Hobby Electronics

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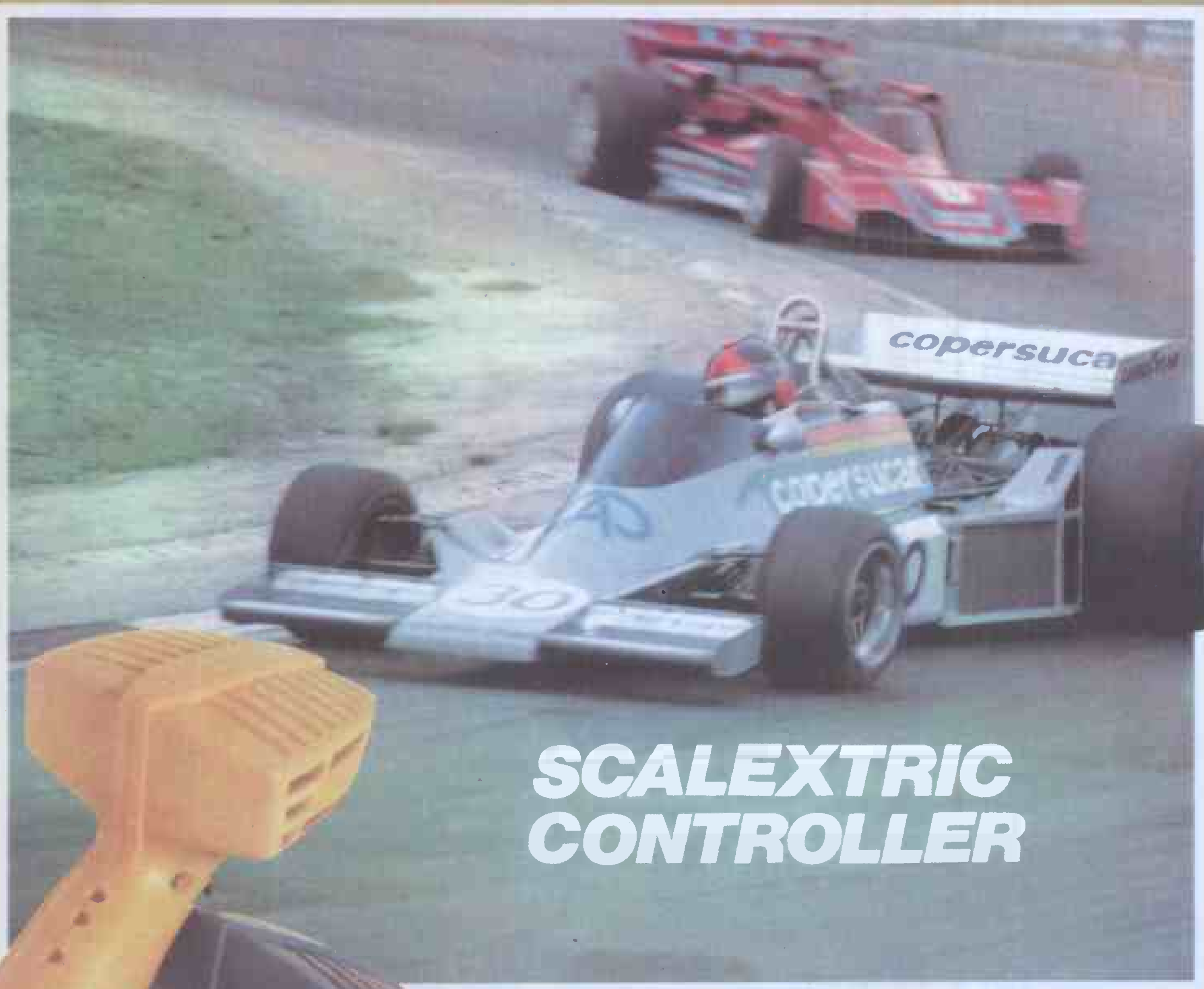
45p



SCALEXTRIC CONTROLLER

Ring Modulator
Do It Like A Dalek

Hebot Pt 2
Stimulating Ideas

TV Receivers
Seeing The Light

Games Offer
Play The Game

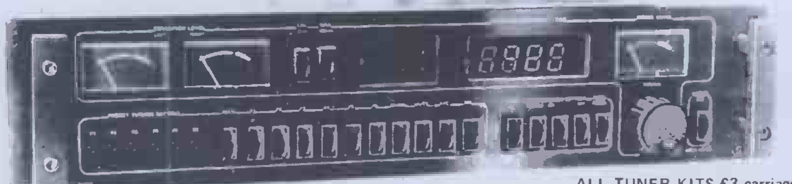
Data Supplement
We Admit All

Bar Graphics
Some New Ideas

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 and visually superior to all others. Some options available, but the illustrated version with reference series modules: £149.00 + £22.35 VAT
With Hyperfi Series modules £185.00 + £27.75 VAT



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 + £4.95 VAT
Complete with digital frequency readout/clock-timer hardware	£99.00 + £14.85 VAT
Complete with MA1023 clock/timer module with dial scale	£66.00 + £9.90 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 + £2.93 VAT, built and tested module £27.00 + £4.05VAT

Ambit stocks and distributes a wide range of frequency counter LSI for all types of DFM- part two of the catalogue contains details of the MSM5523/4/5/6 range, and the versatile MSL2318 divide by ten or hundred prescalar IC. The DFM1 combined counter for AM,FM SW and direct/clock/stopwatch/timers - details available, but SAE please !

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+£5.55vat

VHF MONITOR RX WITH PLESSEY IC

4/9 channel version of the PW design but using standard (fundx9) 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 +£4.68 vat

MICROMARKET — OSTS overflow:

6800P	650p	8212	230p	2102	170p
6820P	600p	8216	195p	2112	340p
6850P	275p	8224	350p	2513	754p
6810	400p	8228	478p	4027	578p
6852	365p	8251	625p	2114	1000p
8080	630p	8255	540p	+15% VAT	

RADIO and AUDIO MODULES : Consistently the most advanced

FOR FM

EF5801-3-4 series: 6 stage varicap tuning, all with oscillator output

5801	Dual gate MOSFET RF stages, bipolar mixer	£17.45 + 2.61VAT
5803	Dual gate RF/mixer stages, amplified LO out	£19.75 + 2.96VAT
5804	'Hyperfi' series, with internal PIN diode agc, and ultra wide range tuning system	£24.95 + 3.74VAT
EF5402	4 stage varicap tuner with TDA1062 and LO output. Uses FET/IC input. PIN agc	£10.75 + 1.61VAT

FOR 30-200MHz

The EF series are available on special order to cover bands (usually approx 20% of the centre frequency) in the range described. Details in our price list.

FOR FM IFs at 10.7MHz

7030	single 6 pole linear phase filter IF with HA1137	£10.95 + 1.64VAT
7130	two 6 pole linear phase filter IF with CA3189E	£16.25 + 2.44VAT
7230	Hyperfi IF, switched bandwidth, AGC IF preamp, linear phase ceramic filters with diode switched narrow filter	£24.95 +3.74VAT

DECODERS for MPX (STEREO)

Various types, guaranteed the world's biggest and best ranges

LARSHOLT FM TUNERSETS

7252	MOSFET front end combined with CA3089 IF	£26.50 +3.97VAT
7252	JFET front end, combined with IF and decoder	£26.50 +3.97VAT

FM/AM tuning synthesiser, see details elsewhere in th is advertisement

COMPONENTS FOR RADIO/COMMUNICATIONS/AUDIO/TV etc.

As usual, Ambit brings you the latest and best, a small selection of which is shown in this advertisement. The Ambit catalogues contain information on most of the devices mentioned here - and an order for the new part three will ensure you stay up with latest developments. Data photocopying service described in pricelist info.

RADIO ICs for FM		vat
CA3089E	1.94	29
CA3189E	2.45	37
HA1137W	2.20	33
HA11225	2.20	33
SN76660N	0.75	11
RADIO ICs for AM/FM		
TDA1090	3.35	50
TDA1083	1.95	29
TDA1220	1.40	21
IF AMPLIFIERS		
KB4406	0.50	07
MC1350	1.20	18
see comms ics also		
COMMUNICATIONS		
KB4412	2.55	38
KB4413	2.75	41
SD6000	3.75	56

SL1600 series		
SL1610	1.60	24
SL1611	1.60	24
SL1612	1.60	24
SL1613	1.89	28
SL1620	2.17	33
SL1621	2.17	33
SL1623	2.44	37
SL 624	3.28	49
SL1625	2.17	33
SL1626	2.44	37
SL1630	1.62	24
SL1640	1.89	28
SL1641	1.89	28
SL6640	2.75	41
SL6690	3.20	48
MC3357	3.12	47
MC1496	1.25	19
NE544	1.70	25

Audio preamps		vat
LM381N	1.81	27
LM382N	1.65	25
KB4436	2.53	38
KB4438	2.22	33
TDA1028	3.50	53
TDA1029	3.50	53
TDA1074	3.75	56
Audio power		
TBA820M	0.75	11
TBA810AS	1.09	16
LM380N	1.00	15
ULN2283	1.00	15
TDA2002	1.95	29
HA1370	2.99	45
TDA2020	2.99	45

2SJ133/2SJ48 £10.00 + £1.50 pr. various high voltage drivers etc from correctly matched Hitachi series transistors. (All 120v types)

FETs, MOSFETs, bipolars, and various others: see PL

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'
7400	13	20
7401	13	20
7402	14	20
7403	14	20
7404	14	24
7405	18	26
7406	38	
7409	17	24
7410	15	24
7411	20	24
7412	17	
7413	30	
7414	51	
7415		24
7416	30	
7417	30	
7420	16	24
7421	29	24
7423	27	
7425	27	
7426		27
7427	27	29
7428	35	32
7430	17	24
7432	25	24
7437	40	24
7438	33	24
7440	17	24
7441	74	
7442	70	99
7443	115	
7444	112	
7445	94	
7446	94	
7447	82	89
7448	56	99
7449		99
7451	17	24
7453	17	
7454	17	24
7455	35	24
7460	17	
7463		124
7470	28	

	'N'	'LSN'
7472	28	
7473	32	38
7474	27	38
7475	38	40
7476	37	38
7478		38
7480	48	
7481	86	
7482	69	
7485	104	99
7486		40
7489	205	
7490	33	90
7491	76	110
7492	38	78
7493	32	99
7494	78	
7495a	65	99
7496	58	120
7497	185	
741XX series		
74107	32	38
74109	63	38
74110	54	54
74111	68	
74112		38
74113		38
74114		38
74116	198	
74118	83	
74120	115	
74121	25	
74122	46	
74123	46	
74124		137
74125	38	44
74126	57	44
74128	74	
74132	73	78
74136		40
74138		60
74139		60
74141	56	

	'N'	'LSN'
74142	265	
74143	312	
74144	312	
74145	65	97
74147	175	
74148	109	191
74150	99	
74151	64	84
74153	64	54
74154	96	
74155	54	110
74156	80	110
74157	67	55
74158		60
74159	210	
74160	82	130
74161		78
74162		130
74163	92	78
74164	104	130
74165	105	
74167	20	
74169		200
74170	230	200
74172	625	
74174	87	120
74175	87	110
74176	75	
74177	78	
74181	165	350
74183		210
74184	135	
74185	134	
74188	275	
74190		92
74192	105	180
74193	105	180
74194	105	
74196	99	110
74197		110
74198	150	
74199	160	
74247		90
74253		105

	'LSN'
74257	108
74260	153
74273	124
74283	120
74293	95
74365	49
74366	49
74367	43
74368	49
74373	77
74374	77
74377	124
74379	130
74393	140

VOLTAGE REGS:

7800 series 1Amp pos	95p
7900 series 1Amp neg	100p
78M series ½Amp pos	90p
78LCP 100mA	35p
78MGT2C variable	175p
79MGT2C variable	175p
723CN variable IC	65p
NE550	73p
L200 variable V and I	195p

MAINS EMI FILTERS
(BS etc approved types)

1 Amp in IEC chassis connector	4.83
6 Amp in IEC	5.83
5 Amp wirein	3.87

(Toroid cores in Cat no. 2)

MISC. Counter/timer, scalar devices............

NE555 30p NE556 78p NE558 180p
LM3909 72p

95H90DC divide by 10/11 to 320MHz	780p
11C90DC divide by 10/11 to 650MHz	1400p
8629 divide by 100 to 175MHz min	420p
MSL2318 divide by 10/100 to 175MHz min	420p
ICM7216BIPI : 8 decade 10MHz DFM counter and full function timer, with direct drive for an LED display (mpx). Uses 10MHz xtal	1982p
ICM7217AIBI ; 4 decade programmable counter with direct LED drive	950p
ICM7207 clock pulse generator	495p
ICM7208 : 7 decade counter display	1495p
ICM7106CP : LCD DVM (3½ digit)	955p
ICM7106CPK : evaluation kit for 7106	24.80
ICM7107CP : LED DVM (3½ digit)	955p
ICM7107CPK : LED DVM kit for 7107	20.65
OKI MSM5523/4 : LED/Fluorescent display driver IC for time/timer/stopwatch/ AM/FM received frequency display and direct counter (use MSL2318 prescalar) inc Crystal	1400p
MSM5525 : AM/FM frequency only couner, for fluorescent displays (6LT06) inc xtal	1100p
MSM5526 : as MSM5525 but for LCD	1100p
4 digit LCD for ICM7106 or MSM5526	1100p
10 LED (2½x5mm) bar graph driver PCB for LOG or LIN (specify). Kit ex leds	300p

IMPORTANT: ALL PRICES SHOWN EXCLUDE VAT - WHICH MUST BE ADDED AT 15% OVERALL.
PLEASE NOTE THE REDUCED CMOS/LPSN TTL RANGES DUE TO CURRENT SUPPLY SHORTAGE

CD4000

4000	17	4522	149
4001	17	4528	102
4002	17	4529	141
4006	109	4532	125
4007	18	4538	150
4008	80	4539	110
4009	58	4543	174
4010	58	4549	399
4011	17	4554	153
4012	17	4558	117
4013	55	4560	218
4014	95	4562	530
4016	52	4566	159
4017	80	4568	281
4018	80	4569	303
4019	60	4572	25
4020	93	4584	63
4021	82	4585	100
4022	90		
4023	17		
4024	76		
4025	17		
4026	180		
4027	55		
4028	72		
4029	100		
4030	58		
4035	120		
4040	83		
4042	85		
4043	85		
4044	80		
4046	130		
4048	60		
4049	55		
4050	55		
4051	65		
4052	65		
4053	65		
4055	135		
4059	563		
4060	115		
4063	109		
4066	53		
4068	25		
4069	20		
4070	20		
4071	20		
4072	20		
4073	20		
4075	20		
4076	90		

LINEARS

CA3130E	84
CA3130T	90
CA3140E	
CA3140T	72
LM301AH	67
LM301AN	30
LM339N	66
LM348N	186
LM3900N	60
709HC	64
709PC	36
710HC	65
710PC	59
723CN	65
741CH	66
741CN	27
747CN	70
748CN	36
NE531N	105

7 SEG DISPLAYS

HP5082 series........

Red	7650	233p
	7653	233p
Yell	7660	233p
	7663	233p
Grn	7670	233p
	7673	233p
Fairchild FND 500/507		150p

MORE FROM THE GENERAL AMBIT CATALOGUE RANGES:

Varicap tuning diodes for AM/FM/TV :
1-9 v AM tuning (Cr 15:1) from TOKO–

KV1211	double matched	175p	26p vat
KV1210	triple matched	245p	37p vat
KV1215	triple snap-apart	245p	37p vat
MVAM115	single 15v	105p	16p vat
MVAM125	single 25v	105p	16p vat
MVAM2	double 25v	148p	22p vat
BB204/104	double FM	40p	6p vat
BA102	single AFC etc	30p	4p vat
BA121/ITT210	single afc	30p	4p vat
BB105B	single UHF	40p	6p vat
PIN DIODES, BANDSWITCH types			
BA479	PIN attenuator	35p	5p vat
TDA1061	Pi-form atten.	95p	14p vat
BA182	Bandswitch	21p	3p vat

All RF semiconductors stocked in depth. Please ask for quantity pricing details.

MPU controllable digital freq. synthesiser PCB. Preliminary:
Serial data controlled, with the standard swallow count system for maximum speed of operation. Multiple time constant filters, suitable for AM/FM and other communications/generator applications. Not for beginners. Full preliminary data package £1 + SAE. No phone enquiries answered on this system for the time being. Watch this space........ Projected cost of the controller PCB less than £30: comprises the two modulus counter, prog.div., phase detector, multiple TC loop filter/integrators.

TOP GRADE LEDS by AEG: PRICES ARE EXC. VAT (add 15%)

SIZE	Red	Green	Yello	Orang
5mm	14p	16p	15p	20p
3mm	13p	15p	18p	19p
2½x5	17p	20p	20p	24p

Quantity discounts for LEDs:
10 per type - less 10%
100 per type - less 30%
100 mix in 10s - less 25%

FUTABA FLUORESCENT VACUUM DISPLAYS for CLOCKs etc

5LT02	clock display (static drive) with AM/PM flags	£9 + 1.35
5LT03	DFM display for MSM5525 LSI counter	£9.45 + 1.42 vat
6LT06	5 digit DFM display (GI AY58100) mpxed	£9.75 +1.46 vat

TOKO COILS, FILTERs, CHOKES, etc for AM/FM/TV comms– (please add VAT @15%)

TYPE	Size: 5mm	7mm	10mm	
AM IF	55p	33p	30p	Various for ICs, transistor etc.
FM IF	55p	33p	33p	Various for ICs, transistor etc.
SW coils			33p	Two impedance series
OSC coils	55p	33p	33p	For LW/MW/SW
TV vif/sif			35p	

Various coils in the range 20kHz to 300MHz - see TOKO catalogue

CERAMIC and MECHANICAL FILTERS (inc MURATA TYPES)

CFT455B/ CFT455C 60p; CFX014 -180p; CFU455C - 85p
CFT470C - 60p; CFU470C -65p
MURATA CFU455H and CFU455F cermic block filters 1.95ea
MURATA CFM455 series ladder filters. D,E,F,G,H bandwidths available now (20,16,12,8,6 kHz) £8.35 ea (metal encapsulated)
SFD455B, SFD470B, SFD472B 85p ea
CFM2 series mechanical elements types A,B,C,D (4-10kHz bandwidth) - 65p ea. (As used in RCME feature)

MULTIPLEX/PILOT TONE FILTERS, FM IF FILTERS (see cat and:)

CFSE10.7/SFE10.7 - stereo FM IF ceramic filters (sim FM4 etc)	50p
CFSB10.7/SFE10.7MJ - mono bandwidth ceramic FM IF filters	50p
SFE10.7ML - ultra linear phase stereo ceramic IF filters	70p
CDA10.7 - 10.7MHz ceramic discriminator (for CA3089 etc)	70p

Current news: A PCB for the Mullard DC tone and volume control system is now available £3 + 0.45 VAT. HMOS PA modules for 60-100W - kit £14 +£2.10VAT, heatsink £4.10+0.61. FM radio control system crystals £3.75 pair inc VAT (Sept on). MK50366N: static drive clock/timer IC £3.78 + 0.57 VAT. 12½kHz channel spacing 8 pole 10.7MHz XTAL filter by TOYO type H4402 £15.50 + £2.32VAT. A further updated pricelist is now available, and we would like to remind you that enquiries can only be answered if accompanied either by an official business letterhead, or an SAE. STOP PRESS: TOKO's new split-apart triple AM tuning diodes are in stock £2.45 + 37p VAT, (KV1215). S BL1 diode DBM 1-500MHz - £4.25+0.64p.

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 ® international

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.

2 Gresham Road, Brentwood, Essex. (0277) 227050

Hobby Electronics

Vol. 2, No. 2 December 1979

PROJECTS

FEATURES

NEWS AND INFORMATION

Hobby Electronics
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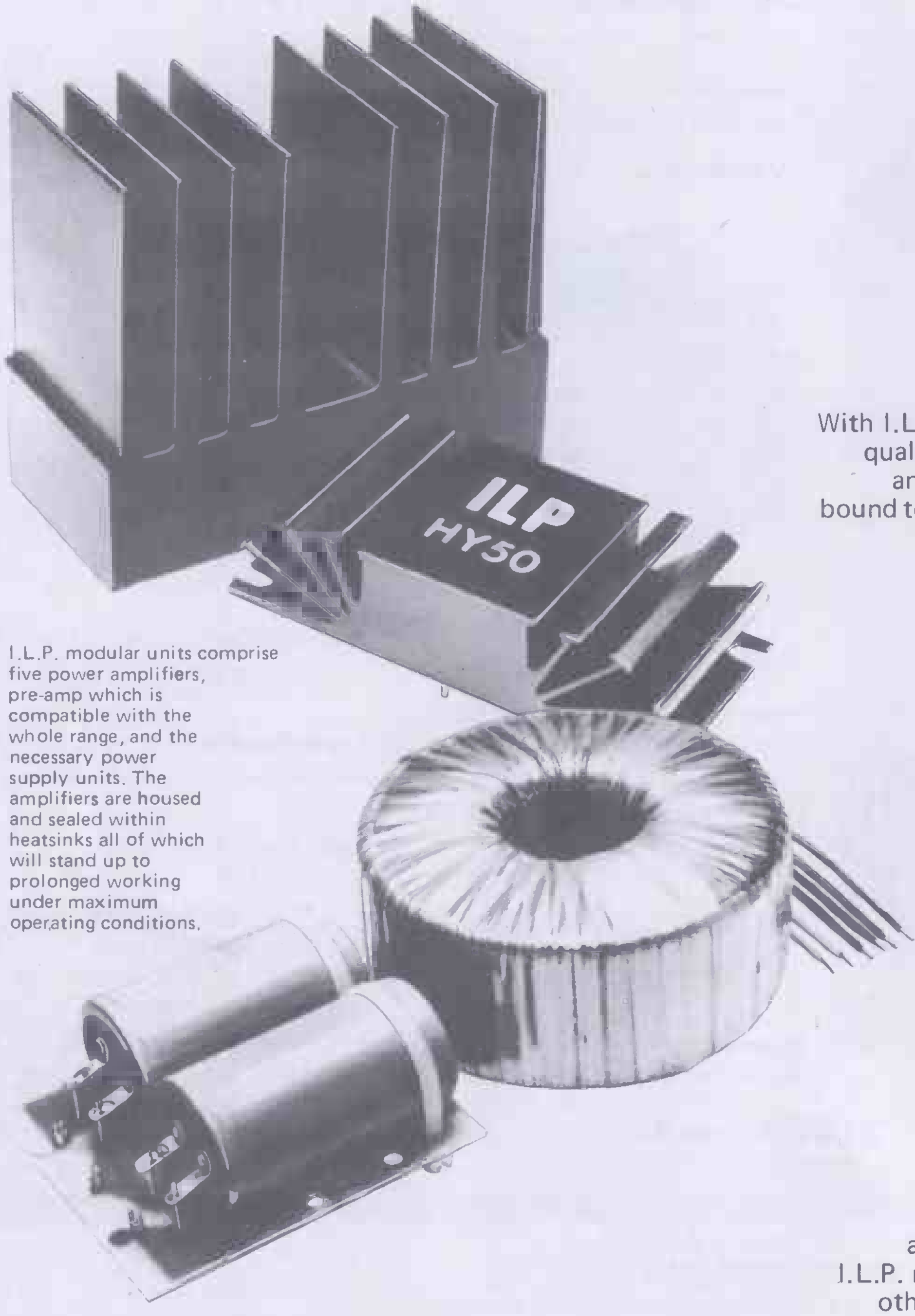
ABC

Simply ahead . .

