCR1 to the anode of SCR2. SCR1 will turn off. C2 will then commence to discharge via R7, falling to a volt or so within 10 seconds. The next code sequence must be dialled within this period, otherwise you will have to return to the 'initial' code.

The second code is then dialled on SW-1 and SW-2, in this case 1 and 11. The gate of SCR-2 will then be forward biased via SW-1 and SW-2, the current it draws will discharge C2. SCR2 will then turn on, applying 12V to the anode of SCR3.

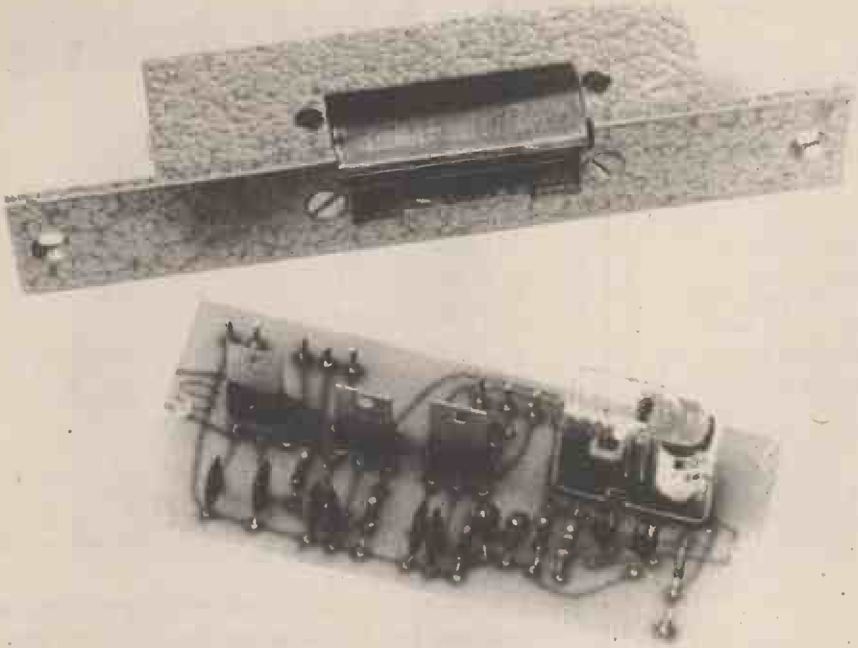
The third code is then dialled on SW-1 and SW-2, in this case 8 and 4. The gate of SCR3 will then be forward biased via R10, turning SCR3 on, energising the solenoid lock. At the end of the 25-second delay, the relay will drop out, resetting the circuit.

An external connection socket, SK1 is provided to enable power to be supplied to the lock should the circuit fail or the batteries run flat.

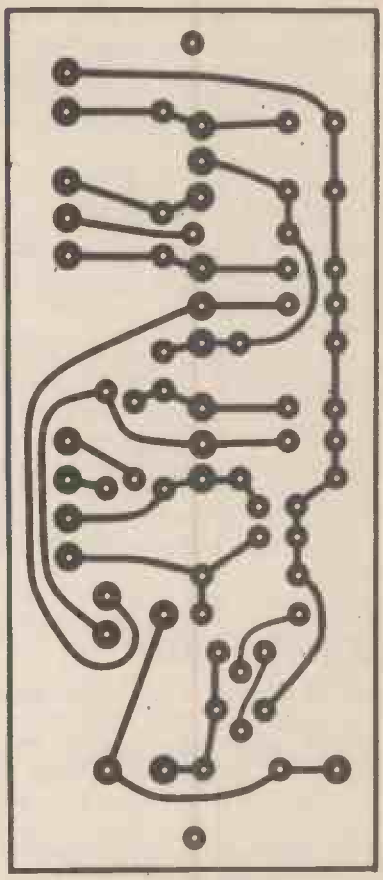
No current is drawn by the circuit until the operating sequence is commenced.

Diode D1 suppresses operating transients from the coil of the relay and D2 prevents possible spurious triggering of SCR2 and SCR3 via the gate of SCR1 when the latter is turned on.

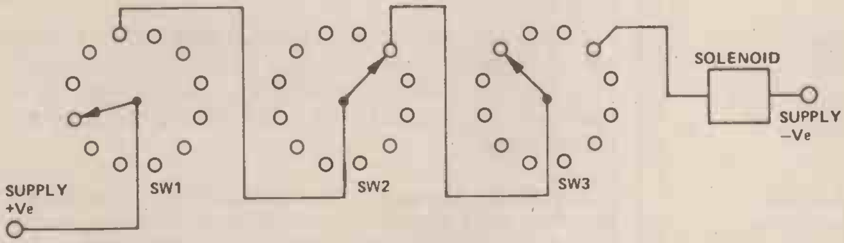
The circuit is protected from spurious triggering by bypass capacitors C3 and C8 and the SCR gate resistors, R6, R8 and R11.



The printed circuit board and solenoid striker plate we used. Naturally any type of solenoid lock can be protected using this system.

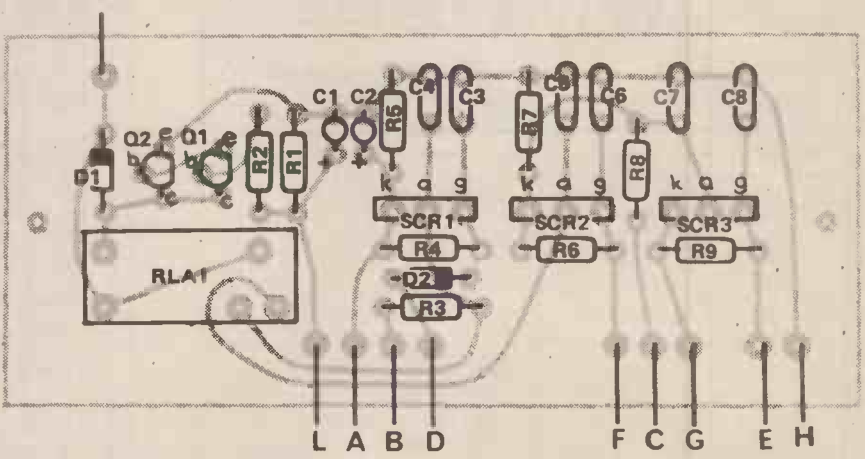


PCB artwork shown full size.



A simple lock using three rotary switches. If you forget to move them off the combination after opening the lock, you'll reveal it.

Fig. 2 The component overlay. See Table 1 and the circuit diagram for an explanation of the lettered AC pins.



Parts List

RESISTORS (ALL ¼ W, 5%)

R1	2M7
R2	470k
R3	1k
R4	100R
R5	1M
R6	100R
R7	560R
R8	1k
R9	100R

CAPACITORS

C1, 2	10u 25V tantalum
C3-8	10n greencap

SEMICONDUCTORS

SCR1-3	C106Y1 or C106D1
Q1, 2	BC107, BC108, BC109 or BC549 or equivalent
D1	1N914
D2	1N4007

MISCELLANEOUS

SW1, 2	1 pole 12 way rotary
PB1	miniature push to make
RLA1	single-pole change-over 12V 180 ohm coil, 240V/5A contacts
SK1	DIN 5-pin or similar

Solenoid-operated lock (see text), 12V battery, pcb: diecast case.

pairs for SW1 and SW2 for each code in the three-step sequence necessary to open the lock.

For example, the code sequence of switch position pairs as shown in the diagram is 4-1, 1-11, 8-4. These are respectively shown connected to pc pins A-A', B-B', C-C'.

INSTALLATION

As this will very much depend on individual circumstances, we can only give you general guidelines.

Firstly, there must be no externally exposed, or visible, wiring. The switches should be mounted such that their shafts protrude from the surface behind which the circuitry is mounted, without the shaft securing nuts being accessible. File a flat on the shafts so that you have a permanent 'location' point for knob grub screws. Better still, use collet knobs.

The external power/connection socket should be placed in a concealed location, known and accessible only to yourself, or those entrusted with the combination.

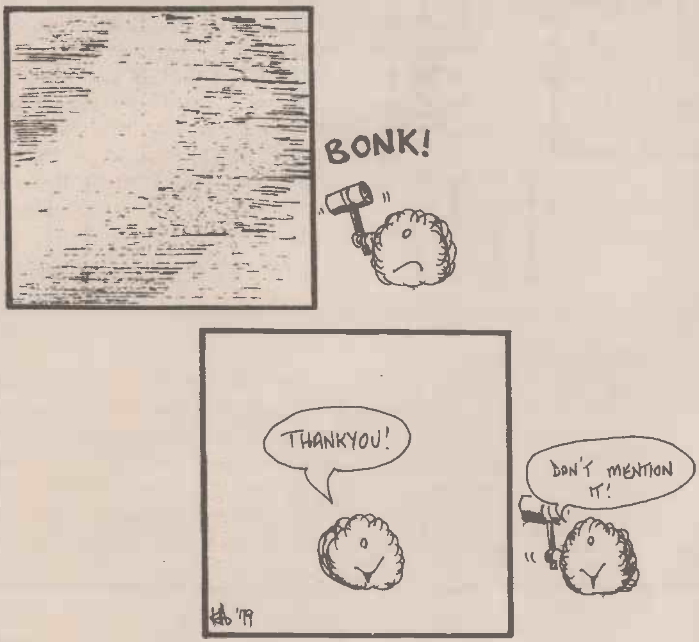
OPERATION

1. Dial the 'initial' code. As illustrated in the circuit, turn SW1 to 4 and SW2 to 1.
2. Press the push button, PB1.
3. Dial the second code. As illustrated, turn SW1 to 1 and SW2 to 11. You have less than 10 seconds to do this.
4. Dial the third code. Turn SW1 to 8 and SW2 to 4, as illustrated.
5. The solenoid lock will release.
6. Twenty-five seconds after operating PB1, the circuit will reset and the lock will return to its latched condition.

HE

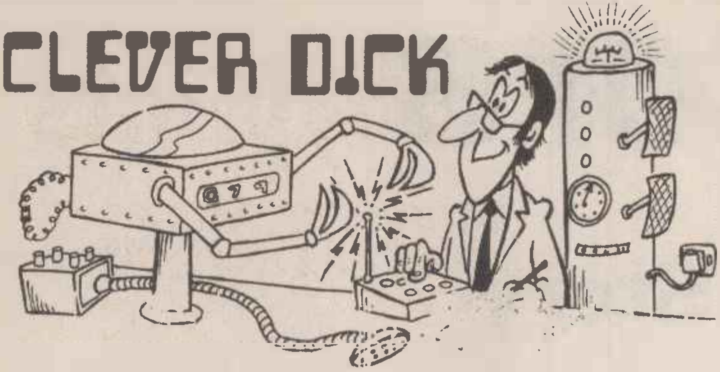
Buylines

There should be no problems in obtaining any of the components used in the Combination Lock.



Hobbyprints

CLEVER DICK



It's all down to the energy crisis this month, don't worry though, Hobby Electronics is guaranteed energy saving, no batteries, no wires and no connections to be made.

WHAT WITH ALL THIS energy crisis business it's to be expected that someone would write in with a request for some kind of solar heating circuitry, Congratulations to Mr N. Shapped for being the first.

Dear HE,
Could I make a suggestion? With the current interest being shown in energy saving, a useful constructional project would be a circuit for the control of a solar energy system.

N. Shapped
Anglesea

Well Mr Shapped, we would be only too happy to publish such a circuit but for one thing. We have heard from reliable sources that the gases used as aerosol propellants are breaking down the upper layers of the atmosphere. This will cause what the experts call the 'Greenhouse effect'. In short the temperature of the earth will steadily rise, making solar heating somewhat redundant. With this in mind we were thinking of developing some kind of Greenhouse effect detector, trouble was we had nothing to calibrate it with.

Two letters this month concerning 'Kit Review' (most unusual). They both happen to be about the June review of the Sparkrite Electronic Ignition, though each makes a different point. The first is from Mr N. Allister of Lichfield, Staffs.

Dear HE,
Having read the Kit review on the Sparkrite Ignition kit an idea sprang to mind. I am keen on motorcycles, unfortunately I can only afford small capacity bikes.

Motorcycles are usually fitted as standard with contact breakers. These are not very reliable and can cost quite a bit to replace. Several companies are now coming out with contactless systems for multi-cylinder bikes, rather pointless for a humble one cylinder machine. (Pun intended.) Anyway these systems use an ordinary LED, the light source being interrupted at the appropriate moment during the ignition cycle and triggering the ignition. I would like to see an article on how to make such a circuit. I hope you give this letter some thought and publish such a circuit in the near future.

N. Allister
Staffs

The second is from Mr George Tworkowsky (we think) of Gwent, he poses a somewhat different question.

Dear Sir,
I read your article 'Kit Review' with great interest. It really is a pity that you did not carry out some detailed tests. I have had some experience with electronic ignition. In two years my own specimen failed three times, this I considered dangerous so I disposed of it. I noticed that my fuel consumption had actually increased with the electronic ignition. A friend brought a Sparkrite with similar results, his cold starting did not improve, still needing four or five attempts before his car would start. I think that electronic ignition has still got a long way to go before it can beat a conventional system. To have any advantage a completely new system is required, not an adaptation to a conventional ignition.

G. Tworkowsky
Gwent

To Mr Allister we must say we would love to publish such a circuit, the trouble is there are so many different bikes around at the moment it would be literally impossible to come up with a 'universal' fitting to suit everyone. Sorry.

Now to Mr Tworkowsky. Unless, as you suggest extensive and exhaustive laboratory type tests are carried out, results will be purely subjective. Two things, however, must be borne in mind. An electronic ignition system cannot improve a badly tuned car, wrongly adjusted tappets for instance. The second thing to remember is that the contact breakers should not wear at anything like the rate of conventional points. That means the points will retain their optimum (hopefully) setting longer, hence improving fuel consumption, and at nearly £1.30 per gallon every little helps. Don't forget that cold starting should also improve, simply because an electronic ignition system will continue to operate satisfactorily at a much lower voltage.

That's about it for this month. We would just like to say thank you to everyone who took the trouble to write in with suggestions for a new name for the column. We've decided to keep it as 'Clever Dick' simply to avoid confusion. Keep your letters coming in to Clever Dick, we'll try to answer as many as possible, it's good to know that such a column was needed judging by the amount of mail we're receiving.

Thyristors

The Great Gate Story

Thyristors often seem to be the poor relation as far as electronic components go, especially these days with new digital ICs appearing almost daily. We would like to dispell any rumours here and now, the thyristor is alive and well, doing things that only they can do. Ian Sinclair looks at this versatile semi-conductor and a few of its unique features.

IF YOUR ELECTRONICS interests are in Hi-Fi, or short-wave reception, chances are you'll never have any need to use a thryristor. There's an awful lot of other branches of electronics, though, in which these devices are extremely useful, so let's take a look at how the thyristor works, what it does, and the sort of circuits that are used.

Unlike the ordinary transistor, a thyristor has four layers of semi-conductor material (Fig. 1). Connections are made to the outer layers of this sandwich, and these are called the anode and the cathode connection. One of the middle layers is also connected to a terminal, called the gate.

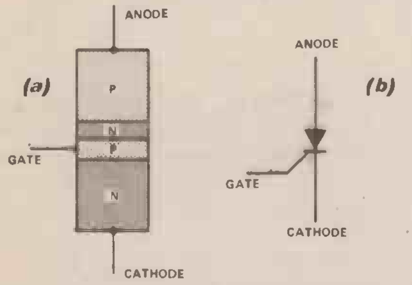


Fig. 1. Four-layer arrangement (a) and the thyristor symbol (b).

How does it work? Imagine the four layers split up as shown in Fig. 2a. This now looks like two transistors (Fig. 2b) connected in series one a PNP type, and the other NPN. More important, there are connections from the collector of the PNP to the base of the NPN, and from the collector of the NPN to the base of the PNP — that means 100% positive feedback. Using this transistor arrangement as a guide, let's see what we would expect to happen as voltages are applied. One thing has to be added though — the connection to the electrode which behaves like the gate has a bit of resistance in series (Fig. 3), and that makes quite a difference.

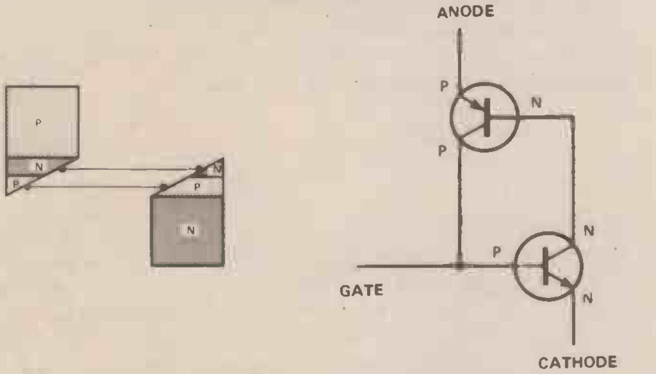


Fig. 2. Two-transistor equivalent (a) as layers, (b) as separate transistors.

With the emitter of the PNP transistor positive and the emitter of the NPN negative, no current will flow when the "gate" voltage is low. Since the "gate" connection is to the base of an NPN transistor, no current will start to flow until the voltage on the box is something like 0.5 V positive to the emitter of the NPN transistor. With the base of this transistor at the same voltage as the emitter, then, there's no conduction in either transistor. Either transistor? Well, you see, the collector of the NPN transistor will be at supply voltage when no current flows, and that keeps the PNP type shut off — a PNP transistor doesn't conduct until its base voltage is **less** than its emitter voltage. Fig. 3 shows a "load" resistor dotted; there's no resistor deliberately placed there but leakage through the semiconductor serves the same purpose.

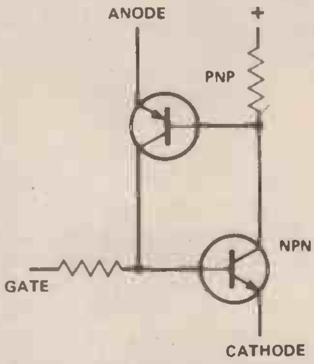


Fig. 3. The equivalent circuit, with gate resistance added.

GATE RESISTANCE

When the base input voltage rises to around 0.5 V, then, the NPN transistor conducts, its collector voltage drops, making the PNP transistor conduct, and current flows from the emitter of the PNP transistor all the way to the emitter of the NPN one.

This is where the resistance at the "gate" input comes in. When the transistors conduct, the collector voltage of the PNP transistor goes high, keeping the base voltage of the NPN one high. If the input voltage goes low now, some of the current from the PNP transistor will flow through the input resistor, but the base of the NPN transistor will still be kept high enough to ensure that current keeps flowing. This is why the thyristor doesn't shut off. In fact, small thyristors **can** be shut off if the supply voltage is low by taking the gate voltage negative, so that the voltage at the base of the NPN transistor drops below 0.5 V.

PEAK CURRENT

There aren't two separate transistors, of course, so what do we look for when we select a thyristor? One obvious factor is the maximum voltage which we can use across the thyristor when it is switched off. This ranges from around 15 V to over 800 V according to the type that is chosen. Note, though, that these voltages are **peak,** so that if you want to use a thyristor with 240 V AC you need a 400 V type to hold off the peak AC voltage.

The next thing to look for is the peak current rating. Many manufacturers quote I_{TSM} — meaning the peak current flowing for a once-only pulse when the thyristor is triggered on. The repetitive peak current (on every cycle) is symbolised as I_{TRM}, and is quite a bit less.

The gate trigger current, in milliamps, is labelled I_{GT} and is usually measured at 25°C — it gets less at higher temperatures. The maximum value for reliable triggering is usually quoted, ranging from about 200 uA for a small thyristor to 30 mA or more for a large one. The actual trigger current is often a lot less — I have triggered **a** small thyristor at 8 uA.

V_{OT}, as the letters suggest, means the gate voltage (maximum) which will ensure triggering. This ranges from 0.8 V for a small thyristor to 1.5 V for a large one — once again most samples will trigger at lower values.

Finally, the quantity I_N is the holding current — at any greater value of current between anode and cathode, the thyristor is guaranteed to keep conducting once triggered. Values range from 5 mA to 40 mA, and, as usual, most samples will stay conducting with quite a bit less.

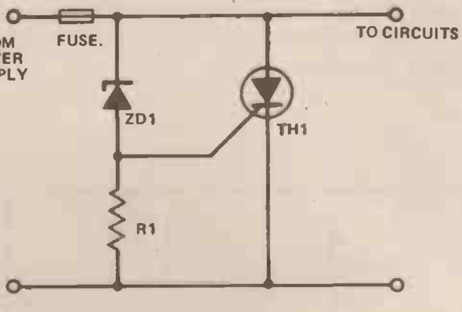


Fig. 4. A crowbar protection circuit.

The thristor therefore behaves like a diode — but only when the voltage at the gate has set the layers of semiconductor conducting. With the gate connected to the cathode, a thyristor is simply an open circuit, no current can flow in either direction unless, of course, the voltage ratings of the thyristor are exceeded. When the gate voltage is increased sufficiently above the cathode voltage — about 0.5 V or so — the thyristor will suddenly become conducting, provided the anode is positive relative to the cathode. In this state, the thyristor is said to be triggered. If the anode voltage is zero or negative, or if the gate voltage is too low, no triggering takes place, and the thyristor remains non-conducting. Let's look now at a circuit which makes use of what we know already about the thyristor. Fig. 4 shows what is called a crowbar circuit — it's designed to shut off the power to a circuit very quickly.

This is a thyristor which is normally non-conducting, with its gate connected to zero volts through R1 and to the positive supply through ZD1, a zener diode. You're not too certain about a zener diode? Well, it's a diode which is used reverse biased, but because of its construction it will suddenly conduct at some voltage, usually in the range 2.7 V to 33 V, which is decided when the diode is made. In this circuit, the diode has been selected so that it breaks down at 5.6 V.

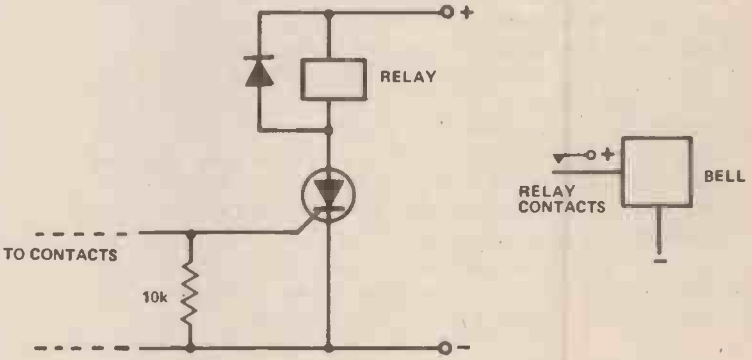


Fig. 5. Burglar alarm basic circuit — the bell cannot be connected directly to the thyristor because each stroke of a bell interrupts the current; this would shut off the thyristor.

FAST FUSE

Now the normal voltage output of this circuit is 5.0 V, and it's intended to supply a lot of IC's whose supply voltage must not rise much above 5.6 V. What happens if the voltage does get too high? Simple — ZD1 conducts and triggers the thyristor. The thyristor can then conduct, shorting out the power supply and causing the fuse to blow. Once the fuse has blown, there's no voltage in the circuit, and the thyristor instantly resets, ready to resume protection duty when the fault that caused the trouble is sorted out.

Now it may look a bit daft using a thyristor to blow a fuse, but it has two important advantages. The most obvious one is the fuses don't blow just because the voltage rises, so that the fuse doesn't protect the circuit against excessive voltage, it only protects the power supply against excessive current. The other point is that a fuse takes some time to blow, several milliseconds. That may not sound like a long time, but several hundred pounds worth of IC's can be destroyed in only a thousandth of that time. The thyristor operates faster, getting the voltage down as soon as it reaches danger level, and blowing the fuse so that some attention is called for. The name "crowbar" circuit is a good one — the action is pretty much the same as that of putting a crowbar across the supply voltage!

To change output voltage, just switch in another zener diode! The output is not easy to smooth to an acceptable standard for most electronics equipment, but is ideal for battery charging or running lights or motors.

The main application for thyristors, however, is the control of lamps or motors, using the gate to control at what part of the wave the thyristor switches on. Fig. 10 shows how this operates when the supply to the thyristor is a full-wave rectified voltage. If the thyristor is turned on at the start of each wave, the output is at full power — the average value of voltage of such a wave is equal to 63% of peak voltage. If the thyristor is turned on at a later part of the wave, the average value of voltage of the output wave is less, down to nearly zero if the thyristor is switched on very late. This is, incidentally, one of two methods of control, the other will be discussed later.

TRIGGERING

The problem now is to trigger the thyristor at the correct part of each cycle. One simple method is to use a capacitor and resistor to delay the rise of voltage at the gate. Fig. 11 shows the simplest type of circuit possible, a capacitor connected across the gate, and a resistor feeding the capacitor from the rectifier supply. As the supply voltage rises from zero, following the shape of a half-wave of AC, the voltage across the capacitor will rise much more slowly, so that the gate voltage does not rise high enough to trigger the thyristor until the supply voltage is quite a bit above zero. We can alter the time (after the wave starts from zero) at which the thyristor fires by altering the time constant of the firing circuit. Unless we discharge the capacitor again, however, the thyristor may fire too soon on the next wave, so that DI is used to ensure that the capacitor discharges when the supply voltage drops at the end of the wave.

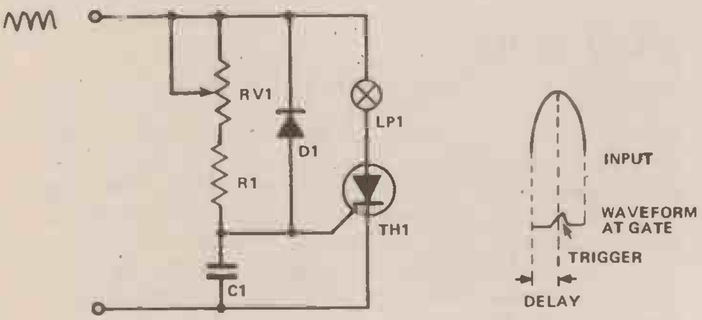


Fig. 11. Simple CR low voltage phase control. Because of the time that C1 takes to charge, the voltage at the gate reaches trigger level some time after the input voltage starts to rise. The delay can be adjusted by altering the setting of RV1. D1 discharge C1 when the input voltage drops to zero again.

One snag of this simple circuit is that the current passing through the charging resistor may not be enough to fire the thyristor, if the resistor is a large value and the thyristor gate needs a large (1 mA or so) current. Most small thyristors will fire with a gate current of a few uA, but the larger types may need quite a bit more.

A method of overcoming this is the trigger diode — a device which is non-conducting until a few volts are applied between anode and cathode (Fig. 12), and which then becomes fully conducting, with only a small voltage drop. Using such a trigger diode, the voltage across the capacitor (Fig. 11) builds up until the voltage across D2 is enough to breakdown the trigger diode.

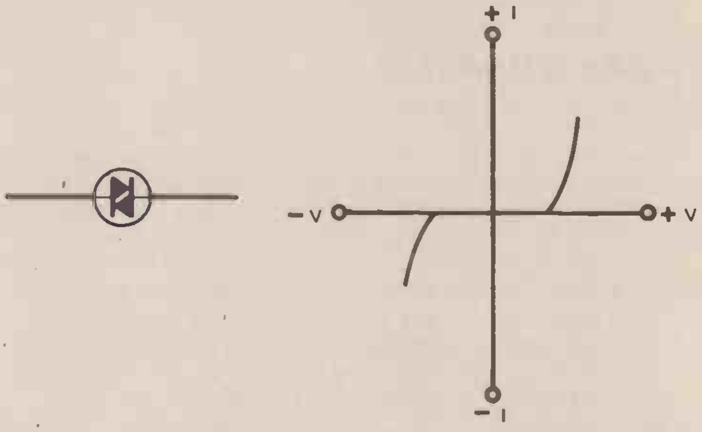


Fig. 12. Trigger diode. (A) symboll (b) characteristic

LOW VOLTAGE

With the diode fully conducting, the voltage at the gate is more than enough to trigger the thyristor, and gate current is provided by discharging CI rather than by the small current through RI.

A version of this basic circuit suitable for low voltage supplies is illustrated in Fig. 13. A transistor takes the place of the trigger diode making use of the principle that a transistor will pass a large current from collector to emitter when a small current passes from base to emitter. The capacitor CI is connected to the base of QI, so that base current will start to flow when the capacitor has charged to about 0.5 V. The base current causes collector current, so that the emitter voltage rises along with the base voltage. When the emitter voltage rises to about 0.5 V (the base will by this time be at about 1.0 V), the thyristor fires.

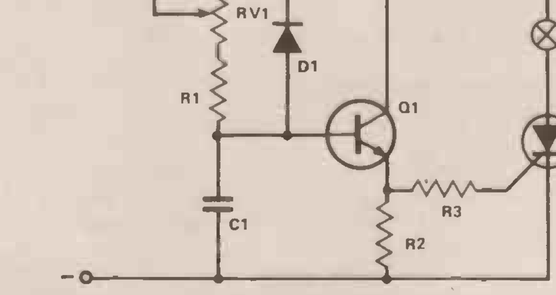


Fig. 13. Using a transistor for triggering a low-voltage circuit.

If the load is AC operated (such as a shaded-pole motor, for example) the circuits used so far do not appear useful because they are based on rectified AC. However, the circuit is still a circuit, whether a rectifier is used or not, and the load can just as easily be connected in the AC part of the circuit (Fig. 14). In this example, the firing of the thyristor completes the circuit, so switching the current on. The change of position of the load from the DC to the AC side of the circuit does not alter the action of the thyristor.

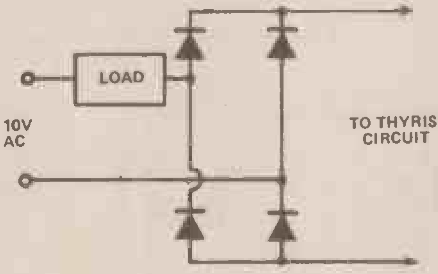


Fig. 14. Using an AC load and a bridge rectifier circuit. The thyristor circuits of Figs. 11 or 13 can be used if the voltage is low.

So far, all the circuits we have looked at have been low voltage circuits, for which ordinary low voltage components and construction methods are suitable. Many thyristor and triac control circuits, however, make use of AC mains voltages, for which a number of special precautions need to be observed. One essential point is electrical safety. In a mains circuit, the thyristor is connected between the load and one of the mains leads, usually neutral. Since the gate must have a fairly low resistance to the cathode, this means that all the electrodes of the thyristor are connected to mains, and any firing circuit of the simple type will also be connected to the mains.

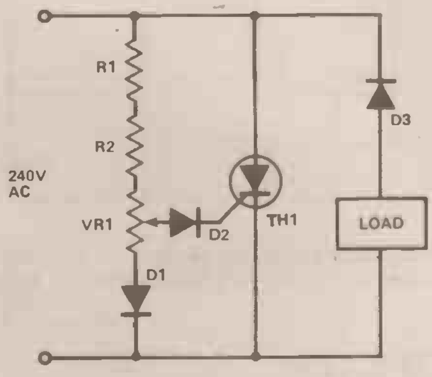


Fig. 15. Mains-voltage power control. All parts of the circuit can be at a dangerous voltage.

Great care must therefore be taken when these mains voltage circuits are isolated from any low voltage circuits and that no mains voltage points can be touched. In the simple power control circuit of Fig. 15, for example, widely used for electric drill or light bulb control, the potentiometer control knob must be well insulated — one useful method is to use a potentiometer with a plastic shaft, with the circuit fitted into a plastic box.

Particular care has to be taken when a heat-sink is needed for the thyristor because the insulators which serve well for mounting power transistors to heat sinks are not good enough for mains voltages. A mains-operated thyristor should never use a metal box as a heat sink — if cooling is needed, the thyristor should be mounted on a finned heatsink mounted on substantial insulators inside a ventilated box.

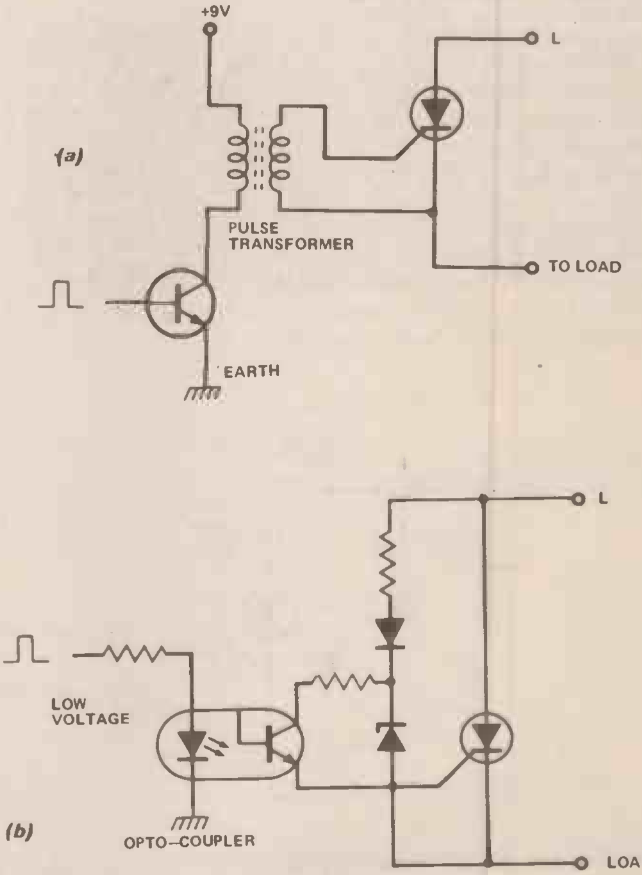


Fig. 16. Isolating the firing circuit from the thyristor. (a) Using a pulse transformer. (b) Using an optoisolator. With either device, the insulation between the circuits can be good enough to withstand several thousand volts.

ISOLATION

Several applications of mains-voltage thyristors and triacs involve driving the gate with signals from low voltage equipment — typical applications include disco lights. There are two safe ways of isolating the thyristors from the low voltage equipment — pulse transformers

Now applications for thyristors such as the crowbar circuit are very useful, but they represent only a fraction of the possible uses. Fig. 5 shows in outline, for example, how a thyristor could be used in a burglar alarm circuit — the point is that the bell will keep on ringing once the thyristor has been triggered, until the power is cut off. Some care is needed, incidentally, in the uses of this circuit. Small thyristors need very little gate current to trigger them, around 1 uA, so that a long lead attached to the gate of a thyristor will pick-up any electrical disturbance (next door washing machine, for example) unless a resistor is connected between gate and cathode. Once again, we are making use of the thyristor as a device which can be switched on by a small and brief change of voltage, but which cannot be switched off the same way. Anything that behaves in this way is called a latching device. Now we can connect up relays so that they will latch, but a thyristor is self-latching — this type of behaviour is built in to the thyristor.

NEGATIVE PULSE

Suppose we **want** the thyristor to stop conducting? it happens, some small thyristors **will** switch off when the gate voltage is pulsed negative, but this is not a reliable way of switching off. Switching off, as far as most thyristors are concerned must be done by reducing the voltage between anode and cathode to a very low value. Once this minimum value, the minimum holding voltage, has been reched, current stops. Unless the gate voltage is kept high, the current will not start to flow again when the anode returns to a positive voltage.

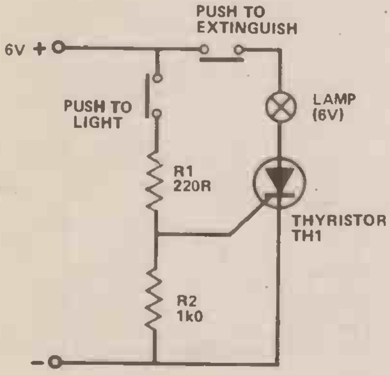


Fig. 6. Simple low-voltage light-switch circuit.

One obvious way to do this, of course, is to interrupt the supply momentarily, as shown in the low voltage lamp circuit of Fig. 6. A less simple method consists of discharging a capacitor at the anode of the thyristor, as shown in Fig. 7. In this circuit, the thyristor is triggered by the action of the push button switch — note the Ik resistor (R2) which prevents the gate from being triggered by stray radiated pulses. Once the thyristor has been triggered on, there is a low-resistance conducting path between anode and cathode, so that the voltage across the thyristor is low, not much above the minimum holding voltage at which the thyristor switches off.

The switch-off method uses a large-value capacitor Cl which charges up when the thyristor conducts. During the time that the thyristor conducts, the capacitor has one plate at supply voltage and the other at the low voltage of the thyristor anode. When the OFF switch is momentarily depressed, the plate of the capacitor which was at supply voltage is suddenly connected to Zero volts. The other plate will follow it, dropping from about 0.2 V to a negative voltage for a few milliseconds. This is time enough to allow the electrons and holes in the N and P layers of the thyristor to clear and the thyristor becomes non-conducting. By the time the capacitor has re-charged through the load, the thyristor is off.

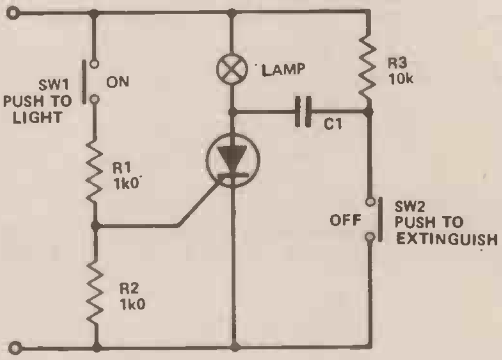


Fig. 7. Using a capacitor to switch off a thyroistor.

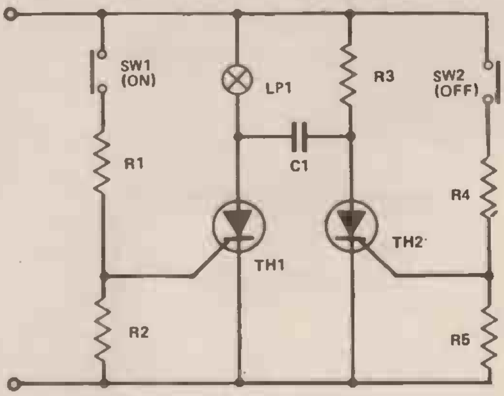


Fig. 8. A two-thyristor switching circuit. The capacitor C1 is connected so that when one thyristor switches on, the other is forced off.

BACK TO BACK

This method works well when the load has a fairly high resistance (such as a low voltage lamp) and when a large value capacitance can be used. The capacitor should be a paper or plastic type, because electrolytics do not take too well to having their plates at reverse polarity, which will happen if the OFF switch is kept closed while the capacitor re-charges through the load. A variation of this method uses two thyristors switching each other (Fig. 8).

Thyristors really come into their own, however, when they can be used with a supply which passes through zero volts at regular intervals. An alternating voltage fits this specification nicely, but a rectified unsmoothed supply is even better. The reason is that a thyristor will pass current in one direction only, so that to cope with AC we need two thyristors, or the ready-made two-thyristor device known as the Triac.

Using an unsmoothed rectified supply ensures that the thyristor will turn off each time the voltage reaches zero (or a fraction of a volt above zero). We don't need any special switch-off circuit, but on the other hand we have lost that rather useful latching action. To keep the thyristor conducting we must either keep a current flowing into the gate, or apply a pulse each time the anode voltage starts to rise.

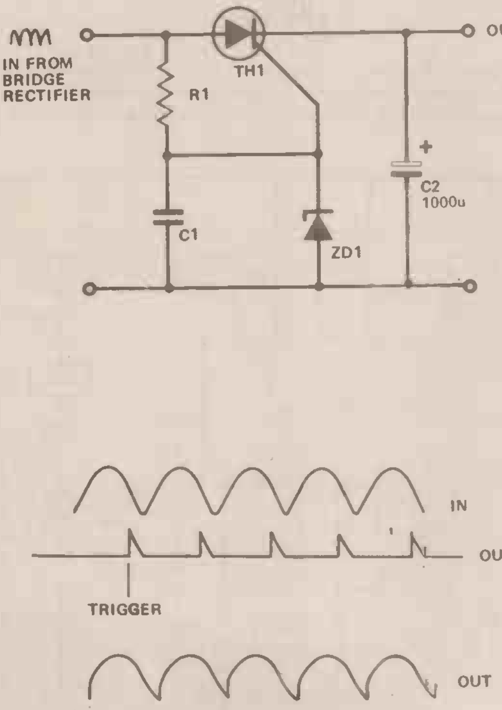


Fig. 9. A simple voltage regulating circuit. If this is used as a better charger (for lead-acid batteries only), C2 can be omitted.

A very simple circuit making use of this principle is shown in Fig. 9. This is a voltage adjuster; which enables you to obtain several switched values of DC voltage from a transformer without using toppings. It's particularly useful for lead-acid (car or motorbike) battery charging, as the voltage is so easy to charge. The principle is that the zener diode, which may be one of several selected by a switch, applies a steady voltage, equal to the zener diode voltage, to the gate of the thyristor. At the anode of the thyristor, the waveform is a full-wave-wave rectified wave from the bridge rectifier. The cathode of the thyristor is connected to the reservoir capacitor C2, a large value electrolytic rated at the full peak voltage of the transformer secondary.

To see what happens, imagine that the peak voltage of the rectified wave is 25 V and that we have a 15 V zener diode. When the circuit is first switched on, capacitor C2 is uncharged, so that the cathode voltage of THI is zero. When the voltage at the anode starts to rise, the thristor will not conduct right away, because ci has to be charged up first. As CI charges, however, THI will switch on, so that current flows, charging C2 to the full peak voltage.

LOADING

Now if there is no load resistor connected across C2, the thyristor will not conduct again even if it is triggered because the anode voltage will not be any higher than the cathode voltage. Any normal power supply is used with a load, however, so that we can assume that the voltage across C2 will drop quite a bit between the time of the first voltage peak and the next one. If the voltage across C2 is higher than the zener diode voltage, though, the thyristor will not trigger, and the next voltage pulse does not cause the thyristor to conduct.

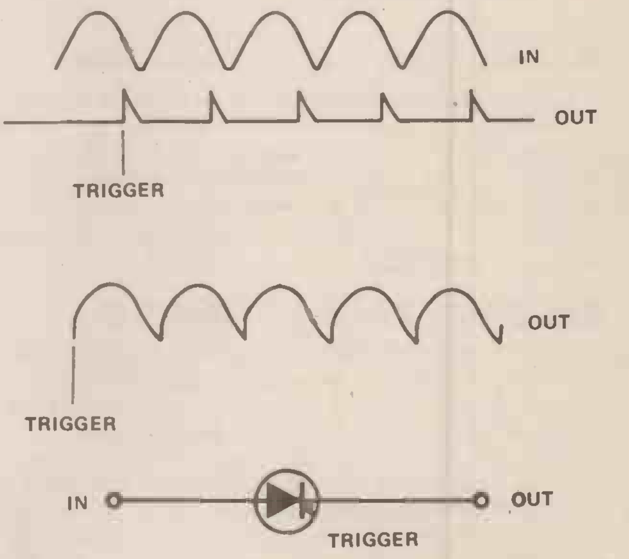


Fig. 10. Phase control of a wave. The average voltage at the output depends on how late in the cycle the thyristor is triggered.

This continues until the output voltage drops to less than the voltage of the zener diode. When this happens, the thyristor will start to conduct whenever the anode voltage is higher than the cathode voltage, and the reservoir capacitor C2 will once again be charged to the full peak voltage. The thyristor will conduct every now and again; enough to keep the **average** voltage at the output fairly steady at around the zener diode voltage.

and opto-isolators, illustrated in Fig. 16. Pulse transformers can be obtained which have insulation guaranteed to 4 kV, but which will fire even a large thyristor when a pulse is applied to the primary. Opto-isolation provide smaller output powers, but can be used to trigger a small thyristor which then fires the main thyristor. Great care must always be taken with disco light equipment, because faulty insulation in such equipment is responsible for an increasing yearly total of deaths caused by electrocution.

The other type of problem which is encountered when thyristors are used with mains voltages is that of radio frequency interference (RFI). When a thyristor switches on suddenly at or near the peak of a wave, a large pulse of current flows, and the steep-sided wave is very rich in harmonics. Such a wave is radiated easily from all the wiring around the thyristor, and interferes badly with radio, particularly on the lower frequencies. The long wave radio-4 transmissions, in particular are badly affected by thyristors in TV receivers, in light dimmers, drill speed controllers and other thyristor power circuits.

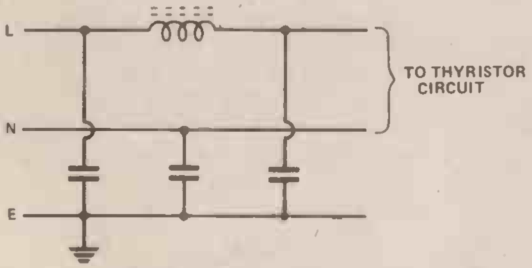


Fig. 17. Reducing radio-frequency interference (RFI).

Complete elimination of RFI is difficult, but a considerable reduction in interference is possible if RF chokes and filter capacitors are fitted into the circuit (Fig. 17). These generally consist of inductors constructed with several turns of insulated wire (typically about 40 turns) on a ferrite rod, with 0.01 uF capacitors to earth on each side of the inductor.

ZERO VOLTAGE CROSSING

A different approach to the problem of interference, and to thyristor control, is the zero voltage crossing control system. This can be used only when the load has a lot of energy storage, such as a large heater, because the idea is to switch the thyristor on when the wave is at zero volts, to keep the thyristor on for several cycles, and then to keep the thyristor off for another few cycles. In this way (Fig. 18) the power can be controlled by varying the ratio of the number of "on" cycles to the number of "off" cycles. Obviously, this is useless for loads such as lights or drill motors, but for loads such as heaters which do not charge noticably when power is removed for several cycles this method has a number of advantages. For one thing, since there are no sudden switch-on pulses, greater amounts of power can be switched. Because the switching occurs at the zero crossing points of the wave, there is no RFI. The only penalty is a more complex circuit due to the need to generate a pulse when the wave passes through zero, and to time a number of cycles on and another number off. Fortunately, integrated circuit zero-voltage crossing controllers can be obtained from Feranti and from Plessey among other manufacturers. Fig. 19 shows the circuitry used with a zero-crossing type of circuit controlling a triac. In general, triacs are used on purely AC circuits, with thyristors being used on DC or rectified AC supplies. When very large amounts of power are to be controlled, thyristor bridges can be used when no triac of suitable power rating is available.

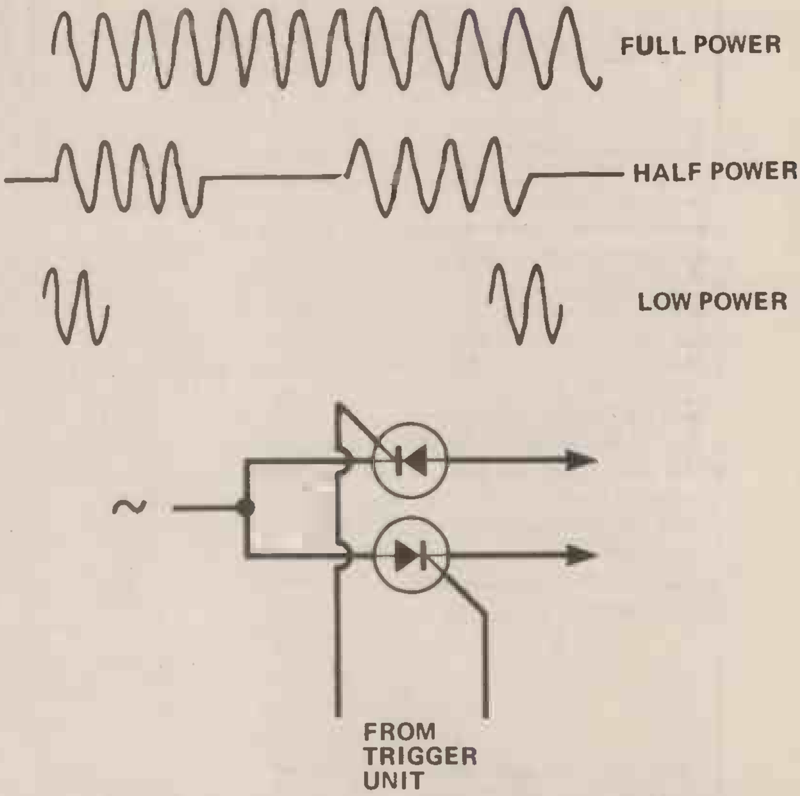


Fig. 18. Zero-crossing control — the thyristor is always switched on just at the zero-voltage level. For full-wave control as shown, two thyristors or a triac would have to be used.

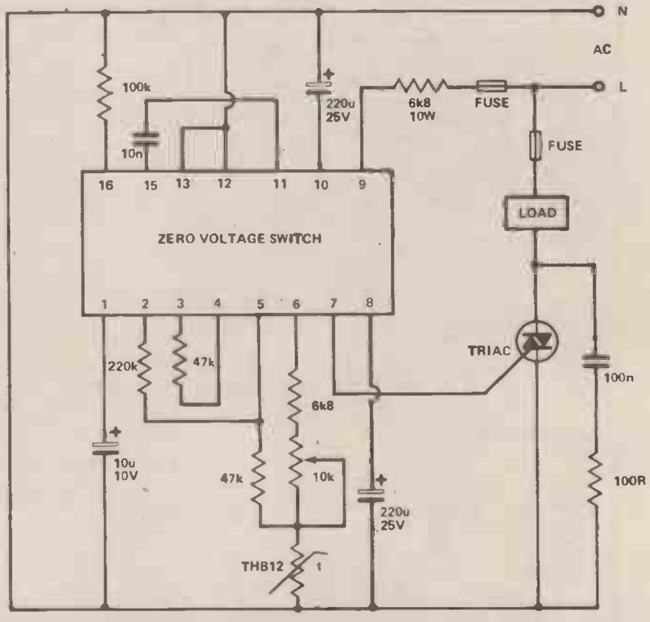
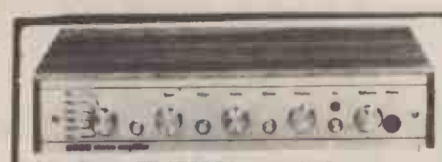


Fig. 19. A zero-crossing switch circuit used for temperature control. Note that all points can be live. (Courtesy of RS Components Ltd).



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Viscount IV unit in teak simulate cabinet Silver finish rotary controls and pushbuttons with matching fascia, red mains indicator and stero jack socket. Functions switch for mic magnetic and crystal pickups, tape tuner and auxiliary. Rear panel features fuse holder, DIN speaker and input sockets 20 x 20 watts RMS 40 x 40 watts peak for use with 8 to 15 ohm speakers

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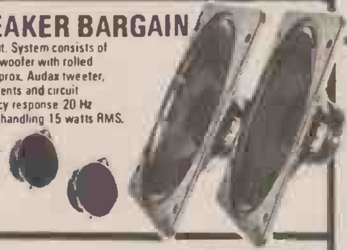

Stereo pair 350 kit. System consists of 13" x 8" approx. woofer with rolled surround, 2½" approx. Audax tweeter, crossover components and circuit diagram Frequency response 20 Hz to 20 KHz. Power handling 15 watts RMS. 20 watts max 8 ohm impedance.

£15.25 Per stereo pair £3.65 p&p

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Belt drive chassis turntable unit semi automatic, cueing device. **£25.50** p&p £2.60

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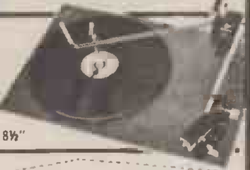
BSR

Manual single play record deck with auto return and cueing lever, fitted with stereo ceramic cartridge 2 speeds with 45 r p m_ spindle adaptor ideally suited for home or disco use. OUR PRICE **£11.25** p&p £2.75



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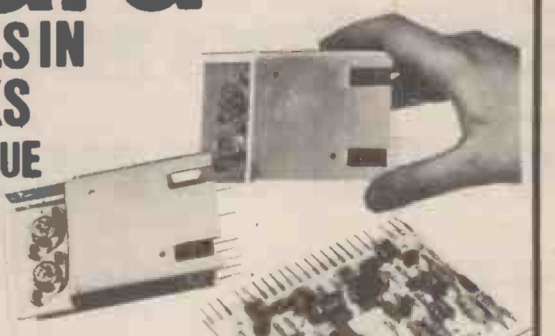

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10 + 10 AMPLIFIER KIT

An opportunity to buy a 10 watts per channel stereo amplifier kit which is suitable for use with a ceramic cartridge. The amplifier utilises proven Mullard modules and is available at a very competitive price The amplifier kit comes complete with instructions and includes: a Mullard LP1183 stereo preamplifier module, two LP1173 power amplifiers with integral heatsinks, a power supply, Zobel networks, front and back mounting panels, a finished fascia panel, all control potentiometers (bass, treble, volume and balance), switches, input, output and headphone sockets, wire, and an easily assembled wrap around cabinet to house the finished unit

Size approximately 9¼" x 8¾" x 4" p&p £2.25 **£12.25**

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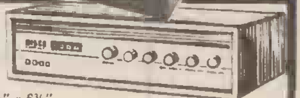
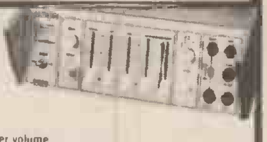
50 WATT MONO DISCO AMP



£30.60 p&p £2.70
Size approx. 13⅜" x 5¼" x 6¾"

50 watts rms. 100 watts peak output. Big features include two disc inputs, both for ceramic cartridges, tape input and microphone input. Level mixing controls fitted with integral push-pull switches. Independent bass and treble controls and master volume.

100 WATT MONO DISCO AMP



Size approx.
14" x 4" x 10¼"
Brushed aluminium fascia and rotary controls.
Five vertical slide controls, master volume, tape level, mic level, deck level. PLUS INTER DECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa Pre fade level control (PFL) lets YOU hear next disc before fading it in. VU meter monitors output level
Output 100 watts RMS 200 watts peak

P&P £4.05 **£66.45**

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Attractive teak finish, modern design, incorporating 2 speaker units – 8" approx woofer and 2½" approx. tweeter. 45 to 1800 Hz Impedance 8 ohms. Power 15 watts RMS
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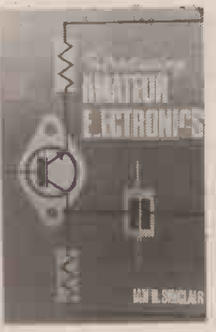

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Starburst

Expand your universe with HE's pulsating phonoptic display. Ordinary LED chasers beware . . . .

LOOKING FOR a novel, economical, yet versatile LED display? Here is the answer to your dreams. Featuring an attractive matrix design, audio control input and a choice of three operating modes, the HE Starbursts adds a new dimension to conventional light-chasers.

Assembled on two printed circuit boards, the unit is designed around readily available CMOS chips and uses only a few other discrete components. The display is arranged as five semicircles of ten LEDs each which are illuminated in bands sequentially producing the illusion of either an expanding line of light or a band of light that grows outward and collapses. A novel bonus of the circuit design is the automatic mode where dots and bars are displayed alternately.

The audio signal pre-conditioner, clock oscillator and counter-decoder-driver circuitry is mounted on one board, whilst the other board holds the display and main decoupling capacitor. The circuit is powered by a single PP9 nine volt battery. Choice of a larger battery ensures longer life as currents of up to one hundred milliamps may be drawn when all the LEDs are lit. No provision is made for the battery or power switch on-board enabling the unit to be neatly boxed and mounted in any suitable remote position.

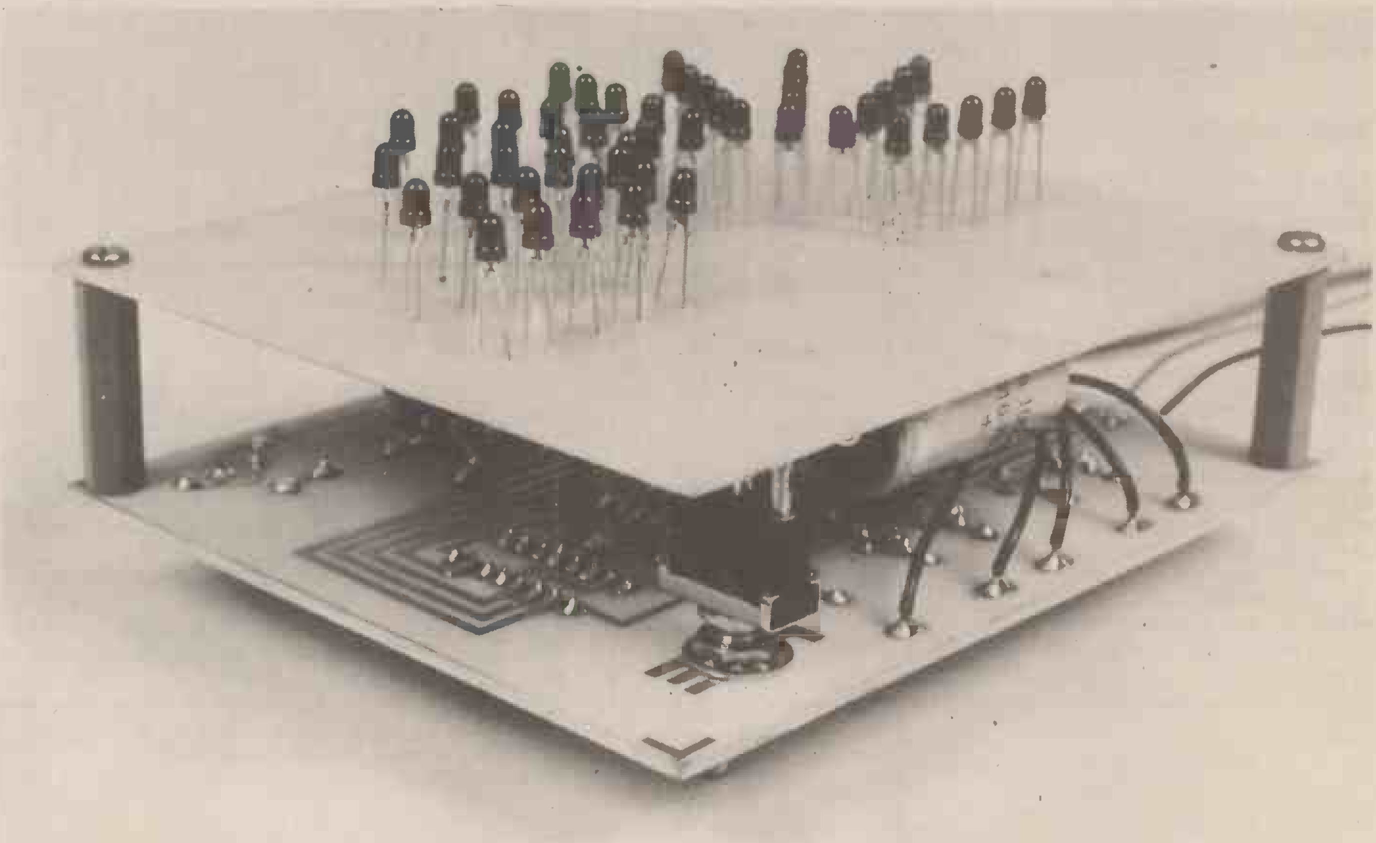
SEEING THE LIGHT

After applying power to the circuit, the LEDs will illuminate from the centre of the display outwards appearing as a bar or dots of light; or alternately depending on the position of mode switch SW1.

Application of an audio signal will cause the frequency of movement to increase. By adjustment of the input level and control RV1, the display can be made to follow the dynamic range of the audio input; increasing in frequency as the audio input level increases in amplitude. Component values shown make the unit more sensitive to input frequencies above 1 kHz or so and more responsive to melody lines in music and to vocal input.

LUCKY NUMBER

At first glance, it would appear that the way to produce a display such as the one described above might be to use a 'bargraph' chip driven from a ramp whose frequency would be controlled by the audio signal. However, the CMOS family contains some not so popular but nonetheless versatile chips which enable an economical



The two boards of the HE "Starburst," the switch in the foreground controls the three modes of display.

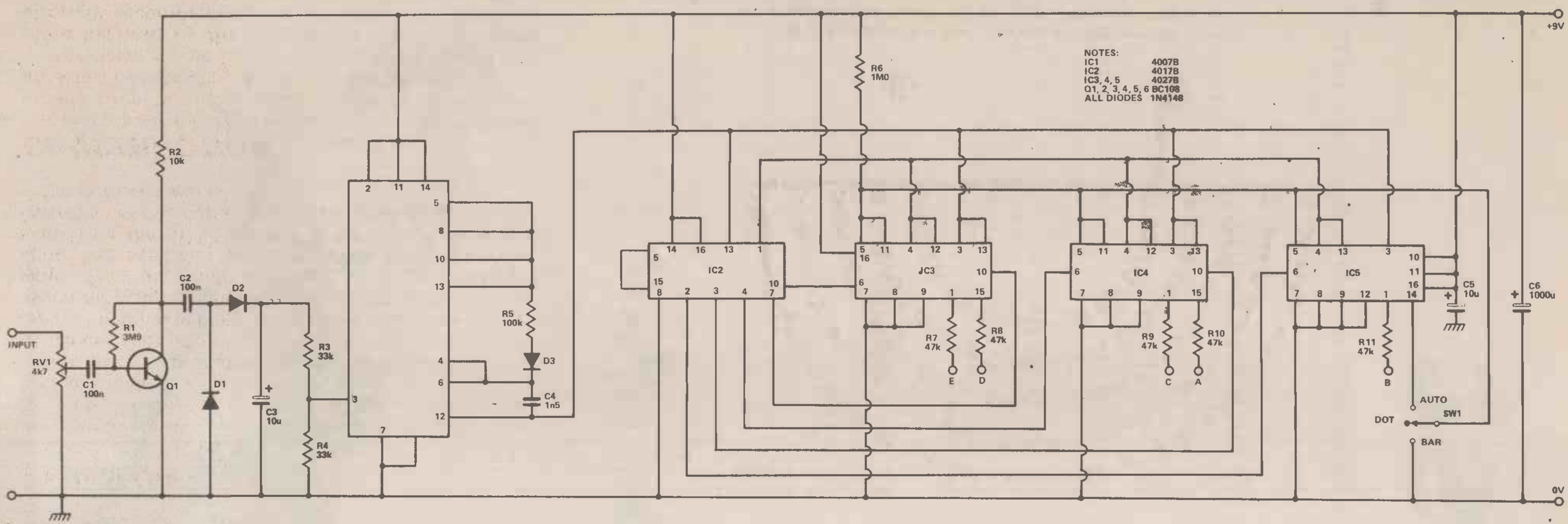
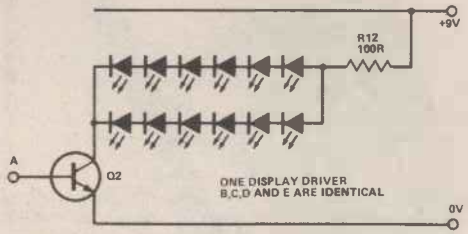
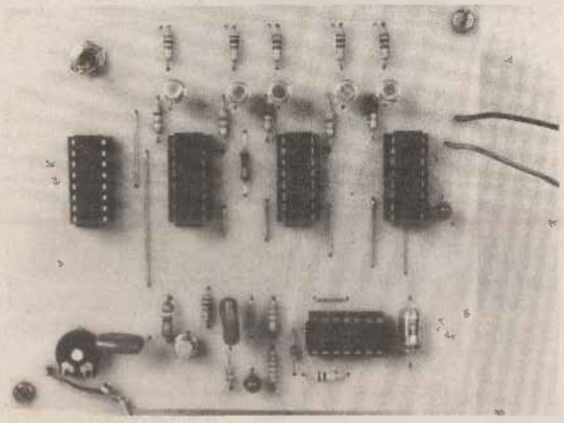


Fig. 1. Circuit diagram for Starburst control circuitry and display. There should be no problem in either obtaining components or assembling the unit.



ONE DISPLAY DRIVER
B,C,D AND E ARE IDENTICAL



How it Works

IC1 is an oscillator whose frequency can be controlled over a limited range by a voltage applied to pin 3. As the voltage rises, the frequency increases. The block diagram does not give much away so the important parts of the circuit have been drawn in simplified form in figure 2.

As can be seen, the chip contains two pairs of complementary transistors which are here connected as inverters and one single transistor (pins 3, 4, 5) which operates as a voltage controlled resistor. It also contains another complementary transistor which is not used here.

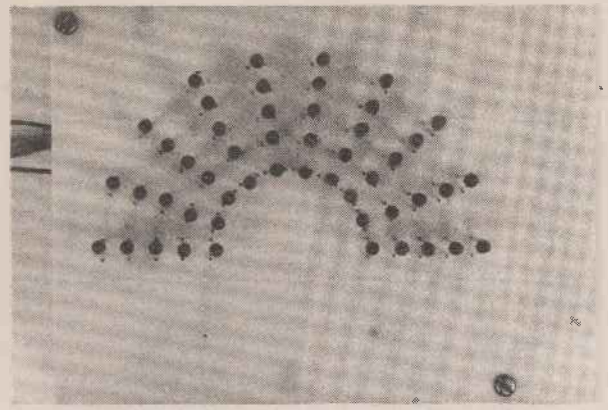
Operation of this network is more easily understood by representing it as shown in figure 3. It is the same circuit, though the complementary transistor inverters are now shown in block diagram form. The remaining transistor and the resistor and diode together form the timing resistance Rx and can be considered as a single resistor.

If the circuit is redrawn (fig. 4), it will be familiar as a conventional CMOS oscillator. The resistor and diode are simply there to modify the duty cycle of the oscillator in order to produce a greater control range from the circuit.

well as providing a discharge path for this capacitor. Comparatively high values can be used for these resistors as there is negligible loading by the very high input impedance mosfet in IC1.

The pulses from oscillator IC1 (pin 12) clock five of the flip-flops in IC3, 4, 5 and the decade counter-decoder IC2 which produces a logic 1 high level at its outputs in turn. These signals could be fed to the transistor LED drivers directly but instead are processed by five of the J K flip-flops in IC3, 4, 5. It is this that enables the different modes of operation from the diplay. The sixth flip-flop is clocked each time a display sequence is completed and its output consists of alternate logic 0s and 1s.

Briefly, these 4027 chips each contain two flip-flops whose outputs following a clock pulse depend on the state of two inputs: J and K. In this design, one input (J) of the five flip-flops is driven by the outputs from the 4017 whilst the other input (K) controls the form the display will take. All the K inputs from these five flip-flops are commoned and brought out to SW1 where a logic '0' or an alternating logic signal is available from the sixth flip-flop. When SW1 is in the centre-off position,



The display board viewed from above, the effects, especially when in the "audio" mode are quite exciting, to say the least.

The control voltage for IC1 is derived from the audio signal input to Q1 via RV1, C1. The amplified signal appearing at the collector of Q1 is coupled via C2 to rectifiers D1, D2 which charge C3. R3 and R4 tap off a proportion of the voltage across C3 as the K inputs are pulled up to a logic '1' by R6 giving a dot display.