ILP'S NEW GENERATION OF HIGH



I.L.P. modular units comprise five power amplifiers, pre-amp which is compatible with the whole range, and the necessary power supply units. The amplifiers are housed and sealed within heatsinks all of which will stand up to prolonged working under maximum operating conditions.

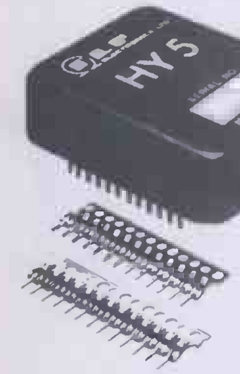
With I.L.P. performance standards and quality already so well established, any advances in I.L.P. design are bound to be of outstanding importance — and this is exactly what we have achieved in our new generation of modular units. I.L.P. professional design principles remain — the completely adequate heatsinks, protected sealed circuitry, rugged construction and excellent performance. These have stood the test of time far longer than normally expected from ordinary commercial modules. So we have concentrated on improvements whereby our products will meet even more stringent demands such, for example, as those revealed by vastly improved pick-ups, tuners, loudspeakers, etc., all of which can prove merciless to an indifferent amplifier system. I.L.P. modules are for laboratory and other specialised applications too.

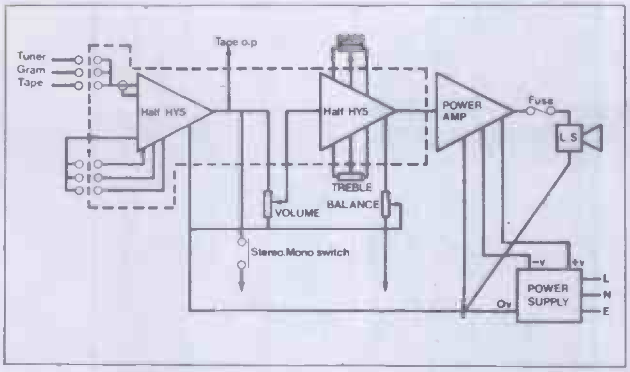
PRODUCTS OF THE WORLD'S FOREMOST SPECIALISTS IN ELECTRONIC MODULAR DESIGN

and staying there

PERFORMANCE MODULAR UNITS

HY5 PRE-AMPLIFIER

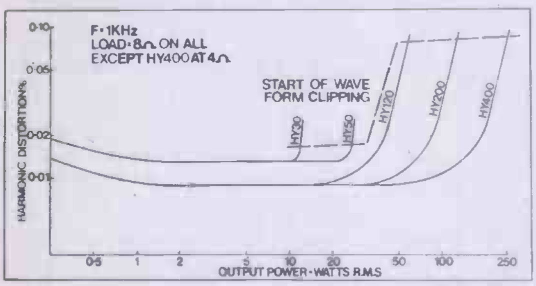




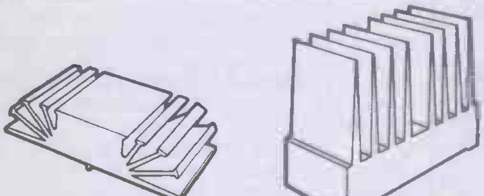
The HY5 pre-amp is compatible with all I.L.P. amplifiers and P.S.U.'s. It is contained within a single pack 50 x 40 x 15 mm. and provides multi-function equalisation for Magnetic/ Ceramic/Tuner/Mic and Aux (Tape) inputs, all with high overload margins. Active tone control circuits; 500 mV out. Distortion at 1KHz–0.01%. Special strips are provided for connecting external pots and switching systems as required. Two HY5's connect easily in stereo. With easy to follow instructions.

£4.64 + 74p VAT

THE POWER AMPLIFIERS

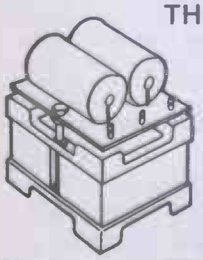


Model	Output Power R.M.S.	Distortion Typical at 1KHz	Minimum Signal/ Noise Ratio	Power Supply Voltage	Size in mm	Weight in gms	Price + V.A.T.
HY30	15 W into 8 Ω	0.02%	80dB	-20 -0- +20	105x50x25	155	**£6.34** + 95p
HY50	30 W into 8 Ω	0.02%	90dB	-25 -0- +25	105x50x25	155	**£7.24** + £1.09
HY120	60 W into 8 Ω	0.01%	100dB	-35 -0- +35	114x50x85	575	**£15.20** + £2.28
HY200	120 W into 8 Ω	0.01%	100dB	-45 -0- +45	114x50x85	575	**£18.44** + £2.77
HY400	240 W into 4 Ω	0.01%	100dB	-45 -0- +45	114x100x85	1.15Kg	**£27.68** + £4.15



Load impedance — all models 4 - 16 Ω
Input sensitivity — all models 500 mV
Input impedance—all models 100 KΩ
Frequency response — all models 10Hz - 45KHz - 3dB

THE POWER SUPPLY UNITS



I.L.P. Power Supply Units are designed specifically for use with our power amplifers and are in two basic forms — one with circuit panel mounted on conventionally styled transformer the other with toroidal transformer half weight and height of conventional laminated types.

PSU 30	± 15V at 100ma to drive up to five HY5 pre-amps.	**£4.50** + 68p VAT
PSU 36	for 1 or 2 HY30's	**£8.10** + £1.22 VAT
PSU 50	for 1 or 2 HY50's	**£8.10** + £1.22 VAT
PSU 70	with toroidal transformer for 1 or 2 HY120's	**£13.61** + £2.04 VAT
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COMPETITION WINNERS.

Pictured here are the two winners of the famous Hobby Electronics picture competition. First prize (top) was won by Darren Wright from Bodmin in Cornwall. He is shown here receiving his prize, a Calscope double beam oscilloscope from the delightful Joanne Barseghian (we just call her Joanne, its so much easier) who drew Darren's winning entry from the hat.

The second prize, a single beam Calscope scope was won by Paul Cheesman, he is receiving his prize from the editor of HE the equally delightful Halvor Moorshead (but not quite so pretty). Both Darren (and his missus Angela) and Paul were given the grand tour of the HE offices, poisoned with several cups of HE coffee and then taken to dinner, and very nice they tasted too. Seriously though, congratulations to both Paul and Darren and all of the runners-up who should have received their Tee-Shirts by now.

IN THE NIC OF TIME

Three new lines from NIC models this month (just hope he realises that he'll never get his review models back). The first offering is a rather cunningly marketed device called a Radatec. Now, no matter what you may think it is not a Radar Detectot because they're illegal, it is simply a radio receiver that happens to operate on the so-called X-band. The fact that you could accidentally pick up police radar traps is purely coincidental, you would obviously only be using it to monitor sunspot activity or any local UFO transmissions, wouldn't you! Anyway, for just £23.95 you can own one of these devices, which funnily enough are made in England by Invicta Plastics the Mastermind people. Incidentally it is not illegal to own one.

The second device is a smoke/fire detector, nothing really earth-shattering, just good old-fashioned commonsense, its shrill siren should awaken even the soundest sleeper long before something really nasty happens. This will set you back £15.90.

The third and last plaything is called Waddingtons Compute-a-tune. It really is good, as soon as you switch it on it will play one of four tunes stored in its memory. When you get bored with those you can write your own tune (up to 32 notes long) into the machine's memory and play it back or re-write it at will, adding various effects such as variable tempo, echo, chord or change the structure of the note completely making it sound like a synthesiser. All of this for only £21. For NICs address see his Ad in this issue.

YET MORE CATALOGUES

Like the falling leaves of autumn the catalogues from the various component houses are starting to slither across our newly polished desks in some quantity. Best of the latest bunch are the three publications from Carel Components Ltd, Badger Sound Services Ltd and ACE Ltd.

Firstly to the offering from Carel, it is aimed mainly at the specialist end of the market, very few actual components are to be seen, though, a very good selection of reasonably priced tools and accessories as well as some interesting information on flexible printed circuits make it well worth getting. More details can be obtained from Carel Components Ltd, 40-44 The Broadway, London SW19 1SQ.

Badger sounds catalogue is another good example of the specialist market, this time dealing with audio equipment. Included in the catalogue are several practical designs for speaker enclosures and crossover networks, worth getting for that alone. Badger Sound will be awaiting your enquiry at 46 Wood Street, Lytham St Annes, Lancashire FY8 1QG.

The ACE catalogue is a slightly slimmer version of their previous edition nevertheless they have managed to get a good selection of components into the space available. Price is 30p from ACE Mailtronix Ltd, Tootal Street, Wakefield, W. Yorks, WF1 5JR.

GAMES OFFER

Look out for the Games Offer on page 46 this month, we really believe that this one will be a winner. Where else can you get a full function calculator that plays three games as good as these, all with sound effects for only £20.95? You tell us and we'll sell it.

LAP COUNTER

Sorry about the lack of a Lap Counter in this month's issue. Pressure of space and a hold up of vital components have forced us to postpone this circuit for a month or so. We promise it will be worth waiting for, so you can get saving now.

News from the Electronics World

A TOUCH OF GLASS

The trend towards microminiaturisation of electronics has brought with it some unexpected headaches (literally) eyes tend to get strained much more easily these days especially when peering into dark corners of boxes filled with electronic exotica. Looking for faults on PCB tracks can also create problems, particularly when working on commercial equipment using those rather gaudy green coloured resist inks.

To the rescue of all those reluctant retinas we have a new handy looking table top magnifier. It is approximately four inches across made from a shatter-resistant acrylic material. Magnification is of the order of 2X, quite sufficient for most situations.

The magnifier comes from Combined Optical Industries Ltd (COIL for short) who have considerable experience in matters optical. It retails for about £4.40 including VAT and should be on sale in most reputable hobbyist shops and opticians about now. If you have any difficulty, try contacting COIL at 200 Bath Road, Slough Sl1 4DW.

DIGITAL DILECTRIC

Anyone wishing to know the value of a capacitor to within 0.1% should pin their eyelids back and pay attention. Continental Specialities Corporation or CSC as they are known to their friends have introduced a new digital capacitance meter to their range. It is quaintly named the 3001 and can be yours for just £155 plus VAT. If you're still with us you may be interested to know that it can read any value on it's 3½ digit display from 1pF to 0.1999 F and if you come across any capacitors outside that range we would be most surprised.

To complement the 3001, CSC can supply you with the Model 333 Tri-Mode Comparator, that's a nifty little gadget that hooks up to the 3001 and will indicate via the three lights whether the capacitor under test falls within the pre-set limits on those two sets of thumbwheels.

If all of this sounds like it is for you then why not get in touch with CSC at: Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ.

A MATTER OF SCIENCE

Time was when you could reliably say to your fellow man, 'man will never fly,' only to discover he had already. Up till only a few years ago you could predict with equal certainity, 'man will never get to the moon'. The trouble is with science, it keeps turning science fiction into fact. Only the other day our HE reporter, the one with his ear permanently glued to the ground discovered that Antimatter has been created for very short periods and in very small quantities. What this will eventually mean to the likes of you and me is anyone's guess. At the moment the problem is not so much what to do with it as how to make enough of it and then keep hold of it. Antimatter you will recall (that's if you've been keeping up with Star Trek) is a physical substance that is 'reversed', that is to say the nucleus would have a negative charge and the electrons would be positive. This means that it is extremely difficult to contain this substance, apparently the only way is to 'suspend' it within a very powerful magnetic field, should it come into contact with any 'matter' it would instantly disintegrate causing a large amount of energy to be released. (Weapon designers please ignore, we've got enough 'doomsday' stuff around already).

Just in case it ever becomes a practical to make and use Antimatter in any quantity we're told that only a few milligrams could yield enough energy to get you to the moon in only a couple of hours. Stay tuned to this space for more information as soon as we have it.

BACK NUMBERS

Please note that as of this month, the price of Back Numbers has been increased from 60 pence to £1.00. Blame this on the Post Office, the Government, inflation and anyone else you may have a grudge against. Sorry.

CHANGE OF ADDRESS

Spectrum Games Ltd would like it to be known that they have changed their address to Spectrum House, 48 Cambridge Road, Barking, Essex. They would now also like to be called Computer Games Ltd, confusing isn't it?

ERRATA

We'll get it right yet. Number one this month is the MiniBoard feature in the November issue. The diagrams for the Opto-Thermo Switch (page 21) got mixed up with the diagram for the Differential Temperature Switch (page 27). The Guitar Tuner also suffered. The overlay and PCB diagrams omitted to show a link between pins and 8 and 9 on IC1, R2 and C2 also got transposed but that won't affect operation. Please note that C1 should be a 0.1µ not 1µ0 as in the diagram. The resistor R3 should also be raised to 100R to reduce current consumption.

R2D2 radio. Fig 1. Q1 emitter should go to 0V and R5 should connect to the junction of C2, R1 and C3.


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Scalextric Controller

Eliminate overheating of hand controllers and car motors with our unique 1- to 4-lane slot car speed control unit. It uses conventional, unmodified hand controllers, is powered from a standard slot car power pack and has independent overload protection on each output.

The Speed Controller set up for a four-lane layout. Refer to the text for setting-up procedure

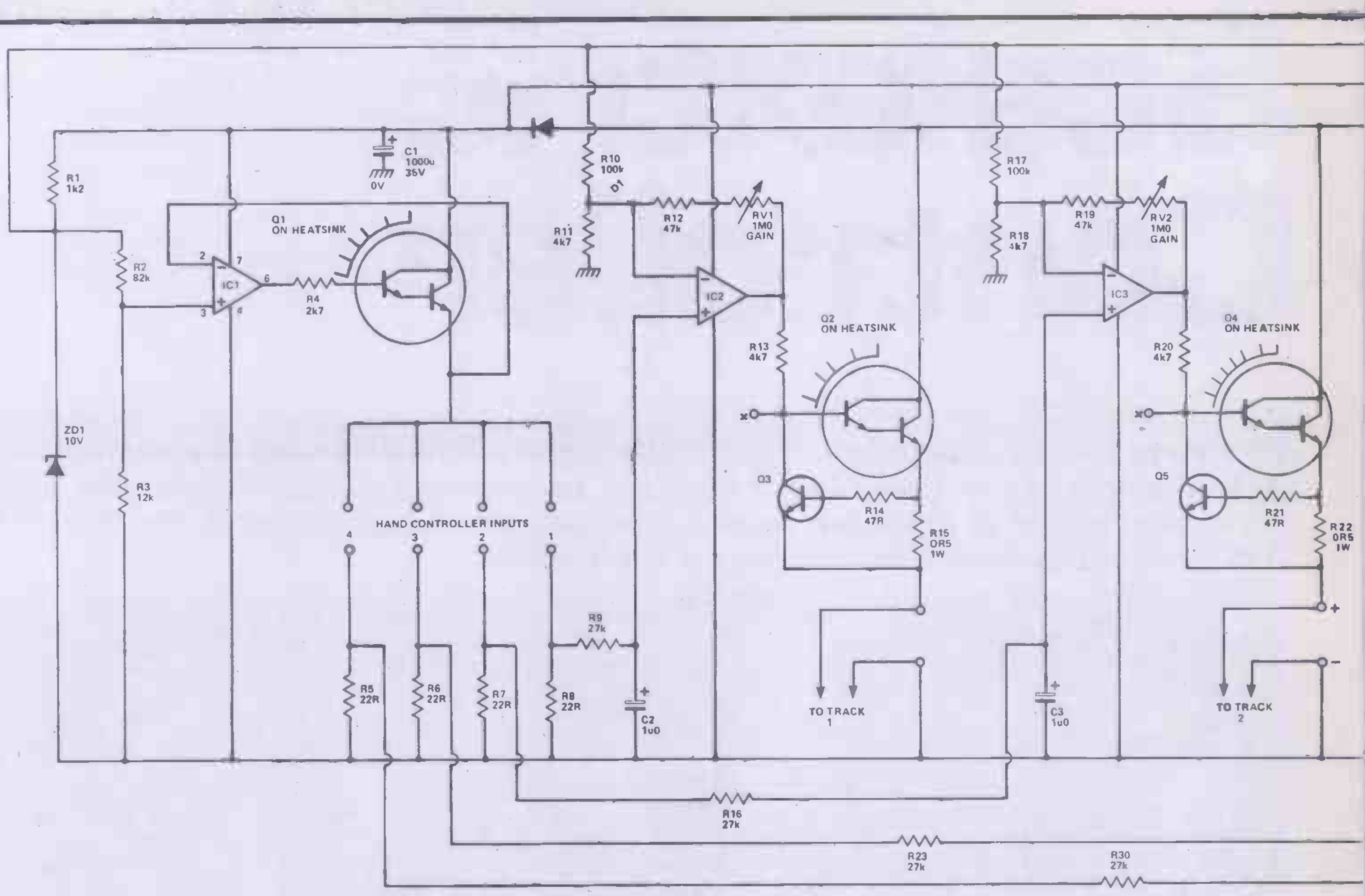
THE HE DESIGN TEAM recently had the good fortune to acquire a pre-production 4-lane Scalextric "600" slot car racing outfit. Naturally, we subjected this new 'goody' to very thorough evaluation testing (we played 'racing cars' for an aggregate time of one hundred hours in two days) and rapidly became addicted to the game.

We soon noticed, however, that our Scalextric outfit, like all other slot car racing systems, suffered from a few annoying defects. Specifically, we found that the hand control units and the car motors became severely overheated after a long running period. So we set about designing an electronic control system that would overcome these defects. The end results of our design efforts are presented here.

Our controller is unique. It is powered from a conventional slot car power pack and can be used to control any make of 1- to 4-lane slot car system. The unit interfaces with conventional and unmodified hand control units, which have their outputs fed to the inputs of the electronic control unit. The outputs of the controller are fed to the slots of the race track via conventional track connectors.

In our system the hand control units have only a few tens of milliwatts developed across them and thus cannot possibly suffer from overheating problems. The power signal fed to the car motors is a reasonably smooth DC signal that is free of repetitive high-surge currents, rather than a conventional unsmoothed full-wave rectified AC signal that produces a high level of repetitive surge currents. Consequently, our system greatly reduces car motor overheating problems.

Our system has a few other advantages as well. Each one of its outputs is provided with its own electronic overload protection system, so a short on one lane does not disable the supply to the other lanes of the slot car system. Each output is provided with a 'compensation' control, which enables the driver to personalise the action of his own hand control unit to suit his own car and his own level of driving skill. All-in-all, a very good project for the slot car buff.



How It Works

Although the unit looks fairly complicated in the circuit diagram it is in reality quite simple and comprises one 'hand controller interface' circuit (Designed around ICI and Q1) and four identical 'power controller' circuits (IC2-Q2-Q3, IC3-Q4-Q5, etc).

The operation of the 'hand controller interface' circuit is quite simple. ICI and Q1 are interconnected as a compound high-current voltage follower which produces an output voltage (to the top of the hand controllers) that is identical to the voltage applied to input pin 3 of ICI. A stable potential of 1.2 volts is applied to this pin and is derived from zener diode ZD1 via potential divider R2-R3. Thus, 1.2 volts is applied to the top of each hand controller that is connected to the unit. The bottom of each controller is taken to ground via a 22R resistor. The four outputs of the 'interface' circuit are taken from across these 22R resistors. A maximum power of only a few tens of milliwatts is dissipated in each controller, so the controllers always run cool in this circuit.

Most hand controller units take the form of a simple rheostat that has a basic resistance of about 50R. When the controller is in the OFF mode the rheostat is open circuit and under this condition zero volts appear across the 22R resistors in the diagram. At the 'minimum' speed setting the rheostat measures 50R and approximately 0.4 volts is developed across the 22R resistors. At the 'maximum' speed setting the rheostat measures zero resistance and under this condition 1.2 volts are developed across the 22R resistors. At intermediate speed settings 0.4 to 1.2 volts are developed across the 22R resistors. These voltages are passed on to the 'power controller' sections of the unit.

All 'power controller' sections of the unit are identical, so let's look at the 'Track 1' (IC2-Q2-Q3) section only. IC2 is an op-amp and konnected as a non-inverting amplifier, with a gain determined by the setting of RV1 and with an offset bias of about 0.4 volts applied to it's non-inverting (—) pin via R10 and R11. The output of the op-amp is fed to the slot car track via Darlington emitter follower Q2, which has overload protection provided via R15 and Q3. Let's assume that RV1 is set so that the op-amp has a gain of 15.

When the hand controller is in the OFF mode zero volts are developed across R8, so the output of Q2 is also zero and no power is fed to the track. When the controller is at the 'minimum' speed setting 0.4 volts are developed across R8, but this voltage is insufficient to overcome the 0.4 V 'offset'

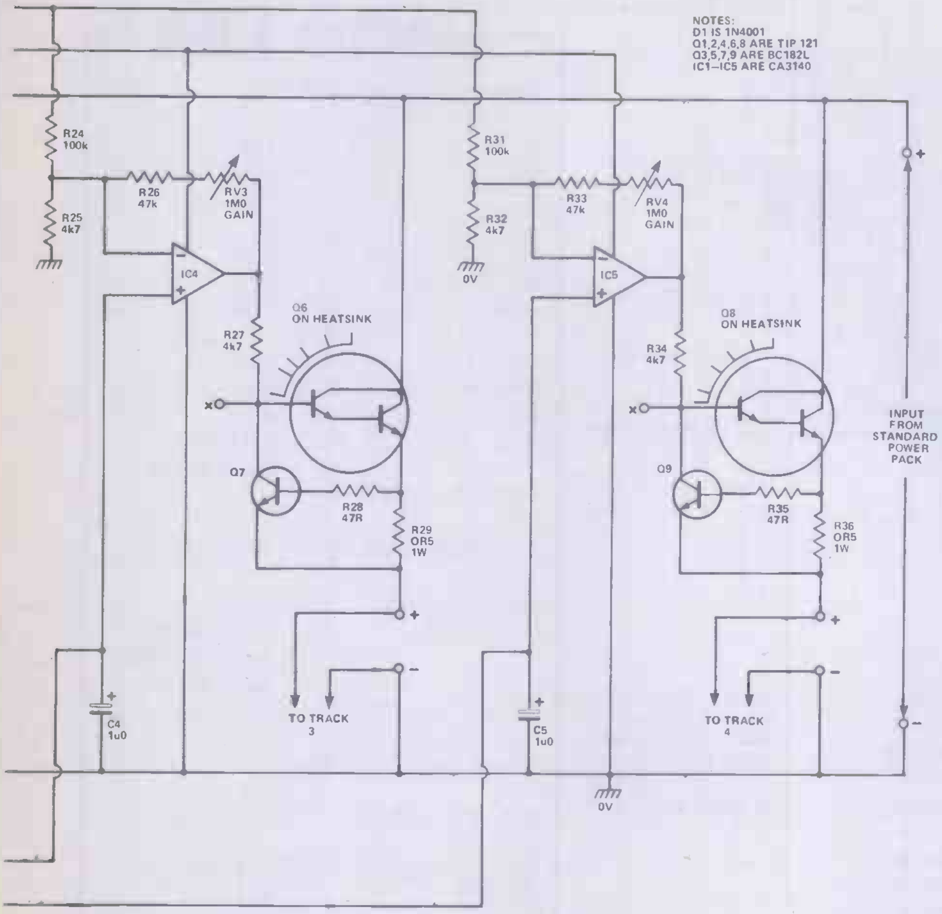


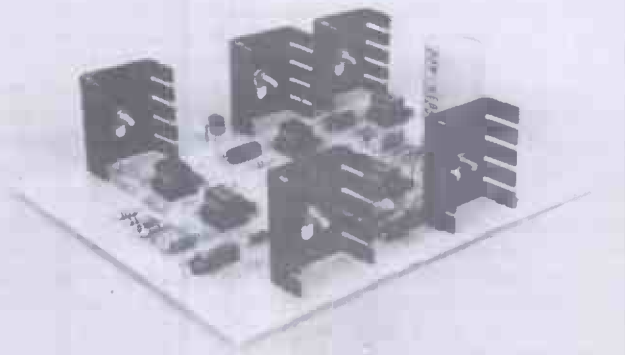
Fig. 1. Circuit diagram for the HE slot-car controller. The transistors Q7, Q4, Q6 and Q8 are obtainable from Watford Electronics (see ad in this issue). Ensure these transistors have a heat-sink.