The outputs from J K flip-flops control transistors Q2-Q6 which drive the LED display. C5 and C6 are power supply decoupling capacitors.

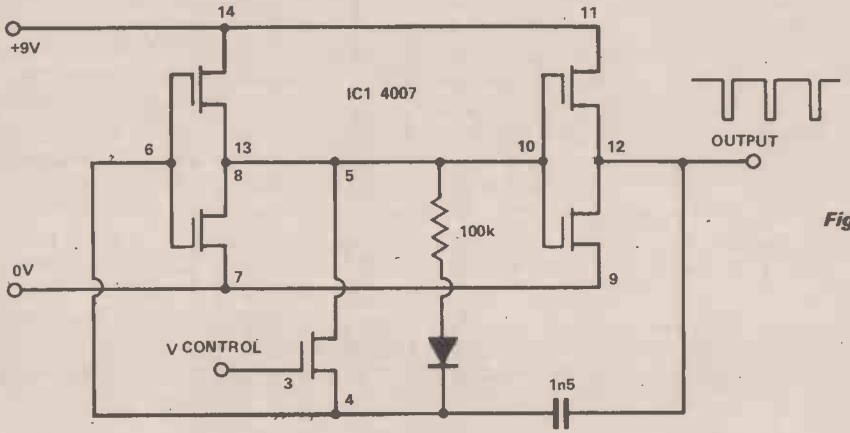


Fig. 2. Simplified view inside the 4007.

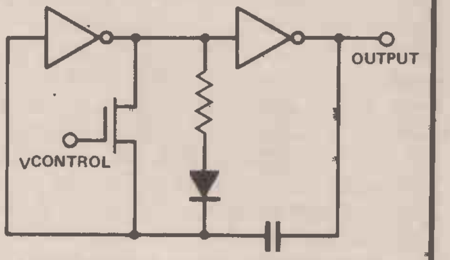


Fig. 3. MOSFET used as a variable resistor.

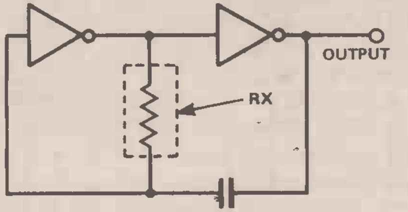


Fig. 4. Conventional CMOS oscillator.

yet sophisticated circuit to be produced. By coincidence, all the chips in this project contain the number seven in their device code. They are the 4007, 4017 and 4027.

SEVEN-UP

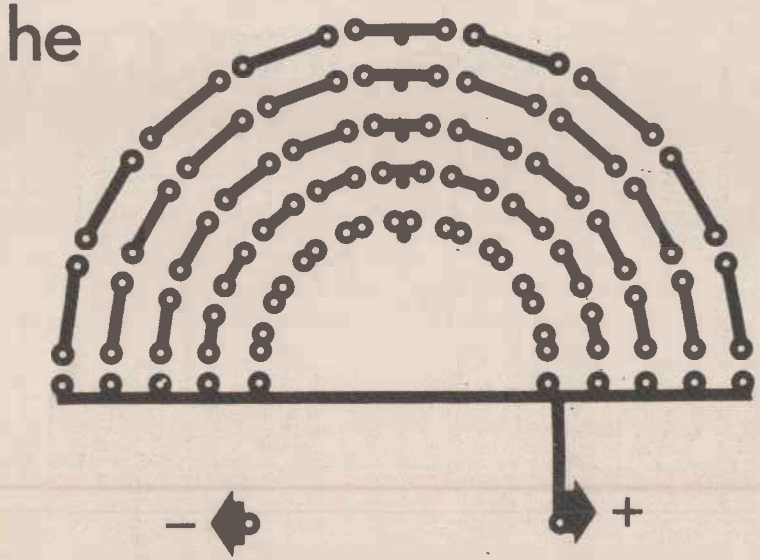
The mainstay of the circuit is the ubiquitous 4017 decade counter-decoder whose outputs are processed by the 4027 chips to produce the logic control signals for the display driver transistors.

The 4007 is probably the least familiar device. It is not strictly speaking a logic chip as it contains only three pairs of complementary metal oxide silicon transistors which may be interconnected in a number of different ways. They are configured here as a noval voltage-controlled oscillator which provides the clock drive signals for the 4017 counter and 4027 JK flip-flops. Operation of this part of the circuit is described in more detail in 'how it works'.

CONSTRUCTION

The unit is assembled on two PCBs. Use of our PCBs will greatly simplify construction as well as enabling an attractive free-standing display to be produced.

Wire links should be inserted first and soldered into place followed by the IC sockets. Use of sockets is strongly recommended. Next, insert the resistors, capacitors and transistors and diodes. Do not insert the ☞



PCB foil pattern for the "Starburst" display board, no problems here, as always take care with your soldering.

CMOS chips at this stage. Note that some of the links pass under the IC sockets. If you do forget to put one in and discover later that it is inaccessible simply use a piece of insulated wire on the underside of the board to complete the connection.

The LEDs are wired in series-parallel and failure of one will cause the other four in an arm to extinguish. The display board can be tested as it is assembled by use of a separate nine volt supply. Insert and solder into place C6 ensuring correct orientation then connect the positive lead of the battery as shown on the overlay and make up a length of wire in series with a 330 ohm resistor. Connect the free end of the resistor to the negative terminal of the battery. Then as assembly of each arm of LEDs is completed, touch the free end of the wire from the resistor to the connector pads on the PCB (shown going to resistors R12 to R16 on the overlay). The LEDs should light. Failure to do so indicates an open circuit or reversed LED. Check for this condition by shorting each LED in turn until the display lights and replace any faulty ones ensuring correct orientation. A short lead, indent or flat on the plastic encapsulation usually indicates the cathode. We used red LEDs. In fact green or yellow LEDs will not work with a nine volt supply as they have a higher forward voltage drop.

Once satisfied that the display board is working correctly, make the remaining interconnections between the boards. We mounted SW1 on the main circuit board, there's plenty of room. Insert the ICs observing the usual CMOS handling precautions and connect a nine volt battery. The display should illuminate. If all is well, connect an audio signal to the input and adjust RV1 for satisfactory operation. Check that operation of SW1 causes the display mode to change.

We used the earphone socket of a transistor radio as an audio source though any signal of around 1 volt peak to peak will do. Finally, disconnect the battery and assemble the boards together using spacing pillars to separate them. That completes construction so switch on, plug in and flash out!

HE

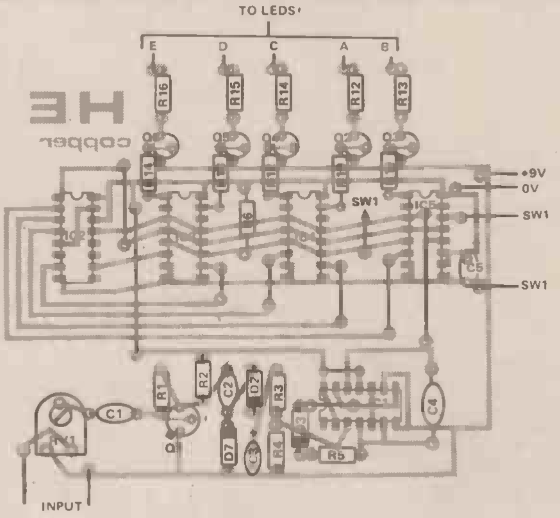
Parts List

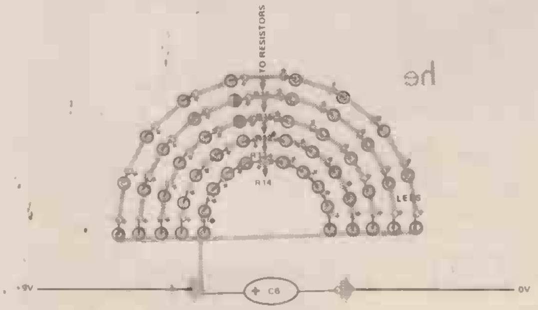
RESISTORS	(all ¼W, 5%)
R1	3M9
R2	10k
R3, 4	33k
R5	100k
R6	1M
R7,8,9,10,11	47k
R12,13,14,15,16	100R
CAPACITORS	
C1, 2	100n polyester
C3, 5	10µ tantalum
C4	1n5 polystyrene
C6	1,000µ electrolytic
SEMICONDUCTORS	
IC1	4007B
IC2	4017B
IC3,4,5	4027B
Q1,2,3,4,5,6	BC108
D1,2,3	1N4148
LEDs	0.125" red (50 are needed if our display board is used)

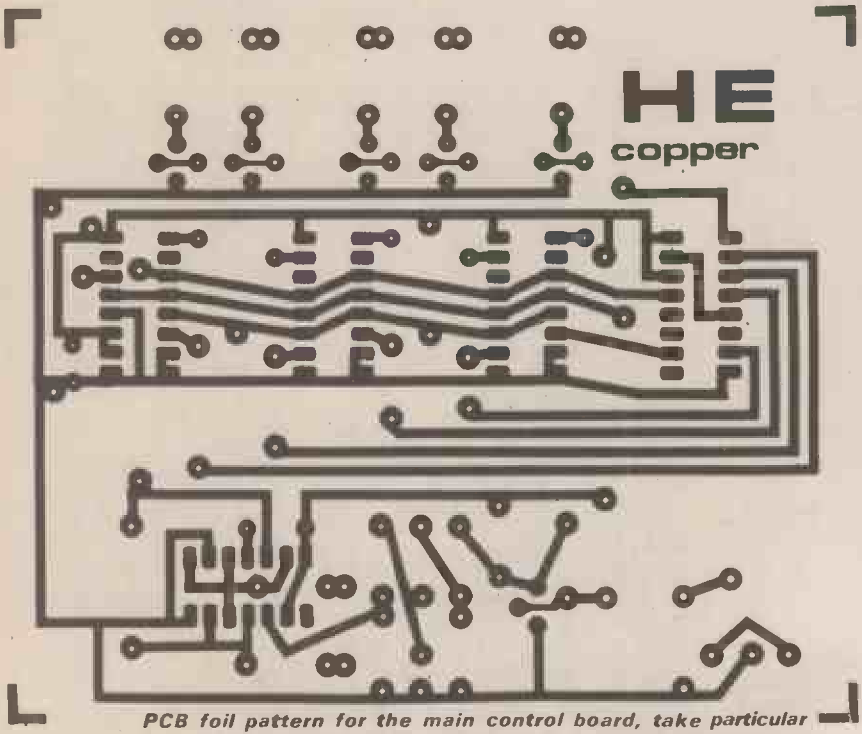
MISCELLANEOUS
SWI SPDT centre off switch. PCB PP9 battery, connectors. Approximate cost £10.00.

Buylines

All the components for this project should be readily available from the usual suppliers. It is worth 'shopping around' for the LEDs as these are sometimes offered in quantity at a discount.







PCB foil pattern for the main control board, take particular care when soldering in the ICs to avoid any solder bridges.

Hobby Chit~Chat

HE project editor and chief designer Ray Marston takes another look at the hobby scene.

THERE ARE GOOD BOOKS . . .

EVERY ELECTRONICS HOBBYIST should make a point of building up a decent collection of electronics reference books. Ideally, you should have at least one really good book that explains the basic principles of electronics, another that outlines the principles of 'advanced' electronics, and one more that gives electronics tables, colour codes, IC outlines, and other pure 'reference' data, etc. The following is our recommended short list.

'Foundations of Wireless and Electronics' by M. G. Scroggie, is probably the best introductory text to electronics ever published. It explains the basic principles of electronics in such a clear manner that even a complete layman can understand it. The subject material of the book spans elementary principles of electricity to fairly advanced electronics.

'Foundations —' was first published in 1936, and is now in its ninth edition. The book has sold some 265 000 copies, which shows how good it is. The latest edition runs to 521 pages, and costs £4.45. It is published by Newnes-Butterworth.

Our next recommendation is for 'Electronics — It's Easy'. This is an ETI publication (ETI is the big brother of HE, if you didn't know), and spans the information range of basic principles of electricity to advanced electronics. It makes an excellent companion to 'Foundations —'. 'Electronics — It's Easy was originally published as a 3-volume ETI 'special'. Volume 1 is now out of print, but the whole three volumes are presently being re-issued as one single book. Release date should be late August, and price about £3.

Our final recommendation is for 'Newnes Radio and Electronics Engineer's Pocket Book', 15th Edition. This is an excellent pocket-sized (you'll need a magnifying glass to read it) reference book of tables, formulae, IC outlines, data, and basic electronic circuits. The book has been compiled by the staff of ETI, is published by Newnes-Butterworth, and is well worth having.

AND THERE ARE AWFUL BOOKS

As a professional book-worm, I'm obliged to read a great many electronics books. Most are pretty mundane, a tiny minority (like those mentioned above) are very good, and a fair number are, frankly, awful. A couple of weeks back, I read what must rate as the most awful electronics book of all. It's called 'Build Your Own Working Robot', is written by an American named D. L. Heiserman, and is published by Foulsham-Tab. It's well worth looking at, simply because it IS so awful, it must be regarded as a classic of its kind.

The first fourteen chapters of the Robot book describe how to build, for a mere few hundred pounds, a device called BUSTER, which is more or less capable of emulating the actions of one of those cheap (about £5) Hong Kong toy cars that change direction whenever they crash into a wall, which is all very amusing if you like that kind of thing. The book really takes off, however, in chapter 15, which has the title HUNGER INTERFACE.

The HUNGER INTERFACE is, to put it as kindly as possible, interesting. Briefly, what happens is that when 'Buster's' 12 volt battery supply falls below 10 volts a pulsed 3 kHz signal is transmitted from its loud speaker, and this signal activates a kind of giant lighthouse (stop laughing at the back there) that is built into one corner of 'Buster's' private room (apparently, 'Buster' is prone to permanent starvation if he moves out of this room). Buster automatically charges at this lighthouse, like a bull at a red rag, whenever it switches on, and ends up impaling himself on a battery recharging circuit. All very clever.

The lighthouse actually consists of a flashing strobe lamp stuck on top of a five foot pole. At the base of the pole is what is described as a 'nest', which includes (amongst miscellaneous bits of wood and a mirror) a battery charger and a couple of massive metal probes, which get rammed up poor old Buster's charging socket whenever he suffers a slight electron deficiency. In front of the 'nest' are two 8-foot lengths of wooden guide rail, which encompass an area of 32 square feet and, working on the 'pea in a funnel' principle, ensure that Buster gets steered into his nest for a re-charge whenever the need arises. So how's that for American technological know-how?

The final chapter of the book describes how to convert Buster into a white-line follower. Which just about sums up the true value of the project that has cost hundreds of pounds to build and sixteen chapters to describe.

To be fair, whatever this Robot book lacks in sophistication of design of its main project is more than compensated for by its author's originality in the use of strange circuit symbols and notations, his sheer guts in presenting photo's of his constructional efforts, and his (thankfully) utter uniqueness of writing style.

As was said earlier, we thoroughly recommend 'Build

Your Own Working Robot' as THE most awful book. You simply must read it. Our congratulations to its author, and to the staff of the Ohio Institute of Technology in Columbus, who helped engineer, build, and debug the super white-line follower known as Buster.

RELAY TIMER CIRCUITS

The real 'guts' of Hobby Electronics is the actual building of, rather than reading about, electronic circuits. One of the most useful circuits that the hobbyist can build is the relay timer. It consists of a relay and a few electronic components, configured in such a way that the relay switches on when you press a START button, and then switches off again automatically after a pre-set time delay. The time delay may vary from seconds to days, and the relay contacts can be used to activate such diverse objects as photographic enlarger lamps, porch lights, battery chargers, and tape recorders, etc.

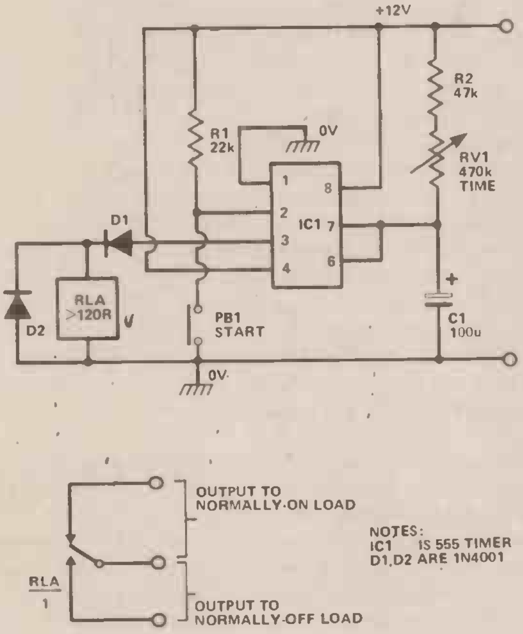


Fig. 1. A simple 6-second to 60-second timer circuit.

Figure 1 shows the practical circuit of a simple 6-second to 60-second timer. The design is based on a type-555 timer IC, wired in the monostable or one-shot mode. The circuit starts a timing cycle when push-button START switch PBI is momentarily operated. Relay RLA immediately turns on, and C1 starts to charge towards the positive rail via R2 and RV1. Eventually, after a delay determined by the RV1 setting, C1 rises to 2/3rds of the supply rail voltage, at which point the IC changes state, the relay turns off, and the timing cycle is complete. External devices can be turned on or off via the relay contacts.

WEAKNESSES

A weakness of the basic Figure 1 circuit is that it permanently draws current from the supply rails, even when the relay is off. Figure 2 shows a 2-range timer circuit that does not suffer from this defect, and which covers the timing range of 6-seconds to 10-minutes. The circuit operates as follows:

When START switch PBI is momentarily closed a START pulse is fed to pin 2 of the IC via R1 and C1, and the relay turns on. Contacts RLA/1 then change over and maintain the power connections to the circuit even when PB1 is released. The circuit then runs through a timing cycle similar to that already described, but with the period determined by either C2 or C3, until eventually the relay turns off, at which point contacts RLA/1 revert to their original state and break the supply connections to the circuit. The timing cycle is then complete. Note that this circuit can be turned off part way through its timing cycle by operating RESET switch PB2.

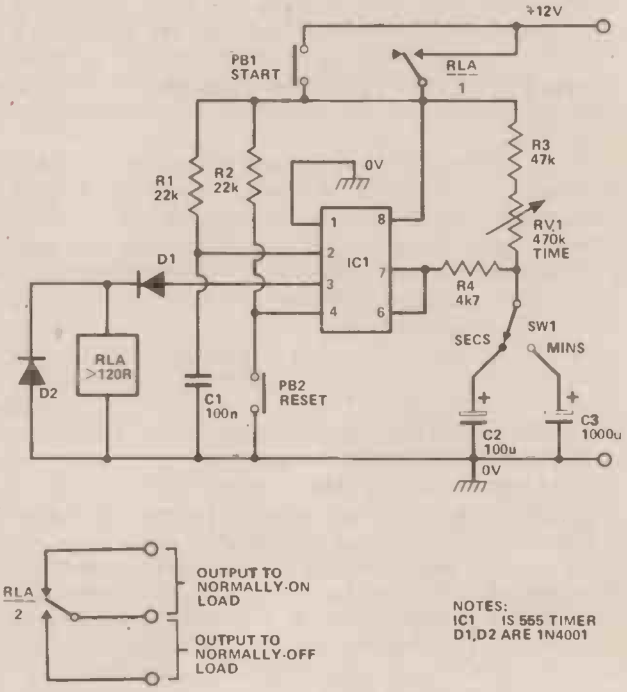


Fig. 2. A 2 range 6-60 second and 1-10 minute timer circuit.

Conventional electrolytic capacitors have very wide tolerances (typically −50% to +100%), and suffer from relatively large and unpredictable leakage currents. Consequently, simple circuits of the types shown in Figs 1 and 2 can not be relied upon to give accurate timing periods, or to give periods that significantly exceed fifteen minutes or so. Figs 3 and 4 show two high-accuracy long-period timer circuits that do not rely on the use of electrolytics for their timing operations.

FREE RUNNING

In both of these circuits, IC1 is wired as a free-running astable multivibrator. In the Fig 3 circuit the astable frequency is divided down by IC2, a 14-stage binary counter, so that the relay turns on as soon as PB1 is momentarily closed, and turns off on the arrival of the 8192nd astable pulse, thereby giving total timing periods in the range of 1 to 100 minutes.

The Fig 4 circuit is basically similar to that of Fig 3, except that an additional decade-divider stage is used in position 3 of SW1, thus giving a maximum division ratio of 81 920, and making maximum timing periods up to 20 hours available from the unit. This circuit is of particular value in giving time-controlled turn-off of battery chargers, etc.

Note in the four timer circuits given that the relay used can be any 12-volt type with a coil resistance greater than about 120 ohms. The relay used in the Fig 2 to Fig 4 circuits should have two or more sets of change-over contacts. **HE**

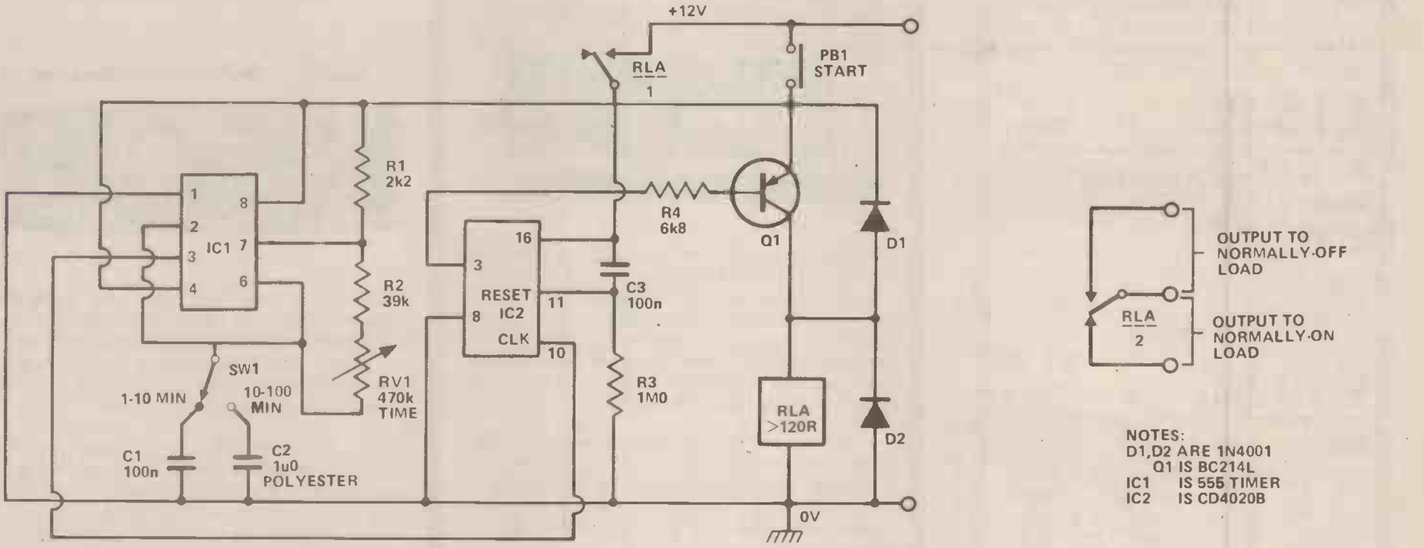


Fig. 3. A 2-range 1-10 minute and 10-100 minute timer circuit.

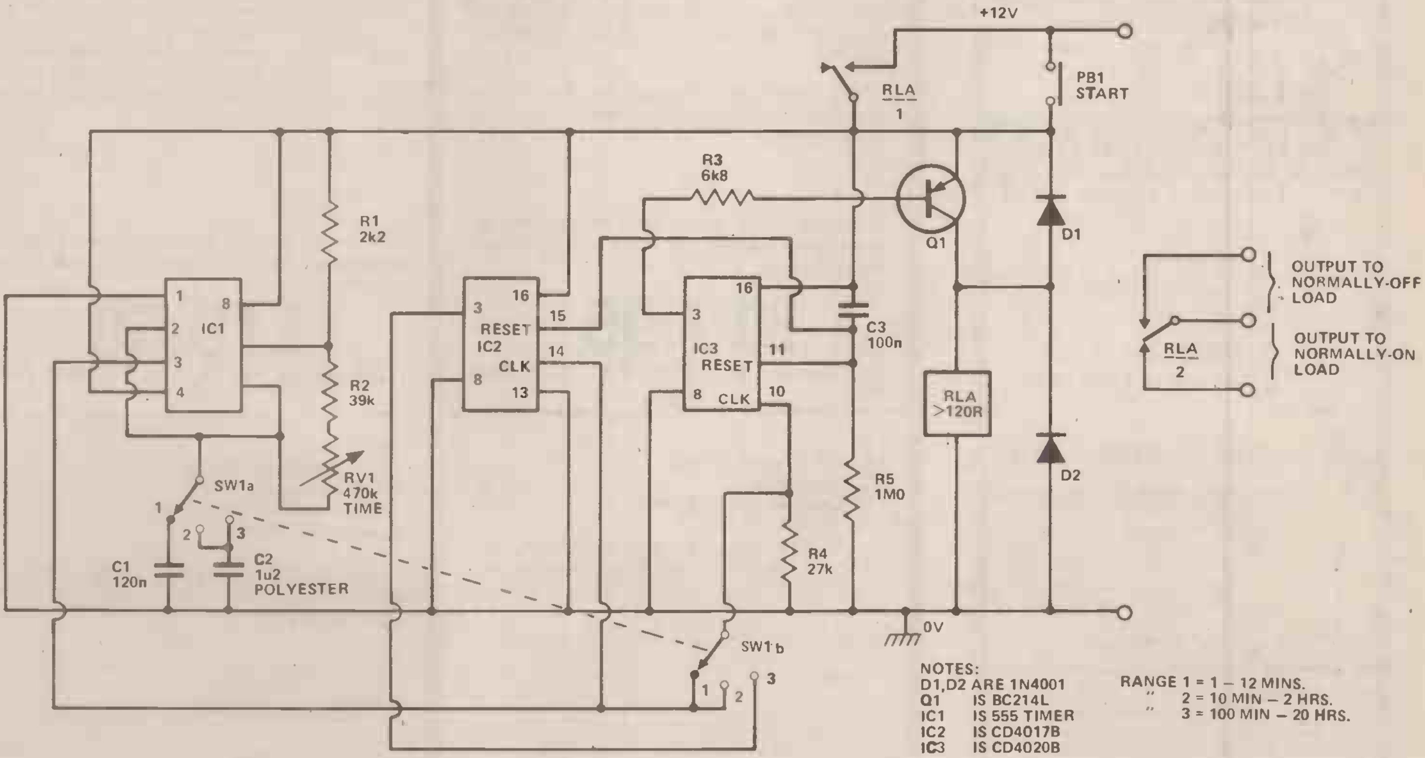


Fig. 4. A wide-range timer covering 1 minute to 20 hours in three ranges.

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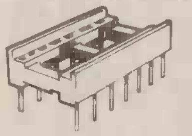

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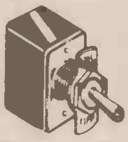

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Design features of the circuit include preset RV1 to allow for component tolerances and individual preferences of light levels, radio frequency interference suppression and an on board fuse to protect the circuit should anything go wrong (and according to Murphy's Law it normally does). Otherwise the circuit is a fairly standard triac/diac power controller which can be used to dim up to 2 kilowatts of bulb power — a fair amount by any standards.

CONSTRUCTION

Fit the PCB to the switch plate (with the switch bits removed) first, before any parts are soldered on, as various holes have to be drilled for screws etc. and this is best done without obstruction.

Once this has been done the parts can be inserted. Make extra sure there are no solder bridges across the tracks.

The triac is the only polarised component which, of course, must be inserted correctly. If you obtain the same device as ours, the TRI 400-8, then it can simply be lined up the same way as in the overlay ie with the heat sink tab closest to the coil L1. If you can't obtain the same triac type, then virtually any type can be used as long as you fit the 3 connections G, MT1 and MT2 in the correct places.

Incidentally, the triac is rated at 8 amps, which is about 2 kW of power. At this rating a fair sized heat sink will be necessary, bolted to the triac. However, at bulb ratings up to 200 watts (adequate for house lighting) no heatsink is necessary.

The coil L1 is not critical and therefore easily made by hand. To construct, Scramble wind 100 turns of 32s.w.g. insulated copper wire around a ½ inch diameter former as in figure 1 (we used the barrel of a pen which was about the right size). Put a spot of glue on the coil of wire and leave it to dry. When dry, slide the coil off the former and fit it to the PCB. Remember to scrape off about half an inch of insulation with wire wool or emery cloth, so that a good soldered connection can be made.

The HE Dimmer in its wall mounting box. For safety we recommend using a plastic, flush mounting box.

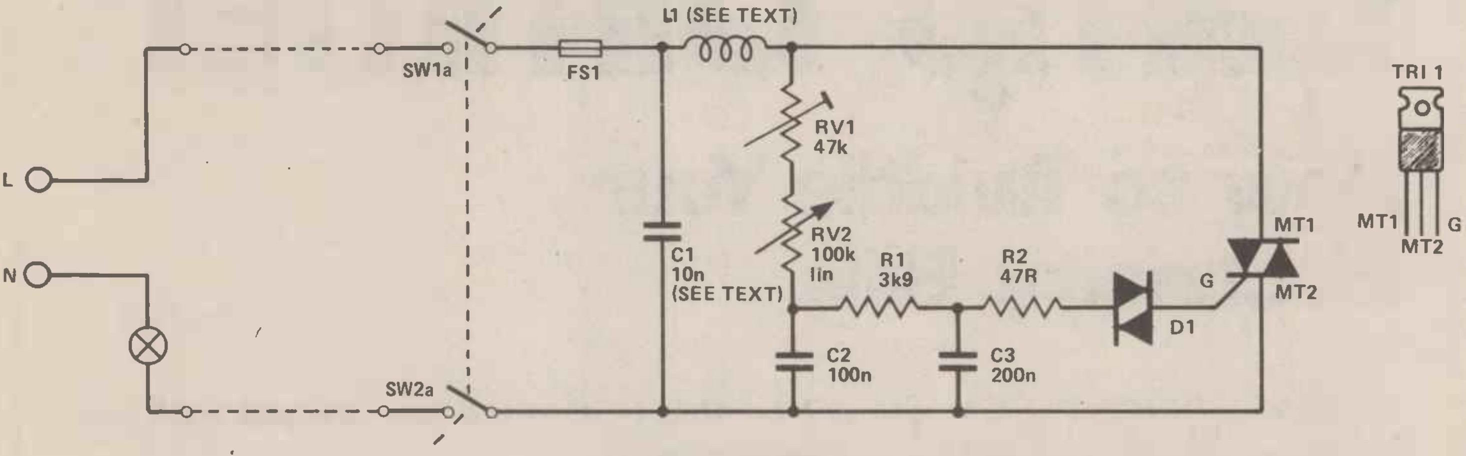
When the unit is complete it only remains to fit it in the wall and adjust it as described in the section on setting up. Only two connections are necessary — the same two that connect to the back of the existing switch plate and its doesn't matter which way round they are. However, certain safety precautions must be adhered to. If your wall has a metal backing box behind the switch then make sure that nothing on the circuit board touches the box — it may even be necessary to remove it and insert a plastic box in its place.

The PCB has **mains** voltages on it and for this reason we advise that the board is to be either sprayed or painted with lacquer (nail varnish will do if you have any!???). This will give a degree of protection against shock — which can be fatal.

SETTING UP

The setting up procedure is simply a matter of adjusting the preset RV1, with RV2 in the low position until the required level of light, in this position, is found. Some people might prefer the main control RV2, to vary from zero to full brightness, but it is probably better to adjust RV1 so that the bulb is just visibly on when the main control is at minimum. This means that it can be visually checked simply by the appearance of the bulb, whether or not the device is off.

Be very careful when adjusting RV1 — do **NOT** use a metal trimmer. Use a plastic one and keep your fingers clear of anything on the PCB whilst connected in circuit.



NOTES:
TRI 1 IS TRI 400-8 OR SIMILAR
D1 IS DIAC TYPE 133 OR SIMILAR

Fig. 1. Circuit diagram of the HE Dimmer, for details of the coil L1 refer to the text and drawing.

How it Works

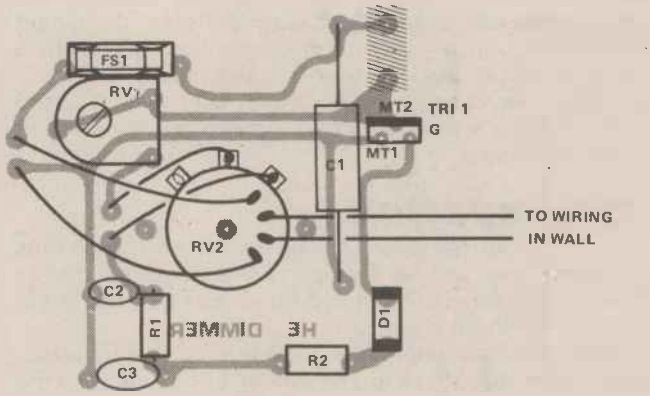
The heart of the project is the triac, which is simply an electronic switch which can be turned on by a small pulse of about 5 volts applied to its gate, G. The switch will stay on permanently, until the applied voltage becomes zero, which with mains A.C. occurs at the end of every half cycle, ie 100 times a second.

The triac is switched on every half cycle at a predetermined time during the wave. The trigger or gate pulse can be altered to occur between the beginning and end of each half cycle, the average length of time which the triac is on can be lengthened and shortened, thus altering the average amount of power applied to the bulb, therefore the brightness of the bulb.

The component which produces the trigger is diac D1. A diac only allows current through it when the voltage across it exceeds its triggering voltage (about 32 volts).

All that remains is to vary the position in the cycle when this triggering of the diac at 32 volts occurs. This is done with the RV1, RV2, C2 time delay circuit. Altering RV1 and RV2 alters the time constant of the circuit (ie the time it takes for the capacitor to charge up to the applied voltage) which alters the phase and therefore the point at which the diac triggers, with respect to the voltage applied to the bulb. Varying the potentiometers therefore, alters the average power applied to the bulb.

Because the voltage applied to the bulb is a bit spiky, radio frequency interference tends to occur and to suppress this, coil L1 and capacitor C1 are included.



NOTE:
RV2 IS MOUNTED ON THE P.C.B. WITH ITS SPINDLE PROTRUDING. SOLDER LEADS ONTO THE TAGS OF RV2 AND INTO THE BOARD.

Fig. 2. Overlay diagram for the HE Dimmer, note the position and orientation of the Diac and Triac, especially if using unspecified devices.

Buylines

The MK rocker type switch plate should be obtainable at any good electrical hardware stockist.

Make sure capacitor C1 is a 300V AC type (or greater), mixed-dielectric capacitors or polypropylene capacitors being normally the only varieties to be so All components should be readily available.

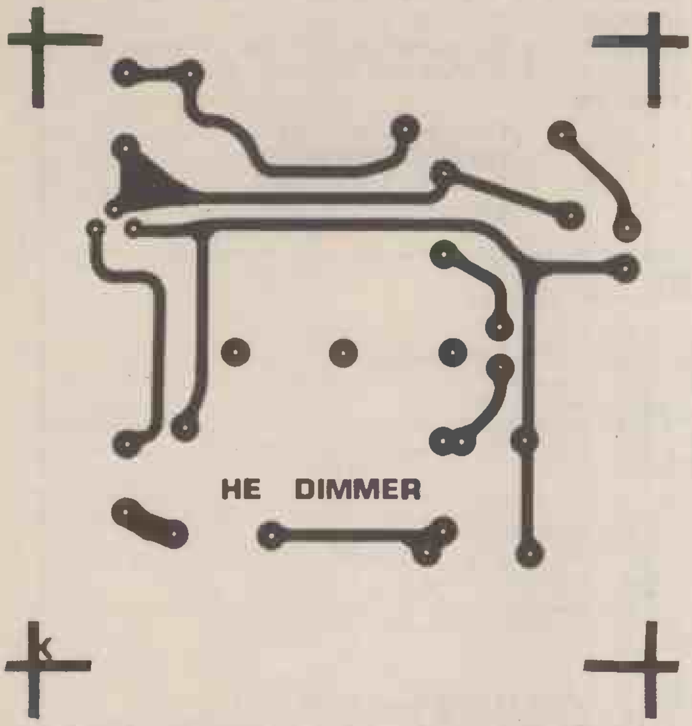


Fig. 3. PCB foil pattern for the Dimmer, take extra care if you make your own PCB to avoid any stray whiskers of copper creating short circuits, mains is dangerous stuff to play around with.

Front panel of the dimmer, experience has shown that a large knob is easier to adjust.

Inside the HE Dimmer, refer to the table for fuse ratings when using high wattage lamps, when adjusting the pot RV1 make sure you use an insulated screwdriver.

Parts List

RESISTORS (All ¼W, 5%)	
R1	3K9
R2	47R
POTENTIOMETERS	
RV1	47K Preset
RV2	100K LIN with DPST Switch
CAPACITORS	
C1	10n Mixed Dielectric or Polypropylene 300V AC
C2	100n Polyester
C3	220n Polyester
SEMICONDUCTORS	
D1	Diac (Type 133 or similar)
TRI 1	Triac (TRI 400-8 or similar)
MISCELLANEOUS	
L1	Coil, 100 turns (see text)
FS1 + Holder	
Rocker type switch plate	
P.C.B.	
Knob to suit	

FUSE RATING	POWER OF BULBS
60 watts	¼ amp
100 watts	½amp
180 watts	1 amp
500 watts	2.5 amp
1 kW	5 amp
2 kW	10 amp

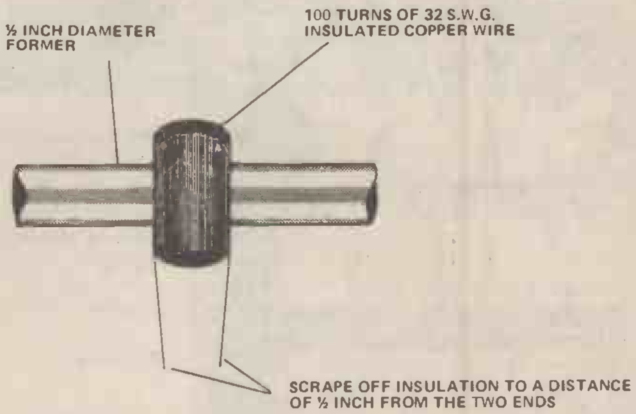


Fig. 4. Details of coil L1, try to keep the coil as neat as possible to avoid any short circuits.

Hobby Electronics Back Numbers

Shown here are all the past issues with their major features and projects. All are available (at the moment) for just 60 pence each, including post and packing. Send your order to:

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NOVEMBER 78 (Hobbyprint A)

Projects: Stereo Amplifier, Digital Clock, Wah-Wah Pedal, Bedside Radio.
Features: The Edison Effect, Robots, Hi-Fi Specs, Kit Review, Transducers, Metal Locators etc.

DECEMBER 78 (Hobbyprint B)

Projects: Metronome, Photon Phone, Audio Mixer, Electronic Dice.
Features: Deep Space Communications, Understanding Bias, Lasers, Photocells, Calculators, The Tesla Controversy etc.

JANUARY 79 (Hobbyprint C)

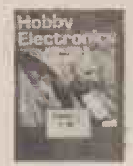
Projects: Graphic Equaliser, Touch Switch, Vari-Wiper, Flash Trigger.
Features: BASIC programming, Viewdata, Starship Daedalus, Pinball Machines, etc.

FEBRUARY 79 (Hobbyprint D)

Projects: Short Wave Radio, Sine/Square Generator, Scratch/Rumble Filter, Car Alarm Project.
Features: Video Tape Recorders, Radioactivity, CA 3130 Circuits, Computer Glossary etc.

MARCH 79 (Hobbyprint E)

Projects: Light Chaser, Tone Controller, Photographic Timer, Cassanova's Candle.
Features: TV Signals, Test Gear, SW Aerials, Interferring Waves, Communications Satellites, etc.



APRIL 79 (Hobbyprint F)

Projects: Model Train Controller, Cistern Alarm, Transistor Tester.
Features: The Telephone System, TV Aerials, Electronics in Warfare, Catalogue Survey etc.

MAY 79 (Hobbyprint G)

Projects: Power Supply, Parking Meter Timer, Digibell, White Noise Effects.
Features: Feedback, Electronic Music, AB Circuits, 555 Circuits, Aerial Tuners, Varicap Diodes etc.

JUNE 79 (Hobbyprint H)

Projects: GSR Monitor, Envelope Generator, Drill Speed Controller.
Features: Citizen Banned, Display Techniques, Moving Coil Meter, Electronics in Music Pt 2, etc.

JULY 79 (Hobbyprint I)

Projects: Shark, Baby Alarm, Point Controller, Linear Scale Ohmeter.
Features: Cassette Decks and Tapes, Binary Numbers, Fixed Resistors, Short Circuits Special, etc.

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Projects: Home Security System, LED Tachometer, Injector/Tracer, Constant Volume Amplifier.
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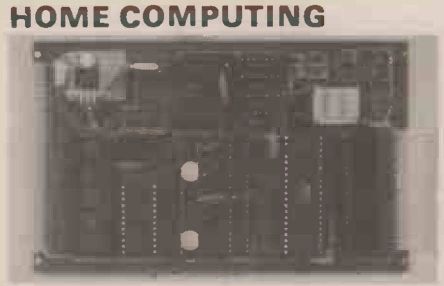
Next Month

Hobby Electronics

ELECTRONIC GAMES

With one eye on Christmas we proudly present the HE review of electronic games. (We enjoy playing with them too). From the humblest hand-held to the most sophisticated video computer, the latest chess playing micros, they're all here next month.

HOME COMPUTING



Sorry about the distinct lack of Computing this month, not to worry though, our resident computer expert Pete Howells takes a personal look at the current computer scene, what it's all about, what's happening now and what we can expect in the very near future.

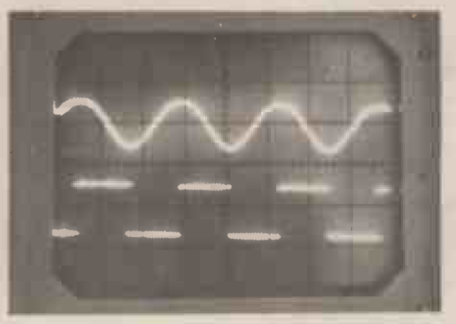
COMPETITION

We hope we will be able to bring you the results of our August picture competition in next month's HE.

MICROWAVE COOKING

What's all the fuss about? Chances are it's because most people don't understand Microwave cookers, they've never gained the wide acceptance they deserve in this country. Next month one of the countries leading authorities on microwaves looks at what makes them tick, just how can a Chicken cook in 30 minutes, or a Hamburger in 5? Find out next month.

AUDIO ANALOGUE FREQUENCY METER



Some people seem to think that unless its got a digital its old-fashioned. We will proove them wrong with this beautifully designed piece of test equipment. The circuit is extremely simple to build yet will give a highly accurate readout of frequencies within the audio range.

If built and calibrated correctly this very useful piece of test equipment should prove to be invaluable for servicing, troubleshooting and experimental purposes. No need to guess anymore.

HOBBYTUNE

We sat around for ages trying to think of a name for this musical project, nothing seemed to do it justice. See what you think about this stylus operated, miniature organ. We won't promise it'll turn you into a virtuoso overnight but we would be surprised if you're not playing tunes in just a couple of minutes. The HOBBYTUNE has many of the features found on instruments costing three or four times as much to buy, a great project for the kids, it must be better than buying them a drum for Christmas.

MULTI OPTION SIREN

Yes folks, it's annoy the neighbours time again. Now you can plague them with a variety of different siren noises, yes before you ask, it will sound like an American police siren, but not only that, like a lot of other sirens too. Not recommended for people of a nervous disposition.

HE TANTRUM

We think the wait will be worthwhile, the Tantrum is a really superb piece of design work. We've incorporated a facility for remote control, (coming up soon) so not only will you be able to enjoy your favourite music from the comfort of your amrchair you'll be able to control it as well. Again apologies for its absence this month, they do say it makes the heart grow fonder.

The October issue will be on sale September 14th

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

Radio Control World

Just in case the R/C modellers have felt neglected in the past few months we've got Bill Berkinshaw, one of the country's leading experts, to review the current radio control scene and some of the technology behind the latest equipment.

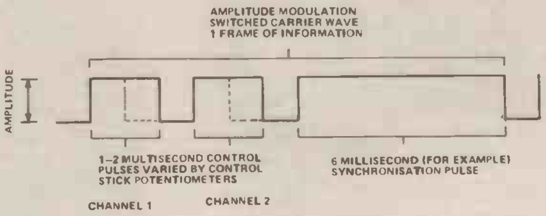
CONTROL OVER DISTANT EVENTS and activities has always been a source of fascination to mankind, many early weapons such as sling shots, bows and arrows and even the gun were manifestations of this phenomena. Couple this tendency with another natural trait of model making, or image creating and in psychologists terms radio control modelling is an absolute natural.

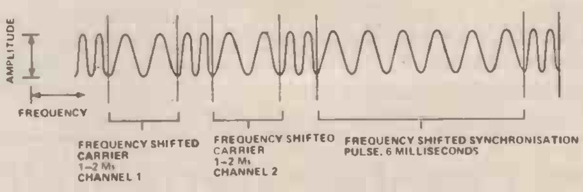
For many years the Leonardo da Vincis, Stephensons and Cayleys of this world have produced models to prove inventions, only to have to face the problems of operating them without damage and under a degree of control. Many early experiments in the field of aviation attempted to tether and thus control their creations with varying degrees of success. But thanks to modern electronic techniques a degree of precise controllability from a remote situation undreamt of even 20 years ago, is a reality for anyone with the interest, and to be fair, the finance to embrace it. Not that radio control of models or full size cars, aircraft or boats is anything like that new. My father for instance held a licence to operate a spark transmitter for remote control of models in the early 1930's, and full size aircraft such as the D.H. Tiger Moth were flown during WWII under radio control.

HOW DOES IT WORK?

A typical radio control system consists of a transmitter, receiver and a number of servos depending on the number of individual items to be operated. Generally the actuation of the controls is by a joystick, either single or dual axis, in the transmitter. Most modern equipment is

Many modellers now use support trays to operate their transmitters in. This transmitter is a four function type — two dual axis control sticks are fitted.





described as "proportional' that is to say a small control stick movement results in a small servo movement — a large control stick movement a large servo movement etc., the servo moving directly in sympathy with the control stick.

The electronics that make it all happen are not very highly sophisticated as modern electronics go, but nonetheless a great deal of careful design work has to go into the system in order that it should work reliably, be light in weight, and of course not cost too much. No electronic knowledge is necessary to operate radio control, only the ability to read instructions and plug in plugs. Most systems are described as Digital Proportional with encoding and de-coding of the signal largely carried out with computer type ICs. A typical transmitter would comprise of an encoding section where a clock generator eg 555 type IC clocks round the various potentiometers coupled to the control sticks. The output from this encoder is then fed, in the form of a chain of pulses of length varying between 1 and 2 mS (milliseconds) plus a larger synchronisation pulse, through a mixer stage and the resulting modulated RF signal fed through various filters to the transmitter aerial.

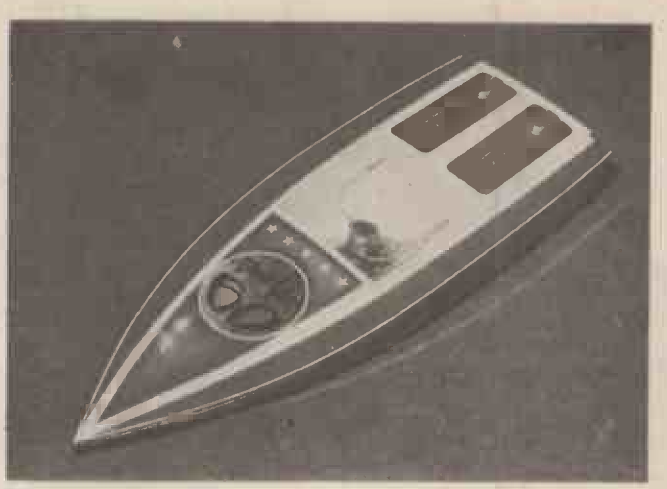
The RF modulation can be of two basic types, Amplitude or Frequency. Many manufacturers are currently changing over from AM to FM systems for as far as Radio Control is concerned the Frequency Modulation systems tend to exhibit better interference rejection characteristics. This is particularly important at present for the high sunspot activity level, and high illegal CB activity level, are combining to make interference a very real problem for 27 MHz radio control operation. Transmitters are all crystal controlled, most have a plug-in crystal facility, the modellers have an agreed list of 'spot' frequencies within the allocated 27 MHz band. Most modern systems will operate quite happily on 25 KHz channel spacing, many of the latest systems will operate on 10 KHz channel spacing. Normally though 12 spot frequencies only are used ranging from 26.960-27.280 MHz.

AM OR FM?

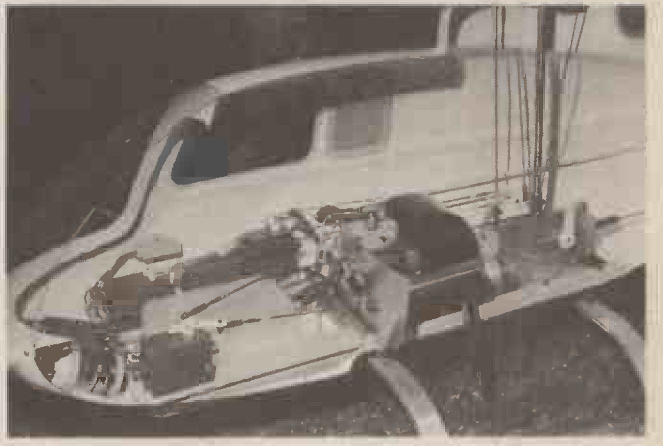
The amplitude modulation systems are very simply 'switched carrier wave' transmitters — the carrier-wave being switched on and off in pulses of varying length as dictated by the control stick positions (see Fig. 1) of course for a fair proportion of the time there is no transmission at all and during this time the Automatic Gain Control of the receiver (AGC) tends to open right up and even with correctly damped AGC the receiver is still wide open to any spurious signals around.

An identical means of encoding is used for the Frequency Modulated system but as there is no 'off' time in the data transmission the receiver is at no time 'open' for interference. Modulation is achieved quite simply by employing a capacitatively coupled crystal with a Varicap diode in series, and as the voltage across the varicap is altered the crystal frequency is swung. A deviation of around 1.5 KHz is sufficient and more would not really be desirable as the available bandwidth as specified earlier is only in the order of 10KHz and allowance has to be made for unwanted sideband transmissions when settling on any deviation level as of course sideband deviates just as much as the centre frequency.

Comparatively simple filtering of the RF output is



A typical G.R.P. hulled R/C speedboat — this example powered by a 10cc engine. Radio control is limited to throttle and steering. Note the water cooling pipes in the engine compartment.



Helicopters are the most complicated of all R/C models. Controls are throttle, collective pitch, main rotor, cyclic pitch (for steering) fore and aft and sideways, and tail rotor pitch. A centrifugal clutch is used between engine and rotors.

This superb scale model of the WWII 'Wirraway' was built and flown by twice National Champion David Vaughan. Note the fire extinguisher and detailed instrument panel — and it flies well too!

used, mainly concentrating on removing 13.5 MHz (fundamental frequency of crystal) and 54 MHz (second harmonic) components, but care has to be taken in design for the systems are frequently used with mismatched ie retracted aerials etc. for not all modellers, indeed very few are electronics experts.

RECEIVERS

Radio control receivers are comparatively simple, not because sophistication is undesirable, but because use of the equipment in models demands that it be light in weight and small in size. Typical radio control receivers weigh in the region of 1.5 ozs and around 2 in square and ⅝in deep. In common with the transmitter, plug-in crystals for easy channel changing are featured. Design follows conventional superhet procedure with double tuned front end, oscillator mixer stage, IF strip, amplification stage then the decoder. Usually this is of CMOS type as any saving in current consumption is worthwhile, and the very low current levels in CMOS ICs represent a very big saving. Discrete component or even TTL logic decoders are now virtually unheard of; 4000 series CMOS types are the norm.

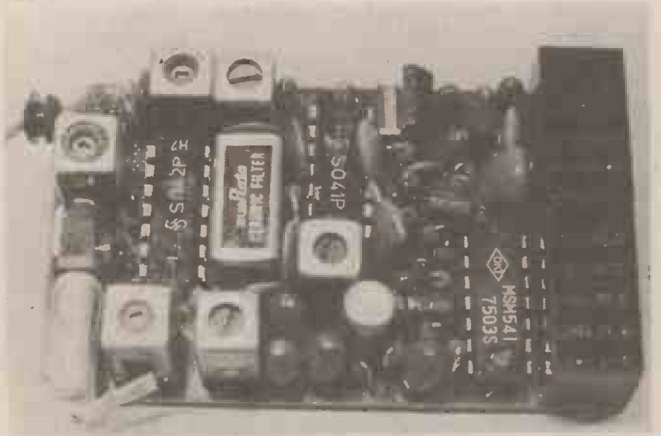
The decoder outputs are fed to a series of servos, these are electro-mechanical devices which receive pulses in turn from the decoder which are images of the pulses encoded by the transmitter. A reference pulse is produced by the servo amplifier which is compared with the pulse received from the decoder. If a difference, either positive or negative is detected then the servo motor is turned on driving the control surface and a feed back potentiometer until the reference pulse, altered by the feedback potentiometer, and the decoded output pulse are equal, whereupon the servo stops. Information updates are fed to the servos from the decoder at the rate of approximately 30 times per second.

Overall accuracy of the system is highly dependent on servo design, not least on the accuracy of the servo feedback potentiometer where much detailed design work has been done to improve upon the resolution and linearity of the servo. Latest of these developments is the use of 'geared-up' feed back potentiometers as use of a larger portion of pot track tends to minimise the effect of minor deviations in resistance from point to point along the track. Of course, similar problems are present right at the very beginning of the chain, at the control stick itself, where potentiometers are also used. It is fair to say that the majority of failures and problems in radio control equipment occur in the electro-mechanical area rather than the electronic.

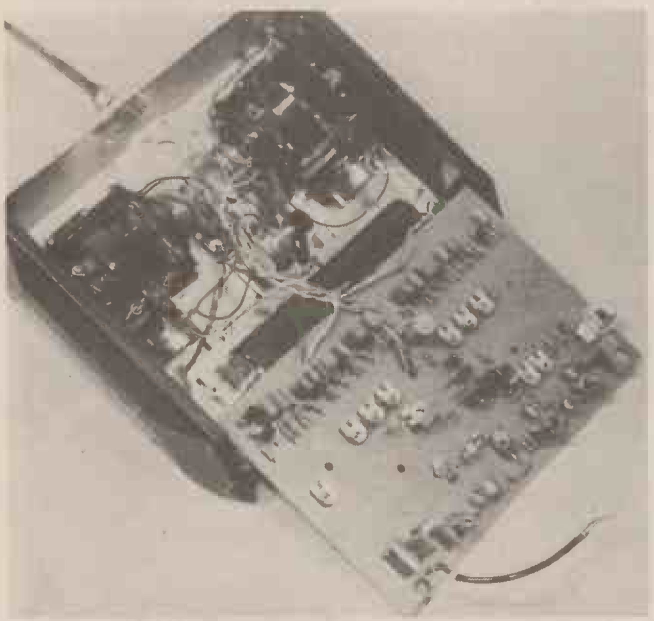
POWER

Power for both transmitter and receiver can be either from dry cells (alkaline type preferred) or from rechargeable Nickel Cadium cells. The latter are by far the most suitable as they are able to cope with occassional high current requirements, have greater capacity and can of course be re-charged indefinitely. From the economic viewpoint alone Ni-Cads are much to be preferred for if any regular use of the equipment is anticipated, continual replacement costs of dry-cells will soon outweight the cost of Ni-Cads. Transmitter operating voltage varies from make to make but is usually 9.6 volts sometimes 12 V. (either 8 or 10, 12 V Ni Cads). Receiver/servo voltage is almost universally

Another of David Vaughan's superb models — this one the P51B.



Futaba 6 channel FM receiver/decoder. Employs 'transistor radio' type ICs and filter. Decoder chip is the one nearest the output block connector on the right of the photograph. Note the plug-in crystal bottom left of the PC board.



Futaba 6 function FM transmitter. Encoding section is a train of 'half shots' in this case on the section of board nearest the case body. The keen eyed will perhaps spot the varicap diode adjacent to the crystal and the trimmer for adjusting centre frequency. The length of screened cable would normally connect to the aerial and has been removed for photographic purposes.

4.8 volts (4 x 1.2 volt Ni-Cads). Cell capacity is usually 500mAh (milliamp per hour) providing a system operating time of 3-4 hours.

HOW FAR, HOW HIGH?

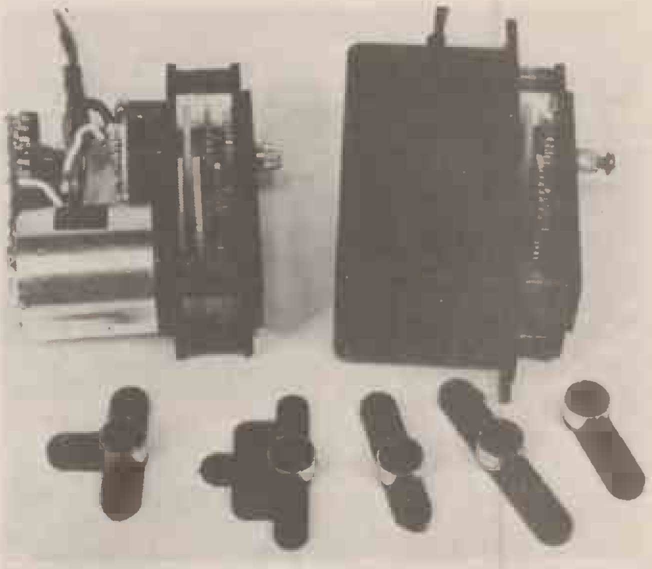
IT is fair to say that all modern R/C equipment has more operating range than the normal operator will ever need. The Home Office regulations governing the licensing of R/C transmitters restrict output to a maximum of 1 watt, a level which few transmitters genuinely achieve. This output level is sufficient for the modeller to be able to control his model as far away or as high up as he can see it. It is obvious that if you can't see it, you can't control it, therefore providing the range is sufficient for control of the largest model at the limits of visual range, then all is well; usually about ¾ mile is the maximum needed.

Range is of course not just dependent on transmitter output but also on receiver sensitivity, which despite the incorporation of good AGC is itself a compromise between overloading at close ranges and lack of sensitivity at extreme ranges. A low output transmitter coupled to a very sensitive and selective receiver is perhaps the optimum but receiver electronics come expensive so the reverse situation is more commonplace. FM systems do score in this respect as they do not employ AGC instead a limiting device is employed and the receiver is able to be much more sensitive without fear of swamping when operated close to the transmitter.

WHAT CAN BE DONE WITH IT?

Fly, drive, sail or just open your garage door from a distance — there is really no limit to the range of models or devices that can be operated by radio control. Take advantage of the precision and reliability to control superb working replicas of full size aircraft or boats or concentrate on the more sporting side of R/C activities. All over the country every weekend competitions are held for aircraft boats and cars ranging from the concours D'Elegance type to thrilling racing with high speed models. Most users are however purely interested in the dual relaxations of building and operating models. Few are interested in the technical details of the circuitry of their equipment but simply take advantage of the 'plug it together, switch on and use' aspect. Very few ever attempt any sort of servicing and tuning, particularly those who use the equipment in model aircraft, preferring to use the qualified expertise of service agents.

Faults are rare in modern equipment, and if they do occur, are usually as a result of the environment in which the equipment is used. High frequency vibration from high revving two stroke engines, shocks from heavy landings and collisions, moisture from boat use, dirt, are all hazards which the equipment withstands with remarkable reliability. Few uninitiated electronics enthusiasts appreciate the high level of performance that R/C aircraft modellers in particular demand. Most of the models in which the equipment is installed are worth several hundreds of pounds and a momentary malfunction, a click or hiss as heard over a hi-fi loud-speaker can spell total disaster to the R/C aircraft modeller whose model may be flying at less than 10ft above the ground at speeds of up to 150 mph, yet the owner of the equipment will expect 100% reliability for several years of life under the arduous conditions already described.



Servo internals; motor and amplifier are fairly obvious — the feedback potentiometer is coupled to the amplifier via short flyleads and is integral with the lower gear frame. Typical output levers are arrayed in foreground. Case top is removed in right-hand servo.

Radio controlled yachts are a relaxing aspect of R/C modelling, that in the foreground is sailed by Jack Barnard and the other by author Bill Berkinshaw.

Typical good quality 6 function system with a comprehensive array of accessories including mains voltage charger for receiver and transmitter batteries, alternative capacity receiver batteries and alternative frequency crystal pairs.

*V. Nordigen about to lift the hat from a stake with a **Jet Ranger** helicopter. Expert pilots can guide models such as this with almost uncanny precision.*

Installation of servos in a typical R/C aircraft. These operate rudder/steerable nose wheel, retractable nose wheel, elevator, and throttle. The main wheel retract servo and aileron servo are mounted in the detachable wing. Switch and foam packed receiver and battery pack are to the right of the servos.

John Ralph, of the North Berks Model Club, launches a thermal soaring glider. The model is towed aloft, as are full size gliders by a line, and then after release float around seeking thermal upcurrents to extend their duration.

FUNCTIONS

For model control at its simplest 2 function equipment is the usual. Aircraft can be flown, cars driven or boats floated with only a steering control but few modellers use less than 2 controls. A simple aircraft can be operated by a steering control (either a rudder or ailerons on the wing) and elevators. Some modellers use an engine throttle to control height gain or loss. Cars normally do not need more than two controls, steering and combined throttle and brake (a centrifugal clutch is generally employed). Boats use steering and throttle controls. More complicated aircraft can use a basic four function system, elevators, ailerons, rudder and throttle, plus such items as retractable undercarriage, flaps brakes, bomb dropping etc. Servos are either of a rotary type output or linear and are coupled up to the various controls by simple wire pushrods and a variety of commercially available plastic horns, cranks etc.

Operating a model by R/C is not anything like as easy as it appears. It is generally fair to say that if the job is difficult to do directly, that is to say 'sitting in it', then to do it remotely by R/C is doubly difficult. The 'Seat of the pants' feel is removed and that otherwise remarkable instrument the human eye is really not very precise at all when it comes to accurately judging distance or altitudes, particularly when the model can be up to half a mile away. It is fairly safe to attempt to drive a car or boat unaided, provided neither are too fast and space is large enough, but to attempt to fly an R/C aircraft without expert help at hand is almost certain to end in disaster. The newcomer to R/C flying will almost certainly not only have his own inexperience to hamper him, but also an untried model and a new engine as well. Most hobby dealers are able to introduce prospective R/C modellers to like minded enthusiasts in their area.

BUILD YOUR OWN

Home built R/C equipment only accounts for a very small percentage of that in use, largely because the R/C modeller is interested in the flying, driving or boating more than in the building, and also not many have the confidence in their own ability to risk a valuable model to what in their minds might be equipment of dubious reliability. Their fears are to a certain extent unfounded, for there are excellent kits available and just recently excellent designs published. Electronics Today International have recently published details of an AM system whilst Radio Control Models and Electronics have published an FM system. Both publications are experienced in publishing articles of this type and both are almost guaranteed fool-proof provided the instructions are strictly adhered to. Of course the big attraction is the amount of money to be saved which can be quite considerable — possibly up to 50%.

Beware of designing your own equipment, I will accept that most people confident enough to embark on a self design project will probably end up with a system that works but at what cost to fellow modellers'. Badly aligned and poorly designed filter networks on transmitters may not affect your model but what of the other users of the R/C frequency allocations? I would suggest that a minimum of test equipment for the home R/C designer would be a spectrum analyser, digital counter and oscilloscope in order that the transmitter can be adequately checked for sideband emissions.

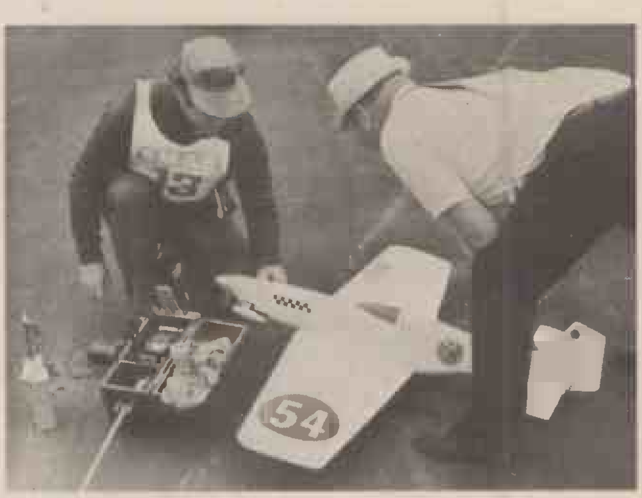
TRY IT YOURSELF

There are now some 70,000 plus licensed users of Radio Control equipment in the UK all participating in a immensely satisfying and creative hobby. There are a host of model clubs in all areas of the country where any would-be members will receive a warm welcome. If you are interested in seeing R/C models in action either visit your local model shops and enquire /look in the yellow pages) or write to one of the national governing bodies for details of nearest local clubs. Do enclose a SAE to those societies though, and don't forget that a licence is needed. This can be obtained by anyone — no age limits or test, from the Home Office Radio Regulations Department, Waterloo Bridge House, Waterloo Road, London SE1. The cost is £2.80 for 5 years so it cannot be described as expensive.

SMAE (Society of Model Aeronautical Engineers),
General Secretary,
Kimberley House,
Vaughan Way,
Leicester.

MPBA (Model Power Boat Association),
The Secretary,
19 Lea Walk,
Harpenden, Hert s.

BRCA (British Radio Car Association),
The Secretary,
7 The Green,
Werriston,
Peterborough.

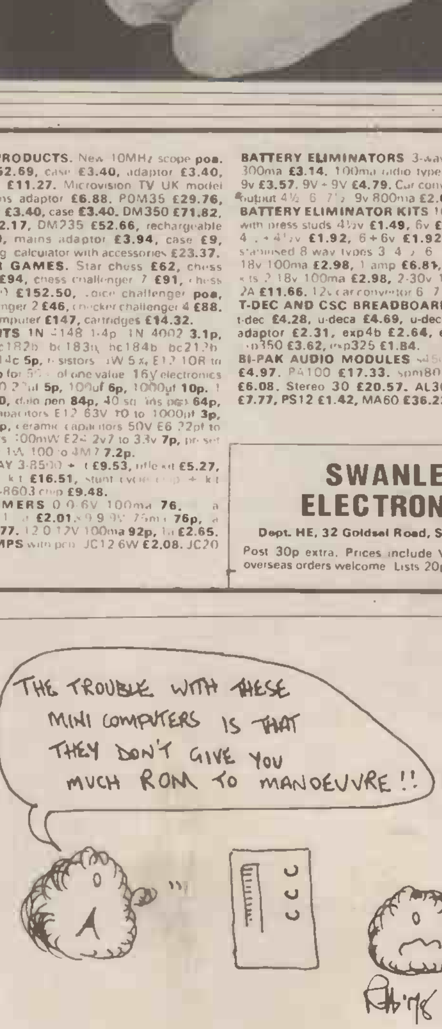


Bill Drury adjusts the engine prior to the start of a 10 lap pylon race. Four models similar to the one shown race for 10 laps around a triangular course at speeds approaching 150 m.p.h.