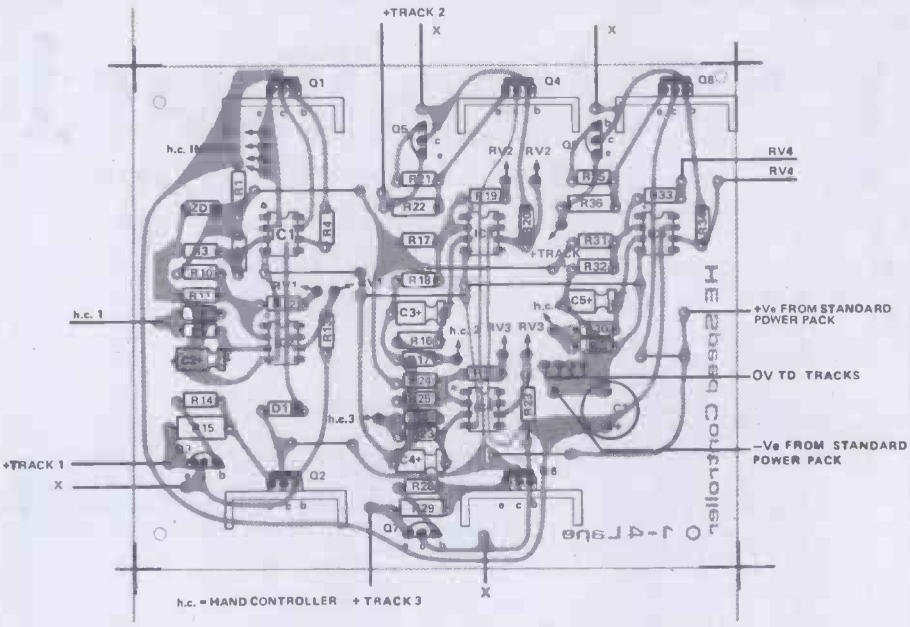
of IC2, so the output of Q2 is again zero and no power is fed to the track. When the controller is at the 'maximum' speed setting 1.2 V is developed across R8, giving a differential input of 0.8 V to IC2, which thus gives an output of 12 V (0.8 V x 15) and full power is applied to the track. At intermediate settings of the hand controller the R8 voltage varies between zero and 12 volts.

The power feed to the track is derived from the unsmoothed full-wave rectified output of a standard power pack via Q2. At speed settings below full power the unwanted 'tops' of this power feed are cut off by Q2, so the car motors are fed with a reasonably smooth d.c. dignal that is devoid of the high-current repetitive surges of 'conventional' controllers. Consequently, our system causes the motor to run far cooler than normal.

In practice, the setting of COMPensation control RV1 can be adjusted to give full power at almost any desired setting of the hand controller unit, thus allowing the controller action to be personalised to suit the characteristics of a given car and the level of skill of the individual driver. The hand controller action can be overriden by applying an external control signal to the point marked 'X' in the diagram.

The Scalextric Controller board, note the heat-sinks. As usual use sockets for the ILS and note the combination of polarised components.





Parts List

RESISTORS (All ¼W, 5%)

R1	1k2
R2	82k
R3	12k
R4	2k7
R5, R6, R7, R8	22R
R9, R16, R23, R30	27k
R10, R17, R24, R31	100k
R11, R13, R18, R20, R25, R27, R32, R34	4k7
R12, R19, R26, R33	47k
R14, R21, R28, R35	47R
R15, R22, R29, R36	0R5 1W wirewound

POTENTIOMETERS

RV1, RV2, RV3, RV4	1M0 Lin.

CAPACITORS

C1, 1000u	35V electro lytic type PCB mounting
C2, C3, C4, C5	1u0 electrolytic

SEMICONDUCTORS

IC1, IC2, IC3, IC4, IC5	CA3140
Q1, Q2, Q4, Q6, Q8	TIP121
Q3, Q5, Q7, Q9	BC182L
D1	IN4001
ZD1	10V BZY88

MISCELLANEOUS

5 Heatsinks

Verocase 202-21035F

CONSTRUCTION

As you can see from the circuit diagram, the unit comprises one 'hand controller interface' circuit (designed around ICI and Q1 and four identical 'power controller' circuits (IC2-Q2-Q3, IC3-Q4-Q5, etc). You thus have a few options when it comes to building the unit. You can either build it all in one go as a 4-lane controller, as shown in the total circuit diagram, or you can build it as a less-than-4-lane controller by simply omitting the components of the unwanted 'power controller' sections.

A fair bit of care is necessary when wiring up the components on the PCB. Start construction by soldering the eight links into place on the PCB, as shown on the overlay, and then fit the five IC holders into position. You can then progress with the assembly of the remaining components, taking special care to observe the polarity of all electrolytic capacitors and semiconductor devices. Note that each of the five Darlington power transistors is fitted to an individual heat sink.

When assembly is complete, double check the wiring and then fit the unit into a suitable case and complete the interwiring to the 1M0 'COMPensation' pots and the input and output terminals. You can then give the unit a functional check by powering it from a standard slot car power pack, connecting the unit outputs to the respective lanes of the slot car layout via standard track connectors and connecting standard hand controller units to the respective input terminals of the unit. The respective COMPensation pots can be adjusted by trial and error to give the best hand controller response for a given set of driving conditions. The final setting of each pot is entirely a matter of personal choice.

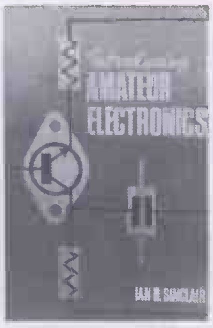
You are probably wondering about the purpose of the points marked 'X' on the diagrams. These points are supposed to be taken to externally-available terminals mounted on the rear of the completed unit and can be used to override the standard hand controller units. Cars can be stopped by taking these points to ground, or can be set to full speed by taking them to the positive supply line. We may present a 'random fault generator' project that will interface with these points and give simulations of tyre blow-outs and engine breakdowns, etc., sometime in the new year.

Above: The overlay for the speed controller. Bottom right: the PCB foil pattern approximately half size.

Buylines

The TIP121 may prove a little difficult to obtain at your local component shop, however this device can be purchased from Watford Electronics along with the LM3914.

Hobby Electronics Book Service



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Unijunction Transistors

The UJT is one of the simplest yet least understood of today's semiconductor devices. In the following pages Ray Marston explains how it works, and shows a stack of practical ways of using it.

THE UNIJUNCTION TRANSISTOR (UJT) is one of the simplest, oldest, and least understood semiconductor devices available to the electronics enthusiast. UJTs first became commercially available some twenty-eight years ago (in 1952), and since then have been widely used in oscillator, timing, and thyristor triggering circuits. In the next few pages we explain how the UJT works, and show some practical ways of using it.

UJT BASIC PRINCIPLES

The UJT is a remarkably simple device. It uses the symbol shown in Fig 1a, employs the form of construction shown in Fig 1b, and has the equivalent circuit of Fig 1c. The device is made up of a bar of n-type silicon material with a non-rectifying contact at either end (base 1 and base 2), and with a third, rectifying, contact (emitter) alloyed into the bar part way along its length, to form the only junction within the device (hence the name 'unijunction').

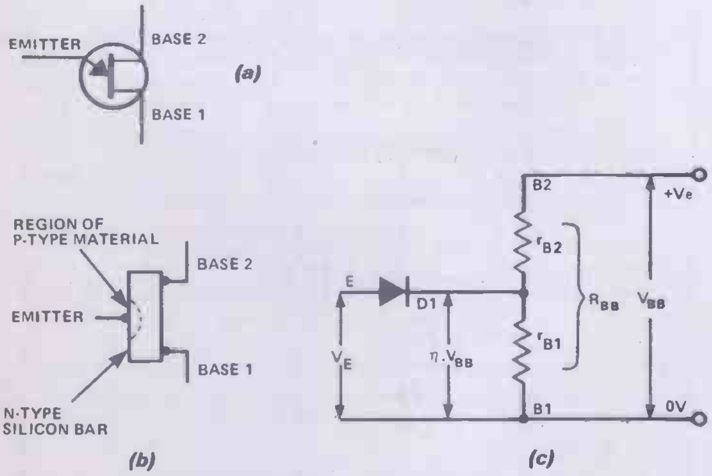


Fig.1.(a) UJT symbol. (b) UJT construction. (c) UJT equivalent circuit.

Since base 1 and base 2 are non-rectifying contacts, a resistance appears between these two points and is that of the silicon bar. This 'inter-base' resistance measures the same in either direction, has a typical value in the range 4kO to 12k, and is give the symbol R_{BB}.

In use, base 2 is connected to a positive voltage and base 1 is taken to zero volts (see Fig 1c), so R_{BB} acts as a voltage divider with a division or intrinsic stand-off ratio' (η) that usually has a value between 0.45 and 0.8. A 'stand-off' voltage of $\eta.V_{BB}$ thus appears across the lower (r_{B1}) half of the bar under quiescent conditions. The emitter terminal of the UJT is connected to this voltage via junction D1. Normally, the emitter input voltage, V_E, is less than $\eta.V_{BB}$, so D1 is reverse biased and the emitter appears as the very high impedance of a reverse biased silicon diode, with a typical impedance of many megohms.

If, however, V_E is steadily increased above $\eta.V_{BB}$, a point is reached where D1 starts to become forward biased, so current starts to flow from emitter to base 1. This current consists mainly of minority carriers injected into the silicon bar, and these drift to base 1 and cause a decrease in the effective resistance of r_{B1}. This decrease in r_{B1} causes a decrease in the D1 cathode voltage, so D1 becomes more heavily forward biased, and the emitter-to-base 1 current increases and causes the r_{B1} value to fall even more. A regenerative action thus takes place, and the emitter input impedance falls sharply, typically to a value of about 20R.

This, the UJT acts as a voltage-triggered switch, and has a very high input impedance (to the emitter) when it is off, and a low input impedance when it is on. The precise point at which triggering occurs is called the 'peak-point' voltage, V_P, and is about 600 mV above $\eta.V_{BB}$.

It can be seen that the UJT is a rather specialised device. It's most common application is as a relaxation oscillator, as shown in Fig 2a. Here, when the supply is first connected, C1 is discharged and the emitter is at ground potential, so the emitter appears as a very high impedance. C1 immediately starts to charge exponentially towards V_{BB} via R1, but as soon as the emitter reaches V_P the UJT fires and C1 discharges rapidly into the low impedance of the emitter. Once C1 is effectively discharged the UJT switches off, and C1 then starts to charge up again and the whole process is repeated. Thus, an approximately saw-tooth waveform is continuously generated between the emitter and ground.

In this circuit, final switch-off occurs in each cycle when the total emitter current (capacitor discharge plus R1 current) falls to a 'valley-point' value, I_V, typically of several milliamps. A minimum 'peak-point emitter current', I_P, is needed to switch the UJT on initially, and typically has a value of several microamps. The maximum useable value of R1 is limited by the I_P characteristic, and the minimum R1 value is limited by the I_V characteristic.

The frequency of operation of the Fig 2a circuit is given approximately by $f = 1/(C.R)$, and is virtually independent of V_{BB}. Typically, a 10% change in V_{BB} results in a frequency change of less than 1%. The value of R1 can typically be varied from about 3k0 to 500k, so an attractive feature of the circuit is that it can be made to cover a frequency range greater than 100:1 via a single variable resistance. The value of C1 can be varied from a few hundred pF to hundreds of uF, so the circuit can cover an exceptionally wide frequency range (from several hundred kHz to as low as one cycle every few minutes).

In most circuits, an additional resistor (R3) is wired between base 1 and ground, as shown in Fig 2b, either to control the discharge time of C1 or to give a brief positive output pulse from the discharge of C1. A resistor (R2) may also be wired in series with base 2, either to improve the thermal stability of the oscillator or to enable a negative output pulse to be made available from the discharge of C1.

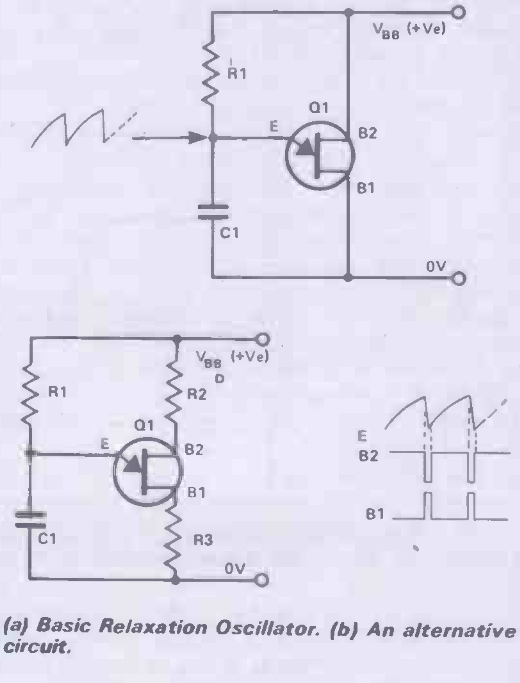


Fig.2.(a) Basic Relaxation Oscillator. (b) An alternative of the basic circuit.

A PRACTICAL UJT: THE TIS43

The TIS43, made by Texas, is probably the most popular and readily available of all unijunction transistors presently in production. It is modestly priced, can be used with supplies up to a maximum of 30 volts, and has a maximum peak-point current rating of 5 uA and a valley-point current rating of 4 mA, thus allowing a wide range of timing resistor values to be accommodated. Basic details of the TIS43, including the outline, are shown in Figure 3.

The TIS43 is used as the basis of all practical UJT projects presented in the rest of this article.

EMITTER REVERSE VOLTS (MAX)	=	30V
V_{BB} (MAX)	=	35V
PEAK EMITTER CURRENT (MAX)	=	1.5 AMPS
POWER DISSIPATION (MAX)	=	300mW
INTRINSIC STANDOFF RATIO, η	=	0.55 TO 0.82
R_{BB}	=	4k0 TO 9k1
Ip (MAX)	=	5uA
Iv (MAX)	=	4mA
OUTLINE (TO 92 CASE)	=	B1 B2 E

Fig.3. Basic characteristics and outline of the TIS 43 UJT.

PROJECTS: WAVEFORM GENERATORS

The TIS43 unijunction transistor can be used in a variety of waveform generator applications, and can readily be used to produce pulse, sawtooth, and rectangle waveforms. Figs 4 to 8 show a selection of practical waveform generator circuits.

Figure 4 shows the circuit of a wide-range pulse generator. A large amplitude pulse is available across both R2 and R3. Both pulses are of similar form, but are in anti-phase, and are available at a low impedance level.

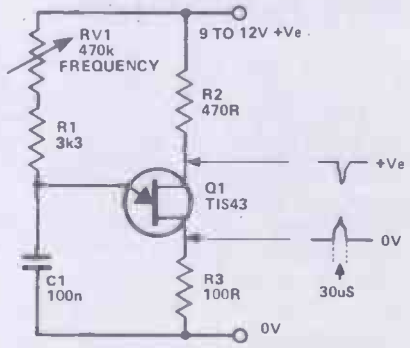


Fig.4. A wide range pulse generator giving 30 uS pulses at 25 Hz to 3 kHz.

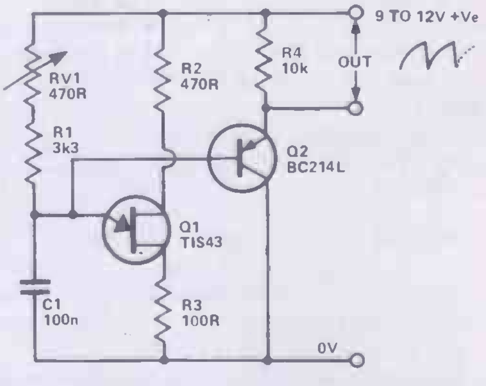


Fig.5. A wide range (25 Hz to 3kHz) Saw-tooth generator.

With the component values shown the pulse width is constant at about 30 uS over the frequency range 25 Hz to 3 kHz (adjustable via RV1). The pulse width and frequency range can be altered by changing the value of C1. Reducing C1 by a decade (to 10 nF) reduces the pulse width by a factor of 10 (to 3 uS) and raises the frequency range by a decade (250 Hz to 30 kHz). C1 can have any value in the range 100 pF to 1000 uF.

A sawtooth waveform is generated across C1 in the Fig 4 circuit, but is at a high impedance level and is thus not readily available externally. Access can be gained to this sawtooth either by wiring a one-transistor PNP emitter follower across the timing resistor network, as in Fig 5, or by wiring a two-transistor (Darlington or super-alpha) NPN emitter follower across C1, as in Fig 6.

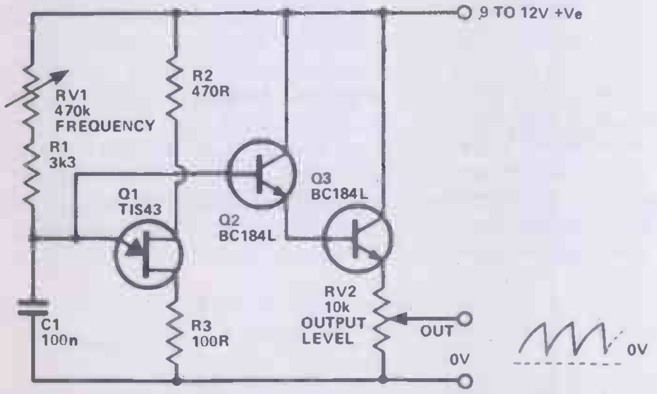


Fig.6. A wide range (25 Hz to 3 kHz) saw-tooth generator with ground referenced variable amplitude output.

In the case of the Fig 5 circuit, the output is of fixed amplitude and is referenced to the positive supply line. In the case of Fig 6 the output is fully variable in amplitude (via RV2), and is referenced to the zero volts line. In both cases, the output waveform is a non-linear sawtooth. The non-linearity is caused by the fact that C1 charges exponentially, rather than linearly, via the RV1-R1 resistor timing network.

The basic unijunction circuit can be made to generate a linear sawtooth waveform by charging the main timing capacitor (C1) via a constant-current generator, rather than by a resistance network. Figure 7 shows the practical circuit of a linear sawtooth generator, which can also be used as a simple oscilloscope timebase.

In this circuit Q1 is used as the constant current generator. A fixed reference voltage is applied to the base of Q1 via the R1-D1-R2 network, and the collector current (which is used to charge C1) is determined by this voltage and the value of the RV1-R3 emitter network. The linear sawtooth that is generated across C1 is made available externally via the Q3-Q4 emitter follower network, and is variable in amplitude via RV3. With the component values shown, the frequency of the circuit is variable from 60 Hz to 700 Hz via RV1. Alternative frequencies can be obtained by changing the C1 value.

The Fig 7 circuit can be used as a simple oscilloscope timebase generator. In this application the sawtooth output should be taken to the 'external timebase' socket of the 'scope, and positive 'flyback' pulses from R5 can be taken via a high-voltage blocking capacitor and used for beam blanking. The generator can be synchronised

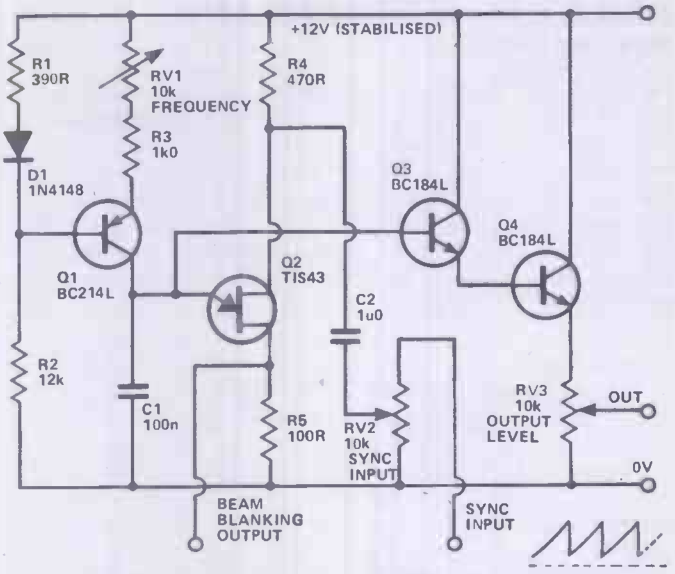


Fig.7. This linear sawtooth generator can be used as a simple oscilloscope timebase.

to an external signal by feeding that signal to base 2 of the UJT via RV2 and C2. This signal effectively modulates the supply voltage (and thus the triggering point) of the UJT, thus causing it to fire in synchrony with the external signal.

Figure 8 shows how a unijunction transistor can be used to generate either a non-linear sawtooth, or a rectangular waveform with an infinitely variable mark-space ratio. The LF356 is a 'fast' operational amplifier, with a very high input impedance. When S1 is in the SAWTOOTH position this op-amp is connected as a unity-gain voltage follower, so the C1 sawtooth appears across output control RV2.

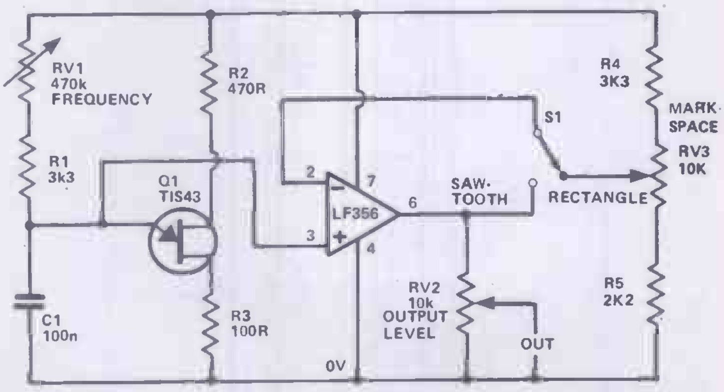


Fig.8. 25 Hz to 3 kHz generator produces a non-linear sawtooth or a rectangular waveform with infinitely variable M-S ratio.