A semi-scale VC10 being demonstrated during a model airshow at Woodvale, Lancs. This model is powered by two internal combustion engines in place of the four gas turbines of the original.

Past British R/C aerobatic champion and World Champs Team Member Mick Birch starts up the engine in his own design Capricorn model prior to a flight at the British National Champs.

HE


THE TROUBLE WITH THESE MINI COMPUTERS IS THAT THEY DON'T GIVE YOU MUCH ROM TO MANOEUVRE!!
Rob '78

Ultrasonic Switch

Repel insects, upset small furry animals and confuse your cat with HE's Ultraswitch.

INVISIBLE RAYS have always exerted a considerable fascination on man down the ages. Isaac Newton watched apples falling under their influence and Uri Geller bent spoons with them (or did he?)

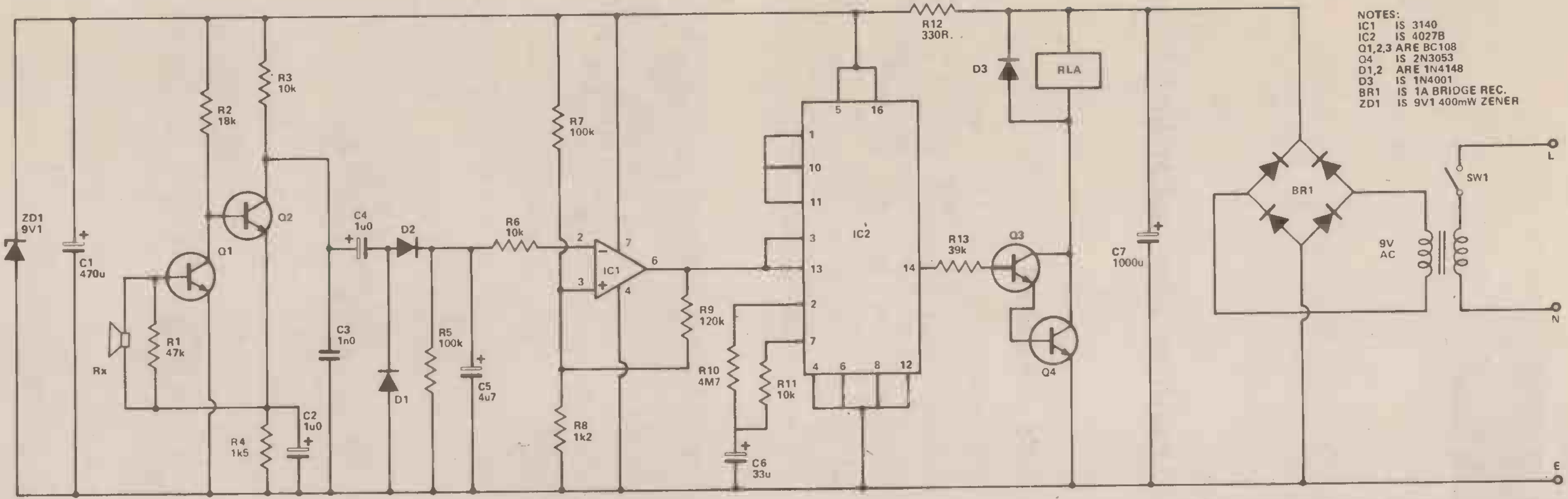
This project falls somewhere between these two extremes of the sublime and the ridiculous. It uses ultrasound; a high frequency sound, well above the range of human hearing to control a relay. By selecting a suitable type you can control your TV, Hi-Fi or bedside light at the touch of a button or as you will see later, with a snap of the fingers.

NOISE ANNOYS

The unit is silent in operation. As the ultrasonic carrier beam consists of very high frequency (40 kHz) waves, special transducers have to be used as ordinary microphones and loudspeakers are very inefficient at this frequency. These transducers are just like crystal microphones and earphones except that they are designed to be resonant, ie very sensitive at a particular frequency. The receiver and transmitter units have different characteristics and best results will be obtained

Completed units make an attractive and efficient pair.

Ultrasonic Switch



NOTES:
IC1 IS 3140
IC2 IS 4027B
Q1,2,3 ARE BC108
Q4 IS 2N3053
D1,2 ARE 1N4148
D3 IS 1N4001
BR1 IS 1A BRIDGE REC.
ZD1 IS 9V1 400mW ZENER

Fig. 1. circuit diagram of the ultra receiver.

How It Works

Transmitter

The transmitter consists of a straightforward CMOS oscillator driving the transducer via two complementary buffer stages. R2 and RV1 together comprise the timing resistance and C1 is the timing capacitor.

Receiver

The ultrasonic signal is amplified by Q1, Q2 a direct coupled amplifier and appears at Q2 collector. C3 is a decoupling capacitor to suppress spurious RF oscillation. The amplified signal charges C5 via C4, D1, D2 and the voltage across C5 is compared with a reference provided by R7, R8 and controls the output of IC1. R9 provides some positive feedback to produce a degree of hysterisis and speed up the transition time.

The output of IC1 clocks IC2. This is a JK flip-flop whose output toggles, ie changes state with each clock pulse. The bistable is disabled for a period determined by R10, C6 to avoid erratic operation. The output of the bistable appears at pin 14 of IC2 and controls super-alpha-pair Q3, Q4 which drive the relay. R12, ZD1 and C1 provide a smooth, stabilised power supply for the amplifier and CMOS circuitry whilst C7 is the main power supply smoothing capacitor.

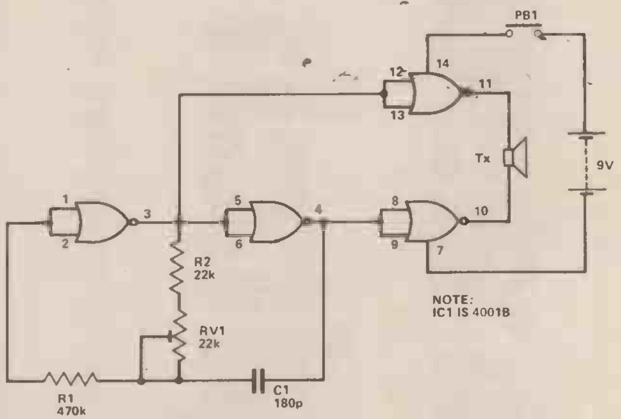


Fig. 2. circuit diagram of the ultra transmitter.

if the correct device is used in each application.

They are usually identified with a suffix 'R' for receiver or 'T' for transmitter marked on the case.

Range obtained will depend to an extent on the sensitivity of the particular transducers used but it is also considerably affected by the conditions under which the unit is operated. Ultrasonic waves are quite directional and can be bounced from hard surfaces like walls and

Parts List

TRANSMITTER

RESISTORS	(all ¼W, 5%)
R1	470k
R2	22k
R12	330R
R13	39k

CAPACITORS

ceilings so that greater range will be achieved in a sparsely furnished room or a corridor and satisfactory operation can often be obtained with the transmitter pointing away from the receiver. Our unit gave a maximum effective range of about twenty feet.

CONSTRUCTION AND USE

Any method of construction may be used although our PCBs are recommended and no special precautions are necessary. However, if you use your unit to control a mains operated device ensure that the mains is kept safely isolated from the control circuitry and use a relay whose contacts are rated for the job.

We mounted our 'Ultraswitch' in an earthed metal case. No special care was taken to protect the transducer from mechanical shock and the unit worked quite reliably.

The transmitter was housed in a small vero-box. Ensure that the transmitter tuning control is easily accessible. It should be adjusted for maximum range. There are no other adjustments to make.

Ultrasonic waves are present in many 'natural' sounds and you will find that the switch will operate at varying range in response to jangling keys, crumpling paper and even, at close range, a snap of the fingers. A novel trick is to operate the unit with a handclap.

Remember to use a suitable relay for your application and make all connections safe. Then press that button and turn on.

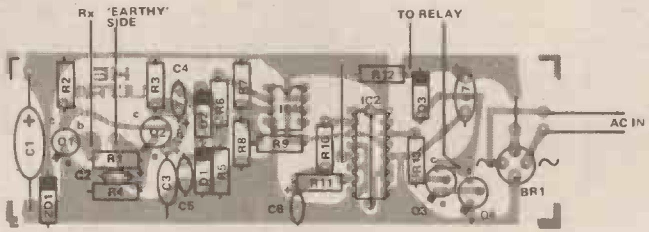


Fig. 3. Receiver PCB overlay.

RV1	22k min horiz. preset
CAPACITORS	
C1	180p polystyrene
SEMICONDUCTORS	
IC1	4001B

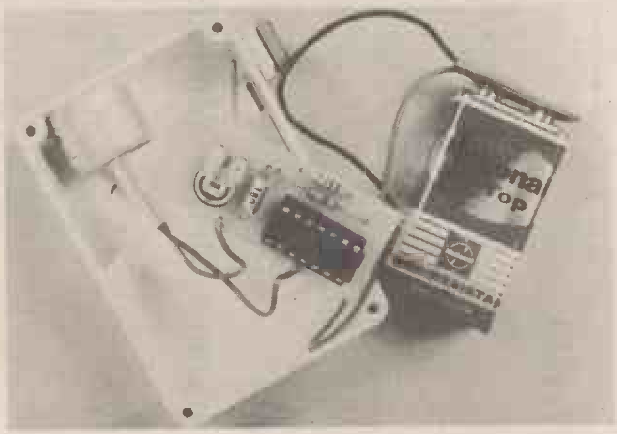
MISCELLANEOUS
Tx Ultrasonic transmitter transducer. PB1 SPST push-button PCB.

RECEIVER

RESISTORS	(all ¼W, 5%)
R1	47k
R2	18k
R3, 6, 11	10k
R4	1k5
R5, 7	100k
R8	1k2
R9	120k
R10	4M7

C1	470μ elect.
C2, 4	1μ tant.
C3	In polystyrene
C5	μ47 tant.
C6	μ33 tant.
C7	1,000μ elect.
SEMICONDUCTORS	
IC1	3140
IC2	4027B
Q1, 2, 3	BC108
Q4	2N3053
D1, 2	1N4148
D3	1N4001
BR1	1A Bridge Rec.
ZD1	9V1 400 mW zener

MISCELLANEOUS
Rx Ultrasonic receiver transducer. Transformer 9V AC 200mA. SW1 SPST switch. RLA 12V relay to suit. P.C.B. Mains neon indicator.
Approximate cost £15.



Internal view of the ultra transmitter.

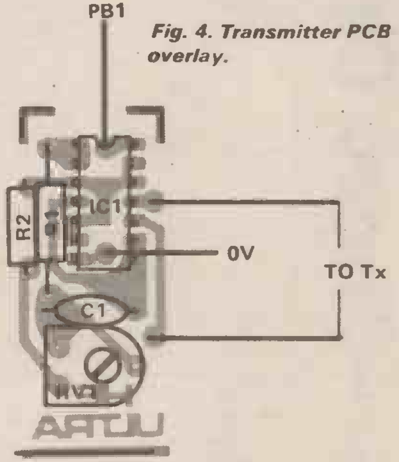
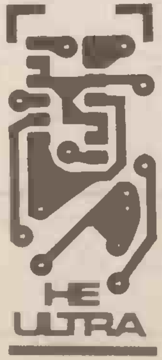
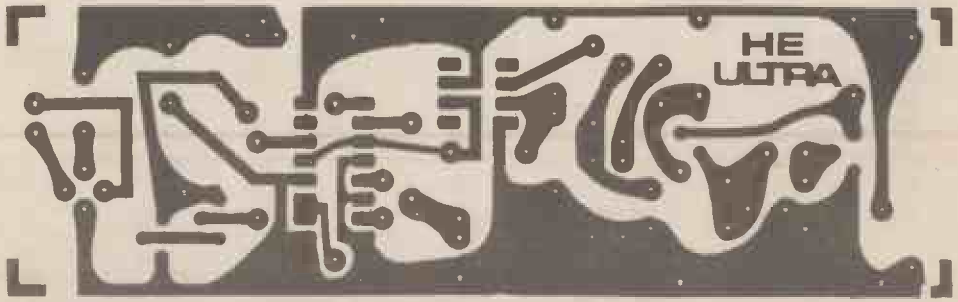


Fig. 4. Transmitter PCB overlay.





LEFT: Fig. 5. Transmitter foil pattern.
RIGHT: Fig. 6. Receiver foil pattern.

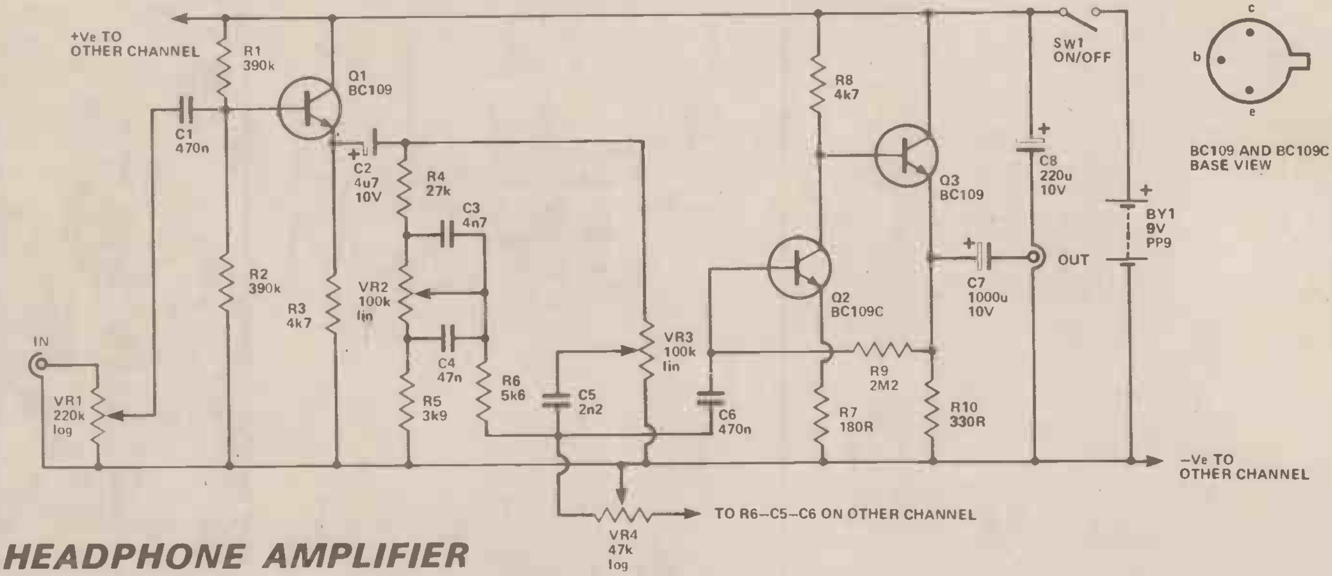
Buylines

The control circuit for this project was housed in an attractive case (model No. K12) produced by Lektrokit Ltd., Sutton Industrial Park, London Road, Earley, Reading, Berks RG6 1AZ. Tel. (0734) 66916/7.

The Ultrasonic Transducers (type RL400BP) are available from:—Arrow Electronics Ltd., Leader House, Coptfold Road, Brentwood, Essex CM14 4BN.

Price for one pair is £4.50 inc. VAT. Postage add 40p.

Short Circuits



HEADPHONE AMPLIFIER

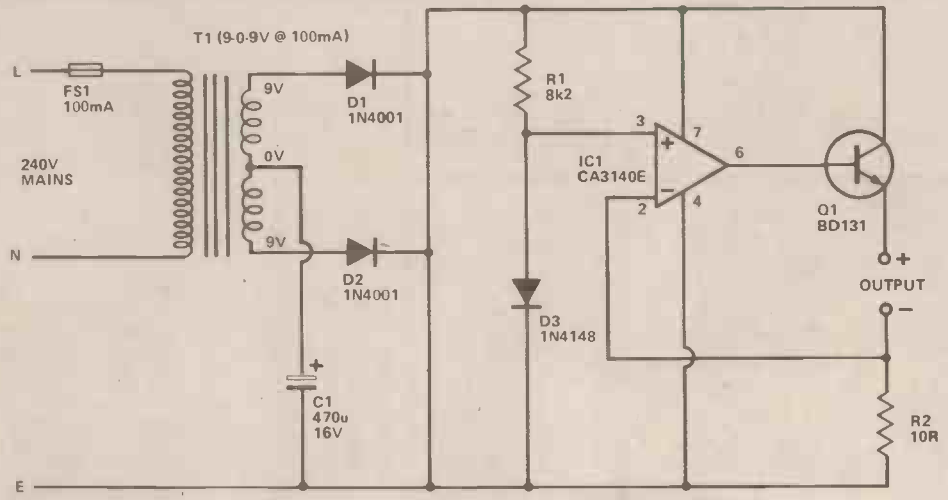
This simple stereo amplifier will drive a pair of stereo headphones, and can take its input from either a tuner or cassette deck. It has the advantage over a normal stereo amplifier of being small, completely self contained, and therefore very portable. Of course, many tuners and cassette decks have a headphone output, but this often lacks sufficient drive, and there are usually no tone controls (or volume and balance controls in some cases). This circuit gives the usual tone, balance, and volume control facilities, and also has plenty of drive. Ideally the unit should be used with phones having an impedance of a few hundred ohms each, and most good quality types fall into this category. It also seems to work perfectly well with inexpensive 8 ohm types.

The circuit shown here is for one channel, all the components being duplicated in the other channel except for S1, BY1, and RV4, which are obviously common to both channels. The two RV1s are a dual gang component, as are the two RV2s and the two RV3s.

The input signal is applied to volume control VR1, and from here it is coupled to a buffer stage based on Q1. This gives the unit a reasonably high input impedance of at least 100k. Its output feeds a conventional passive tone control circuit that can give bass lift or cut using RV2, and treble lift or cut using RV3. RV4 is used in the standard balance control arrangement. The output from the tone controls is coupled by C6 to a two stage direct coupled amplifier. This uses Q2 in the common emitter mode to give sufficient voltage gain for an output level of up to about 2 V RMS from most sources. Q3 is an emitter follower buffer stage which matches the output from Q2 to the relatively low impedance of the headphones.

The unit has a total current consumption for both channels of about 30mA.

NICAD CHARGER

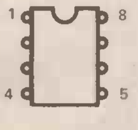


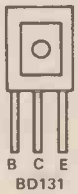
This charger is intended for use with the popular AA size NiCad batteries (similar to ordinary HP7 cells). A special charger is needed for NiCad calls because they have a very low internal resistance, leading to an excessive charging current even if the applied voltage is only marginally high. The charger must therefore incorporate a circuit to limit the charge current to the appropriate level.

In this circuit, T1, D1, D2, and C1 form a conventional stepdown, isolation, fullwave rectifier, and smoothing circuit. The other components provide the current regulation. IC1 is used as a comparator with discrete buffer stage Q1 giving a suitably high output current capability for this application. IC1's non-inverting input is fed with a 0.65 V. reference potential provided by R1 and D3. The inverting input is taken to earth by R2 under quiescent conditions, causing the output to go fully positive. With a NiCad cell connected across the output a high current will attempt to flow, causing the voltage across R2 to increase. It can only rise to 0.65V. however, as a higher voltage here reverses the comparative input levels to IC1, resulting in the output going lower in voltage, and reducing the voltage across R2 back 0.65V. The maximum output current (and the charge current obtained) is therefore the current produced with 0.65 V. across 10 ohms, or 65 mA. in other words.

Some AA NiCad cells have a maximum recommended charge current of only about 45 or 50 mA, and for these types R2 should be increased to 13 ohms in order to obtain the appropriate charge current. Some rapid charge types will take 150 mA, and this necessitates reducing R2 to 4.3 ohms (3.3 ohms plus 1 ohm in series if a suitable component cannot be obtained). Also, T1 should be changed to a type having a current rating of 250 mA., and Q1 should be fitted with a small bolt-on finned heatsink. The unit can charge up to four cells (six if T1 is made a 12 V type), and these must be connected in series across the output, not in parallel.

CA3140E TOP VIEW





24 TUNE DOOR CHIMES

DOOR TUNES £16.44 + VAT.

Waddington's Videomaster announce a doorbell that doesn't go Brrringgg, Ding-Dong or Bzzzzzz. Instead it plays 24 different classical and popular tunes. It will play the tune you select for your mood, the season or the visitor you are expecting to call. Door tunes is not only great fun and a wonderful ice breaker, but is also very functionally and beautifully designed to enhance your home. There is something for Christmas, something for your continental visitors or your relations from the states, and even something for the Queen. Door tunes is easy to install and has separate controls for volume, tone and tempo.

T.V. GAMES

PROGRAMMABLE £29.50 + VAT.
COLOUR CARTRIDGE T.V. GAME.

The TV game can be compared to an audin cassette deck and is programmed to play a multitude of different games in COLOUR, using various plug-in cartridges. At long last a TV game is available which will keep pace with improving technology by allowing you to extend your library of games with the purchase of additional cartridges as new games are developed. Each cartridge contains up to ten different action games and the first cartridge containing ten sports games is included free with the console. Other cartridges are currently available to enable you to play such games as Grand Prix Motor Racing, Super Wipeout and Stunt Rider. Further cartridges are to be released later this year, including Tank Battle, Hunt the Sub and Target. The console comes complete with two removable joystick player controls to enable you to move in all four directions (up/down/right/left) and built into these joystick controls are ball serve and target fire buttons. Other features include several difficulty option switches, automatic on screen digital scoring and colour coding on scores and balls. Lifelike sounds are transmitted through the TV's speaker, simulating the actual game being played.
Manufactured by Waddington's Videomaster and guaranteed for one year.

EXTRA CARTRIDGES:

ROAD RACE – £8.87 + VAT.
Grand Prix motor racing with gear changes, crash noises

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Motorcycle speed trials, jumping obstacles, leaping various rows of up to 24 buses etc.

NON-PROGRAMMABLE TV GAMES

6 Game – COLOURSCORE II – £13.50 + VAT.

10 Game COLOUR SPORTSWORLD £22.50 + VAT.

CHESS COMPUTERS

STAR CHESS – £55.09 + VAT,
PLAY CHESS AGAINST YOUR PARTNER,

using your own TV to display the board and pieces. Star Chess is a new absorbing game for two players, which will interest and excite all ages. The unit plugs into the aerial socket of your TV set and displays the board and pieces in full colour (or black and white) on your TV screen. Based on the moves of chess It adds even more excitement and interest to the game. For those who have never played, Star Chess is a novel introduction to the classic game of chess. For the experienced chess player, there are whole new dimensions of unpredictability and chance added to the strategy of the game. Not only can pieces be taken in conventional chess type moves, but each piece can also exchange rocket fire with its opponents. The unit comes complete with a free 18V mains adaptor, full instructions and twelve months guarantee.

CHESS CHALLENGER 7 – £85.65 + VAT.
PLAY CHESS AGAINST THE COMPUTER.

The stylish, compact, portable console can be set to play at seven different levels of ability from beginner to expert including "Mate in two" and "Chess by mail". The computer will only make responses which obey international chess rules. Castling, on passant, and promoting a pawn are all included as part of the computer's programme. It is possible to enter any given problem from magazines or newspapers or alternatively establish your own board position and watch the computer react. The positions of all pieces can be verified by using the computor memory recall button.
Price includes unit with wood grained housing, and Staunton design chess pieces. Computer plays black or white and against itself and comes complete with a mains adaptor and 12 months guarantee.

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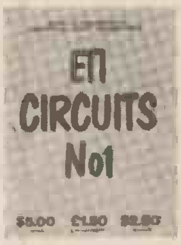

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Comprised entirely of new material, the edition covers such diverse topics as Star Wars and Hi-Fi! The magazine contains projects for everyone — none of which have appeared in ETI — and a look at the future of MPUs, audio, calculators and video. How can you not read it?

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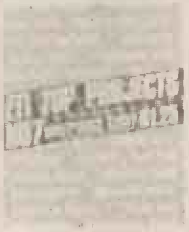
Book 3: SOLD OUT! Book 4: £1.00 + 25p P&P. Book 5: £1.00 + 25p P&P. Book 6: £1.00 + 25p P&P.



TOP PROJECTS
Book 7: £1.25 + 25p P&P.

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Electronic Timekeeping

Seconds Out

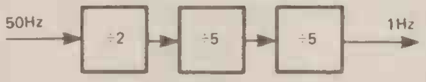
If you want to know the time ask a policeman. That may not be such a bad idea these days, especially if his little radio is capable of picking up the time code from Rugby. The ever punctual Rick Maybury looks at atoms that tick phones that tock and watches that don't make any noise at all.

IT HAS ALWAYS BEEN EASY to tell the time, even if you haven't got a clock or watch you could probably guess to within half an hour. Even before the development of reliable mechanical timepieces, the sundial, sand clock, water clock or even a slow burning candle could indicate the time to the nearest minute. Probably the single most important invention in timekeeping was the pendulum in 1582, it enabled time to be measured to the second. After that things remained fairly static for the next couple of hundred years. Mechanical escapements improved over the years to such a degree that fractions of a second, as little as 100th of a second, could be accurately measured. Very little new technology came into the field of timekeeping until along came our old friend electricity, then it all began to happen.

Electronic Timekeeping, Hobby Electronics style, these are just some of the examples of electronic timekeeping available from our Marketplace special offers. The HE Digital Clock was featured as a project in our very first issue in November '78.

TIME ON TAP

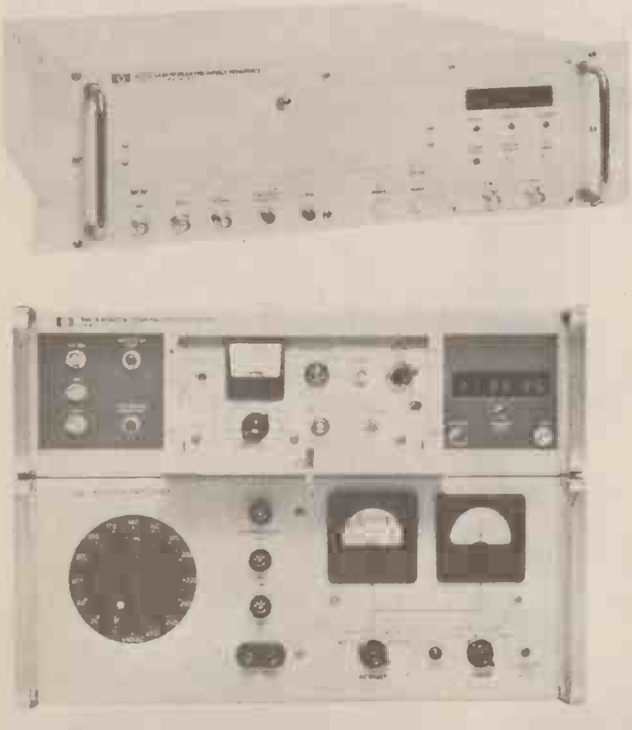
At first electricity just replaced mechanical energy in electric clocks, until some bright spark in 1918 discovered that an AC electric motor could be synchronised (synchronous motor) to the frequency of the mains. It didn't take long for the electricity board to latch on to this and ensure that over a 24-hour period their generators maintained an average frequency. A clock locked to mains frequency could be compared with a known standard and any losses or gains by the mains-linked clock could be compensated for by slowing down or speeding up the generators. This system of using a central oscillator was the forerunner of today's central standard clock operated by the National Physical Laboratory.



Divider chain for decoding the mains 50 Hz into a 1 Hz output, the 1 Hz is then used to drive a further chain (see page 54) which will generate the various hours, minutes, seconds and calendar outputs.

ATOMIC TICK TOCK

The NPL clock and all standard clocks around the world are based on Atomic Time (AT). There are two main methods of deriving atomic time, they are both based on the natural vibrations of certain materials. These vibrations or Atomic Resonance happens to be one of natures invariables, rather like the speed of light, it is a fixed constant.

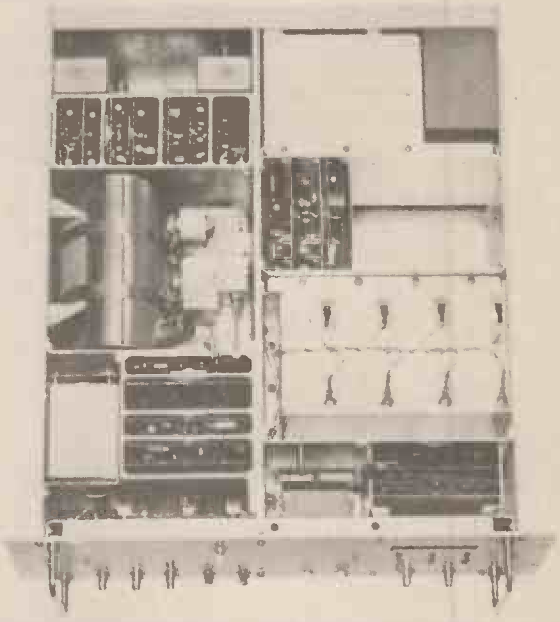


Atomic clocks. The upper one is a laboratory standard Cesium Beam Frequency Reference, a time output is displayed on the right. The lower one is a portable version of the Cesium Beam clock intended for experimental use, the freedom from mains electricity enables the clock to operate safely even during power cuts.

The oldest and most accurate type of atomic clock is the Cesium Atomic Beam Controlled Oscillator, quite a mouthful for a really quite simple device. (No we won't be featuring one as a project in HE, it's not *that* simple). The 'clock' is based upon a quartz oscillator, usually running at 5 MHz. This is multiplied up, to the resonant frequency of Cesium. This is a good point to do a bit of defining:

A second is defined as: The duration of 9,192,631,771 periods of transition within the Cesium atom.

So to put it crudely the 5 MHz is bumped up to around 9192 MHz and fed to a microwave cavity full of Cesium vapour. The Cesium will of course resonate at only that frequency. Any disparity between the quartz oscillator and the resonating Cesium will generate a difference signal that can be 'fedback' to the crystal oscillator. A frequency lock circuit keeps the crystal oscillator running at the same frequency as the vibrating cesium atoms. In practice the output from this now very stable oscillator is divided down to a usable frequency, usually 1 MHz and 100 kHz so further manipulation will provide an output suitable for timekeeping.



Inside an Atomic Clock, the cylinder in the middle, on the left-hand side is the actual gas cell, the control circuitry and quartz oscillators can be seen at the top, again on the left.

The second main type of Atomic clock is the Rubidium Gas Cell Controlled Oscillator. To cut a very long story short, the Rubidium clock operates in a very similar manner to the Cesium clock. Suffice it to say that it is not quite as accurate in the long term as the Cesium clock, variables like the pressure of the Rubidium vapour and the 'buffer gas' that has to be mixed with the Rubidium vapour can affect its overall stability. (We are still talking about a second in a thousand years, but who's quibbling, its doubtful if anyone is going to be around that long to complain).

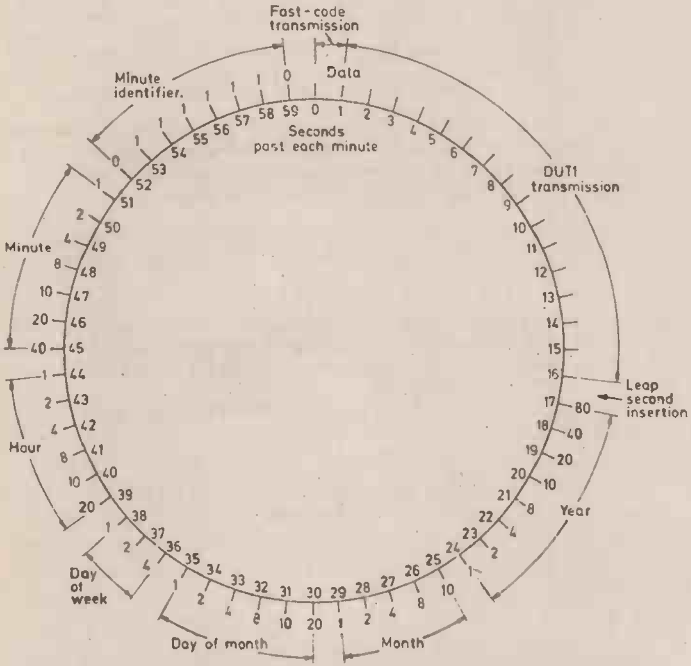
Of the two main types of Atomic Clock the Cesium clock is referred to as a 'Primary Standard,' that simply means they cannot be calibrated because other than other Cesium clocks there's nothing accurate enough! The Rubidium clock because of its slight deficiencies is relegated to the Secondary Standard league.

It's interesting to note that the United States national standard clock consists of no less than a dozen Cesium clocks all checking one another. Our own British Standard clock is operated by the National Physical Laboratory and a comprehensive time signal is transmitted via radio from their Rugby laboratories.

IT'S NOT CRICKET

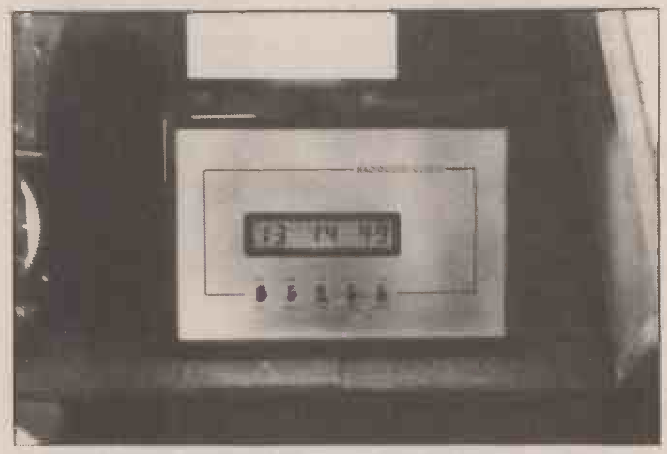
The Rugby clock is designated the call sign MSF and is transmitted on 60 KHz at around 50 kW RF power. It can be heard on a specialised receiver throughout most of western Europe. The actual signal transmitted consists of three 'codes', the first two are designated; Fast Code and DUTI. The third code is a Slow Code using UTC or Co-ordinated Universal Time, (probably French if its back to front). The difference between the two can be about one second. UTC is based on the solar cycle, (the same as GMT and BST), as the earth does not rotate on its axis or around the Sun at constant speed its necessary to introduce a 'leap second' every now and again. Strangely enough this was only noticed when the Atomic Clock was developed. The first two codes are based on Atomic Time, the code DUTI stands for Difference between Universal Time and is a slow version of the Fast Code. (Confusing isn't it?)

The Fast Code is transmitted during the first second of each minute and consists of about 30 bits of BCD (Binary Coded Decimal) information giving the Hour, Minute, and Day and Date. The DUTI signal is transmitted between the first and 16th second (Hence Slow Code) and contains all the information of the Fast Code, except at a slower rate. The 17th second is set aside for a control bit to indicate whether or not a 'Leap Second' need be inserted. The final segment from the 17th to the 59th second is full of BCD information for the UTC time.



The Rugby MSF clock, this diagram represents one minute in the clock's cycle. The fast code lasts from the zero mark to the first second. The two fast codes are from the second second (oh dear, oh dear) to the 16th second and the 17th to the 59th.

Special receivers can decode this information directly into a time readout. In practice though a receiver will only decode one of the three codes. Being a radio signal it is freely available to anyone wanting to know the right time, and we mean the right time. Recent Cesium clocks are quoted as having an accuracy of not less than one second in 5,000 years.



A typical MSF receiver, this one operates on one of the 'slow codes', as you can see the controls are kept to a minimum. We wonder how long it will be before a domestic version is on sale.

TIM AND TELETEXT

Both TIM (the Post Office speaking clock) and the BBC (Ceefax) and IBA (Oracle) Teletext services are linked to the Rugby MSF time signal.

TIM is a pre-recorded (in 1963 would you believe) on to a rubber tape (mixed with Iron Oxide particles you fool). The rubber tape or 'tyre' is fitted over a spinning brass drum. The 'tape' is split into 79 tracks containing all the well known phrases. Track number one has the 'At the third stroke it will be . . .' phrase. Tracks 2 to 12 have the hour phrases, '. . . o'clock'. The next 60 tracks have the minutes, 'one to fifty nine', and the final six tracks have the ten second intervals and the famous 'precisely'. In all there are 12 replay heads scanning the 'tape, they are not actually in physical contact with the tape to avoid wear.

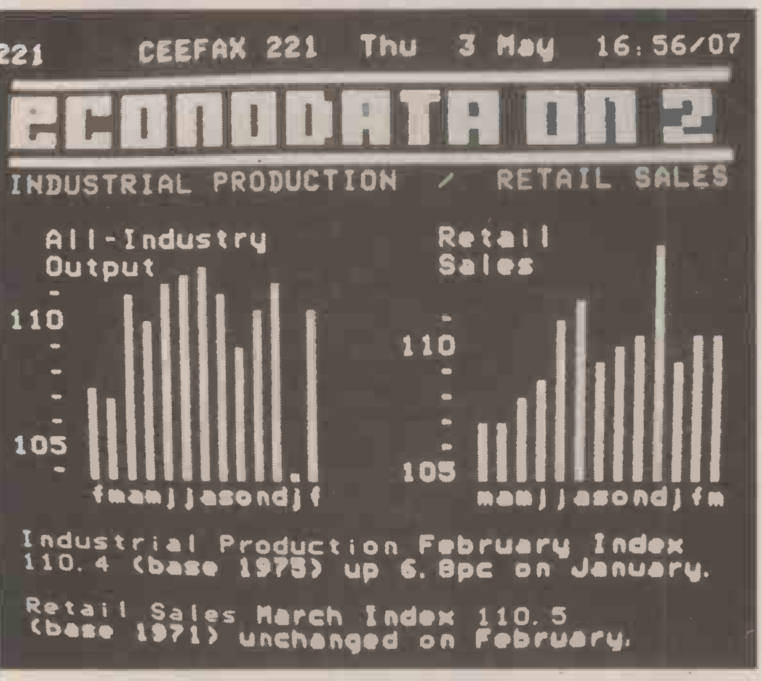
Mr and Miss TIM, the lady is Miss Pat Simmons who gets something like 430 million phone calls a year; we're told she even phones herself every morning to check the time. Pat retired in 1976 but her original recording made in 1963 will continue for many years to come. The recording actually took over two weeks to record, we're not surprised.

There are four main speaking clocks in the British Isles, one in constant use (plus one for backup and checking) in London and a further two in Liverpool.

The accuracy of TIM is checked against MSF Rugby and any variation is compensated for by 'advance and Retard' circuits that regulate the speed of the spinning drum. TIM is accurate to within 2 mS (milliseconds) in any one second and an average of 6 mS in any 24-hour period, not bad for 2 pence.

TELLY TIME

Both the major Teletext services, Ceefax and Oracle are now linked to MSF via their computers. The Ceefax clock (transmitted on the top of every teletext page) is accurate to within 1 / 50th of a second. The Oracle (also on the top of every page), clock has at the time of writing only just been connected to MSF so figures are not available but we would suspect its accuracy to be similar to Ceefax.



221 CEEFAX 221 Thu 3 May 16:56/07

ECONODATA ON 2

INDUSTRIAL PRODUCTION / RETAIL SALES

Industrial Production February Index 110.4 (base 1975) up 6.8pc on January.

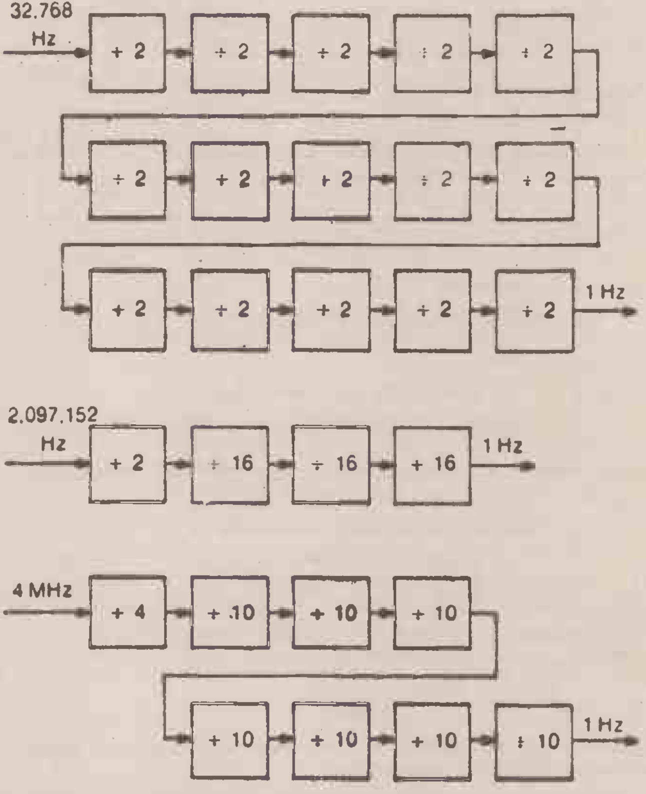
Retail Sales March Index 110.5 (base 1971) unchanged on February.

CEEFAX, the clock can be seen on the 'header' on the left-hand side. CEEFAX and ORACLE are both linked to the MSF clock at Rugby so should be accurate to within one-fiftieth of a second.

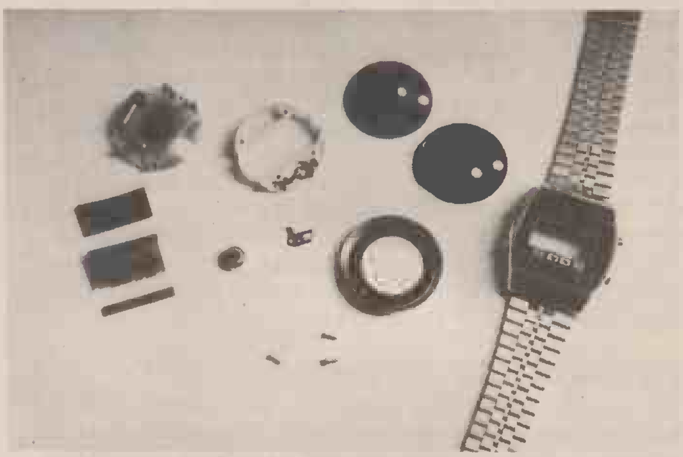
PERSONAL TIME

All the timepieces discussed so far rely upon a central source of reference, either the Atomic Standard, the mains frequency or even the Sun in the case of a sundial. When time keeping gets to a portable level, ie a wristwatch it becomes necessary to carry around your own reference. At the moment its a little impractal to carry a Cesium beam oscillator on your wrist so our old friend the Quartz crystal oscillator has to suffice. A few years ago, 1960 to be precise (pun intended), the first electronic wristwatch from Bulova actually contained an electronically driven tuning fork. This was mechanically connected via a ratchet wheel to the hands. In its day it was as good if not better than most mechanical chronometers, the manufacturers even gave a written guarantee confirming it to be accurate to within a second per month. Many so-called electronic 'chronographs' of today are hard pressed to better that. Unfortunately, the watch for all its ingenuity still relied on moving parts to operate, and eventually they would wear out.

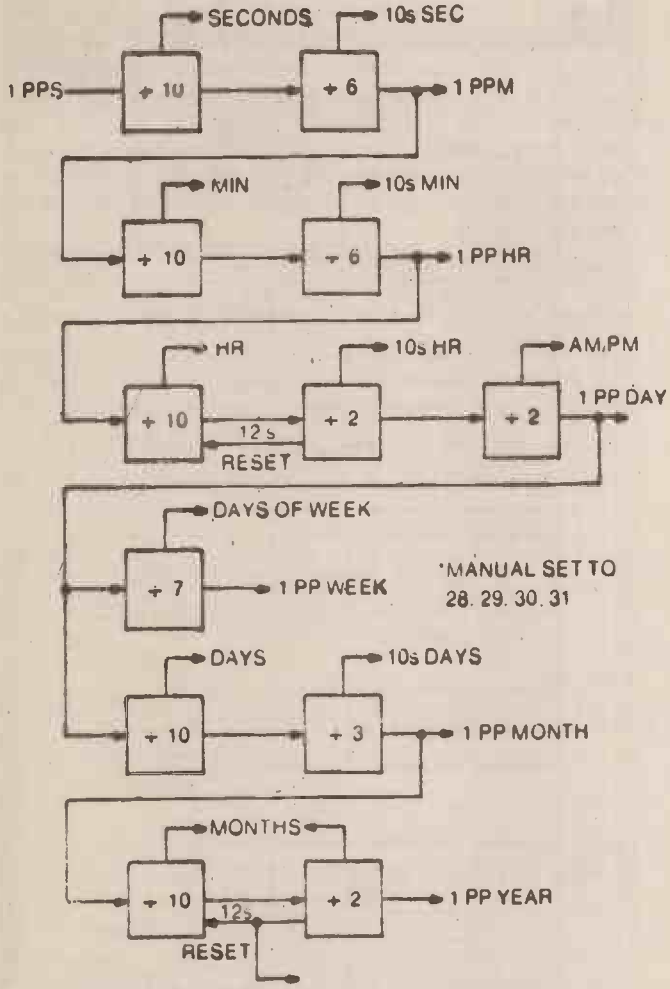
Back to the present. Today's LCD, LED and now Lithium digital watches all have one thing in common, a quartz oscillator. Up until quite recently they all worked at 32.768 kHZ, this strange figure is actually deliberate because it is easily divided with modern digital ICs to a usable 1 Hz. Lately though, higher frequencies of 2.09 and 4 MHz have begun to gain wider acceptance because a higher frequency leads ultimately to greater accuracy.



Divider chain found most modern digital watches, the three frequencies are the most common ones in use today. The actual frequency is governed by a quartz crystal oscillator, this is fed to the chain inside the IC. (See page 54.)



Inside one of our own digital alarm watches, we were surprised to discover the actual bleeper consists of a thin slice of piezo electric crystal on a metal diaphragm inside the back cover. The little grill on the front is in fact a dummy, nonetheless it's loud enough to wake most people. The electronics are sited on the small PCB top left. The display, beneath the PCB is a liquid crystal device, it displays a stopwatch, calendar and of course the time at the expense of only one or two microwatts.



Divider chain for turning a 1 Hz pulse into hours, minutes, seconds, days, months, etc, etc.

By using modern CMOS and I²L technology, coupled to an LCD or Lithium display (LEDs tend to be a bit juicy) current consumptions of around 2-5 uA are the order of the day. Indeed a typical LCD watch battery should last in excess of one year. One final point with LCD displays, they are a chemical display and as such have a limited life. Even with modern processes a life expectancy of around five years is to be expected. Remember that next time you see one for £100, check how long its guarantee lasts for. With so many LCD watches around the £20 mark its just not necessary to spend that much. Wonder how long it'll be before someone comes up with a disposable watch. If the battery life expectancy of these watches is extended much more they'll start to outlive the displays.

THE FUTURE

An obvious development has got to be a domestic MSF receiver, (who knows they may even make a wrist-watch version) already there are commercially available receivers but they tend to be a little too expensive for us mere mortals.

The current flood of cheap mains-locked LED, and Flourescent bedside, alarm, and mantplepiece clocks will continue to grow, after all who wants to keep winding an old clockwork clock that doesn't tell the time to the second. (Funny thing though, they always did seem to keep going during power cuts.)

The way modern society seems to be going, time, (and we mean accurate time) will continue to play a more important role. Clocks and watches will get more and more accurate, cheaper and cheaper and doubtless sprout more and more semi-useless functions. Look out for the Lithium displays, they rely upon a minute piece of radio-active material to illuminate a small screen. This type of display does have a long life and is readable in the dark, something the LCD watch has never been very good at, even with a backlight.

Well, that's about it, we've literally only just scratched at the surface of electronic timekeeping, one thing you can expect though, is its a subject that is going to get even more involved in the next few years, so keep your eyes peeled for an update in the near future.

HE

This is where it all began, man's quest for accurate timekeeping relied upon logging regular events. The sundial kept track of the apparent motion of the sun. The more sophisticated sundials were accurate to within 10 minutes at any time of year, quite an achievement. Today we measure much shorter events, the 50 Hz of the mains, the oscillations of the quartz crystal, and if you're really fussy you can count the vibrations of the Cesium atom and you can't get much more accurate than that!

We would like to thank Hewlett Packard Ltd, the BBC the Post Office and the National Physical Laboratory for their help in preparing this article.

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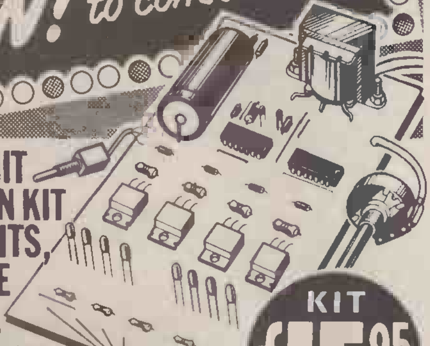

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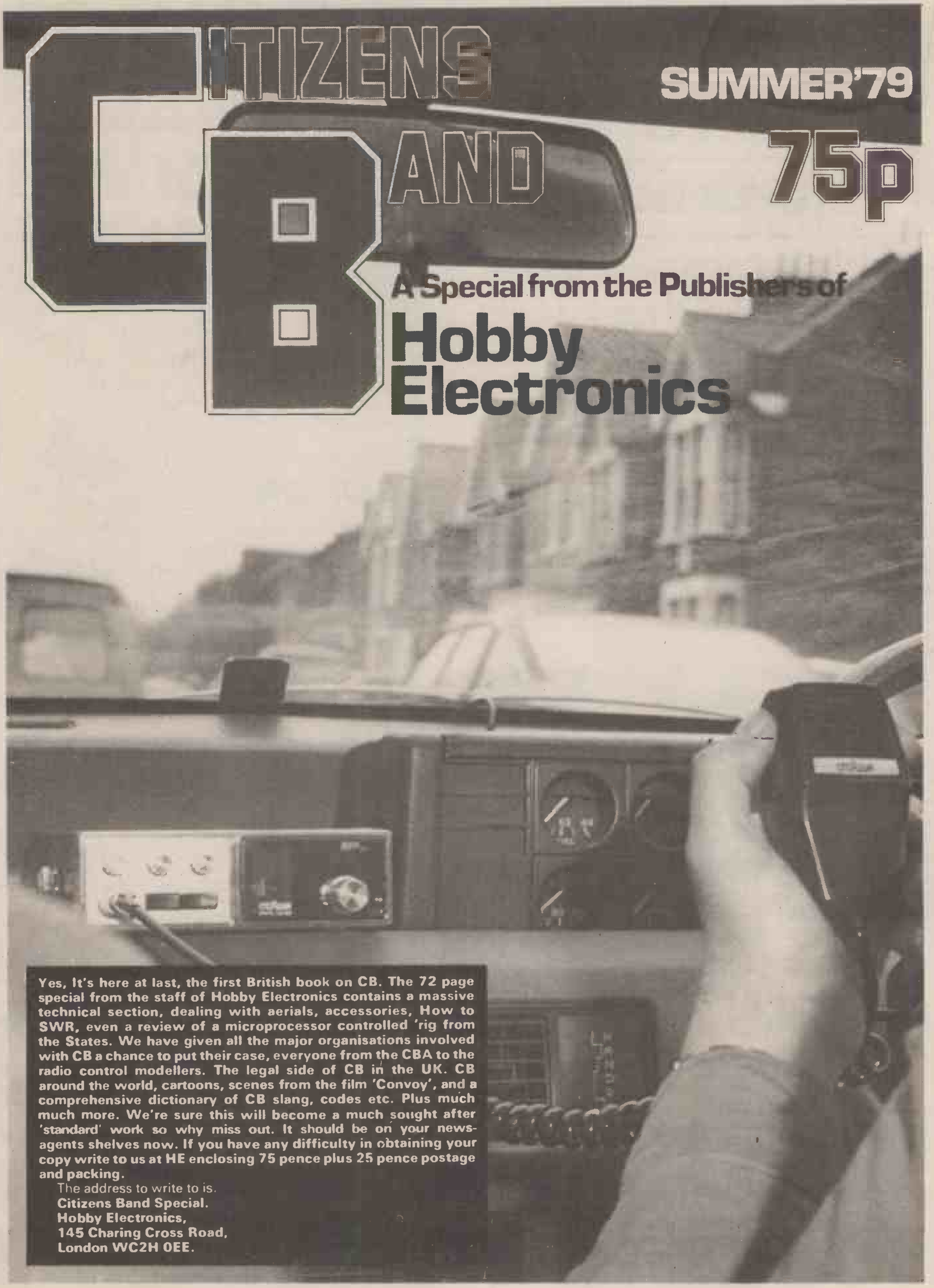


Yes, It's here at last, the first British book on CB. The 72 page special from the staff of Hobby Electronics contains a massive technical section, dealing with aerials, accessories, How to SWR, even a review of a microprocessor controlled 'rig from the States. We have given all the major organisations involved with CB a chance to put their case, everyone from the CBA to the radio control modellers. The legal side of CB in the UK. CB around the world, cartoons, scenes from the film 'Convoy', and a comprehensive dictionary of CB slang, codes etc. Plus much much more. We're sure this will become a much sought after 'standard' work so why miss out. It should be on your newsagents shelves now. If you have any difficulty in obtaining your copy write to us at HE enclosing 75 pence plus 25 pence postage and packing.

The address to write to is.
Citizens Band Special.
Hobby Electronics,
145 Charing Cross Road,
London WC2H 0EE.

Breaker One-Four

Send any news, comments, or information you may have to:
Breaker One Four,
Hobby Electronics,
145 Charing Cross Road,
London WC2H 0EE.

This is more like it, we've had a very large postbag for Breaker One-Four over the past four weeks, several clubs contacted us, alas one or two were a touch too late to get in this month but we'll be devoting quite a bit of space to them next month. As you can see the CB scene is really hotting up so keep those letters coming.

CB SPECIAL

Sorry about the delays and confusion over the special but we had some legal problems. Happily they're all sorted out and it should be on your newsagents shelves now. We have included everything from the legal side to a massive technical section, easily the largest outside the States. Look out for scenes from the film "Convoy," cartoons, a comprehensive CB dictionary of slang and codes, CB around the world and a whole lot more. See the Ad elsewhere in this issue for further details.

CB STICKER

As promised we've produced a "Legalise CB" sticker for your car, the good news is that it is FREE. All you have to do is write to us, mark your envelope CB Sticker and enclose a SAE. Sorry, only one sticker per envelope.

SLANG COMPETITION

Whilst we were compiling the CB dictionary in our "special" it occured to us just how American it all was. There's nothing wrong with that, except we're British (and proud of it). So each month we'll be holding a CB slang competition, we'll print the best each month, and the winners will each receive a HE Tee-Shirt as well as a place in our all new British CB dictionary that we will be compiling over the next few months.

The only conditions are: it must be new, it must be as British as possible and of course as clean as possible. Remember the purpose of slang is to convey an often repeated message as simply and as quickly as possible over what is potentially a very noisy medium. Send your entries to: CB Slang, Hobby Electronics, 145 Charing Cross Road, London WC2H 0EE.

CB ON TAPE

Even if you can't operate CB in this country (yet, we're working on it) you can listen to, and learn all about "stateside" CB. A cassette tape now on sale over here contains plenty of examples of yankee CB and has a very comprehensive commentry from some (unnamed) American gentleman. The tape is a full length C60 and costs £2.50 from Dave Mills. Every aspect of CB is covered, from how to choose a "handle" to how to check our your rig. With the tape comes an explanatory leaflet containing all the 10 codes, glossaries etc, and even a mention for HE (thanks Dave). For your copy send your £2.50 (Inc P&P) to: Dave Mills, 267 Charminster Road, Bournemouth, Dorset.

CB BAR-BE-Q

The men from the UKCBC have been telling us about a open day they're planning, Bar-B-Q drinks etc, no firm date as yet but you can be sure we'll let you know, we might even get along ourselves. Venue as far as we can make out is somewhere in Wales.

PETITION

We've settled on the closing date for the Petition, it's the 30th August, unfortunately Parliament are on holiday then so we'll let you know next month of the actual date we will be handing it over.

RUMOUR TIME

If we were to believe all the rumours we hear during the month it would seem that CB will be legalised on just about every day until the middle of 1980. Those sorts of rumours we expect, what we would like help in dispelling are one or two of the more serious rumours that seem to be flying about lately.

Both are of a medical nature, so if there are any doctors out there perhaps they could get in touch with us. The first concerns interference to heart pacemakers, obviously we are most interested in finding out whether the illegal 27 MHz system does any harm in that respect but does RF generally interfere and at what power, any comments?

The second is the problem of paging systems, can someone tell us what kind of power they work at and more specifically, what frequency and what type of coding system they use, particularly hospital pagers. Do they suffer from interference or is it the other way round? Perhaps someone from the R/C modellers would like to comment on that, are you affected by paging systems?

CLUB CB

In by the skin of their teeth are a new club in the Weymouth area. The news comes from Ray Howes who tells us that they have twice monthly meetings on Sundays at around 8 pm at 39 St Thomas Street, Flat 1, Weymouth, Dorset. Sorry it's a bit brief but we only heard the day before we went to press. More details next month.

BREAKER BREAK.

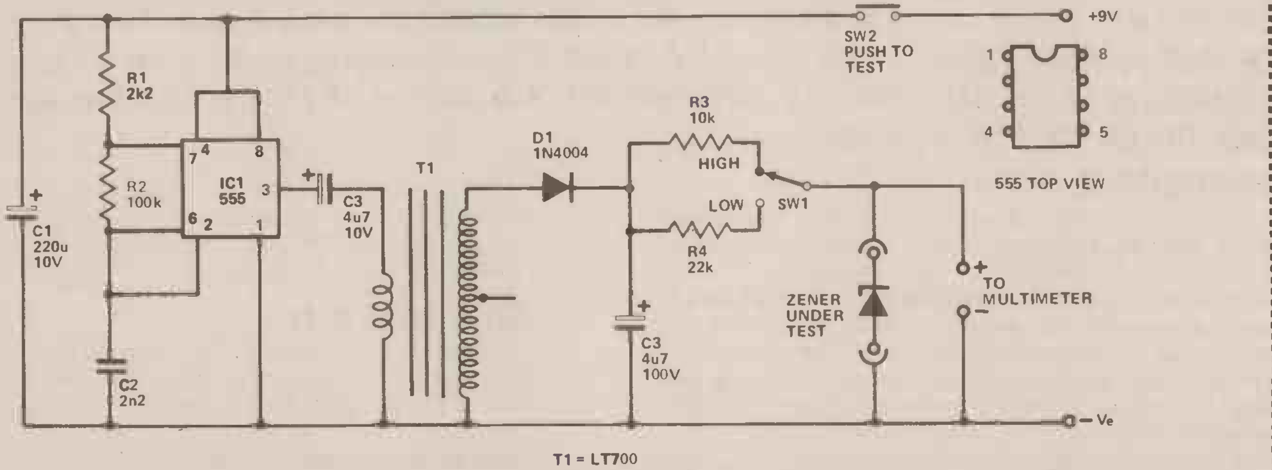
Short Circuit

ZENER DIODE TESTER

This circuit is an add-on unit for a multimeter having a sensitivity of 20k/V or better, and it enables a rough check to be made on zener diodes having operating voltages of up to about 33 volts. The unit operates from a standard 9 volt battery (PP6, PP7, or PP9 size), no mains supply or special ,high voltage battery being required.

In order to obtain a suitably high voltage for this application from an ordinary 9 volt DC supply it is necessary to have a volatage step-up circuit of some kind. In this case an audio oscillator using IC1 is used to drive the prmiary winding of step-up transformer T1, giving about 50 V AC from the secondary winding. T1 is actually intended for use as a step-down transformer in transistor amplifier output stages, but it provides satisfactory results when employed in reverse to give a voltage step-up. The output from T1 is halfwave rectified and smoothed by D1 and C3 to give to give an unloaded DC supply of about 75 to 80 volts (about 40 to 50 V when loaded).

With SW1 at the 'low' position, a current of about 1 to 2 mA. (depending upon the voltage of the zener under test) is fed to the test device through current limiting resistor R4, when W2 is operated and power is applied to the circuit. The multimeter, which is switched to an appropriate DC voltage range, is connected in parallel with the test device and registers its zener voltage. Switching SW1 to the 'high' position causes about double the previous current to flow through the zener under test, as a lower value current limiting resistor (R3) is then switched into circuit. If the test device is fully functional this should cause only a very small increase in the meter reading, and there may well be no noticeable change in the meter reading at all.



Books from the HE Book Service

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Richard Torrens. The projects can be split down into simple building blocks which can be recombined for ideas of your own.

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R. N. Soar. The author has managed to compile no less than 50 interesting and useful circuits using this range of devices, covering many different aspects of electronics.

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FET Special

Down the Gain Drain

This feature was prepared from '50 FET Projects' by F. G. Rayer, published by Bernard Babani at £1.25. It contains many practical constructional projects using readily available FET devices.

As our project editor is always saying, the best way to get to know something is to get it on the work bench in front of you. This month we get hold of the FET and show you just what you can do with it (no that's not meant to be rude).

INTRODUCTION

FIELD EFFECT TRANSISTORS find application in a wide variety of circuits. The projects described here include radio frequency amplifiers and converters, test equipment and receivers, as well as various miscellaneous devices which are useful in the home.

It will be found that in general the actual FET used is not critical, and many suitable types will perform satisfactorily. The FET is a low noise, high gain device with many uses, and the dual gate FET is of particular utility for mixer and other applications.

This article should be found to contain something of particular interest for every class of enthusiast — short wave listener, radio amateur, experimenter, or audio devotee.

FET OPERATION

Figure 1 will help clarify the working of the field effect transistor. (a) represents the essential elements of the device, which has Source lead S, Gate lead G, and Drain connection D. The path for current is from Source to Drain through the semi-conductor material, this path being termed the channel. With the N-channel FET, the carriers are electrons. The Source is connected to negative of the supply, and Drain to positive.

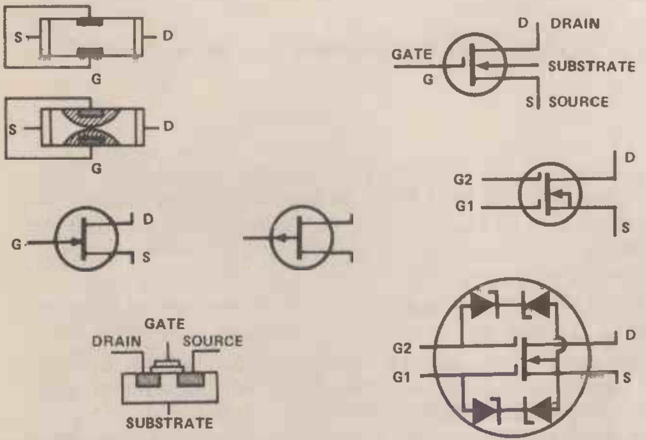

Fig. 1. Construction and symbols used for field effect transistors.

P-type gates are formed on the N-type channel, providing PN junctions. When these junctions receive reverse bias, areas surrounding them are emptied of electron carriers. These ''depletion areas'' reduce the width of the carrier channel, as at (b). As a result there is a drop in the passage of current carriers from Source to Drain. Increasing the bias causes the depleted regions to extend, and the channel grows smaller, reducing current even further. Eventually the gate can be made so negative that the channel is virtually closed. This is the pinch off region, and current is practically zero. The current from source to drain, and through external circuit items, can therefore be controlled by adjusting the gate voltage. Since the gate to channel junction area is reverse biassed gate current is extremely small, and thus the gate input impedance is very high. Generally, the gate current is negligible.

(c) is the symbol for this FET, with S indicating Source (negative), G for Gate, and D for Drain (positive). Such N-channel FETs are conveniently operated with a negative ground or source line. ''D'' is the symbol for a P-channel FET. Typical types and lead outs are shown later.

(e) represents an insulated gate FET. The gate is insulated from the channel by an extremely thin dielectric so tht there is no junction in the way described for (a). The substrate is P-type material with positive hole carriers. When the gate is made negative, positive charges move from the substrate towards the gate, so that the width of the conducting channel is reduced, and thus also the current from drain to source.

MEDIUM FREQUENCY AMPLIFIER

This circuit, Figure 2, is primarily intended for use over the 1.7MHz to 30MHz range, and will be found to provide considerable gain. RF amplifiers of this kind are generally used to improve long distance short wave reception, to increase volume, and to reduce second channel interference on the higher frequencies.

To avoid winding coils and permit easy band changing, Denco (Clacton) miniature plug in coils may be used. These are the ''Blue'' (Aerial) ranges, valve type. The most useful coils will be Range 3, 1.67-5.3MHz, or 580 to 194 metres; Range 4, 5-15MHz, or 60 to 20 metres; and Range 5, 10.5-31.5MHz, or 28 to 9.5 metres. Exact coverage depends on the setting of the adjustable cores, and will also be modified if VC1 is of different value. The coils are inserted in a B9A type holder. If only a single range is wanted, the coil can be mounted by its threaded end, and leads are then soldered directly to the pins.

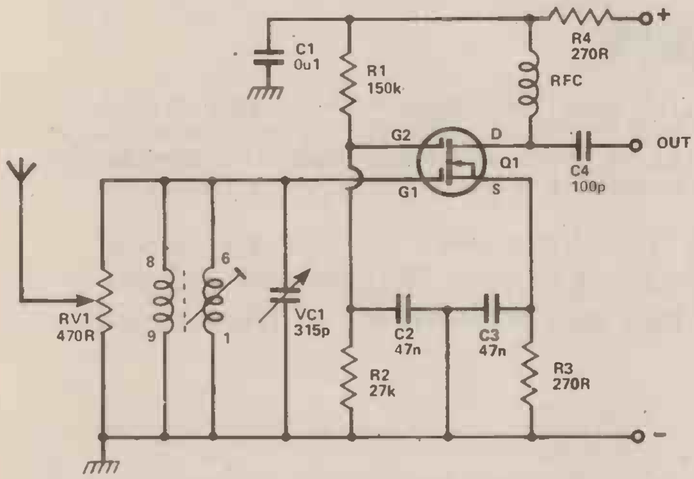

Fig. 2. Circuit diagram for a Medium Frequency RF amplifier.

RV1 is an adjustable aerial input control, as overloading may easily arise with strong signals. R1 and R2 provide the voltage for gate 2, and R3 is for source bias.

The drain circuit is arranged for capacitor coupling by C4 to the aerial socket of the receiver. This lead should not be unnecessarily long, as this may cause losses, as well as picking ujp signals which cause second channel interference. If the lead is screened,it must be no longer than necessary. A 2.6mH short wave sectionalised radio frequency choke will be satisfactory for the frequencies mentioned.

Construction is best in a metal case, which can have a hinged lid if plug-in coils are to be fitted. No ganging difficulties can arise with VC1, which is adjusted for best volume.