When S1 is set to the RECTANGLE position, the op-amp is configured as a fast voltage comparator, with the basic sawtooth waveform fed to one input terminal and a dc reference voltage (variable via RV3) fed to the other. This simple arrangement causes the input sawtooth to be converted to a rectangular output waveform, with a mark-space ratio determined by the setting of RV3. The mark-space ratio of the output waveform is independent of the frequency of the sawtooth input.

PROJECTS: GADGETS AND NOVELTIES

Figures 9 to 13 show a number of ways of using the unijunction transistor in miscellaneous gadgets and novelties. Figure 9 is the circuit of a morse-code practice oscillator. Here, the UJT is wired as a simple 300 Hz to 3 kHz oscillator, but has a speaker wired between base 1 and ground and has the morse key wired in series with the positive supply line. Thus, whenever the key is pressed the UJT oscillates and a low-level audible tone is generated in the speaker.

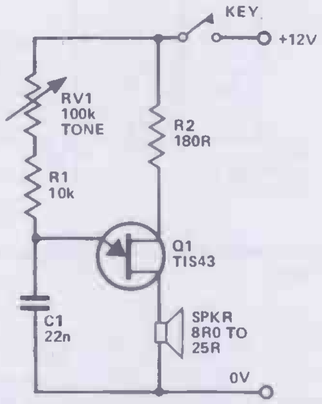


Fig.9. Simple 'code-practice' oscillator with tone variable from 300 Hz to 3 kHz.

Figure 10 is the circuit of a musicians metronome. The beat rate is variable from 20 to 200 per minute via RV1. The output pulses from across R3 are fed to the input of common emitter amplifier Q2, which uses a speaker as part of its collector load. Thus, a distinct 'click' is heard in the speaker each time the UJT completes a timing cycle.

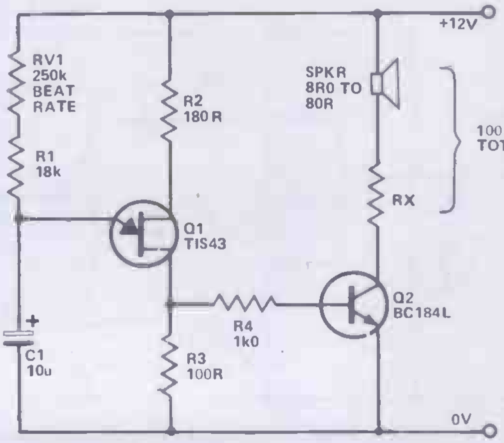


Fig.10. Musician's metronome giving 20 to 200 beats per minute.

Fig 11 is a simple multi-tone signalling system. The UJT oscillator is normally off, but turns on when any one of the PB1 to PB3 push-button switches is closed. Each switch connects its own unique value of timing resistor to the oscillator, so each switch causes a distinct tone to be generated. The circuit can be used with further switches, if required, so long as each switch is given its own distinct value of timing resistor.

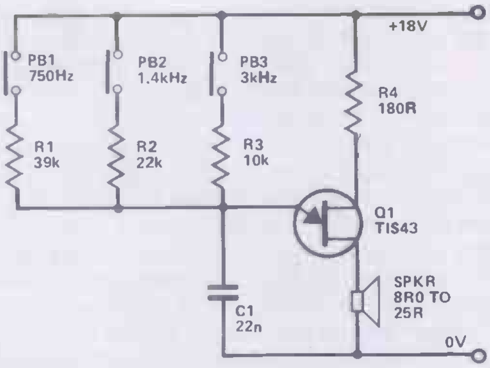
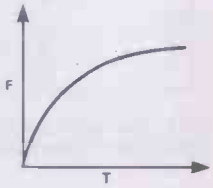


Fig.11. Simple multi-tone signalling system.

Figure 12 is the circuit of a simple rising-tone siren. The circuit operates as follows. When power is first applied, C1 is fully discharged (at zero volts), so the UJT oscillates at a low frequency determined by R3 and C2. As soon as power is applied, however, large value capacitor C1 starts to charge up via R1, so a slowly rising exponential voltage is developed across C1. This voltage is used to add charge to main timing capacitor C2 via R2 and D1, so the frequency of the oscillator slowly rises as C1 charges up. The graph shows how the frequency rises exponentially with time.



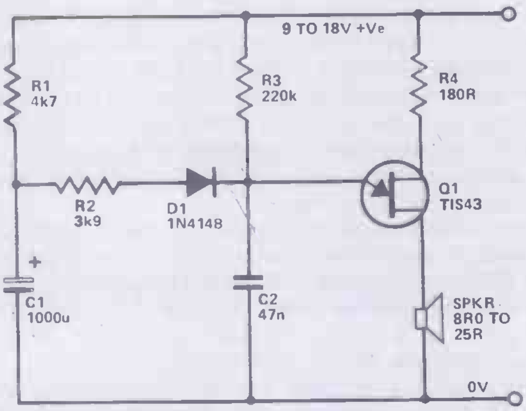


Fig.12. Simple rising-tone siren.

Finally, Fig 13 shows how the UJT can be used as a light-sensitive oscillator by using light-dependent resistor LDR as the main timing resistor of C1. Under dark conditions the value of the LDR is very high, so the operating frequency is very low and is determined mainly by the value of R1. Under very bright conditions the resistance of the LDR is very low, so the operating frequency is high and is determined mainly by R2. At intermediate light levels the operating frequency is determined mainly by the value of the LDR, and thus by the light level. This circuit can thus be used as a simple musical instrument that can be played by the light of a torch or by shadows cast by the hand.

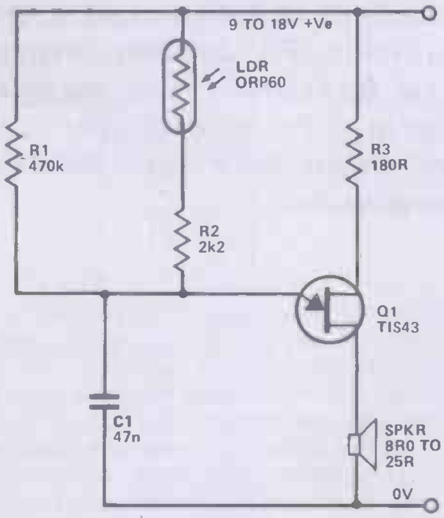


Fig.13. Light sensitive oscillator.

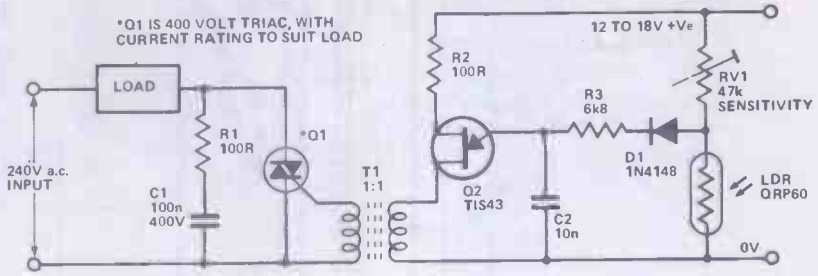


Fig.15. Simple isolated-input AC power switch.

PROJECTS: THYRISTOR POWER CONTROL

UJT circuit can produce output pulses with high peak energy which can easily be used to control triacs and other types of thyristor. The thyristors themselves can be used to switch mains power to electric lamps, heaters, motors, etc. Although the UJT circuits provide high peak output power, via the rapid discharge of a timing capacitor, they consume only a low level of mean power in slowly charging up the timing capacitor in the first place and thus have easily satisfied power supply requirements.

Figures 14 to 16 show four relatively simple ways of using UJTs to control triac power switches. The Fig 14 circuit is a simple on/off unit, in which the UJT circuitry is electrically fully isolated from the high voltage triac system via pulse transformer T1 (this type of transformer is available from Watford Electronics and some of the other large mail order companies that advertise in this magazine).

When S1 of the Fig 14 circuit is closed, the UJT oscillates and its output pulses are coupled to the gate of the triac via T1, so the triac turns on and applied power to the mains load. The UJT, which is powered from a low voltage DC supply, can in turn be activated by additional electronic circuitry, as shown in the example of Fig 15.

In the Fig 15 circuit RV1 and the LDR form a light-sensitive potential divider which has its output taken to the UJT timing resistor via D1. Under bright conditions the LDR resistance is low and the output voltage of the potential divider is insufficient to enable the UJT to trigger, so the triac is off. Under dark conditions the LDR resistance is high and the output of the potential divider enables the UJT to oscillate, so the triac turns on and applies power to the load. The circuit thus acts as a light-sensitive AC power switch.

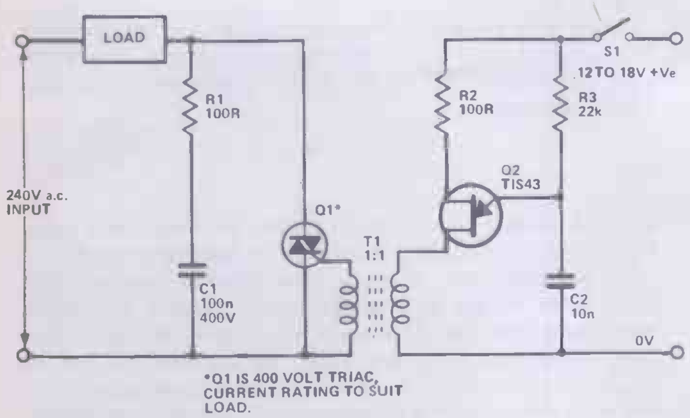


Fig.14. Isolated input AC power switch.

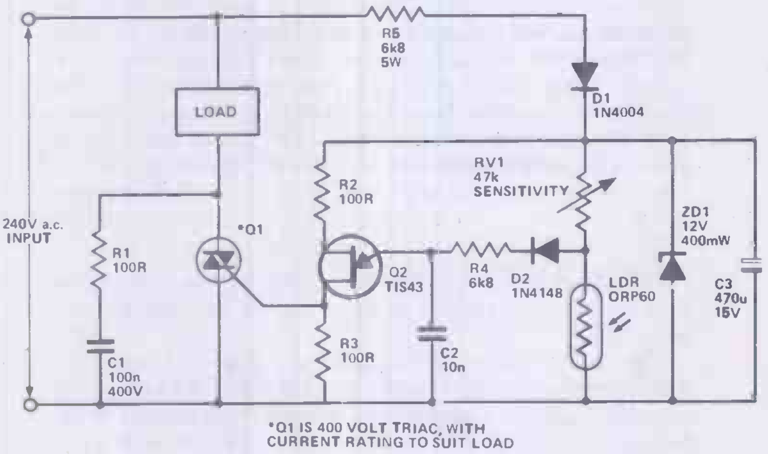
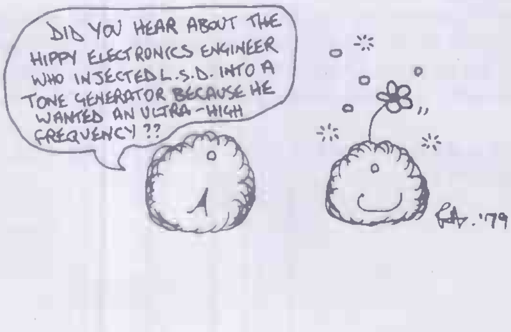
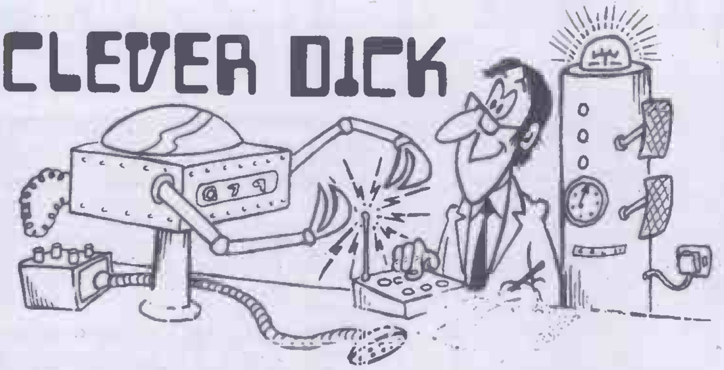


Fig.16. Light activated AC power switch with non-isolated input.

Fig 16 shows an alternative version of the above circuit in which the UJT is not electrically isolated from the triac. In this case the UJT output pulses are fed directly into the gate of the triac and the UJT is powered from a 12 volt DC supply that is derived from the mains via the R5-D1-ZD1-C3 network. **HE**



CLEVER DICK



A good selection this month, we are also pleased to announce the birth of the HE Binders to keep your copies in good condition. For anyone interested in Ni-Cad batteries we suggest a modification to a charger circuit published some time ago. What more could anyone ask?

Sometimes it's not our fault, take the comments from Mr Scotney of Nottingham, he says;

Dear Dick,
I write regarding a couple of articles in HE that have, possibly through my own ignorance, given me a fair bit of trouble.
The first point is in the Multi Option Siren. (Oct HE). In the parts list, PCB overlay and circuit diagram you show four potentiometers but there does not appear to be more than three on the completed unit. Secondly, there is only one connection shown to switch two. Is this correct and always the case, taking for granted that the other terminal is connected to the supply.
My final point is regarding the siren circuit published in conjunction with the Burglar Alarm in the August HE. After constructing this (the siren) it was found to be non-operational. Upon close inspection of the PCB it was found that D1 and D2 had not been connected to the supply. After connecting the two relevant tracks the alarm was found to function perfectly. I hope you can clear up these two points so that I can put to use several pounds of components and also satisfy my eager son.

K B Scotney
Nottingham.

We must admit that we put the control on the rear of the case but this can clearly be seen on the photograph on page 60.
The switch connects between pin 3 of IC1 and C2, the upper position (IC1) is the square wave. As you point out on the burglar alarm siren the track does appear to be missing but this was a printing problem and only happened on a few copies — sorry.

The energy crises have reared their unhappy heads again in the shape of battery power. The rising costs of dry batteries have made the Nickle Cadmium rechargeable battery a more attractive posposition Even taking into account their initial cost they will more than repay themselves in only a very short time.
All of this brings us to a question from Mr N G Corbett, he asks:

Dear Dick,
With reference to the Ni-Cad bettery charger that appeared in the Short Circuits feature in the September HE. Can this circuit be used to charge A PP3 type battery, if not why not and how about a more useful circuit that can.
How about an AF signal generator as one of your projects?

N G Corbett
Birmingham.

After a degree of head scratching we came to the conclusion that virtually any Ni-Cad (within reason) can be efficiently charged with this circuit. The limiting factor is resistor R2, this determines how much current is passed through the battery. Our calculations show that as the optimum charging current is around ten times less for a PP3 type battery than for an HP7, the value of R2 needs to be increased by a factor of ten so it should now be 100R. As for AF signal generators we have published two so far in the February and August issues.

Burglar alarms are always popular projects so we were not surprised to receive this letter from Mr Deans:

Dear CD,
Would you please refer me to any of your publications which give constructional details of a 'secret ray' type of burglar alarm.
Any other information on this matter would be appreciated.

D H Deans
W. Sussex.

We haven't published anything along these lines as yet but don't despair our workshop are currently experimenting with Infra-Red devices with a view to producing a highly sophisticated burglar alarm, look out for that in the coming months.

Now it's pat our back time. George Bell from Cornwall asks a most opportune question to which we are only too happy to reply.

Dear Dick,
Could you please tell me the price and department from which I may obtain HE magazine binders. I have not seen any adverts for them in HE (perhaps I have not looked hard enough).

George Bell
Liskeard.

What a lovely excuse to tell you all about our new binders (Actually that's a bit untrue because we didn't have any old ones). We are now offering custom built binders for Hobby in a rather stunning Blue with gold embossed lettering. They will be on sale at the end of next month and will be all yours for the miserly sum of £3.20 including VAT etc. If you are interested please see the ad in this issue but do allow three weeks for delivery.

One of our most popular projects in recent months has proved to be the Hobbytune. Electronic music is a very recent newcomer to our hobby it is a field that has still plenty of room for experiment so it would seem quite natural for someone to want to take the Hobbytune a stage further. This letter from Mr Tibbings poses an interesting question.

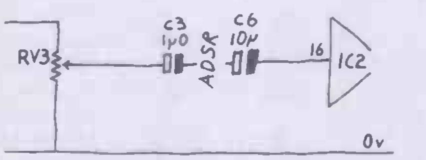
Dear HE

I am building your Hobbytune from the October issue and am planning to build the ADSR envelope generator straight into the same box.

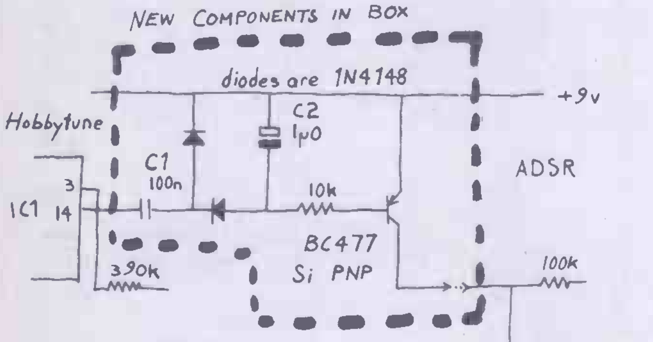
Is it possible to supply me with information on how to connect the two units together. Is it possible to run both units from the same battery and is it possible to connect the ADSR output stage into the Hobbytube amplifier itself, without having to build a separate amplifier, if so how?

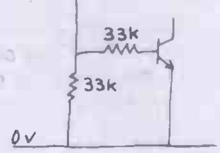
M. Tibbings
Stockport

In reply to your interesting question Mr Tibbings we're cornered John FitzGerald (the designer of the ADSR and Hobbytune) to come up with a few ideas. His scribblings appear below. Hope it's OK.



Connect ADSR at input of Hobbytune Amplifier as shown above.



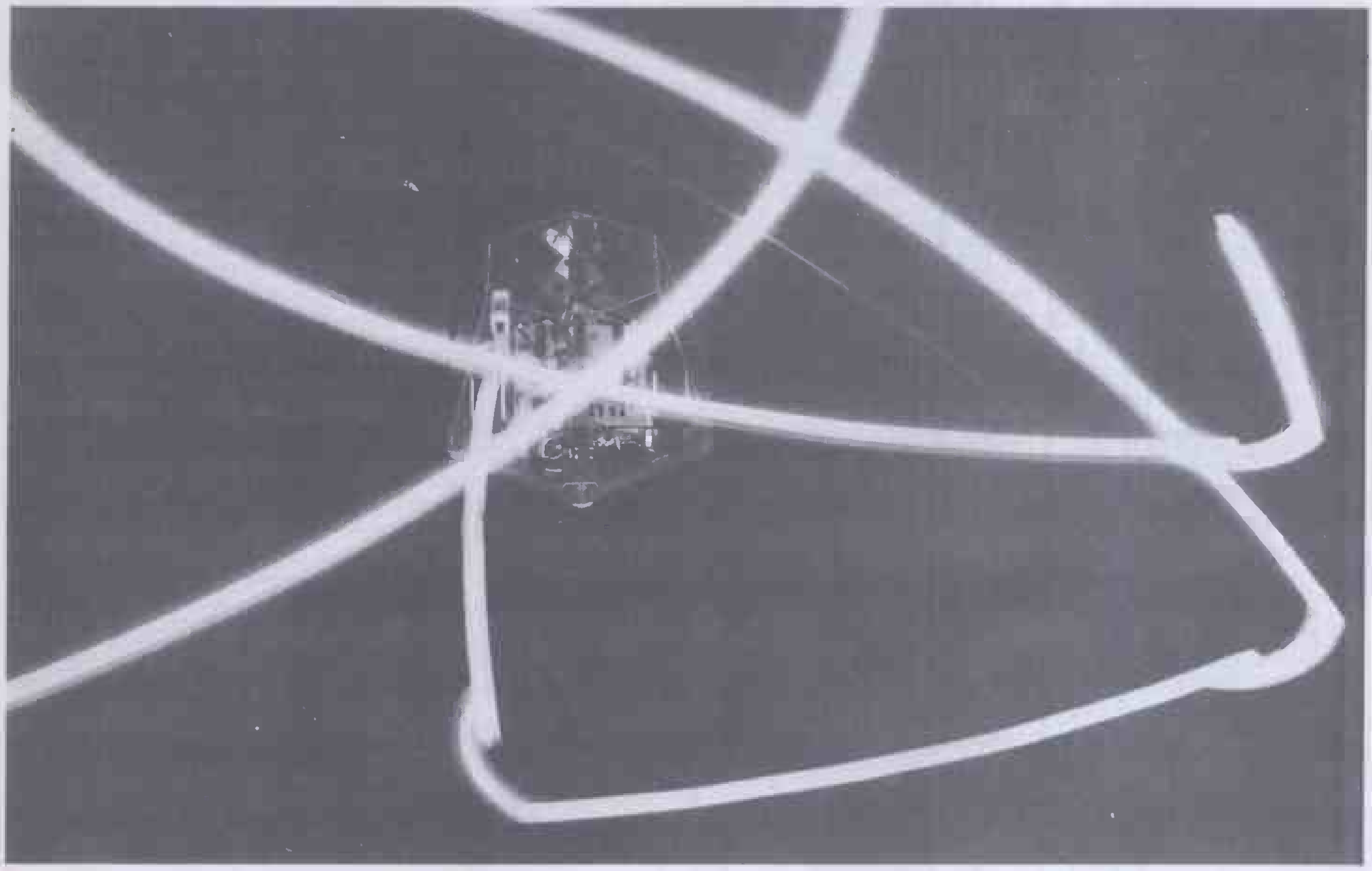


NOTE: ADSR and Hobbytune share same power supply. 'RELEASE' will not work as there is no output from Hobbytune at this time. Attack, Decay and Sustain all work. You may have to experiment with the values of C1, 2.

Well, that's about it for another month, thanks for keeping your letters a bit shorter this month as you can see it enables us to get several more in as well as the circuit diagram. We will try to incorporate more things like that in the future. See you next month Dick.

Hebot II

Continuing story of home Hebotics



Time-lapse photography shows HEBOT exploring a maze.

THIS MONTH we will begin to describe how to add sound to the Hebot and sensitise it to light, sound and electromagnetic radiation enabling Hebot to search for and find a recharging nest.

Before describing these functions in more detail, we will take a look at some of the points arising from last month's feature. As described in the text, unused inputs of IC3 should be connected to minus five volts to ensure proper operation of the chip. The uncommitted inputs of IC's 4, 5 may be left floating without any problems. As transmission gates, they are designed to accept any voltage within the supply range at their signal inputs anyway. The motor-servo-amps are very simple and depend for their proper operation on use of a split supply. If Hebot were to travel in one direction only for most of the time then only one half of the battery supply would be discharged. This is unlikely to cause any problems; however, to allow for any subsequent design changes in this section of the circuitry, this month's board has been designed to operate from a single supply voltage. The 'mid-rail' zero volt line is generated electronically 'on-board'. All the CMOS chips are buffered; 'B series', and the capacitors should be sixteen volts working or higher.