Second channel interference is caused by signals which are 2×1F frequency from the wanted signals. With a 470kHz intermediate frequency, these offending signals will be 940kHz from the wanted transmission. As a result, interference from this cause is unlikely at low frequencies, but very probable at high frequencies. Such second channel interference is considerably reduced, or completely avoided, by using a tuned RF stage of this kind, actual results in this direction depending on the receiver IF, and frequencieds tuned.

A 9 V supply is adequate, and current may be drawn from the receiver if convenient. Only about 2mA to 3mA or will be wanted. The MEM618, 40602, and 40673 will be found satisfactory here.

144MHz CONVERTER

The reception of 2 metre signals is generally with a converter and short wave receiver, preferably of communications type. The latter will have sensitivity and selectivity better than average. With such an arrangement of equipment, the 144MHz or other VHF signal is changed in frequency so that the converter output falls within the tuning range of the receiver.

A converter of this type often has its own RF amplifier, and a relatively low frequency crystal controlled oscillator, followed by frequency multipliers. This allows high sensitivity and excellent frequency stability, but is a relatively complicated and expensive item. Bearing in mind that at this frequency the RF amplifier will not contribute very much gain, and that tunable VHF oscillators are used in many domestic VHF receivers, it is possible to use the much simpler circuit in Figure 3.

L1 is broadly tuned to the wanted frequency band by T1, and signal input is to gate 1 of Q1. Q2 is the local oscillator, and the operating frequency here is determined by L2 and T2. Oscillator injection is via C3 to gate 2 of Q1. The frequency of the output from the drain of the mixer Q1 is the difference between G1 and G2 frequencies. Thus if the signal at G1 is 144MHz, and Q2 is tuned to oscillate at 116MHz, output will be at 144 minus 116MHz, or 28MHz. Similarly, with the oscillator set at 116MHz, an input at 146MHz to G1 will give an output of 30MHz. Therefore 144-146MHz can be covered by tuning the receiver from 28MHz to 30MHz. L3 is broadly tuned to this band, and L4 couples the signal to the short wave receiver.

The oscillator can actually be tuned above or below the aerial circuit frequency of the converter, as it is the difference between converter signal input and oscillator frequencies which determines the converter output frequency. It is also possible to choose other reception and output frequencies, provided L1, L2 and L3 are chosen to suit.

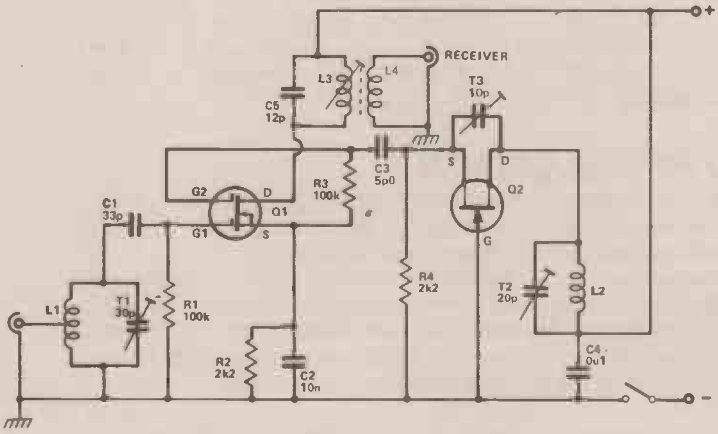

Fig. 3. Circuit for a 144 MHz converter for short wave receivers.

L1 and L2 are wound in the same way, except that L1 is tapped one turn from its grounded end. Each coil has five turns of 18 swg wire, self supporting, formed by winding the turns on an object 7mm in diameter. Space turns so that each coil is ½in or about 12mm long.

L3 is fifteen turns of 26swg enamelled wire, side by side on a 7mm former with adjustable core. L4 is four turns, overwound on the earthed (positive line) end of L3. Layout should allow very short connections in the VHF circuits. A co-axial aerial socket is fitted near L1. A screened co-axial lead is preferred from L4 to the receiver, to avoid unnecessary pick-up of signals in the

28-30MHz range. The converter will operate from a 9 V to 12 V supply.

L3 should first be peaked at about 29MHz. If a signal generator is available couple this to Q1 drain by placing the output lead near the drain circuit. Tune generator and receiver to 29MHz, and adjust the core of L3 for best results. Otherwise, couple an aerial by means of a small capacitor to the drain circuit, and tune in some signal in the 28-30MHz range, to allow adjustment of the core of L3.

It is now necessary to tune L1 to about 145MHz, and L2 to 116MHz, or 174MHz. If an absorption frequency indicator is available, this will permit an approximate setting of T2. A dip oscillator will also allow T1 to be adjusted. Subsequently adjust T2 to bring the wanted signals in at the required frequencies on the receiver, and peak these for best volume with T1, and check the setting of L3 core.

The converter is best assembled in a small aluminium box, completely closed, which can be placed behind the receiver. Note that if Q2 is not oscillating, no reception is possible through the converter. Q2 should be a VHF FET, such as the BF244, MPF102, and similar types, and if necessary T3 may be adjusted to secure oscillation here. The 40602, 40673, and similar VHF types will be satisfactory for Q1. If needed, frequencies can be brought within the swing of T1 and T2 by stretching or compressing L1 or L2.

The aerial may be about 38½in long, constructed as a simple self-supporting or wire dipole, with a feeder descending to the converter. Amateur activity is most likely to be greatest at weekends, and in many areas a whip or very short wire aerial will provide local reception.

FIELD STRENGTH METER

The device in Figure 8 will operate at any frequency up to 250MHz or even higher if necessary. A short whip, rod, telescopic or other aerial picks up radio frequency energy, and rectification by diode D1 provides a positive voltage for the FET gate, across R1. This FET is only operating as a DC amplifier, and the 2N3819 and other general purpose transistors will be satisfactory.

The "Set Zero" potentiometer may be 1k to 10k. With no RF signal present, it allows gate/source potential to be adjusted, so that the meter shows only a small current, which rises in accordance with the strength of the RF present. For high sensitivity, a 100 uA meter can be fitted. Alternatively, a meter of lower sensitivity, such as 25 uA, 500 uA or 1 mA can be used, and will provide enough indication in most circumstances.

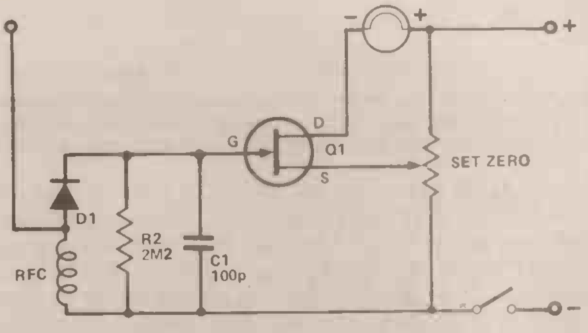

Fig. 4. Field strength meter, useful for determining the efficiency of RF equipment.

Should the field strength meter be wanted for VHF only, a VHF choke can be used, but for general usage over lower frequencies, a short wave choke is necessary. An inductance of about 2.5mH is satisfactory for 1.8MHz and higher frequencies.

The device can be constructed in a small insulated or metal box, with the aerial projecting vertically. In use, it allows tuning up a transmitter final amplifier and aerial circuits, or the adjustment of bias, drive and other factors, to secure maximum radiated output. The effect of adjustments will be shown by the rise or fall of the reading of the field strength meter.

FET TRF RECEIVER

Figure 9 is a circuit giving good headphone reception for persons listening, and it can if wished be contructed as a miniature receiver with a short throw-out aerial. Alternatively, it can be used with reduced range by relying on the ferrite rod alone for signal pick-up.

Q1 is the detector, and regeneration is obtained by tapping the source up the tuning coil. The use of regeneration greatly improves selectrivity, and also sensitivity to weak signals. The potentiometer RV1 allows manual adjustment of the drain potential of Q1, and so acts as a regeneration control.

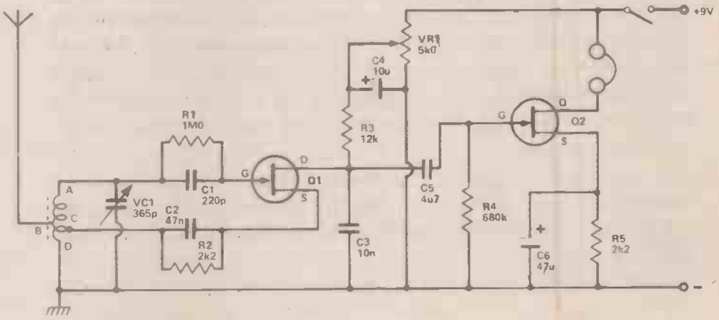

Fig. 5. FET TRF receiver.

Audio output from Q1 is coupled to Q2 by C5. This FET is an audio amplifier, operating the headphones. A complete headset is preferable for general listening, and phones of about 500 ohms DC resistance, or about 2k impedance, will give very good results here. If a miniature earpiece is wanted, this should be a medium or high impedance magnetic unit. A crystal earpiece will require resistance capacity coupling.

The tuning inductor is fifty turns of 26swg wire, on a ferrite rod about 5in × 3/8in. If the turns are wound on a thin card sleeve which can be moved on the rod, this will allow adjustment of band coverage. The winding begins at A, and aerial tapping B is at about twenty-five turns. D is the grounded end of the coil. The best position of the tapping C depends somewhat on the actual FET, on the battery voltage, and on whether the receiver is to be used with an external aerial wire or not. Should the tapping C be too near to end D, no regeneration will be obtained, or regeneration will be weak, even with RV1 rotated for maximum voltage. On the other hand, with too many turns between C and D, oscillation will begin with RV1 only slightly advanced, and signals will be weak. Best results are expected when regeneration begins smoothly, with RV1 about halfway through its rotation. It was found that only one to two turns were required between C and D. As changing the whole coil by a turn or so has little practical effect on frequency coverage, the best method is to make C two turns from D. Then if necessary unwind half a turn or more at D.

When regeneration is obtained, a heterodyne will be heard if the receiver is tuned through a transmission. RV1 should then be turned back very slightly. Maximum possible sensitivity is achieved when Q1 is almost in the oscillating condition. RV1 has to be set to suit the frequency tuned by VC1, so that final critical adjustment can be made. It is useless to regard RV1 as a gain control, and set it at maximum.

A metal case is suitable where an external aerial wire will be used. Where the ferrite rod only will be employed, for local signals, the box or case must be of plastic or other insulating material.

TIMER

An adjustable timer, giving a delay of about 10 seconds to 1 minute, can be used for photographic and other purposes; or with various games where each competitor must make his move within the agreed period.

The circuit in Figure 11 can be employed in various ways, as will be explained. When the switch is moved to the "On" position timing begins, and C1 commences to charge through R1 and RV1. The two resistors R4 and R5 hold the source of Q1 at approximately a fixed potential. When the voltage across C1 has reached a high enough level Q1 gate is positive, so that drain current flows through R3. This causes a voltage drop in R3, so that the base of Q2 moves negative. Q2 is a PNP transistor, so conducts, and collector current flows in the relay coil, closing the relay contacts. When the switch is returned to the "Off" position, C1 is discharged through R2, so that the interval can be repeated.

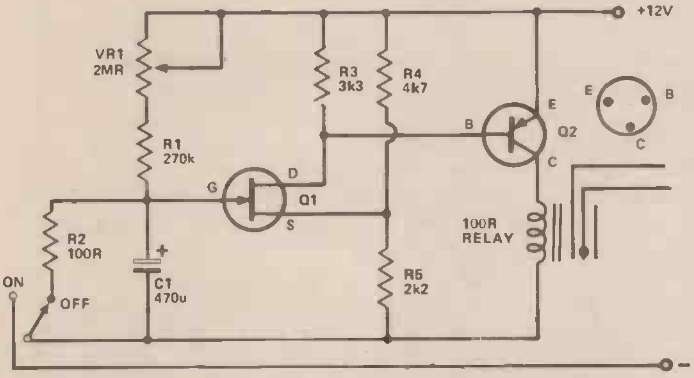

Fig. 6, A timer using a FET, the delay can be varied from about 10 seconds to 1 minute.

A 2N3819 is suggested for Q1, and AC128 for Q2. With C1 as shown (470uF) the interval was found to lie between 10 seconds with a total of 250k in the R1/RV1 position, up to 1 minute with 2 megohm. So the values in Figure 42 can be expected to allow any interval to be set from approximately 10 seconds to 60 seconds. Increasing C1, R1 or RV1 will lengthen the interval. Smaller values here will reduce it. This was with current rising to 40mA, with a 100 ohm relay.

It is not of course essential that these values or transistor types be followed exactly, and other relays would also be practicable, provided the circuit and Q2 allows a satisfactory current and voltage to suit the winding. Generally, a relay with a coil resistance of about 100 to 250 ohms will be most satisfactory.

The relay contacts can be so wired, that when the relay coil is energised, the circuit is completed, or interrupted. The former will most usually be wanted. Closure of the contacts can then light an indicator lamp, or sound a buzzer or bell. The use of opening contacts will be convenient for repeating a set interval when enlarging. A 2-pole 2-way switch is then required, so that switching the timer on lights the lamp to begin the exposure, which continues until the relay contacts open.

For games and similar purposes, a 12 volt 3 watt indicator lamp can be operated from the same 12 V supply. Should any kind of mains-voltage circuit be controlled, the relay must be a type intended for this purpose, and care must be taken to arrange mains circuit so that no danger can arise for the user. **HE**

Type No.	Base	Maximum Ratings	Other Information
2N3819	1	200mW 25v	General purpose AF and RF. N-channel.
2N5457/ MPF103	2	310mW 25v	General purpose AF. N-channel.
2N5458/ MPF104	2		
2N5459/ MPF105	2	200mW 25v	General purpose AF and RF. N-channel.
BF244	1	200mW 25v	VHF. N-channel.
7644/ BF244	5	200mW 25v	VHF. N-channel. (Sub. lead omitted)
MPF102	2	200mW 25v	VHF. N-channel.
2N5450/5	3	310mW 25v	General purpose AF. P-channel.
40602/ MEM618	4	330mW 20v	Dual-gate VHF amp and mixer.
40673	4	330mW 20v	Dual-gate VHF amp and mixer.
2N3823	5	300mW 30v	VHF amp/mixer. N-channel.
2N2497/ 500	6	500mW —	Low noise. P-channel.
80111	7	100mW 20v	RF amp. N-channel.

Table showing all the important parameters for the various FETs used in the circuits, the types used are all freely available and with only one or two exceptions are not very specialised.

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Short Circuits

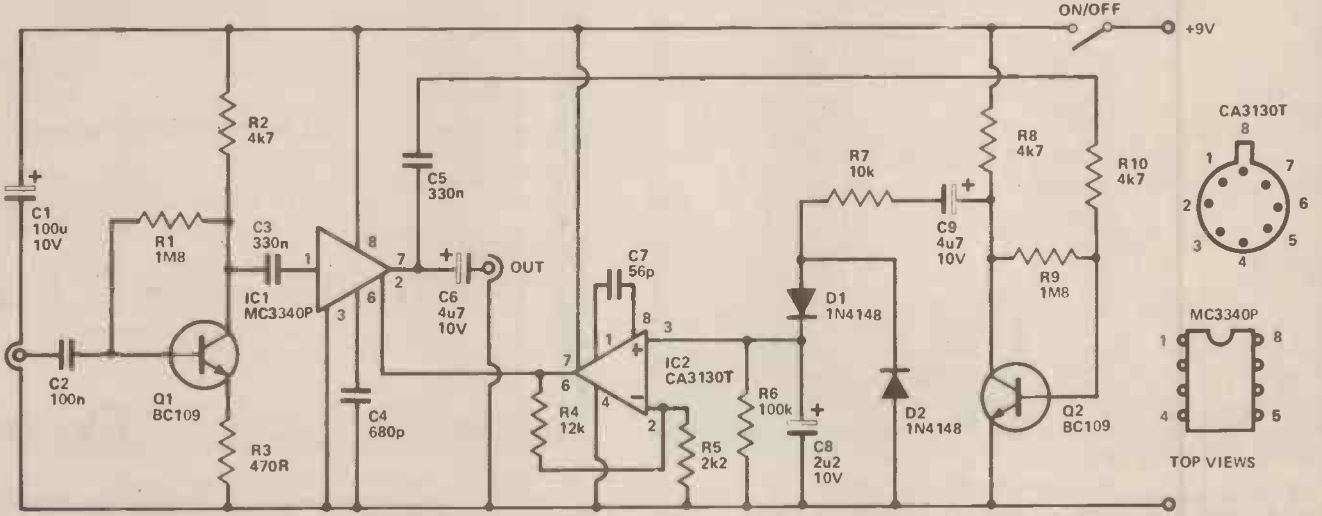
SUSTAIN UNIT

Normally each note from a guitar has a high initial volume that rapidly decays to a much lower level, and the gradually fades out. A sustain unit provides a relatively constant output level when used with an electric guitar, despite the wide range of input levels. The most simple form of sustain unit is a clipping amplifier, but these inevitably introduce quite large amounts of distortion. A better method, and the one used in this unit, is to use a compression circuit having fast attack and decay times. This type of circuit is basically a voltage controlled amplifier, the gain of the circuit being controlled by an output level sensing circuit which varies the gain to produce a fairly consistent output level. Little distortion is produced using this method.

Q1 is used as a low noise preamplifier having a voltage gain of about 20dB. Its output is fed by C3 to the input of IC1, the voltage controlled amplifier device. This has a quiescent voltage gain of about 13dB, but this can be reduced to an attenuation of over 70 dB by taking pin 2 of the device several volts positive. C6 couples some of the output from IC1 to the output socket, and C5 couples the remaining output to a common emitter amplifier based on Q2. The amplified signal at Q2 collector couples via C9 and R7 to a conventional smoothing and rectifier network. The positive bias produced by this network is fed to the control input of IC1 via a low gain amplifier and buffer stage based on IC2.

With low input levels (below about 1mV) the control signal is too small to affect the gain of IC1. Higher level signals produce a proportionately larger control voltage and lower gain through IC1, preventing the output level from rising much above about 30mV RMS, and giving the required virtually constant output level. The attack and decay times of the circuit are both quite short so that the unit responds suitably rapidly to changes in input level, but neither of these time constants are so short as to cause serious distortion.

The unit will be most effective with the volume control on the guitar set at maximum, unless the output should then be so high as to overload the unit and cause distortion.

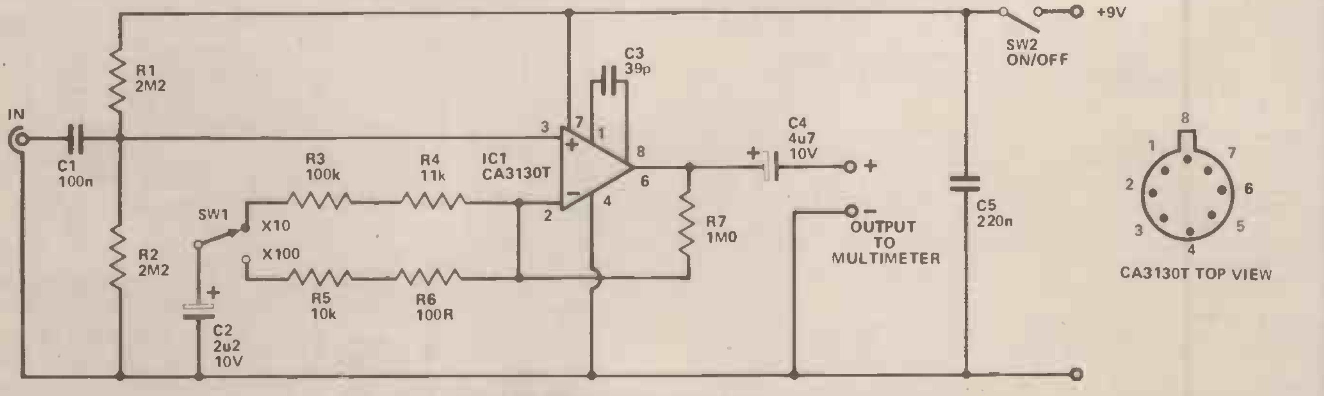


AC METER BOOSTER

Measuring small audio frequency signals is often impossible using an ordinary multimeter because most of these have a lowest AC range of about 1 to 5 V FSD. A simple and inexpensive solution to the problem is to add an amplifier, such as the one shown here, ahead of the multimeter. The amplifier has a switched voltage gain of 10 or 100, and would therefore boost the sensitivity of (say) a multimeter switched to the 2.5 V AC range to 250 mV and 25 mV FSD respectively. Measurements down to just a few mV RMS can then be made with reasonable accuracy.

The circuit uses a CA3130T operational amplifier in the non-inverting mode. The non-inverting input is biased to about half the supply voltage by R1 and R2, and the input signal is coupled to this point by C1. The input impedance of the circuit is set at over 1M by R1 and R2, so that the unit places little loading on the circuit under test. R7 biases the inverting input and gives a quiescent output voltage of about half the supply potential. Although IC1 has an extremely high (open loop) voltage gain, the voltage gain of the amplifier as a whole (closed loop) is much lower, and is set by the ratio of two resistances. With SW1 in the 'X 10' position the two resistances are R7, and R3 plus R4. The voltage gain is equal to the sum of the two resistances divided by the shunt resistance (R3 + R4) in this negative feedback network. This gives almost exactly the required figure of 10 with the specified values. With SW1 in the 'X 100' position the lower shunt resistance of R5 and R6 is switched into circuit, boosting the voltage gain to almost exactly 100.

DC blocking at the output is provided by C4. C5 is a supply decoupling capacitor and should be mounted physically close to IC1. C3 is the compensation capacitor for IC1, and prevents the device from becoming unstable. Note that a carefully designed layout having the input and output well isolated from one another is required, or the circuit as a whole may become unstable. Screened input and output cables should be used to drive the primary winding maximum output of about 3 V RMS. It should therefore be used with the multimeter set to a range of 3 V or less, or if a higher range must be used, the part of the scale above 3 V is ignored. The amplifier has a flat response up to about 30kHz in the 'X 100' mode, and up to about 300kHz in the 'X 10' mode.



R3, R4, R5 AND R7 ARE 2% OR BETTER

TANTALUM BEAD

.1 35V	.10
.15 35V	.10
.22 35V	.10
.33 35V	.10
.47 35V	.10
.68 35V	.10
1 35V	.10
1.5 35V	.11
2.2 16V	.10
2.2 35V	.12
3.3 16V	.11
3.3 35V	.12
4.7 10V	.11
4.7 25V	.12
4.7 35V	.13
6.8 35V	.15
10 6.3V	.12
10 16V	.13
10 25V	.15
10 35V	.18
15 16V	.15
15 25V	.18
22 10V	.15
22 16V	.16
22 35V	.26
33 10V	.16
33 16V	.24
33 25V	.26
47 6.3V	.18
47 10V	.18
47 16V	.26
68 3V	.15
100 3V	.16
100 6.3V	.24
100 10V	.28

RADIAL ELECTROLYTICS

.47 50V	.06
1 50V	.06
2.2 50/63V	.06
3.3 50V	.06
4.7 35V	.06
4.7 50V	.07
10 16V	.06
10 25V	.06
10 63V	.08
22 10V	.05
22 16V	.06
22 35V	.07
22 50V	.08
33 16V	.06
33 25V	.07
47 16V	.07
47 25V	.08
47 63/50	.15
100 10V	.06
100 16V	.08
100 25V	.09
100 63V	.22
220 10V	.08
220 16V	.10
220 35V	.19
330 10V	.15
330 25V	.19
470 6.3	.09
470 16V	.15
470 25V	.21
470 50V	.35
1000 16V	.18
1000 25V	.35
2200 6.3	.24
2200 16V	.38
2200 40V	.64
4700 6.3	.38
TAG 2200 63V	1.72
TAG 4700 63V	1.99

AXIAL ELECTROLYTICS

.47 63V	.08
1 63V	.08
2.2 63V	.08
4.7 25V	.06
4.7 63V	.08
4.7 450V	.19
10 25V	.08
10 63V	.10
10 450V	.27
22 25V	.08
22 450V	.47
33 25V	.08
47 10V	.07
47 25V	.08
47 63V	.12
47 450V	.60
100 16V	.10
100 25V	.10
100 63V	.19
220 16V	.12
220 25V	.13
220 63V	.30
470 25V	.20
680 16V	.35
1000 25V	.33
2200 25V	.70
2200 40V	.75
4700 25V	.85

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.1	.035 ea.
.47	.06 ea.
.68	.08 ea.

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.001	.06
.0015	.06
.0022	.06
.0047	.06
.0068	.06
.01	.06
.015	.06
.022	.07
.033	.07
.047	.07
.068	.08
.1	.10
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.47 (100V)	.22
.68 (100V)	.25
1mfd (100V)	.28

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.1	.09

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100-150pf 2% (Low K)	.055
180-820pf 10% (Med. K)	.03
1000-2200pf 10% (Med. K)	.04
3300-4700pf 10% (Med. K)	.05
10,000-20 + 80 40V	.035
22,000 .20 + 80 40V	.06

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Ohms: 22. 33. 5. 1. 1.2. 1.5. 1.8. 2.2. 2.7. 3.3. 3.9. 4.7. 5.6. 6.8. 8.2. 10. 12. 15. 18. 22. 27. 33. 39. 47. 56. 68. 82. 100. 120. 150. 180. 220. 270. 330

5 watt ± 5% Tol. Following values only — 12p each
5.1. 2.2. 3.3. 3.9. 4.7. 6.8. 8.2. 10. 12. 15. 18. 22. 25. 33. 39. 47. 60. 75. 82. 100. 120. 130. 150. 180. 220. 250. 270. 300. 330. 470. 500. 560. 680. 820. 1k. 1k2. 1k5. 2k. 2k2. 2k5. 3k3. 4k7. 5k6. 6k8. 7k5. 8k2. 10k. 12k.

10 watt ± 5% Tol. Following values only — 14p each
1. 2.2. 3.3. 4.7. 6.8. 7.5. 8.2. 10. 12. 15. 18. 22. 25. 33. 39. 47. 70. 82. 100. 120. 150. 200. 250. 330. 470. 560. 680. 750. 1k. 1k2. 1k5. 1k8. 2k. 2k2. 2k7. 3k. 3k5. 4k7. 5k. 5k6. 6k8. 10k. 15k. 18k. 20k. 25k.

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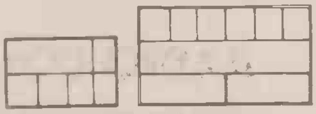

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Analog delay

Since the advent of CCD (charge coupled devices) you could be forgiven for believing that all other methods of obtaining a time delay on a signal have curled up and died.

This is simply not so, and next month Tim Orr takes time off from String Thing to explain this largely unknown flourishing field.

RADIO CONTROLLED

Of course you've all built our radio control project out there haven't you? No? . . . Oh.

Well the reason why not could simply be that you haven't seen this article yet. Written by Geoff Chapman — one of the few real experts in the field, it illustrates the different types of model that can be operated by R/C and how to get them operational!

Full of the kind of detail you'd spend years of lost patience gathering.

Into Linear ICs

By Ian Sinclair Part 3

Deep breath, this month Ian Sinclair (with the help of twenty practical circuits) describes how the 741 op amp can be used to make anything from a 'boing' generator to 'pepping' up the output of your cassette recorder.

THE 741 IS GOING TO BE our introduction to linear ICs. It would be difficult to choose any other chip, because the 741 is probably the most frequently used of all linear ICs. It can come with a variety of letter codings (LM, MC, CA, NE and others), but as long as these letters are followed by the number 741, it's the same chip. It's also found in a variety of packages, but the one we shall use is the DIL 8-pin one, which is the most convenient one for our purposes.

The 741 is classed as an operational amplifier, meaning that it's a direct-coupled amplifier with a very large voltage gain — 100 000 times or more — and the usual two inputs to which signals or feedback can be connected.

The pinout for the 8-pin package is shown in Fig. 3.1. Note that not all of the pins are connected internally, and two of the pins that are connected are seldom used — we'll show later how and when they are used. Like most operational amplifiers, the 741 is intended for dual +ve and —ve power supplies, but the circuit designs can nearly always be adapted for a normal +ve and 0V type of supply as we shall see.

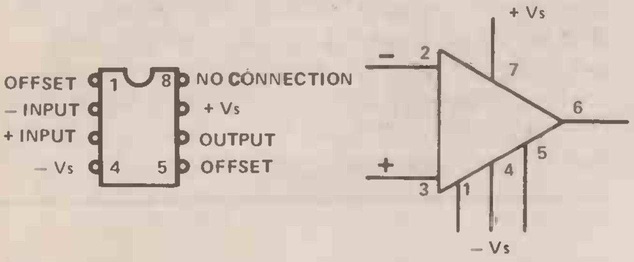

Fig. 3.1 The pin-out diagram of the 741 showing the chip appearance and the circuit symbol.

CIRCUITS AND MORE CIRCUITS

Now for some circuits. Fig. 3.2 shows what is called a voltage follower. The — (minus) input of the 741 is connected directly to the output through a resistor R1, with no other components in the way, so that there is 100% feedback of bias and signal voltages. The + (plus) input is earthed through another resistor R2, and is used as the signal input.

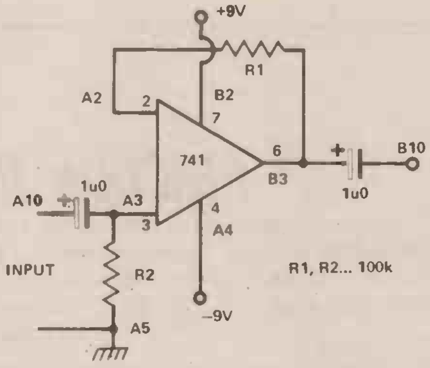

Fig. 3.2 The voltage follower circuit using dual power supplies. The dotted lines indicate where capacitors can be used connected to isolate the 741 from bias voltages in any circuits it's connected to. The letter/number references are to the line positions of the Eurobreadboard.

What does this do? There's no voltage gain, to start with. The signal voltage out is exactly equal, as far as we can measure, to the signal voltage in, which at first sight doesn't seem too encouraging. There is, however, a huge difference between the input and the output resistances. Remember what that's about? Any electronic device behaves as if it had a resistance at its input and another resistance at its output. When we connect these devices (transistors, ICs or whatever) together, these resistances form potential dividers, reducing the amount of signal which can be passed from one device to the next, as illustrated in Fig. 3.3. An ideal amplifier would have a very high input resistance and a very low output resistance. This way we could connect any source

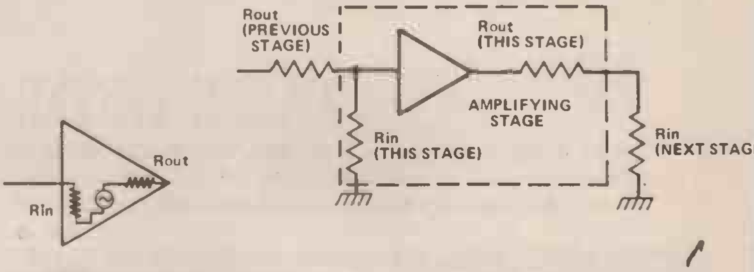

Fig. 3.3 Internal resistances (a) and how they act as potential dividers (b) for the signal.

of signal (tape, disc, microphone, radio . . .) to the input with no loss of signal, and in the same way have no loss of signal at the output even if we connected a very low resistance (such as a loudspeaker) to the output. Sometimes we prefer a lower input resistance for other reasons, but these are the rules for ensuring the greatest possible transfer of signal from one stage to the next.

The circuit of Fig. 3.2 certainly has the correct resistance values, very high at the input and very low at the output, so that the lack of gain isn't always a disadvantage. We can, for example, connect a very high resistance crystal pickup to the input and a low-resistance magnetic earpiece to the output and get a detectable signal at the output. If we connected the pickup directly to the earpiece, we don't hear a thing. This isn't because of a low signal from the pickup — crystal pickups can produce a volt or more of signal — but because of mis-match. The very high resistance of the crystal pickup is connected to the very low resistance of the magnetic earpiece, and the signal is simply divided out of existence! The 741 circuit of Fig. 3.2 is called a voltage follower, and it's a useful headphone amplifier. You can connect its input almost anywhere in an amplifier circuit without affecting the signal voltage (why? Because of the high resistance) and that's not something you can risk with headphones. If you're going to use the voltage follower in this way, though, it's advisable to use a 0µ1 coupling capacitor at the input so that the 741 is not affected by any bias voltage at the place where it's connected. In addition, stick to battery-operated equipment until you have a lot of experience in servicing — you don't get a second chance where there are mains voltages around.

BIASSED TOWARDS COMPONENTS

Fig. 3.4 shows another version of this circuit, re-drawn this time so that a single supply of 18 V can be used. You can see that this needs more components because the bias on the + input has to be set at a voltage midway between the positive and the zero supply lines. In this circuit, equal value resistors R3 and R4 set the midway voltage to which the + input is returned. The — input is biased by feedback as before, but the input and output have to be capacitor coupled because of the bias voltages.

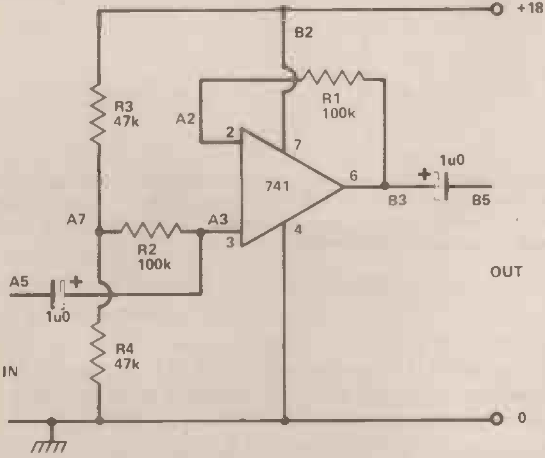

Fig. 3.4 The single-supply version of the circuit of Fig. 3.2. Eurobreadboard line A7 is used for the additional resistors R3, R4 junction with R2.

Both circuits are shown with the letter-and-number locations for a suggested Eurobreadboard layout, with pin 1 of the IC on line A1 of the breadboard. A simple way to demonstrate the high input resistance goes like this. Connect an LED and a 2K2 resistor in series to the board as shown in Fig. 3.5: note the two possible connections according to whether you've built the dual or the single power supply version. Now, with no signal of any sort into the 741, the LED should not light, because the output voltage of the 741 is the same as the voltage at the cathode of the LED. Now touch the input of the 741 circuit with one finger and the +9 V supply with another finger — what happens? Could the resistance between your fingers possibly supply the LED directly (Fig. 3.6)? This 741 circuit is the basis for countless circuits which detect small voltages; circuits such as moisture detectors, 'lie'' detectors, continuity testers and so on.

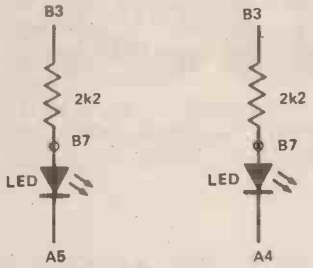

Fig. 3.5 Using an LED voltage detector (a) for the circuit of Fig. 3.2, (b) for the circuit of Fig. 3.4 R2 should be 1M in this circuit when the LED is being used as a detector.

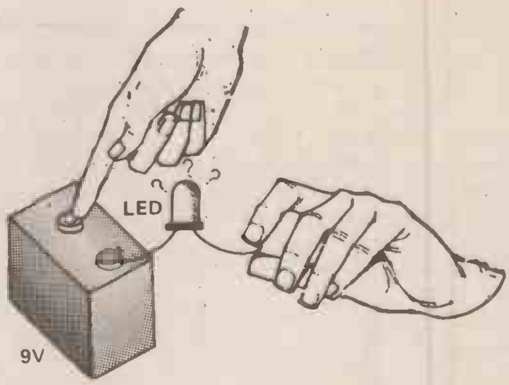

Fig. 3.6 Can enough current pass through your fingers to light an LED?

We needn't, of course, use 100% feedback for our voltage amplifier. Fig. 3.7 shows a circuit which feeds back only a fraction of the output signal. Using a dual voltage supply, this is easily arranged by connecting a potential divider from the output to earth, and taking the — input to the output of the potential divider. This kind of circuit is called a follower-with-gain. It has the same high input resistance as the simple voltage follower, but a voltage gain which is greater than one. The value of voltage gain is given by the ratio:

$$\frac{R1 + R2}{R2}$$

so that if, for example, R1 = 47K and R2 = 15K, then the gain is

$$\frac{47 + 15}{15}$$

which is 4.13, as near 4 as makes no difference. The single voltage version of this circuit isn't nearly so simple. The resistor R2 can't be connected directly to earth without disturbing the bias on the + input, so that an isolating capacitor is needed. The usual pair of resistors to set half-supply-voltage, and the coupling capacitors to avoid shorting out the bias will also be needed.

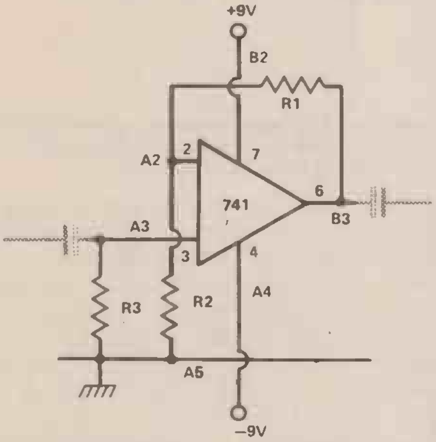

Fig. 3.7 The follower-with-gain. The (dotted) capacitors will be needed if the circuit is to be connected to any points which are not at earth voltage.

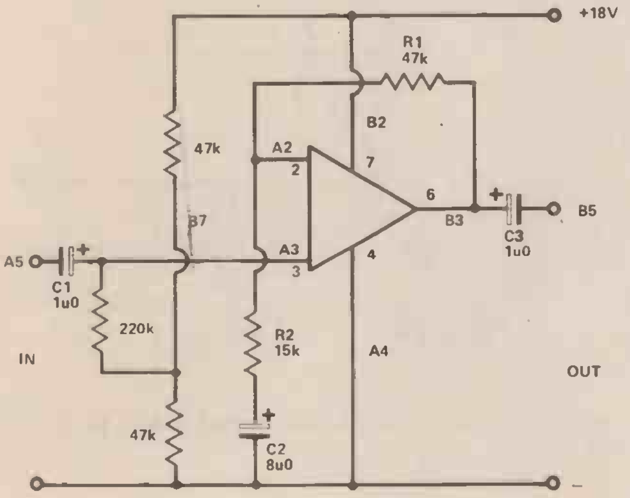

Fig. 3.8 Single-supply version of the follower-with-gain. C2 is needed to prevent the voltage at A2 from being reduced by the potential divider circuit, R1, R2.

GAIN

The gain which this circuit can have makes it much more useful. It can, for example, be used to amplify the signal at a detector diode to form a modern version of the old-fashioned crystal set, as shown in Fig. 3.9. It's also an excellent pre-amplifier circuit, giving a moderate gain along with high input resistance and low output resistance. The output will drive magnetic earpieces quite happily, though the low-resistance earphones which are used along with stereo receivers usually need a bit of resistance connected in series if they are not to overload the 741. For the same reason, low resistance loudspeakers (4R to 15R) should not be used, though the old "transistor radio" 80R loudspeakers will work quite nicely.

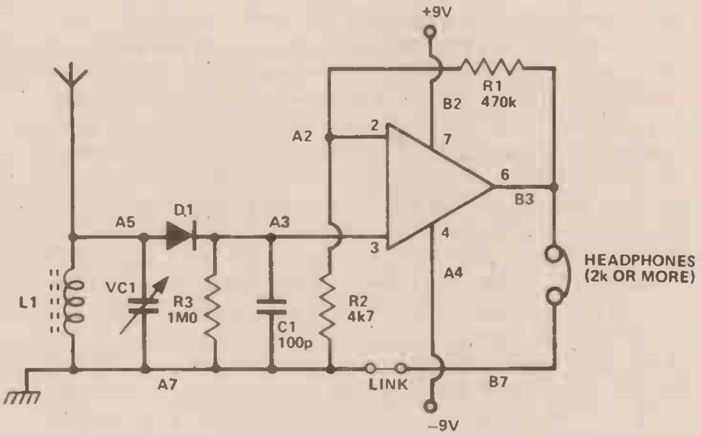

Fig. 3.9 A simple radio circuit, using the high gain of the 741 to amplify the feeble signals from the diode detector. D1 must be a germanium diode such as OA91. Note the link (wire) between A7 and B7 to ensure enough plug-in points on the earth line.

Now for the next trick. This time, instead of using the + input for signals, we'll use the — input. Yes, I know that we take the feedback to this input as well, but we can get around that, as we'll see. The circuit of an inverting amplifier, as this type is called, which uses dual power supplies is shown in Fig. 3.10. As usual, the use of two separate supplies makes the circuitry simple, with the + input connected through a resistor to earth.

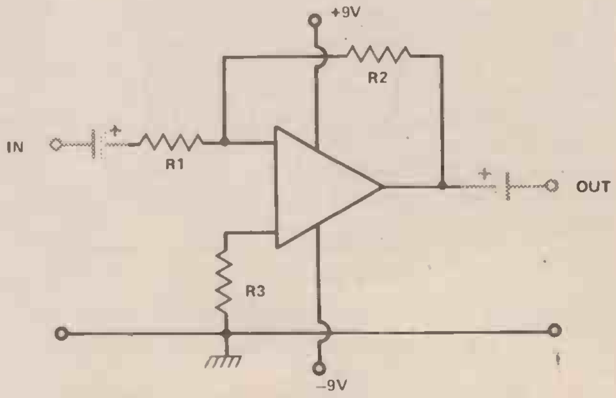

Fig. 3.10 The basic inverter-amplifier circuit. The value of R3 should be chosen so as to equal R1. Capacitors, shown dotted, should be used if the input or output is connected to points which are not at earth voltage.

This circuit is different in a number of ways. For one thing, we find that if we connect our signal directly to the — input, the input resistance is as near as we can measure, zero! It's so near zero in fact that the — input is often called a virtual earth — there's zero resistance to earth for signals at this point. We can add some resistance, however, in the shape of R1, and when we do the voltage gain of the circuit is easy to calculate — it's just R2/R1. The output resistance is low, the input resistance is R1, and the output signals are inverted compared to the input signals.

How can we try this one out? One way is to use it with a signal source which has a low resistance. We can, for example, use a small loudspeaker as a microphone. Fig. 3.11 shows a suitable circuit, with a magnetic earpiece used at the output, which can be used as a remote listening device — not everyone knows that a loudspeaker can double as a microphone.

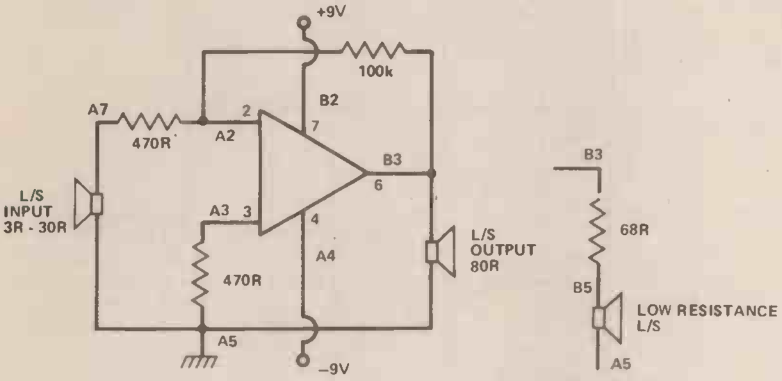

Fig. 3.11 An eavesdropper circuit. (a) The loudspeaker at the input can be of high or low resistance, but the loudspeaker at the output can be a high resistance type. (b) shows how a lower resistance loudspeaker can be used at the output.

As usual, the circuit is a bit more complicated when a single power supply is used, and coupling capacitors have to be connected to prevent the bias from being shorted out. Fig. 3.12 shows the single-supply version of the circuit of Fig. 3.11.

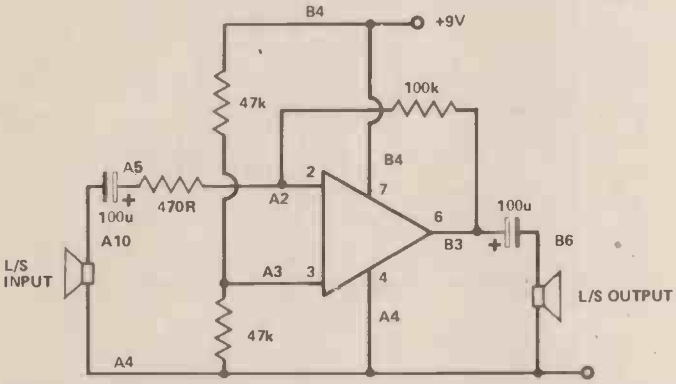

Fig. 3.12 A single-voltage supply version of the circuit of Fig. 3.11.

FOR OUR NEXT TRICK . . . .

These circuits are basic circuits — they illustrate with only a few components what a 741 can do. By adding more components we can end up with a lot of useful project ideas, and that's the next step. As always, we've shown the suggested Eurobreadboard layouts along with each circuit diagram. One such circuit is illustrated in Fig. 3.13. This one is an overload compressing amplifier; a boon if you use a microphone live or for tape recording. All microphones give a much greater output when you're close to them than when you're a few feet away, so if you set the gain of an amplifier to be just right when you're three feet from the mike, it's horribly overloaded and distorted when you come closer. The compressor circuit has a variable gain which corrects this situation — when the signals are small, the circuit has a large gain; when the signals are large the gain drops. It's like having a very smart operator at the volume control, but with the additional advantage of being automatic.

How does it work? The circuit (Fig. 3.13) is basically an inverting amplifier but the feedback is through a pair of diodes, D1 and D2. Now, as you'll recall, diodes conduct one way only, so that to ensure that both halves of a signal voltage will be fed back, we have to use two diodes connected back-to-back. Even when the anode of a diode is positive to the cathode, however, a diode does not conduct until there's enough voltage across it, about 0, 15 V for a germanium diode, and 0.5 V for a silicon diode. Once the diode starts to conduct, what's more, it doesn't obey Ohm's law, or anything like it. There's no fixed single value of resistance for a diode, the value of resistance changes as the current through the diodes changes, becoming smaller when there's a lot of current through the diodes, and large when the diodes are almost cut off.

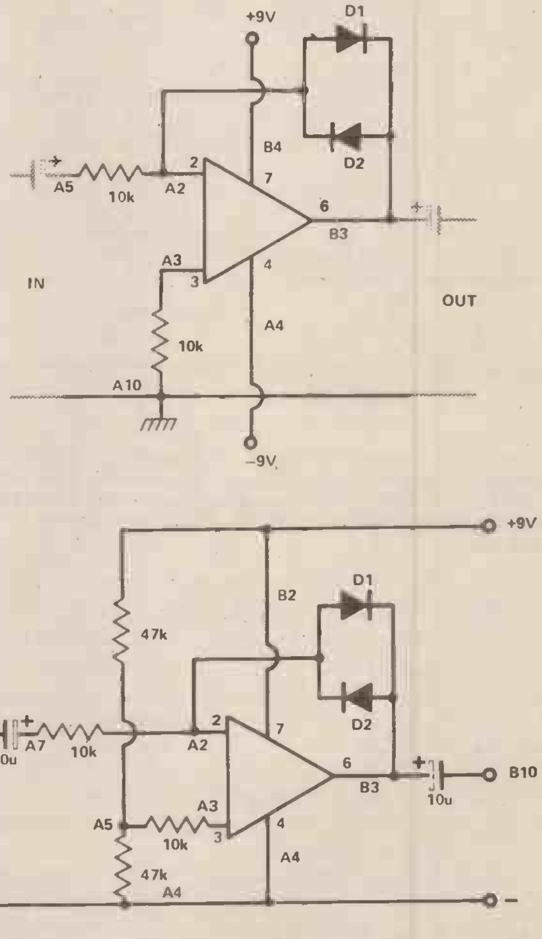

Fig. 3.13 The diode compressor circuit (a) dual voltage supply version, (b) single voltage supply version.

COMPRESSION

How does this achieve compression? Well, if the input signal is very small, the amplified signal at the output may be too small to make the diodes conduct, in which case there's no feedback and the circuit operates at full gain. When a larger input signal happens along, the diodes start to conduct, and their resistances act as a negative feedback resistor, reducing the gain of the amplifier. Still larger input signals make the diode resistance lower, causing more feedback and less gain. In the circuit which is shown, the gain for a 1 mV signal is about 20 times (output 20 mV), but the gain for a 1 V signal is about 0.5 (output 500 mV). One thousand time the original input signal has caused only 25 times the output signal — that's compression!

If you want to use this in a microphone circuit, you'll have to experiment with the best place to connect the compressor — either between the mike and the pre-amp, or between the first stage of the pre-amp and the second. Remember to use coupling capacitors if you're connecting to anywhere which has a bias voltage, and don't take risks with mains-operated equipment.

Something different now, in the circuit of Fig. 3.14. This one is called the 'Buzby-cheeper' because it can be inserted between two stages in an amplifier to make the output sound as if it had come from a telephone. It's a circuit which is very useful in radio and taped plays, and I sometimes wonder if it's not used in 'phone-in' programs. The circuit needs a lot more components than any of the circuits we've used up to now, but it's not going to clutter up the wide open spaces of your Eurobreadboard. As usual, the dual-supply version is simpler, but Fig. 3.15 shows an alternative single-supply circuit. The signal input in each case is to the + input of the 741, with feedback of DC bias and of signal through the resistors and capacitors which are connected between input and output — an arrangement which is called a 'network'.

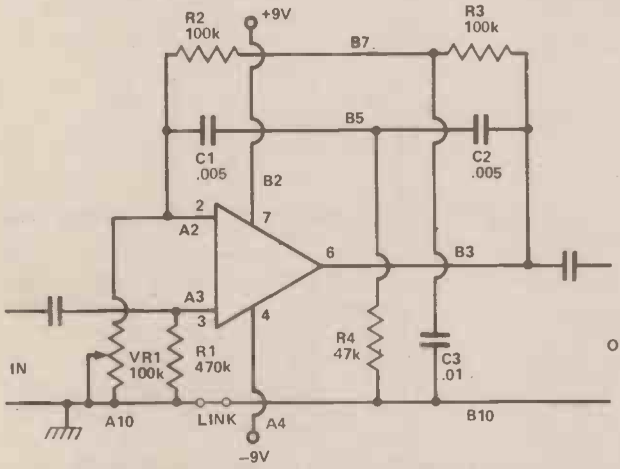

Fig. 3.14 The 'Buzby-cheeper', dual voltage supply version. Input and output capacitors are shown dotted; they will not be needed if the input is a microphone and the output is to an amplifier or tape recorder. RV1 controls the amount of 'cheep' in the sound.

These resistors and capacitors aren't just any old values, they've been chosen so that they control the feedback of signals. At one particular frequency, around 400 Hz, there's less feedback of signal than there is at other frequencies. The result is that we get more gain at that particular frequency range, around 400 Hz, than at other frequencies. It's this feature which makes the Buzby sound, because a telephone acts also to emphasise these same frequencies. The telephone does it unintentionally — it's the construction of the telephone microphone and earpiece which filters out all the other frequencies, but our circuit does this deliberately and with some control because of the use of the 100K potentiometer. With this control at its maximum resistance setting, the sound isn't terribly 'Buzbied', but decreasing the resistance of RV1 will increase the effect, even to the extent of letting the whole circuit oscillate, generating a tone.

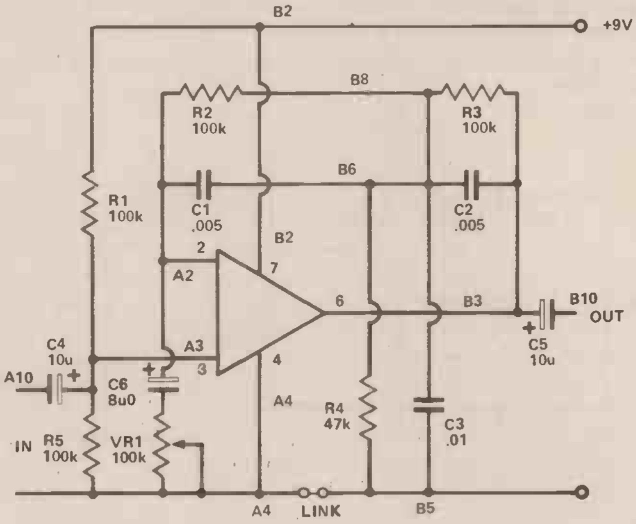

Fig. 3.15 Single-voltage supply version of the Buzby-cheeper.

Try this one out between a microphone and a tape recorder or between a tape recorder and an amplifier — but if you use a small cassette recorder, the sound may be pretty well Buzbied even without this circuit!

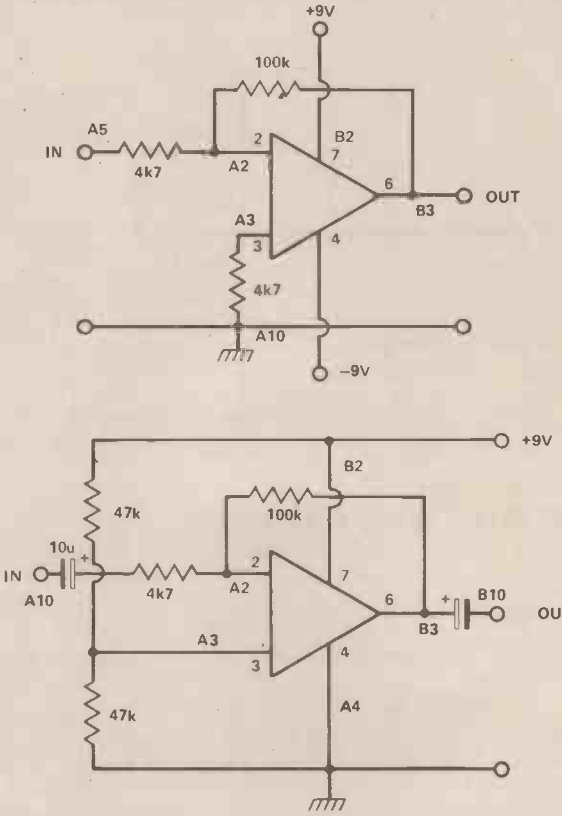

Fig. 3.16 Microphone booster circuits (a) dual supply, (b) single supply.

TALK ABOUT TAPE

Talking about recorders, is your cassette recorder sensitive enough when you use it with a microphone? If it isn't, then the circuit of Fig. 3.16 could prove useful. This is a booster preamp which uses the microphone as its input and delivers a boosted signal to the recorder. It can't be used with the built-in microphones which some cassette recorders have, of course, but most recorders have a separate microphone which is seldom very sensitive.

The circuit is straightforward, particularly when dual supplies can be used. The gain is fixed at about 25 times, because there's not much point in having a variable-gain pre-amplifier when the recorder itself has a gain control or has automatic gain-control circuits.

Connections can be a bit awkward when you're trying out the circuit. For testing the breadboarded circuit, I used crocodile clips to connect to the jack plug which was on the end of the microphone cable, with short lengths of wire plugging into the board. The recorder which I used also had a 5-pin socket input, and wires from the board could be inserted (once I found the correct holes) to make contact. A better method would be to solder wires to a jack socket for the input and connect a jack-plug to the board (Fig. 3.17) for the output. Remember that stranded wire must NEVER be plugged into the Eurobreadboard — not all the strands will come out again, and the lost strands will create short circuits inside the board until you peel the backing off and remove them.

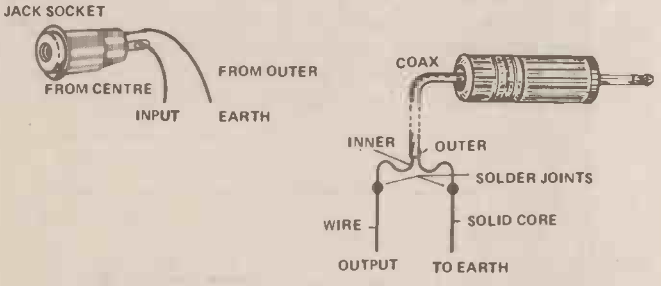

Fig. 3.17 Making connections to and from the booster.

Has that lot whetted your appetite for 741 circuits? If it has, the next one will also be of interest, because it allows you to get a fair amount of audio power to a loudspeaker by adding a couple of cheap transistors to the IC circuit. At the same time, it's not too hard on batteries because the current which the circuit takes is fairly low unless you turn the volume right up.

SOUNDING OFF

The 741 is a voltage amplifier, and its output resistance is not low enough to drive much current into a low-resistance speaker. In addition, to prevent overheating, the 741 is fitted with circuits which limit the amount of current which can be passed. The transistors which we've added in Fig. 3.18 can pass rather more current to the loudspeaker than a 741, and are completely controlled by the 741. One of these transistors, Q1 is a PNP type, and the other is NPN, but you can't tell them apart by looking at the cans, so be careful not to rub the labels off. An alternative is to use a waterproof marker pen, the kind that's used for marking PCB tracks is ideal, to mark P on top of the PNP can, and N on top of the NPN can. With a dual 9 V supply, this circuit can pass rather a lot of signal current into an 8R loudspeaker, so that emitter resistors R6 and R7 have been added for safety. These resistors also control the bias in the output pair of transistors, so don't be tempted to omit them!

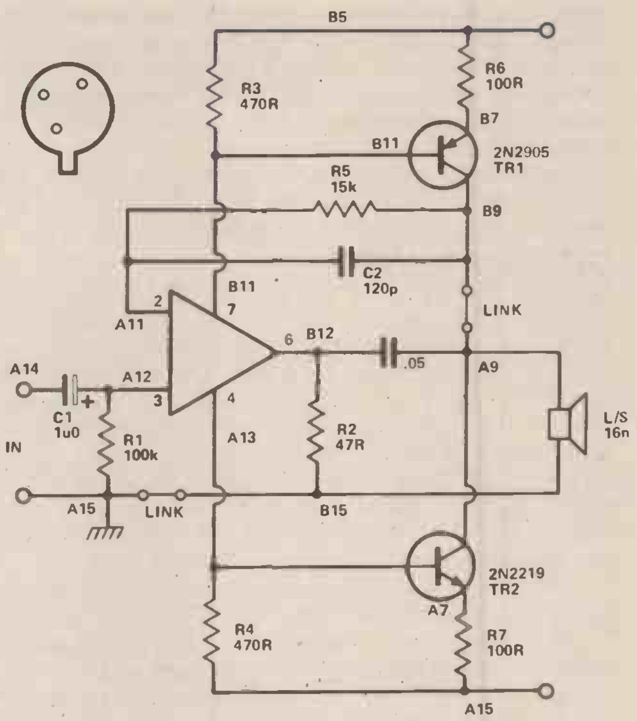

Fig. 3.18 A medium-power output stage using a 741 with two transistors.

The circuit is a bit unusual, because it doesn't use the output of the 741 directly. The output is simply connected to earth through a resistor, and the output transistors are driven from the power supply terminals! It certainly looks unusual, but it's quite a reasonable way if using the 741, because most of the current flowing in the power supply terminals goes to the output terminal.

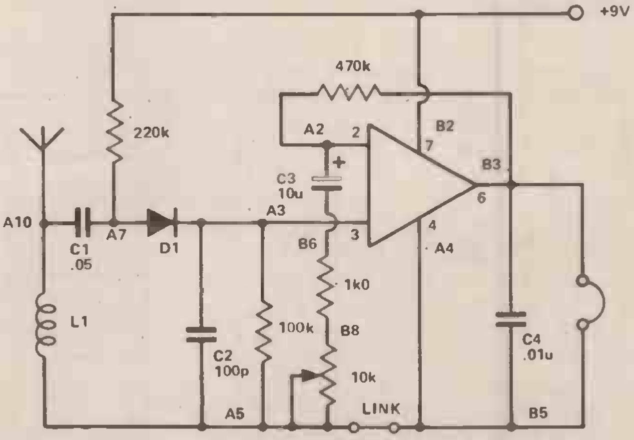

Fig. 3.19 A simple radio circuit using a single voltage supply.

On one half of the signal sinewave current flows mainly through R3 into the 741, and to earth through the output and R2. On the other half of the sinewave, current flows through R2, the output, and so through the 741 to the — supply terminal then thought R4. On the positive half of the wave, the voltage across R3 biases Q1 on (it's PNP, remember, so that it turns on when its base voltage is more negative than its emitter voltage. Q1 then passes current to the loudspeaker. On the other half of the cycle, Q1 is biased off, and the voltage across R4 turns Q2 on, so that current flows through the loudspeaker in the opposite direction and through Q2.

Because of the difference between this and the other circuits we've looked at so far, the constructional methods for this one should be rather different.

DC COUPLING

Because the circuit is completely DC coupled, the bias/feedback connection is very important. Any fault in this line can cause one of the output transistors to pass a lot of DC through the loudspeaker, and this can happen also if the input line is biased above or below earth voltage. For safety, then, it's a good idea to use an old loudspeaker when the circuit is first tried out, and to couple to the input through a capacitor. Since this is a power amplifier, there isn't much voltage gain, and a preamplifier will be needed if very small signals are to produce an output which can be clearly heard.

The high gain which can be obtained from a 741 can be used for simple radio circuits. The circuit of Fig. 3.19 is just another up-to-date version of the old crystal set, but it's a useful way of using the gain of the 741 to display the principles of radio reception, and quite acceptable results can be obtained if a long-wire aerial is used.

In the circuit of Fig. 3.19 L1 is a tuning coil which consists of 50 turns of enamelled copper wire wound on to a ferrite core. This is connected in parallel to a 500 pF tuning capacitor, so forming a resonant circuit which can be tuned to various frequencies by altering the setting of the variable capacitor. The radio frequency which is selected by the tuned circuit is detected by diode D1, and the resulting audio frequencies are amplified by the 741.

The audio output can be heard if a pair of high-resistance (2K or more) headphones are connected to the output, alternatively a high resistance (80R) loudspeaker can be used.

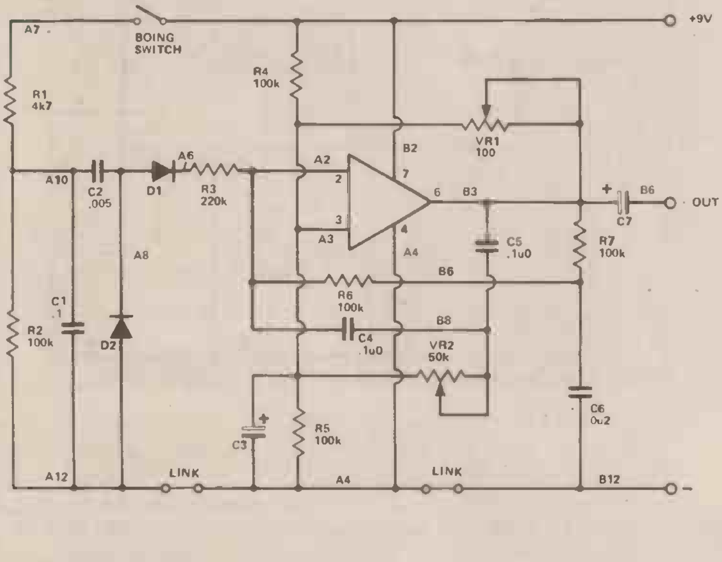

Fig. 3.20 The 'Boing' circuit.

'BOING' 'BOING'

How about something different? Fig. 3.20 is a *'boing'* circuit — if the signal at its output is taken to an amplifier and loudspeaker, then a drum-like *'boing'* sound will be produced each time the push-button is pressed. The pitch of the note can be varied by adjusting RV2, and the amount of *'boing'* by adjusting RV1.

It works like this. The 741 has two feedback circuits. One of them uses capacitors and resistors, like the circuit of Fig. 3.14, to ensure that the gain of the 741 is greatest at one selected frequency. There's a variable resistor included in this bit of the circuit to control the pitch (frequency) of the note that we get when the *'boing'* occurs. The other bit of the feedback circuit is just a variable resistor, RV1. This, along with resistor R3 decides what the gain of the 741 is for a signal which comes in through D1. When the push-button is pressed, C1 is quickly charged to +9 V, and the rise of voltage is passed through C2 and D1 to the 741 input. This disturbance causes the 741 to give an output, and the feedback network of C4 to C6 and R6 to R7 turns this into a continuous signal. As the charge on C2 leaks away through R3, the — input is slowly biased off, so that the signal produced by the feedback network dies away — end of boing.

MILLIVOLTMETER

Finally, Fig. 3.21 shows a circuit for an AC millivoltmeter, which allows you to measure the size of small AC signals which are at audio frequencies. The 741 is connected as an inverting amplifier so as to amplify the audio signals at the input. At the output of the 741, the signals are forced by diodes (it's the familiar bridge rectifier circuit) to pass through the meter M, a 1 mA meter, before being fed back through resistor R5 to the — input of the 741. Because of the way the diodes are connected, signal current always passes through the meter in one direction, so that the meter reads average current. The resistors in the circuit are there to ensure that the meter readings correspond to RMS values of a sine-wave input; their values muct not be altered.

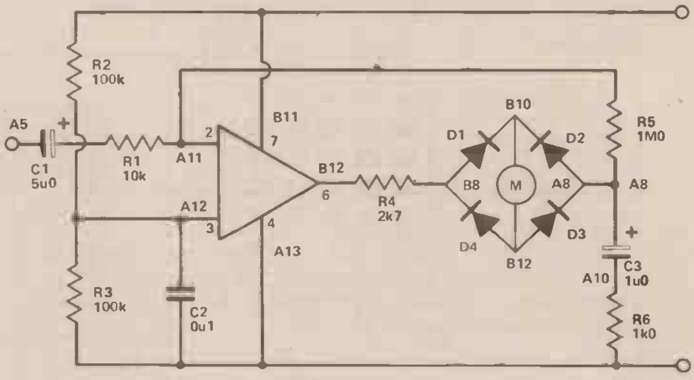

Fig. 3.21 The AC milliammeter circuit.

The sensitivity of the circuit is selected by the value that is chosen for R1. With the value shown, 10K, the meter reads full-scale for an input of an input of 10 mV RMS; other ranges can be selected by using switched valves for R1. A value of 100 K gives a sensitivity of 100 mV, and a value of 1M gives a sensitivity of 1 V for full-scale meter deflection. For a lot of applications a cheap edge-type meter is adequate, so that the AC millivoltmeter needn't be an expensive project. **HE**

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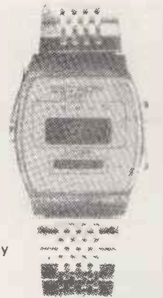

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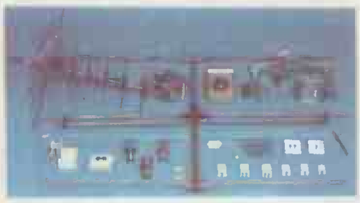

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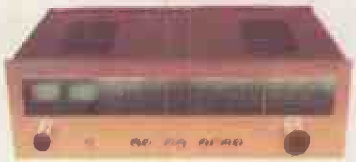

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