TWIST AND SHOUT

The circuitry on the second board described here is mostly concerned with searching and driving towards a light (phototropism) and tracking a cable by detecting an AC energising signal. The details of operation of these circuits will be dealt with fully next month.

The rest of the circuitry enables Hebot to perform a random walk, generate a short tone and respond to loud noises. 'Random walk' is something of a misnomer as Hebot actually executes a series of spirals as shown in our photos enabling him to 'look around' his environment. The circuit which generates this motion is very simple and quite elegant consisting of a single op-amp connected as a conventional astable oscillator. To operate, all you need to do is connect pin 10, IC3 to plus five volts and connect pins A, B to pins 1, 12, IC4 (X 0 Y,0). It does not matter whether A or B goes to pin 1 or 12. This only affects the direction of the spiral motion.

We have also given Hebot a voice. The circuitry around IC5 accomplishes this. IC5 is a 555 timer connected as an astable oscillator whose output is gated on and off by driving the reset input via transistors Q6, 7. Whenever input pin Y is driven to plus five volts, a

How it Works

All the circuitry on this board is powered from the plus and minus five volt supply. Although the junction of the batteries (0 V) is available, an artificial 0 V is generated on-board by R2, 3, C2 and appears at pin 1, IC1. The op-amp is connected as a voltage follower and merely provides a low impedance output to drive other circuitry. This feature enables the board to be operated from a single supply ensuring a more flexible system.

The 'random walk' is produced by driving the servo-amps with signals from an astable oscillator formed by components R4, 5, 6, C1 and one of IC1's amplifiers. The outputs are taken from C1 and the junction of R5, 6 and appear at A and B. Resistors R1, 7 protect the diode networks inside the CMOS multiplexer chips IC4, 5 to which these outputs will be connected. Note that the bottom of R6 goes to pin 1, IC1; effectively 0 V.

The remaining two amps in IC1 and all of IC3 together form the wire tracking circuitry enabling the Hebot to follow a cable back to its nest by detecting an AC signal. There are two identical input stages whose outputs are pins 7, 8, IC1. An AC signal from the sensor coils is coupled to the inputs (pins 6, 9, IC1) by capacitor Cx or directly. Each amplifier operates as a current-to-voltage converter and produces an alternating voltage output. The detection stages are identical. The signal at pin 8, IC1 is coupled via C3 to rectifiers D1, 3 and charges C5 producing a DC voltage which is proportional to the strength of the input signal from the sensor coils. This voltage varies between —5 V and approximately +1 V and appears at pins E, F where it should be coupled to pins G, H. Two of the amps in IC3 are used with resistors R16, 17, 18, 19 to convert the output voltages from C5, 6 to signals swinging between 0 V and +3.5 V suitable for driving the motors forward via the multiplexers and servo amps. The signals appear at pins I and J.

Hebot needs to know whether there is any useful signal at these outputs and this is accomplished by measuring the average voltage across capacitors C5, 6. This signal appears at pin 14, IC3. When it rises above about 0.7 V (measured with respect to Q1 emitter) transistor Q1 is biased 'on' and the voltage at its collector will fall towards —5 V. This signal is input to the Schmitt trigger (pin 9, IC3) and appears inverted at pin M. An identical signal appears at pin L. However, this output may be disabled by pulling pin K to —5 volts. Resistors R25, 26 and capacitor C7 provide a bias voltage for the Schmitt trigger.

The circuitry around IC2 enables Hebot to detect and steer towards a source of light. The two input stages are identical. A current flows through Q2 which is proportional to the incident light. This is converted to a voltage which varies between 0V and +3.5 V and is output at pin 1, IC2 (pin P). The output from Q3 appears at pin Q.

The output levels at P, Q are suitable for driving the motors forward via the multiplexers and servo-amps. Resistors R27, 28, 29 form a potential divider which drives the Schmitt trigger (input pin 9, IC2) whose output is normally 'high' (at about +3.5 volts). When the average voltage at P, Q rises

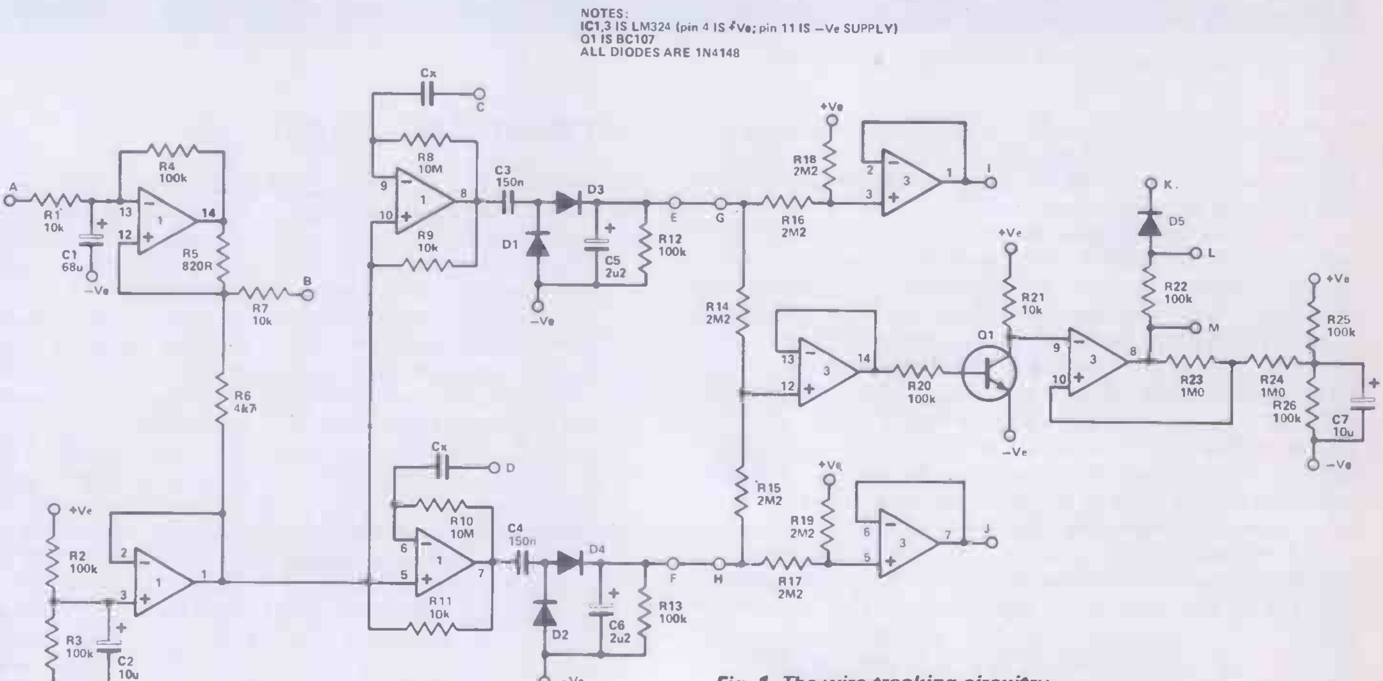


Fig. 1. The wire tracking circuitry.

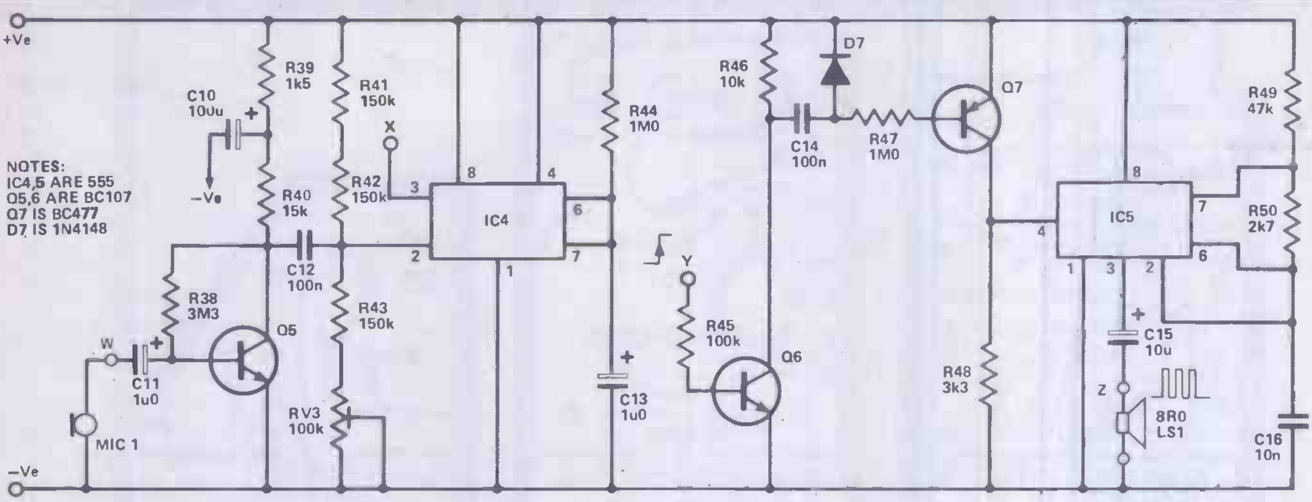


Fig. 2. Sound detection and generation circuitry.

above about 0.5 volts, ie when Hebot sees light, the output of the Schmitt trigger goes 'low' (to about —5 volts) biasing off Q4 and causing the voltage at its collector (pin T) to rise from —5 V to +5 V. This signal is repeated at pin U but may be disabled by pulling pin K to —5 volts.

The remaining section of IC2 may be used to give a visual indication of operation of other parts of the circuit. It is connected as a conventional inverting amplifier with an input resistance of ten million ohms.

With the input (pin S) disconnected, the LED will glow at medium brilliance. Connecting pin S to pin V will cause it to glow brightly indicating a positive input, while connecting a negative input (pin R) will extinguish the LED.

Integrated circuits IC4, 5 enable Hebot to detect and generate sound. Both devices are 555 timers. IC4 will produce a positive output at pin x of monostable period determined by R44, C13 (about one second with the values shown) when triggered by a sound at the microphone, MIC1. The sensitivity of the circuit is set by adjustment of RV3. The trigger input of the chip (pin 2, IC4) is normally held above the trigger voltage of one-third of the supply voltage by bias resistors R41, 42, 43, RV3. Any sound picked up by the microphone produces an alternating voltage at Q5 collector which is coupled to the trigger by C12. A loud noise will produce a signal of sufficient amplitude to trigger IC4. The output signal (pin X) could be used to throw Hebot into reverse, a spin, or just stop him in his tracks.

IC5 produces a short burst of sound each time input Y is taken from —5 volts to +5 volts. Each positive transition of this input causes Q6 collector to go low to —5 volts. This signal, coupled to Q7 by C14, R47 causes the reset input (pin 4, IC5) to be pulled to +5 volts enabling the oscillator to produce a short tone burst. Any digital signal may be input to pin Y. If 'avoid' (pin 12, IC11 board one) is connected, a tone will be produced each time Hebot encounters an obstacle. The loudspeaker is AC coupled to IC5 to avoid excessive current flow. The frequency can be changed by adjustment of R49 or C16.

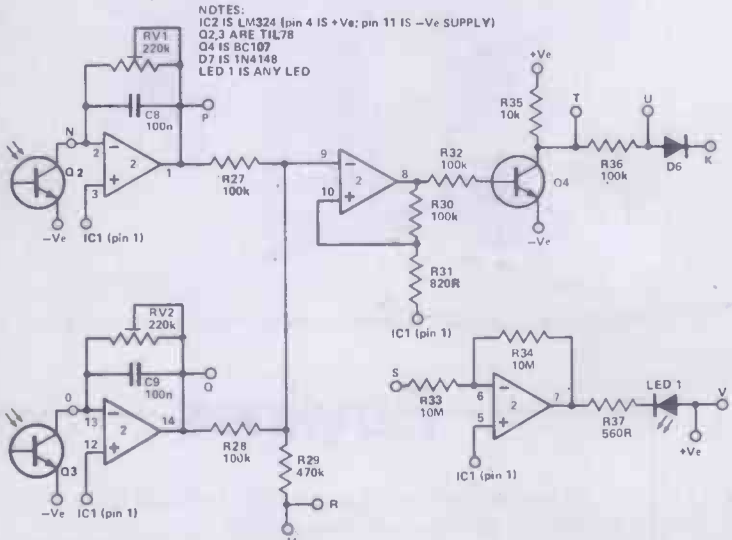
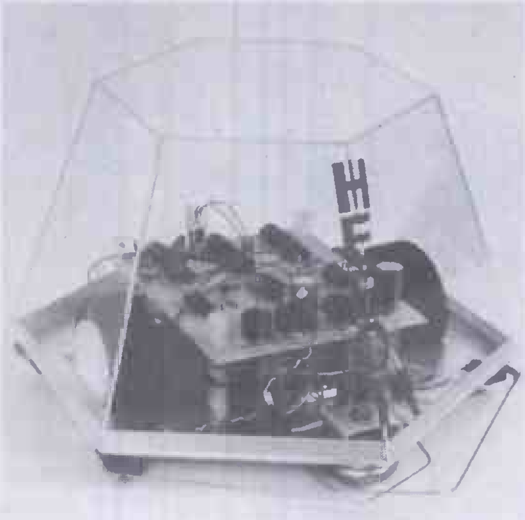


Fig. 3. The light seeking circuitry.



The HEBOT, conceived by the HE design team led by Ray Marston

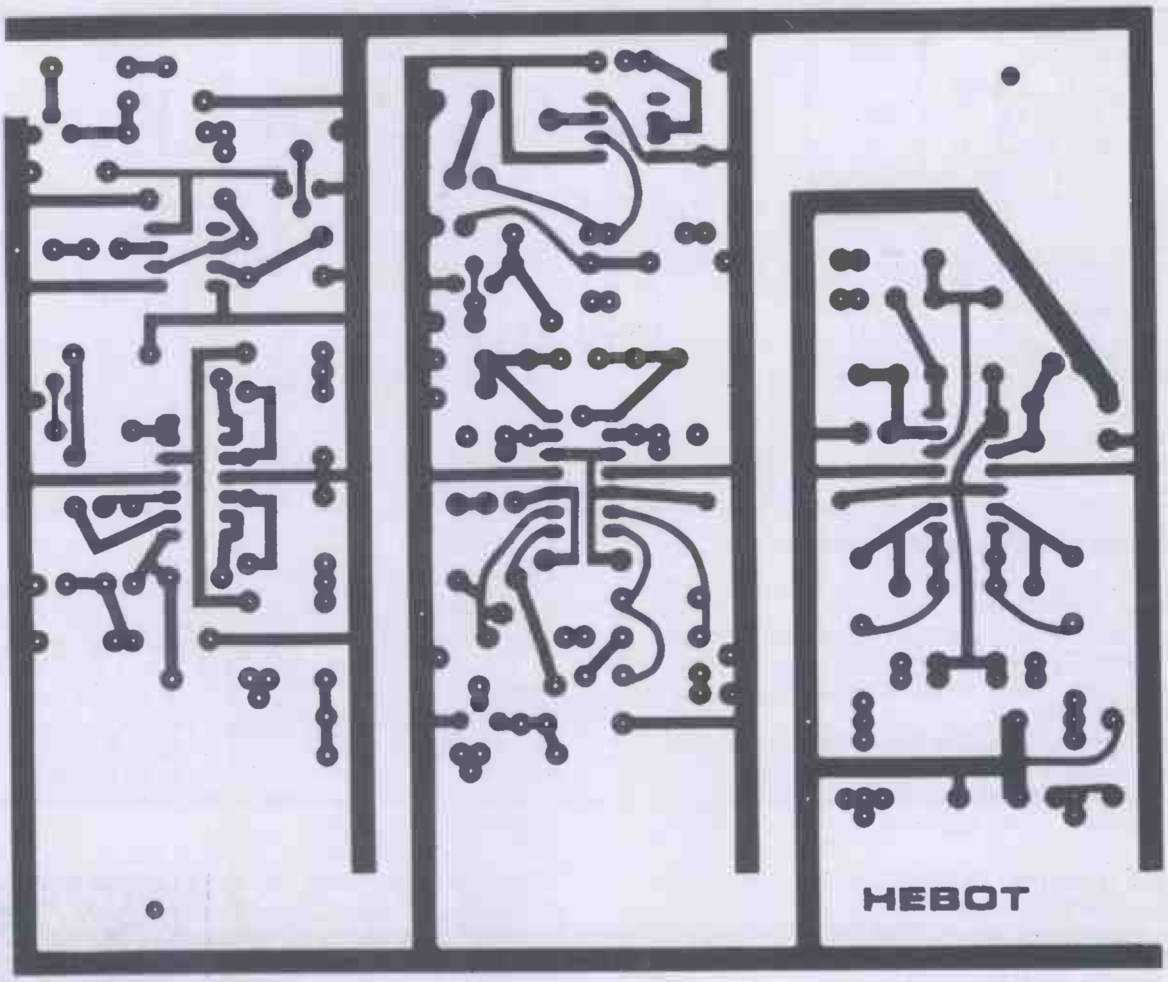


Fig. 4. PCB foil pattern for HEBOT.

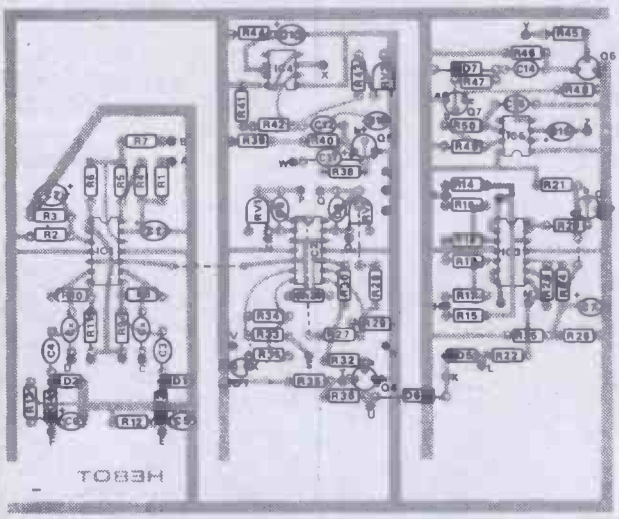
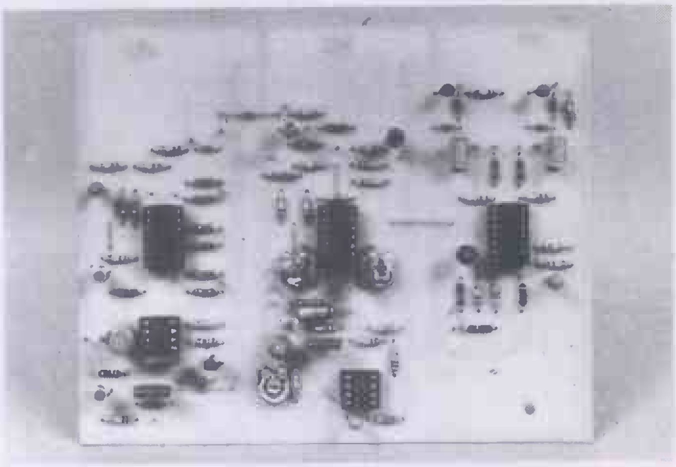
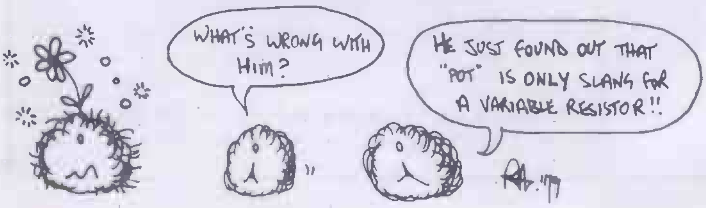


Fig. 5. PCB overlay for HEBOT.



HEBOT's second board contains mostly analogue circuitry.



Buylines

All the components for this board should be readily available from your usual suppliers.

Parts List

RESISTORS (all ¼W 5%)	
R1, 7, 9, 11, 21, 35, 46	10k
R2, 3, 4, 12, 13, 20, 22, 25, 26, 27, 28, 30, 32, 36, 45	100k
R5, 31	820R
R6	4k7
R8, 10, 33, 34	10M
R14, 15, 16, 17, 18, 19	2M2
R23, 24, 44, 47	1M0
R29	470k
R37	560R
R38	3M3
R39	1k5
R40	15k
R41, 42, 43	150k
R48	3k3
R49	47k
R50	2k7

POTENTIOMETERS	
RV1, 2	220k
RV3	100k

CAPACITORS	
C1	68μ tantalum
C2, 7	10μ tantalum
C3, 4	150n polyester
C5, 6	2μ2 tantalum
C8, 9, 12, 14	100n polyester
C10	100μ tantalum
C11	1μ0 electrolytic
C13	1μ0 tantalum
C15	10μ electrolytic

SEMICONDUCTORS	
Q1, 4, 5, 6	BC107
Q2, 3	TIL 78
Q7	BC 477
D1 thru D7	all 1N4148
IC1, 2, 3	LM324
IC4, 5	555

MISCELLANEOUS

MIC1 any microphone (crystal or balanced armature inserts work well)
LS1 any loudspeaker (we used an 8 ohm 1½ inch loudspeaker)
PCB, IC sockets, terminal pins
LED1 any LED (we used TIL 220)

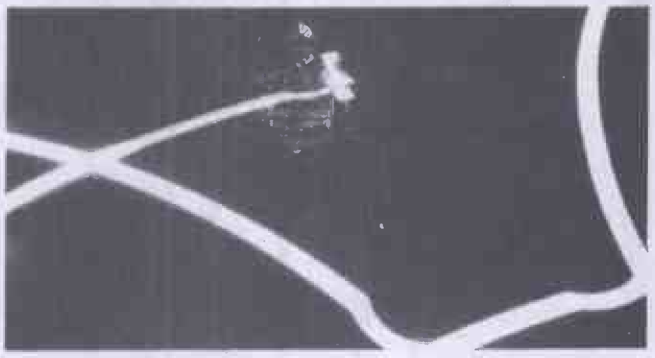
short tone is produced. If you connect pin Y to the 'avoid' output of last month's board, Hebot will emit a surprised squeak following each collision.

The other 555 is used with Q5 to detect sounds. Hebot can be made sensitive to loud noises by adjustment of RV3. Any sufficiently loud noise will cause the 555 output (pin X) to rise from minus to plus five volts for about one second. Pin X may be connected to any of the inputs of IC3 (only one connection to each input though!) to make Hebot select control from any X, Y set of inputs. If pin X were connected to input '7' (pin 4, IC3 board one) and X7 (pin 4, IC5) were connected to plus five volts with Y7 (pin 11, IC5) connected to minus five volts then Hebot would execute a spin following each loud noise. Note that in this case, the avoid manoeuvre circuitry would be inoperative as level seven has the highest priority.

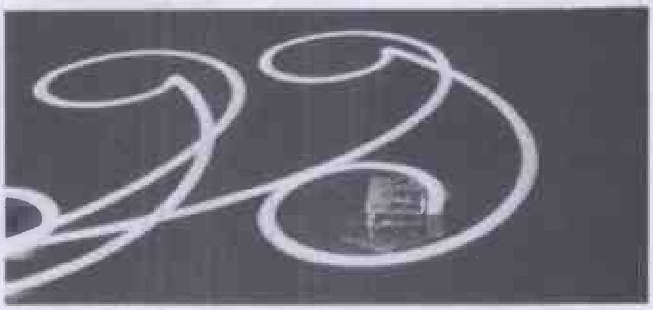
CONSTRUCTION

Use of our PCB is essential (try putting it together on 'S-DEC!). The wire links should be inserted first; note that one passes beneath an IC holder. Sockets are recommended though none of the chips on this board are sensitive to static discharge. The other components may be inserted in the usual order; resistors, capacitors and semiconductors. Take care not to overheat any components and beware of shorting copper tracks with solder bridges as some of them pass quite close to each other. Also, of course, note the polarity of the semiconductors, IC1, 2, 3 point up while IC4, 5 point down.

Do not be afraid to experiment with other configurations than the ones described and try designing your own circuitry. Make Hebot a vehicle for *YOUR* ideas.



HEBOT's avoidance manoeuvre (above) and the 'random walk' (below).



Next month's article will describe the beacon circuitry and ni-cad charging unit with a pin by pin account of how to get the rest of the circuitry up and running and elicit express action from the educated electrons as they run around the tracks. Chips with everything . . . don't miss it! **HE**

STEVENSON
Electronic Components

CMOS

		4020	50p	4050	25p
		4022	50p	4060	80p
		4023	13p	4066	30p
		4024	40p	4068	13p
4001	13p	4025	13p	4069	13p
4002	13p	4026	90p	4070	13p
4007	13p	4027	28p	4071	13p
4009	30p	4028	45p	4072	13p
4011	13p	4029	50p	4081	13p
4012	13p	4040	55p	4093	36p
4013	28p	4041	55p	4510	60p
4015	50p	4042	55p	4511	60p
4016	28p	4043	50p	4518	65p
4017	47p	4046	90p	4520	60p
4018	55p	4049	25p	4528	60p

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TTL

		7473	20p	74141	55p
		7474	22p	74145	55p
7400	10p	7475	25p	74148	90p
7401	10p	7476	20p	74150	55p
7402	10p	7485	55p	74151	40p
7404	12p	7486	20p	74154	65p
7406	22p	7489	135p	74157	40p
7408	12p	7490	25p	74164	55p
7410	10p	7492	30p	74165	55p
7413	22p	7493	25p	74170	100p
7414	39p	7494	45p	74174	55p
7420	12p	7495	35p	74177	50p
7427	20p	7496	45p	74190	50p
7430	12p	74121	25p	74191	50p
7432	18p	74122	35p	74192	50p
7442	38p	74123	38p	74193	50p
7447	45p	74125	35p	74196	50p
7448	50p	74126	35p	74197	50p
7454	12p	74132	45p	74199	90p

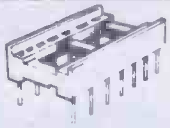
OPTO

LED's	0.125in	0.2in	each	100+
Red	TIL209	TIL220	9p	7.5p
Green	TIL211	TIL221	13p	12p
Yellow	TIL213	TIL223	13p	12p
Clips	3p	3p		

DISPLAYS

DL704	0.3 in CC	130p	120p
DL707	0.3 in CA	130p	120p
FND500	0.5 in CC	100p	80p

SKTS



Low profile by Texas

8pin	8p	18pin	14p	24pin	18p
14pin	10p	20pin	16p	28pin	22p
16pin	12p	22pin	17p	40pin	32p

3 lead T018 or T05 socket. 10p each
Soldercon pins: 100:50p 1000:370p

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Size in	0.1in	0.15in	Vero
25 x 1	14p	14p	Cutter 80p
2.5 x 3.75	45p	45p	
2.5 x 5	54p	54p	Pin insertion
3.75 x 5	64p	64p	tool 108p
3.75 x 17	205p	185p	
Single sided pins per 100	40p	40p	

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0.5W	1.5p	1.2p	1p

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		LM308	60p	NE556	60p
		LM318N	75p	NE567	100p
		LM324	45p	RC4136	100p
709	35p	LM339	45p	SN76477	230p
741	16p	LM378	230p	TBA800	70p
747	45p	LM379S	410p	TBA810S	100p
748	30p	LM380	75p	TDA1022	620p
7106	850p	LM3900	50p	TL081	45p
7107	900p	LM3909	65p	TL084	125p
CA3046	55p	LM3911	100p	ZN414	80p
CA3080	70p	MC1458	32p	ZN425E	390p
CA3130	90p	MM57160	590p	ZN1034E	200p

TRANSISTORS

				ZTX500	16p
				2N697	12p
		BCY72	14p	2N3053	18p
AC127	17p	BD131	35p	2N3054	50p
AC128	16p	BD132	35p	2N3055	50p
AC176	18p	BD139	35p	2N3442	135p
AD161	38p	BD140	35p	2N3702	8p
AD162	38p	BFY50	15p	2N3703	8p
BC107	8p	BFY51	15p	2N3704	8p
BC108	8p	BFY52	15p	2N3705	9p
BC108C	10p	MJ2955	98p	2N3706	9p
BC109	8p	MPSA06	20p	2N3707	9p
BC109C	10p	MPSA56	20p	2N3708	8p
BC147	7p	TIP29C	60p	2N3819	15p
BC148	7p	TIP30C	70p	2N3820	44p
BC177	14p	TIP31C	65p	2N3904	8p
BC178	14p	TIP32C	80p	2N3905	8p
BC179	14p	TIP2955	65p	2N3906	8p
BC182	10p	TIP3055	55p	2N4058	12p
BC182L	10p	ZTX107	14p	2N5457	32p
BC184	10p	ZTX108	14p	2N5459	32p
BC184L	10p	ZTX300	16p	2N5777	50p
BC212	10p				
BC212L	10p				
BC214	10p				
BC214L	10p				
BC477	19p				
BC478	19p				
BC548	10p				
BCY70	14p				
BCY71	14p				

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1N4001	4p	1N5401	13p
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	100						13p
			220				20p
25V	10	22	33	47			5p
	100						8p
		220					10p
				470			15p
	1000						23p

CONNECTORS

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

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3pin	11p	9p	14p
5pin 180°	11p	10p	14p
5pin 240°	13p	10p	16p

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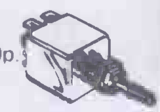
SWITCHES



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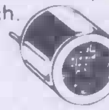

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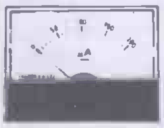

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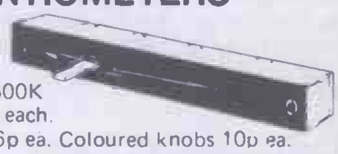

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Television Receivers

Have you ever wondered how a swiftly moving spot of light can make a picture? Well, switch off the telly, sit back and find out now. Rick Maybury explains.

SO WHAT HAPPENS when a TV set is switched on? Quite a lot really. If you consider that a modern domestic TV receiver is one-third ordinary ratio receiver (but operating at a much higher frequency) and nearly two-thirds solely devoted to driving and controlling the large glass object in the centre of the box, it seems appropriate that we should confine ourselves to this aspect of TV as there are more than enough descriptions of the operation of radio receivers.

Producing the picture is undoubtedly the tricky bit. Until the much promised (but rarely seen) solid-state, flat screen appears we must make do with the rather 'brutal' method of image production known as the Cathode Ray Tube or CRT.

To display a picture on a CRT we must have three things. The first is a source of very high voltage or EHT (Extra High Tension). This is fed to the final anode (often the metalised face plate of the screen). Its purpose is to attract a fine stream of electrons through the near vacuum of the tube, from the cathode of the electron gun, onto the phosphor-coated face-plate. This will glow when 'struck' by the electron beam. A typical black and white set requires something in the order of 5-10 thousand (or kilo) volts to achieve this. A colour ⅝V is somewhat more demanding, needing around 25kV. Something like one-third of the bulk of a TV set is used to generate and control these substantial voltages.

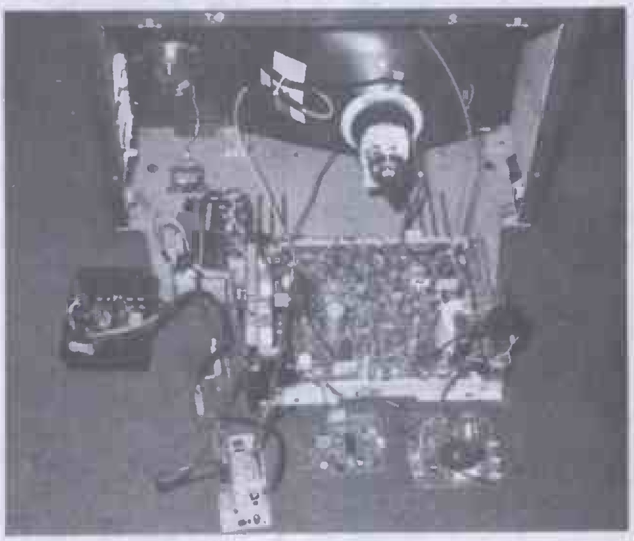
MIGHTY MAGNETS

The second requirement is for two highly intense and accurately controlled magnetic fields. These are generated in two sets of coils wound around the neck of the CRT. They are concerned with moving the electron beam around the inside of the tube. The 'line' scan coils deflect the beam from side to side and the 'frame' scan coils move it up and down.

Our last requirement is to be able to vary the intensity or modulate the brightness of the spot. This is accomplished by changing the applied voltage to either the electron guns control grid or cathode. It does this on instruction from the transmitted signal from the studio after being suitably decoded.

FLYING SPOT

To combine all of these elements we must first arrange to produce what is called a raster, this is basically a blank screen that can be lit or modulated according to our requirements. This involves scanning the tube. We must ensure that the two magnetic fields make the electron beam run across the width of the screen and when they have reached the other side to switch off and go back to the left hand side, go down a little, switch on and cross the screen again. If you can persuade the electron beam to do this very quickly it will eventually cover the whole screen area. Do it 50 times a second and the human eye cannot detect the movement and the screen will appear to be one solid light. It's only when you get close you can distinguish individual lines — 625 of them in a modern British TV picture, 405 lines if you've got a very old set (you had better get a new one soon if you've got one of these as the 405 service is due to be discontinued in the next year or so), and various other numbers, depending upon which part of the world you happen to live in.



The business end of a TV receiver. This particular model is a particularly good example of state-of-the-art TV technology. It is the Rank Toshiba X53 colour set. In this picture the set has been stripped down to show the various parts of the receiver. Inside the cabinet are the tube and speaker. The main board in the foreground contains all of the electronics for signal demodulation and tube drive, the tuner unit can be seen on the flying lead (far left).

For our next trick we will 'modulate' or vary the brightness of the spot, if we can do this very, very quickly and at the same time as a similar spot is flying about inside the tube of the camera at the TV studio we have a picture. Add some sound and we have Television, simple isn't it?

If only it was that simple, unfortunately we have to contend with something called 'Synchronisation'. 'Sync.' is the technique employed to ensure that the picture that originates from the TV studio is in perfect step with the picture on your TV. If at any given instant the spot on your screen is exactly dead centre, (say) you can be sure that the spot within the camera tube is in exactly the same position. If it is not you will almost certainly be suffering from frame roll where a broad band splits two halves of the picture at the top and bottom of the screen, or 'tear' where the picture seems to be trying to escape through the side of the set. In severe cases of sync loss you may suffer a combination of both and the picture ceases to be at all recognisable looking like a complete mess.

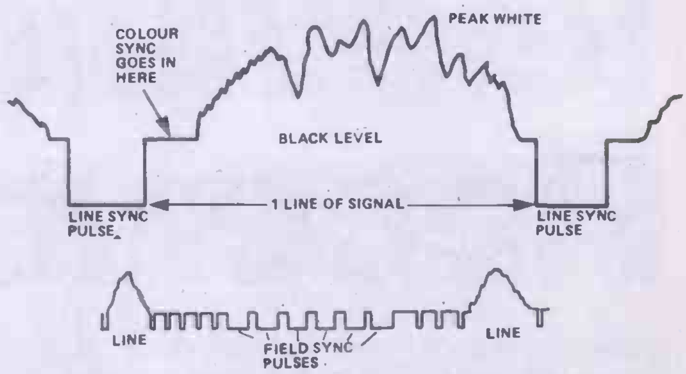
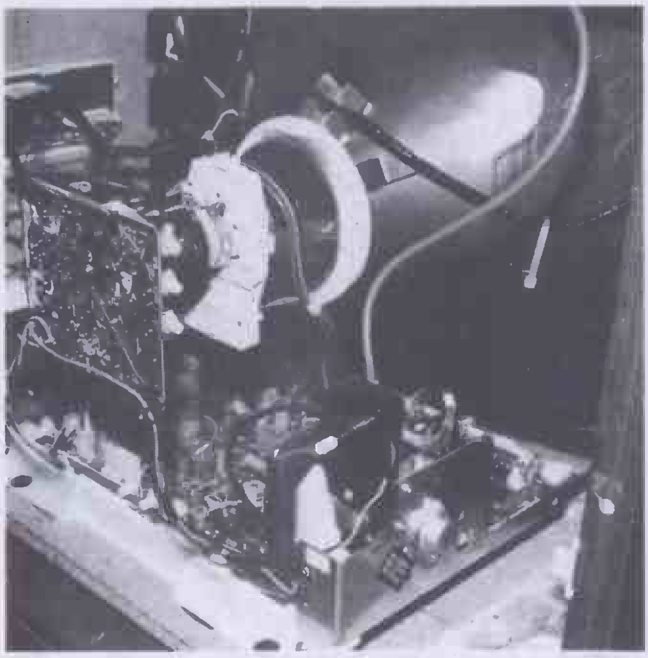


Fig. 1. The TV signal waveform (top) the lower diagram shows the position of the frame sync pulses at the end of the last line of the frame.

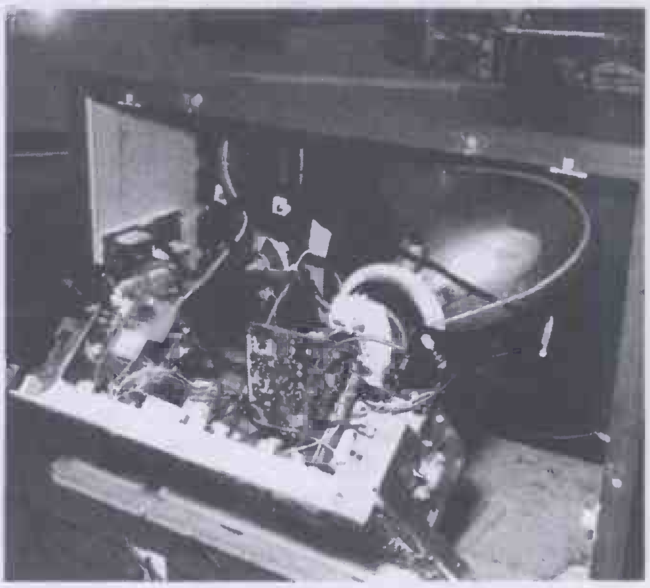


Close-up of the 'scan' coils (around the tube neck) and the EHT and scan drive circuitry. The light coloured lead on the left of the picture carries the EHT to the final anode button on the top of the tube.

A SYNC IN THE LIVING ROOM

The mechanism of synchronisation is fairly simple, at the beginning of each line a large pulse is added to the signal at the transmitter. It is in the opposite polarity to the picture information at what is called below 'black level', this is to prevent it appearing on the screen during viewing. This pulse is detected by circuitry within the set and upon receiving it, will instruct the horizontal deflection circuitry or Line Time Base (LTB) to commence a 'scan' and deflect the dot across the screen. At the same time the vertical deflection circuitry or Frame Time Base is generating a magnetic field within the 'Field' coils to deflect the spot downwards. A further, much longer pulse from the transmitter instructs the Frame Time Base when it should have reached the bottom of the screen and tells it to allow the spot to return to its starting position at the top left hand corner of the screen. The two timebases will operate in the absence of sync pulses using a system called 'Flywheel' sync, this means that the timebases are running at their appropriate rates or frequencies but will change 'speed' upon getting sync information from the transmitter. Rather like a flywheel that runs at a constant speed but can be 'sped up or slowed down' to match the speed of another flywheel.

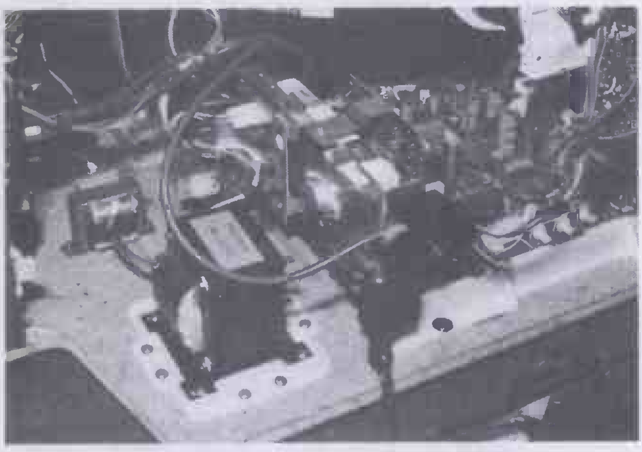
The combined effect of these two circuits is to produce a 'frame' that is repeated 50 times a second. To prevent an unnecessary amount of radio space or bandwidth being taken up a simple technique called 'interlace' is employed. This works by sending the picture in two halves, the first half consists of lines 1, 3, 5, 7 etc. until the screen has been filled, then the missing lines 2, 4, 6, 8 etc. are transmitted to fill in the gaps. This is done at the rate of 25 times a second—twice, the overall effect is to produce an image repetition rate of 50 frames a second.



The chassis tilted into its 'service' position. The engineer can gain access to both sides of the set, again this is the Rank Toshiba X53.

INTERESTING INTEGERS

Time for some statistics. The frequency of the 'frame' timebase is 50 Hz, the Line Timebase runs at 15.65 kHz, the dot takes exactly 64 microseconds to traverse the width of the screen. If all of these figures seem a bit 'arbitrary' to you, try relating them to each other, remembering that frequency = 1/time, you should get some interesting results, showing that an awful lot of thought has gone into what we glibly call TV.



Close-up of the 'signal' circuitry. This side of the main board is primarily concerned with processing the incoming signal from the tuner and de-coding it into its various components to operate the rest of the circuits.

CUNNING COLOUR

Colour TV is worth a mention (though not an explanation, as it would take a book equivalent to at least one entire volume of HE to do that). Colour TV is basically reliant upon another quirk of human eyesight, our ability to 'mix' colours. This is similar in concept to colour printing, next time you look at a colour picture in a magazine take a closer look, you should be able to see that the picture is made up of millions of little dots that merge into a colour image when viewed at a distance. If you look closely at the screen of a colour TV you should be able to see thousands of little red, green and blue dots or strips.

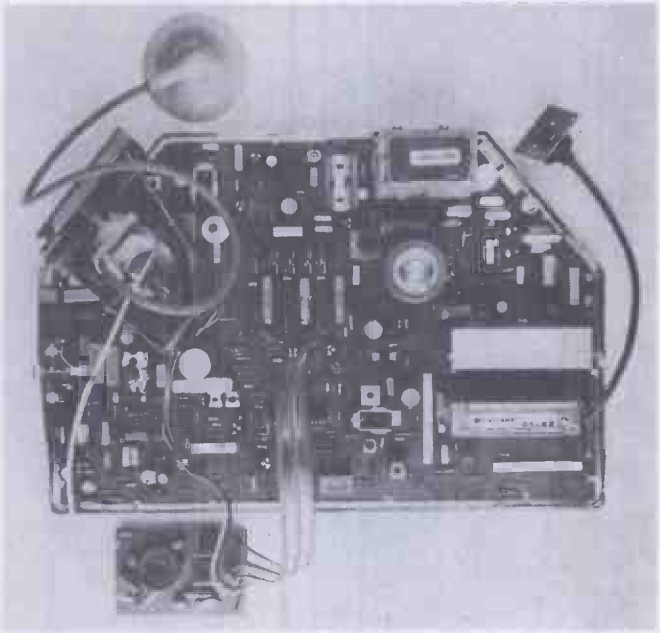
Three separate electron guns are focused onto all of these dots by a cunning device variously known as a Shadowmask or Apature Grille. (Incidentally this is why it requires a higher EHT as the thin perforated plate that makes up the Shadowmask or Apature Grille tends to absorb much of the energy of the three electron beams).

Apart from a much more complicated decoder circuit and the duplication of the electron gun and drive circuitry, a colour TV is exactly the same when it comes to scanning, synchronisation and sound.

Up until only a few years ago quite a large percentage of colour TVs had additional circuitry for something called convergence. This was wave-shaping circuitry designed to ensure that the three colour images that went to produce a colour picture, fell exactly on top of each other. A mis-converged set is usually detected by looking for 'fringe' areas and colours around the edges of objects on the screen. However, do not attempt to adjust the convergence on a colour set unless you know what you're doing, nine times out of ten it will end up worse than when you started. Many of the colour TVs made in the last five years now use a TV tube called the Precision In Line (or PIL) and this effectively reduces the convergence circuitry by about three-quarters. Because of the greatly increased deflection angles (110 degrees is the norm), the modern sets tend to be a lot slimmer than their counterparts of only five years ago.

REPAIR$

The trend of simplification and standardisation has given the TV industry some unexpected headaches. Up until only a few years ago a service engineer could reasonably hope to be able to fault find a TV to component level. Today with the ever increasing use of ICs and modular construction it makes it both impractical and undesirable to do this. Indeed many of today's so-called TV engineers are little more than 'board-changers', a faulty board once located and replaced will be returned to the service centre or factory, where someone with specialist knowledge on that particular board only will make the repair.



Another one-board colour TV chassis. This time its the Thorn TX 9 TV. The bulk of the board is taken up with the generation of EHT and theline and frame scan circuitry. The EHT tripler/output transformer can be seen inside the screened box on the top left hand side. The flying lead is the EHT, final anode connection. The screened can on the bottom right is the varicap tuner box. The small board at the bottom connects to the tube base, the three wire ribbon cable is the Red, Green, Blue or RGB drive. The flying lead on the extreme right is for the aerial socket.

THE FUTURE

The growth in IC technology has been fairly slow to affect the TV industry, apart from a few sound-output ICs nothing much really happened until a couple of years ago. Modern colour TVs now bristle with them, especially if they sport remote control or teletext decoders. This has turned the TV into something more aptly called a home video display unit. TV games, home computers, video tape recorders and of course Teletext and Prestel all use the TV to display their wares. If you are lucky enough to own a TV camera you can even make your own TV programmes. Where will it all end. Keep reading HE and find out.

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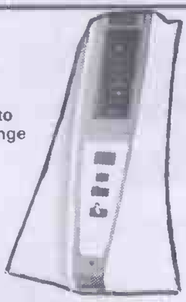

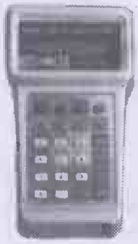

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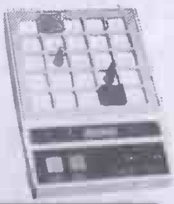

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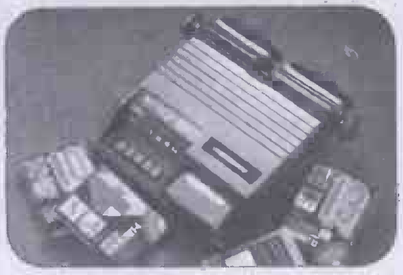

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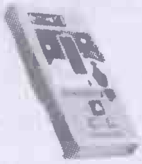

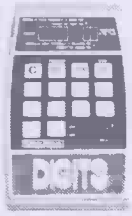

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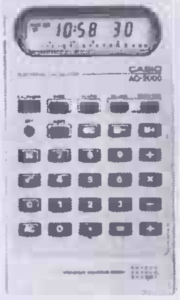

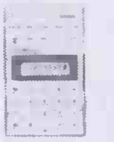

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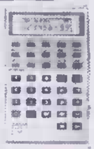

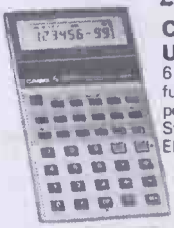

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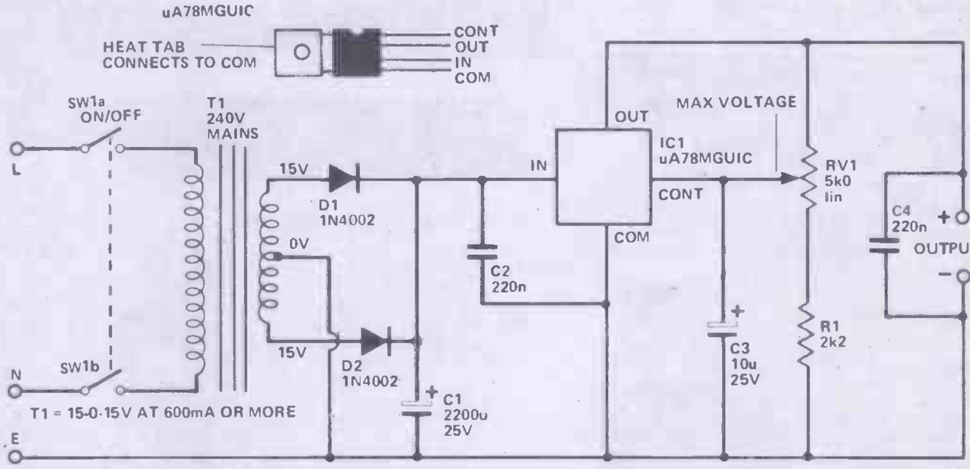

Although variable voltage power supplies having good regulation and electronic overload protection used to be fairly complex pieces of equipment, using modern circuitry it is possible to build such a unit using just one IC and a few passive components. The unit described here has an output voltage which is variable from 5 to 15 volts, and a maximum output current of 500mA, can be provided. The output is extremely well stabilised and the output noise is well below 1mV.

The mains supply is connected to the primary winding of isolation and step-down transformer T1 through on/off switch SW1. The centre tapped secondary of T1 feeds a standing fullwave rectifier and smoothing circuit which uses D1, D2 and C1.

IC1 is the voltage regulator chip, and this has four terminals. The unregulated input voltage is applied to the "IN" and "COM" terminals, while the stabilised output is taken from the "OUT" and "COM" terminals. The fourth terminal is the "CONT" one, and if this is fed from the output via a potential divider, a negative feedback action will stabilise the voltage at this terminal at a nominal level of 5 volts. In this case the potential divider is formed by RV1 and R1. If RV1 slider is at the top of its track the output will be stabilised at 5 volts. A higher voltage would take the "CONT" terminal (which is directly connected to the output) above 5 volts, causing the error to be sensed and corrected. Similarly, a lower voltage would take the "CONT" terminal below 5 volts, causing the output to swing more positive and correct the error.

If TV1 slider is moved down its track, the voltage fed to the "CONT" terminal will decrease, sending the output higher in order to return this potential to 5 volts. Thus RV1 can be used to vary the output voltage, with a maximum potential of about 16 volts or so appearing at the output when RV1 slider is at the bottom of its track. The feedback action accurately stabilises the output at the potential set using RV1, but only at output levels up to about 15 volts. Above this level, at high output currents, there will be insufficient input voltage from the rectifier and smoothing circuit to properly maintain the output voltage.

The regulator device has built-in foldback current limiting which prevents the output from much exceeding 500 mA in the event of a minor overload. Stronger overloads result in decreased output current, the short circuit current being only about 200 mA!

Decoupling capacitors C2 and C3 should be mounted physically close to IC1. IC1 must be mounted on a substantial heatsink, which can be the metal case of the unit.

DATA SUPPLEMENT PART 2

PRESENTED FREE WITH DECEMBER HOBBY ELECTRONICS

As promised we now proudly present part two of our sixteen page data supplement. This month we cover such diverse subjects as Batteries, what they do and what they are good for, and MPU glossary, we hope to be dealing with these beasts in some detail in the not-too-distant future, so keep it handy. TTL Pin-Outs, they may not be as popular as CMOS but there's still a lot that only TTL devices can do, so they'll be with us for some time yet.

We hope you will keep this supplement handy, you should be able to find out just about anything you will ever need to know but just in case we've left anything out we will be updating these pages from time to time and you can be sure that if anything radically new comes along we will be amongst the first to tell you about it. Pull it out and staple it to part one.

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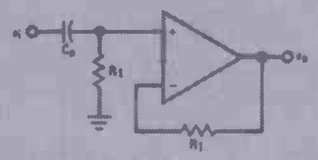
STANDARD OPERATIONAL AMPLIFIER CIRCUITS

Non-Inverting Buffer



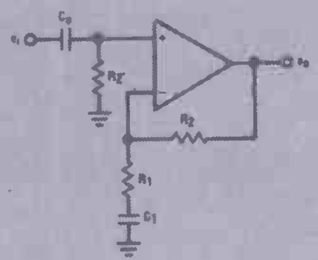
$A_v = 1$

$R_{in} = R_1$

$f_o = \frac{1}{2\pi R_1 C_o}$

Definitions.
Av = Closed loop AC Gain
fo = Low frequency −3dB corner
Rin = Input Impedance

Non-Inverting AC Amplifier

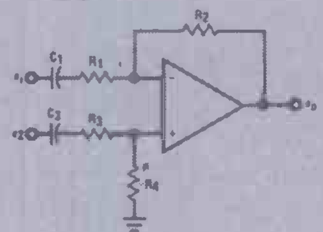


$A_v = 1 + \frac{R_2}{R_1}$

$R_{in} = R_2$

$f_o = \frac{1}{2\pi R_2 C_o} = \frac{1}{2\pi R_1 C_1}$

Difference Amplifier



$e_o = \left(\frac{R_1 + R_2}{R_3 + R_4}\right)\frac{R_4}{R_1} e_2 - \frac{R_2}{R_1} e_1$

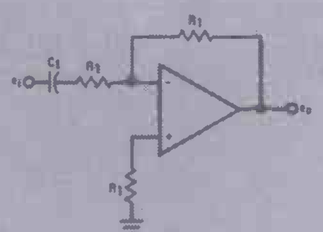
IF $R_1 = R_3$* AND $R_2 = R_4$* THEN

$e_o = \frac{R_2}{R_1}(e_2 - e_1)$

$f_o = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi (R_3 + R_4) C_3}$

$R_2 = R_4$ FOR MINIMAL OFFSET ERROR

Inverting Buffer

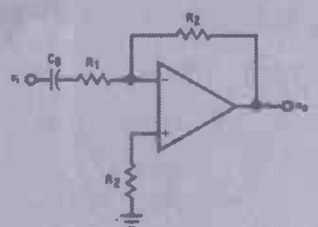


Av = −1

$R_{in} = R_1$

$f_o = \frac{1}{2\pi R_1 C_1}$

Inverting AC Amplifier

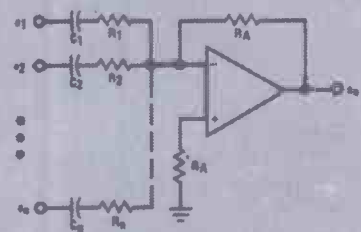


$A_v = -\frac{R_2}{R_1}$

$R_{in} = R_1$

$f_o = \frac{1}{2\pi R_1 C_o}$

Inverting Summing Amplifier



$e_o = -R_A\left(\frac{e_1}{R_1} + \frac{e_2}{R_2} + \ldots + \frac{e_n}{R_N}\right)$

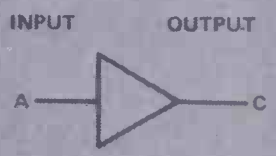
IF $R_1 = R_2 = \ldots = R_N$ THEN

$e_o = -\frac{R_A}{R_1}(e_1 + e_2 + \ldots + e_n)$

THE SUPPLY CONNECTIONS HAVE BEEN OMITTED IN THE ABOVE CONFIGURATIONS FOR THE SAKE OF CLARITY.

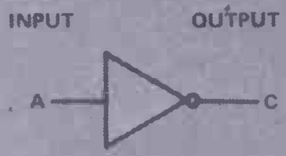
LOGIC GATE TRUTH TABLES

BUFFER



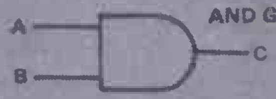
A	C
0	0
1	1

INVERTER



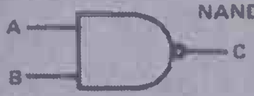
A	C
0	1
1	0

AND GATE



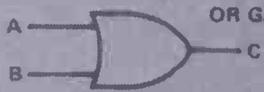
A	B	C
0	0	0
1	0	0
0	1	0
1	1	1

NAND GATE



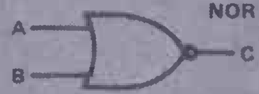
A	B	C
0	0	1
1	0	1
0	1	1
1	1	0

OR GATE



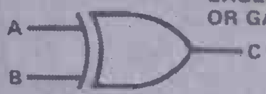
A	B	C
0	0	0
1	0	1
0	1	1
1	1	1

NOR GATE



A	B	C
0	0	1
1	0	0
0	1	0
1	1	0

EXCLUSIVE OR GATE



A	B	C
0	0	0
1	0	1
0	1	1
1	1	0

EXCLUSIVE NOR GATE

A	B	C
0	0	1
1	0	0
0	1	0
1	1	1

LAWS OF BOOLEAN ALGEBRA

$A + 0 = A$ $\quad$ $A.A = A$

$A + 1 = 1$ $\quad$ $A + \overline{A} = 1$

$A.0 = 0$ $\quad$ $A.\overline{A} = 0$

$A + A = A$ $\quad$ $A.1 = A$

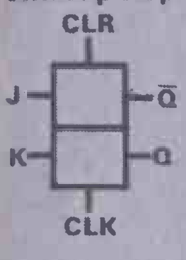
$A.B + A.C = A(B + C)$

$A + B.C = (A + B)(A + C)$

$\overline{A.B.C} = \overline{A} + \overline{B} + \overline{C}$

$\overline{A}.\overline{B}.\overline{C}. = \overline{A + B + C}$

J.K. Flip Flop



INPUTS				OUTPUTS	
CLR	CLK	J	K	Q	$\overline{Q}$
0	X	X	X	0	1
1	⎍	0	0	Qo	$\overline{Qo}$
1	⎍	1	0	1	0
1	⎍	0	1	0	1
1	⎍	1	1	TOGGLE	

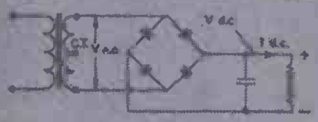
⎍ –HIGH LEVEL PULSE, DATA IS TRANSFERRED ON FALLING EDGE OF PULSE.

Qo –THE LEVEL OF Q BEFORE INDICATED INPUT CONDITIONS WHERE ESTABLISHED.

TOGGLE –EACH OUTPUT CHANGES TO ITS COMPLEMENT ON EACH ACTIVE TRANSIENT (PULSE OF CLOCK).

STANDARD POWER SUPPLY CONFIGURATIONS

FULL-WAVE BRIDGE – CAPACITIVE INPUT FILTER

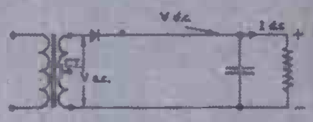


V d.c.=1·41×V a.c.
I d.c.=0·62×I a.c.

FULL-WAVE BRIDGE – RESISTIVE LOAD

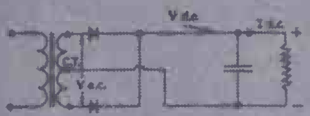
V d.c.=0·90×V a.c.
I d.c.=0·90×I a.c.

HALF-WAVE – CAPACITIVE INPUT FILTER



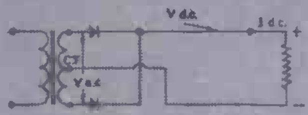
V d.c.=1·41×V a.c.
I d.c.=0·28×I a.c.

FULL-WAVE – CAPACITIVE INPUT FILTER



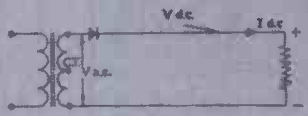
V d.c.=0·71×V a.c.
I d.c.=1·0×I a.c.

FULL-WAVE – RESISTIVE LOAD



V d.c.=0·45×V a.c.
I d.c.=1·27×I a.c.

HALF-WAVE – RESISTIVE LOAD



V d.c.=0·45×V a.c.
I d.c.=0·64×I a.c.

TTL FUNCTIONS

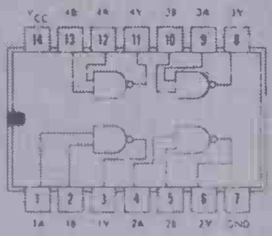
Device	Description
7400	Quad 2-input Positive NAND Gate
7401	Quad 2-input Positive NAND Gate (open collector o/p)
7401A	Quad 2-input Positive NAND Gate (open collector o/p)
7402	Quad 2-input Positive NOR Gate (open collector o/p)
7403	Quad 2-input Positive NAND Gate (open collector o/p)
7404	Hex Inverter
7405A	Hex Inverter (open collector o/p)
7406	Hex Inverter/Buffer 30V o/p
7407	Hex Buffer 30V o/p
7408	Quad 2-input Positive AND Gate
7409	Quad 2-input Positive AND Gate
7410	Triple 3-input Positive NAND Gate
7412	Triple 3-input NAND Gate (open collector o/p)
7413	Dual 4-input Schmitt Trigger
7414	Schmitt Hex Inverter Buffer
7416	Hex Inverter/Buffer 15V o/p
7417	Hex Buffer 15V o/p
7420	Dual 4-input Positive NAND Gate
7421	Dual 4-input AND Gate
7426	Quad 2-input High Voltage Interface NAND Gate
7427	Triple 3-input NOR Gate
7428	Quad 2-input NOR Buffer (Fan Out 30)
7430	8-input Positive NAND Gate
7432	Quad 2-input OR Gate
7433A	Quad 2-input NOR Buffer 15V
7437	Quad 2-input NAND Buffer
7438A	Quad 2-input NAND Buffer 15V
7441A	BCD-to-Decimal Decoder/Nixie Driver
7442	BCD-to-Decimal Decoder
7445	BCD-to-Decimal Decoder/Driver 30V output o/c
7446A	BCD-to-Seven Segment Decoder/Driver 30V/40mA
7447	BCD-to-Seven Segment Decoder/Driver 15V/20mA
7447A	BCD-to-Seven Segment Decoder/Driver 15V/40mA
7448	BCD-to-Seven Segment Decoder/Driver
7450	Expandable Dual 2 wide, 2 i/p AND-OR-INVERT Gate
7451	Dual 2 wide, 2 i/p AND-OR-INVERT Gate
7453	Expandable 4 wide, 2 i/p AND-OR-INVERT Gate
7454	4 wide 2-input AND-OR-INVERT Gate
7460	Dual 4-input Expander
7470	Positive Edge-triggered J-K Flip Flops
7472	J-K Master-Slave Flip Flops (AND inputs)
7473	Dual J-K Master Slave Flip Flops
7474	Dual D-Type Edge Triggered Flip Flops
7475	4-bit bistable latch=Quad bistable latch
7476	Dual J-K Master Slave Flip Flops+preset and clear
7481	16-bit Active Element Memory
7482	2-bit Binary Full Addder
7484	16-bit Active Element Memory
7485	4-bit Comparator
7486	Quad 2-input Exclusive Or Gate
7489	64-bit RAM (16 x 4W)
7490	Decade Counter
7491	8-bit Shift Registers
7492	Divide-by-twelve Counter
7493	4-bit Binary Counter
7494	4-bit Shift Registers (Parallel-In, Serial-Out)
7495	4-bit Right Shift, Left Shift Register
7496	5-bit Shift Registers (Dual Para-in, Para-Out)
74100	8-bit Bistable Latch
74107	Dual J-K Master Slave Flip Flop
74121	Monostable Multivibrator
74122	Monostable Multivibrator with reset
74123	Dual Monostable Multivibrator with reset
74124	Universal Pulse Generator
74138	3 line to 8 line Decoder/Demultiplexer
74141	BCD-to-Decimal Decoder/Driver
74145	BCD-to-Seven Segment Decoder/Driver 15V output
74150	16-bit Data Selector
74151	8-bit Data Selector (with strobe)
74153	Dual 4 to 1 line Data Selector 1 MPX
74154	4 line to 16 line Decoder
74155	Dual 2-to-4 line Decoder/DeMPX (totem pole output)
74156	Dual 2-to-4 line Decoder/DeMPX (open collector output)
74157	Quad 2 line to 1 line Selector
74160	Synchronous Decade Counter
74162	Synchronous Decade Counter
74163	Synchronous Binary Counter
74164	8-bit Shift Register, Serial In-Parallel Out
74165	8-bit Shift Register, Parallel In-Serial Out
74174	Hex Type "D" Flip Flop
74175	Quad "D" Flip Flop with common reset
74180	8-bit Odd/Even Parity Generator/Checkers
74181	4-bit Arithmetic Logic Out
74182	Carry-Look-Ahead Unit
74190	Synchronous Up/Down Decade Counter (Single Clock Unit)
74191	Synchronous Up/Down 4-bit Binary Counter
74192	Synchronous 4-bit Up/Down Counter
74193	Synchronous 4-bit Up/Down Counter
74195	Synchronous 4-bit Parallel Shift Register with J-K inputs
74196	50Mhz Presettable Decade Counter/Latch (Bi-Quinary)
74200	256-bit Random Access Memory (RAM)

TTL PIN-OUTS

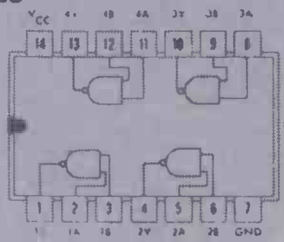
TTL devices are almost as numerous as CMOS ICs, so we've had to condense this section of the Data Supplement into what we consider are the most popular or yet to be rivalled devices. Manufacturers are making extravagant new claims for their new devices almost daily but we firmly believe that TTL will be with us for some time to come. The high frequency ability and their inherent ruggedness in the face of high voltages or static discharge make them indispensible for many applications.

For further information on these devices see page xi in this supplement. For a comparison of the various functions between CMOS and TTL see page 111 in last month's data supplement. The truth tables on page x apply equally to both TTL and CMOS so will give you a clearer insight into the operation of these devices.

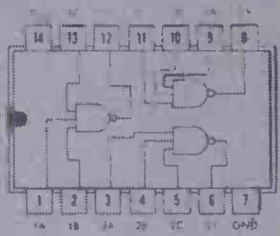
SN7400 QUADRUPLE 2-INPUT POSITIVE NAND GATES



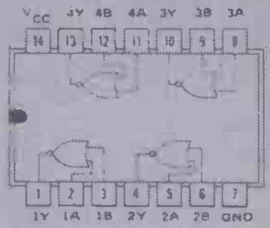
SN7401 QUADRUPLE 2-INPUT OPEN-COLLECTOR NAND GATES



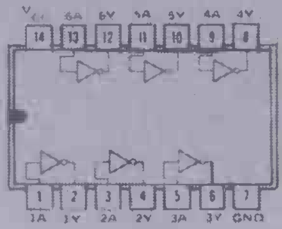
SN7410 TRIPLE 3-INPUT POSITIVE NAND GATES



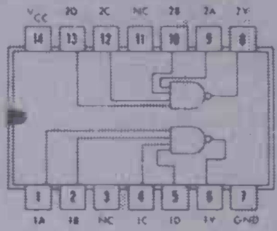
SN7402 QUADRUPLE 2-INPUT POSITIVE NOR GATES



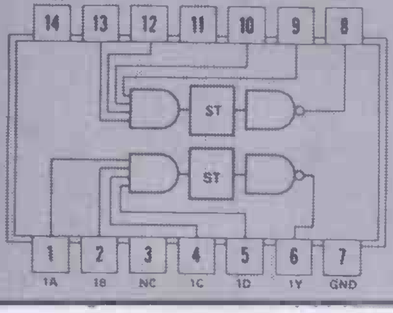
SN7404 HEX INVERTERS



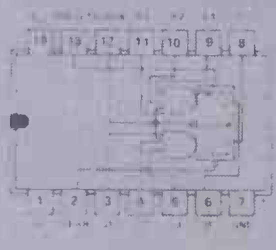
SN7420 DUAL 4-INPUT POSITIVE NAND GATES



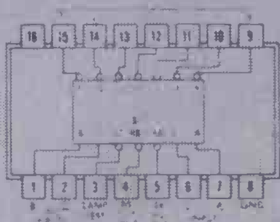
SN7413 DUAL NAND SCHMITT TRIGGERS



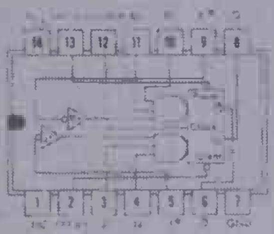
SN7472 J-K MASTER SLAVE FLIP-FLOPS



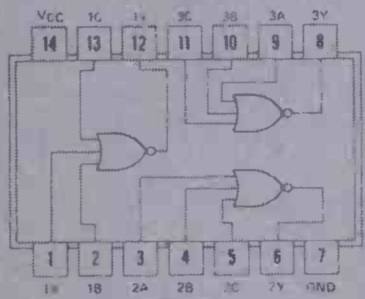
SN7447A BCD-TO-SEVEN-SEGMENT DECODER/DRIVE



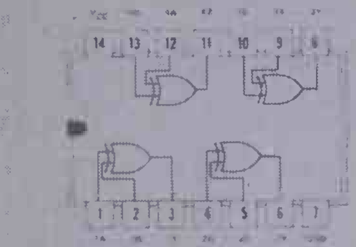
SN7470 EDGE-TRIGGERED J-K FLIP-FLOPS



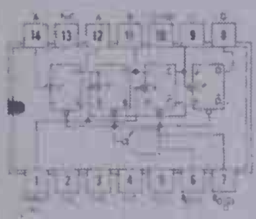
SN7427 TRIPLE 3-INPUT POSITIVE-NOR GATES



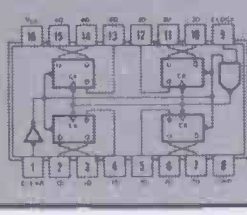
SN7486 QUADRUPLE 2-INPUT EXCLUSIVE-OR GATES



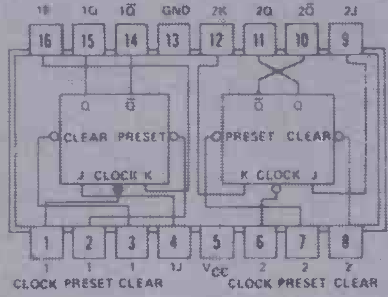
SN7492 DIVIDE-BY-TWO AND DIVIDE-BY-SIX COUNTERS



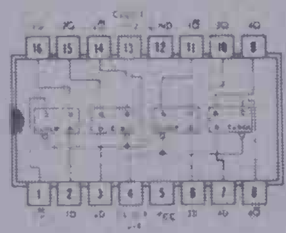
SN74175 QUAD D-TYPE FLIP-FLOP



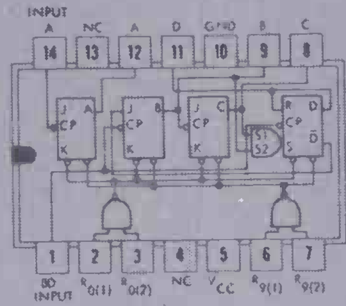
SN7476 DUAL J-K MASTER-SLAVE FLIP-FLOPS WITH PRE-SET AND CLEAR



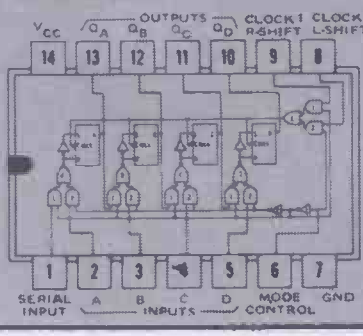
SN7475 4-BIT BISTABLE LATCHES



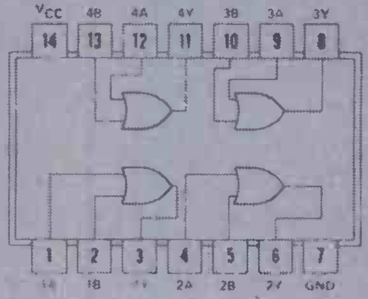
SN7490 DECADE COUNTERS



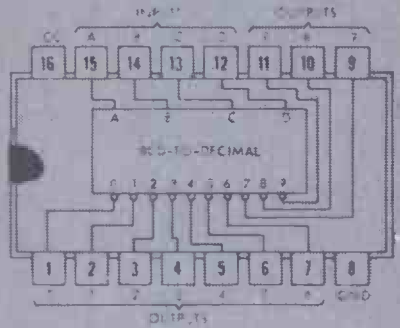
SN7495A 4-BIT RIGHT-SHIFT LEFT-SHIFT REGISTERS



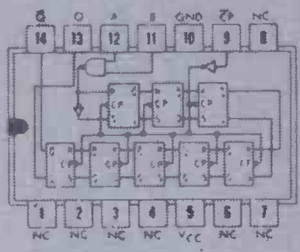
SN7432 QUADRUPLE 2-INPUT POSITIVE-OR GATES



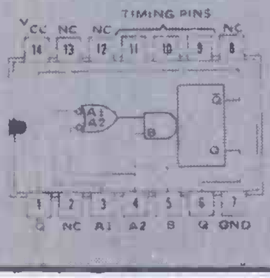
SN7445, SN74145 BCD-TO-DECIMAL DECODER/DRIVERS



SN7491A 8-BIT SHIFT REGISTERS



SN74121 MONOSTABLE MULTIVIBRATORS



System	Anode	Cathode	Electrolyte	Open current voltage,	Typical operating voltage;	Capacity Ah/lb[a]	Capacity Wh/lb[b]	Remarks
Primary systems Leclanche	Zn(Hg)	$MnO_2(C)$	$NH_4Cl-ZnCl_2$	1.6	0.9-1.4	23	30	most common form of the dry cell; extensive applications; sloping discharge curve
Alkaline Zn-MnO_2	Zn(Hg)	$MnO_2(C)$	KOH	1.52	0.9-1.2	30	33	suitable for greater drain rates than Leclanche cells; sloping discharge curve
mercury cell (Rubin)	Zn(Hg)	HgO(C)	KOH-ZnO	1.35	1.30	40	53	constant voltage during discharge; heavier drains and higher capacity than Leclanche cells
Mg–MnO_2	Mg	$MnO_2(C)$	$MgBr_3$, Li_2CrO_4	2.0	1.6-1.8	30	46	higher capacity and voltage than Leclanche cell; 35–40% of magnesium consumed in hydrogen liberation during discharge
air-depolarised Zn	Zn(Hg)	$O_2(C)$	KOH	1.36	1.1-1.2	60[b]	70[b]	utilizes oxygen from air; wet type used for railway signals, home radios; dry type available but moisture loss a problem
Zn-AgO	Zn	AgO	KOH	1.8	1.4-1.5	35	53	one-shot, high-drain-rate reserve cell; also available in another form as a secondary battery
Zn-PbO_2	Zn	PbO_2	H_2SO_4	2.5	2.0-2.3	12	26	one-shot, high-drain-rate reserve cell
Zn-CuO	Zn(Hg)	CuO	NaOH	1.06	0.9-1.0			low operating voltage; used principally for railway signals
Zn-Cl_2	Zn	$ZnCl_2$	Cl_2	2.1	1.5-1.9			one-shot, high-drain-rate cell
Pb-PbO_2-$HClO_4$	Pb	PbO_2	$HClO_4$	2.0	1.6-1.8	11	19	one-shot, high-drain reserve types used for military applications
thermal cell	Ca	$PbCrO_4$(Ni)	LiCl, KCl fused	2.8	2.2			must be heated to melt electrolyte, one-shot, high-drain, military type cell
Mg-Cu_2Cl	Mg	Cu_2Cl	$MgCl_2$	1.4	1.1-1.3	25	30	one-shot, high-drain reserve cell; may be activated with sea water
Mg-AgCl	Mg	AgCl	$MgCl_2$	1.6	1.3-1.5	54	75	one-shot, high-drain reserve cell with very high capacity; may be activated with sea water
Zn-V_2O_3	Zn	V_2O_3	NH_4OH, ethylene glycol, boric acid	1.2	1.2			available commercially as a bias cell providing stable voltage at zero current over long periods
Weston standard	Cd(Hg)	Hg	$HgSO_4$, $CdSO_4$	1.019	1.2			used as a voltage standard
solid electrolyte	Ag	$CuBr_2$	AgBr	0.75				power source for radiation warning devices; charging source for low-leakage capacitors
Fery cell	Zn	$O_2(C)$	NH_4Cl	1.2	0.7			used extensively in foreign countries for telegraphy and telephone service; performs efficiently at low drains
Zn-AgrO	Zn	Ag_2O	KOH or NaOH	1.6	1.5	33	49	small sealed primary cell for electric wrist watch or hearing aid use; hermetically sealed
In-HgO	In	HgO	KOH	1.15	1.05			electric wrist watch battery; hermetically sealed
Experimental cells (primary) organic cathode	Mg	*m*-dinitro-benzene	$MgBr_2$	1.65	1.15[d]	56	65	one of the more promising of a large number of organic compounds being considered; multistep discharge
solid electrolyte	Ag	V_2O_3	AgI	0.46	0.38-0.46[d]			typical of a variety of similar systems that could be made commercially if applications warranted: thin flat cells providing 100 V/in. of battery length
Al-MnO_2	Al	MnO_2	$AlCl_3.(NH_4)_2Cr_2O_7$	1.7	1.3			higher capacity and voltage than Leclanche cell; wasteful corrosion of aluminium remains a major problem
Mg-Bi_2O_3	Mg	Bi_2O_3	$MgBr_2$	1.6	1.0	6		operates 0.2-0.3 V lower potential than HgO-Zn system but otherwise has similar voltage-time discharge characteristics
Secondary cells lead acid	Pb	PbO_2	H_2SO_4	2.2	1.95-2.05	10	20	conventional lead storage cell
Edison	Fe	Ni oxides	KOH	1.6	1.2-1.4	10	13	much longer useful life than lead storage cell but lower capacity and more expensive
	Cd	Ni oxides	KOH	1.35	1.1-1.3	10	12	available as a completely sealed cell
Cd-NiO Zn-AgO	Zn	AgO	KOH, ZnO	1.8	1.4-1.5	35	53	very high capacity and suitable for high discharge rates but smaller number of cycles than Ni-Cd or lead storage cells
Cd-AgO	Cd	AgO	KOH	1.4	1.0-1.1	30	33	greater number of cycles than Zn-AgO secondary cell
MnO-Zn	Zn	MnO_2	KOH	1.5		8	9	available only as a completely sealed cell

a Based on total weight of commonly available size of commercial cells.
b Exclusive of O_2 consumed from air.
c Average voltage for light-drain application.
d 2×10^{-10} A/in.^{2} drain for the first 7 yr of cell life.

MPU GLOSSARY

ACCUMULATOR The register where arithmetic or logic results are held Most MPU instructions manipulate or test the accumulator contents
ACCESS TIME. Time take for specific byte of storage to become available to processor
ACIA Asynchronous Communication Inter-face Adapter Inter-face between asynchronous peripheral and an MPU
ALU Arithmetic and Logic Unit The part of the MPU where arithmetic and logic functions are performed.
ASCII American Standard Code for Information Interchange Binary code to represent alphanumeric special and control characters
ASSEMBLER Software which converts assembly language statements into machine code and checks for non valid statements or incomplete definitions
ASSEMBLY LANG Means of representing programme statements in mnemonics and conveniently handling memory addressing by use of symbolic terms
ASYNCHRONOUS Operations that initiate a new operation immediately upon completion of current one — not timed by system clock
BASIC Beginner's All Purpose Symolic Instruction Code An easy to learn widely used high level language
BAUD Measure of speed of transmission line Number of times a line changes state per second Equal to bits per second if each line state represents logic 0 or 1
BAUDOT CODE 5 bit code used to encode alphanumeric data
BCD Binary Coded Decimal Means of representing decimal numbers where each figure is replaced by a binary equivalent
BENCHMARK A common task for the implementation of which programmes can be written for different MPUs in order to determine the efficiency of the different MPUs in the particular application
BINARY The two base number system The digits are 0 or 1 They are used inside a computer to represent the two states of an electric circuit
BIT A single binary digit
BREAKPOINT Program address at which execution will be halted to allow debugging or data entry
BUFFER Circuit to provide isolation between sensitive parts of a system and the rest of that system
BUG A program error that causes the program to malfunction
BUS The interconnections in a system that carry parallel binary data Several bus users are connected to the bus, but generally only one sender and one receiver are active at any one instant
BYTE A group of bits — the most common byte size is eight bits.
CLOCK The basic timing for a MPU chip
COMPILER Software which converts high level language statements into either assembly language statements or into machine code
CPU. Central processor unit The part of a system which performs calculation and data manipulation functions
CROM Control Read Only Memory
CRT Cathode Ray Tube. Often taken to mean complete output device
CUTS Computer Users Tape System Definition of system for storing data on cassette tape as series of tones to represent binary 1 s and 0 s
DEBUG The process of checking and correcting any program errors either in writing or in actual function
DIRECT ADDRESSING An addressing mode where the address of the operand is contained in the instruction
DMA Direct Memory Access
DUPLEX Transfer of data in two directions simultaneously
ENVIRONMENT The conditions of all registers flags etc at any instant in program
EPROM Electrically Programmable Read Only Memory Memory that may be erased (usually by ultra violet light) and reprogrammed electrically
EXECUTE To perform a sequence of program steps
EXECUTION TIME The time taken to perform an instruction in terms of clock cycles
FIRMWARE Instructions or data permanently stored in ROM
FLAG A flip flop that may be set or reset under software control
FLIP-FLOP Two state device that changes state when clocked
FLOPPY (DISK) Mass storage which makes use of flexible disks made of a material similar to magnetic tape
FLOW CHART A diagram representing the logic of a computer program
GLITCH Noise pulse
HALF DUPLEX Data transfer in two directions but only one way at a time
HAND SHAKE System of data transfer between CPU and peripheral whereby CPU 'asks' peripheral if it will accept data and only transfers data if answer is yes
HARD COPY System output that is printed on paper
HARDWARE All the electronic and mechanical components making up a system
HARD WIRE Circuits that are comprised of logic gates wired together, the wiring pattern determining the overall logic operation
HASH Noisy signal
HEXADECIMAL The base 16 number system Character set is decimal 0 to 9 and letters A to F
HIGH LEVEL LANGUAGE Computer language that is easy to use but which requires compiling into machine code before it can be used by an MPU
HIGHWAY As BUS
IMMEDIATE ADDRESSING Addressing mode which uses part of the instruction itself as the operand data
INDEXED ADDRESSING. A form of indirect addressing which uses an Index Register to hold the address of the operand
INDIRECT ADDRESSING Addressing mode where the address of the location where the address of the operand may be found is contained in the instruction
INITIALISE Set up all registers flag etc to defined conditions
INSTRUCTION Bit pattern which must be supplied to an MPU to cause it to perform a particular function
INSTRUCTION REGISTER MPU register which is used to hold instructions fetched from memory
INSTRUCTION SET The repertoire of instructions that a given MPU can perform
INTERFACE Circuit which connects different parts of system together and performs any processing of signals in order to make transfer possible ie serial — parallel conversion)
INTERPRETER An interpreter is a software routine which accepts and executes a high level language program but unlike a compiler does not produce intermediate machine code listing but converts each instruction as received
INTERRUPT A signal to the MPU which will cause it to change from its present task to another
I O Input Output
K Abbreviation for 2^{10} = 1028
KANSAS CITY (Format) Definition of a CUTS based cassette interface system
LANGUAGE A systemmatic means of communicating with an MPU
LATCH Retains previous input state until overwritten
LIFO Last In First Out Used to describe data stack
LOOPING Program technique where one section of program the loop) is performed many times over
MACHINE LANG The lowest level of program The only language an MPU can understand without interpreter
MASK Bit pattern used in conjunction with a logic operation to select a particular bit or bits from machine word
MEMORY The part of a system which stores data working data or instruction object code
MEMORY MAP Chart showing the memory allocation of a system
MEMORY MAPPED I O A technique of implementing I O facilities by addressing I O ports as if they were memory locations
MICRO CYCLE Single program step in an MPUs Micro program The smallest level of machine program step
MICRO PROCESSOR A CPU implemented by use of large scale integrated circuits Frequently implemented on a single chip
MICRO PROGRAM Program inside MPU which controls the MPU chip during its basic fetch execute sequence
MNEMONIC A word or phrase which stands for another longer) phrase and is easier to remember
MODEM Modulator demodulator used to send and receive serial data over an audio link
NON VOLATIVE Memory which will retain data content after power supply is removed e g ROM
OBJECT CODE To bit patterns that are presented to the MPU as instructions and data
O/C Open Collector Means of tieing together O/P s from different devices on the same bus
OCTAL Base 8 number system Character set is decimal 0-8
OP CODE Operation Code A bit pattern which specifies a machine operation in the CPU
OPERAND Data used by machine operations
PARALLEL Transfer of two or more bits at the same time
PARITY Check bit added to data can be odd or even parity In odd parity sum of data 1 s + parity bit is odd
PERIPHERAL Equipment for inputing to or outputting from the system e g teletype VDU etc)
PIA Peripheral Interface Adapter
POP Operation of removing data word from LIFO stack
PORT A terminal which the MPU uses to communicate with the outside world
PROGRAMS Set of MPU instructions which instruct the MPU to carry out a particular task
PROGRAM COUNTER Register which holds the address of next instruction (or data word) of the program being executed
PROM Programmable read only memory Proms are special form of ROM which can be individually programmed by user
PUSH Operation of putting data to LIFO stack
RAM Random Access Memory Read write memory Data may be written to or read from any location in this type of memory
REGISTER General purpose MPU storage location that will hold one MPU word
RELATIVE ADDRESSING Mode of addressing whereby address of operand is formed by combining current program count with a displacement value which is part of the instruction
ROM Read Only Memory Memory device which has its data content established as part of manufacture and cannot be changed
SCRATCH PAD Memory that has short access time and is used by system for short term data storage
SERIAL Transfer of data one bit at a time
SIMPLEX Data transmission in one direction only
SOFTWARE Programs stored on any media
SOURCE CODE The list of statements that make up a program
STACK A last in first out store made up of registers or memory locations used for stack
STATUS REGISTER Register that is used to store the condition of the accumulator after an instruction has been performed e g Acc = 0)
SUB ROUTINE A sequence of instructions which perform an often required function, which can be called from any point in the main program
SYNTAX The grammar of a programming language
TRAP Vector) Pre-defined location in memory which the processor will read as a result of particular condition or operation
TRI STATE Description of logic devices whose outputs may be disabled by placing them in a high impedance state
TTY Teletype
TWO S COMPLEMENT ARITHMETIC System of performing signed arithmetic with binary numbers
UART Universal Asynchronous Receiver Transmitter
VDU Video Display Unit
VECTOR Memory address provided to the processor to direct it to a new area in memory
VOLATILE Memory devices that will lose data content if power supply removed i e RAM)
WORD Parallel collection of binary digits much as byte

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2 Gresham Road,
Brentwood,
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Ware,
Herts

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Birmingham,
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GREENBANK
92 New Chester Road,
New Ferry,
Wirral,
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Essex,
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MARSHALLS
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STEVENSON ELECTRONIC COMPONENTS
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BR1 1DE

TECHNOMATIC LTD
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London,
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WATFORD ELECTRONICS
33/35 Cardiff Road,
Watford,
Herts

ERRATA—HE COMES CLEAN

To date we have made one or two errors, so for everyone that may have missed our regular Errata update in our Monitor pages, we've decided to own up and publish all of the errors we've managed to track down. Obviously during the course of a year, especially our first year, there are quite a few but we think we've got most of them. Rest assured though, if we do this, on our second birthday there won't be enough to fill one line — we hope.

NOV 78

HOBBIT
RV1, RV2 — 100k lin.
RV3 — 47k lin.
RV4 — 47k lin

WAA-WAA
Bottom of RV2 connected to IC1 pin 3.
Overlay, input and output from C1 and C4 are via SW2.

DEC 78

LED DICE
Pin-outs on LEDs as shown are not universal — reverse if inoperative.

SHORT CIRCUIT — ONE TRANSISTOR AMPLIFIER
R1 and R2 = 100k, current = 10µA.

FEB 79

SINE/SQUARE GENERATOR
SW1b. Invert position of Cs 5-8 with switch.
SW2b. Position 3 disconnect, connect 1 and 2.

MAY 79

DIGIBELL
Link missing between D1 and IC2 pin 1 on PCB. Connect pins 5, 6, 8, 9, 12, 13 to 0V line to reduce current consumption.

WHITE NOISE GENERATOR
PCB foil pattern reversed.

AUGUST 79

INJECTOR/TRACER
PCB overlay 180° out of registration.

SEPT 79

ULTRASONIC REMOTE CONTROL
Values of C5 and 6 correct on parts list.

COMBINATION LOCK
Connection D to tage 1 on SW2.
Connection F to tag 11 on SW2.
Connection C to tage 8 on SW1.
Connection E to tag 4 on SW2.

STARBURST
R14, 13, and 12 should read R7, 8, and 9. 0V and 9V connections on overlay reversed.

Project Fault Finding

One of the backroom boys on the Project Team, Keith Brindley, comes up front to discuss a largely ignored topic in the art of project building and gives a few hints how to go about fault finding.

IN THE BEGINNING there's the first project — a fuzz box, a light chaser or a photographic timer — and it doesn't work!! You spend hours going through the circuit, checking that you have got all the components in as the diagram says and you *still* can't figure out what the fault is. Blast — throw it in the bin. But wait a minute, it cost you £6.50. Well maybe you can re-use the components in your next project. Let's see, what's in this month's copy of Hobby?

Bang — and before you know it, you have caught the bug (No, not 'flu' you fool — the electronics bug). And if you are like countless thousands of others you'll never get rid of it. Every time you go into a newsagent's your eyes will wander to the magazine section looking for the new edition of Hobby or ETI. You may even sink low enough to look at some of our competitors — not buy, just look (of course, you will *only* buy Hobby).

Be that as it may, your first project doesn't work and what is more your second probably won't either. But don't let me put you off or depress you. After all, YOU are our livelihood. In fact, figures would probably show that a beginner only stands about a one in 10 chance of first time success. However, looking on the brighter side, the chances are that the reasons for your circuit not working are only minor.

The trick is to be able to detect a fault, because unfortunately they don't jump up and shout to be found. Normally this knack will only be acquired with practice of building circuits, but that is not to say that it can't be learned!

TROUBLESOME TWOSOME

Faults can broadly be classified into two groups:
1) user induced
2) component fault

Of the two groups, the most likely to cause a fault would be group one — user induced faults. This is mainly to do with the fact that the beginner, not knowing the right techniques, can make unintentional mistakes to his or her disadvantage. The obvious example of a fault in this category is a dry soldered joint.

Components, if bought from reliable stockists are not normally prone to faults if handled correctly, but it has been known.

Sometimes the two groups overlap — the reason being that the user has somehow induced a component fault. An example of this might be damage of a transistor by overheating when soldering.

A FAULT IS A FAULT IS A FAULT

Anyway, however caused, once the fault is there, it is not going to remove itself! It has to be located and repaired and the aim of this article is to suggest a few hints and clues how to go about this.

Every home should have one. The multimeter is the first and probably most useful piece of test-gear you can buy.

The best technique is to adopt a system of logical progression, eventually isolating the cause, or causes of non-function. There should be no guesswork involved.

First check the printed circuit board, making sure that all components are in their correct place. What about electrolytic capacitors — are they the right way round?

Are all semiconductors ie diodes, transistors, integrated circuits in the correct way? Remember that there is a possibility that a semiconductor which had previously been inserted incorrectly, could be damaged by this, and reinsertion in the correct manner may not repair the fault. A new component may be necessary.

As a matter of good practice it is better to undertake all of these suggested checks before even the first switch on — it may save the expense of a replaced component.

Look for dry joints (they have a knurled, grey appearance). Later in this article we look at a simple procedure for isolation of dry joints, which a visual check might not find.

Next, get a good idea of how the circuit works. This is done by reading the "How It Works" section which we publish with every project in Hobby. You may even have to read it a few times before it sinks in. As a general rule we try to describe a circuit in as simple a fashion as space allows, to help the amateur constructor. Try to picture what is going on in there eg in an audio amplifier bear in mind that a small input produces a large output. The input signal may be about 200 mv, but the output signal could be 10 volts. The popular integrated circuit amplifier, the LM 380 provides a useful case-study. Figure 1 shows the IC in a typical circuit, a two watt audio amplifier.

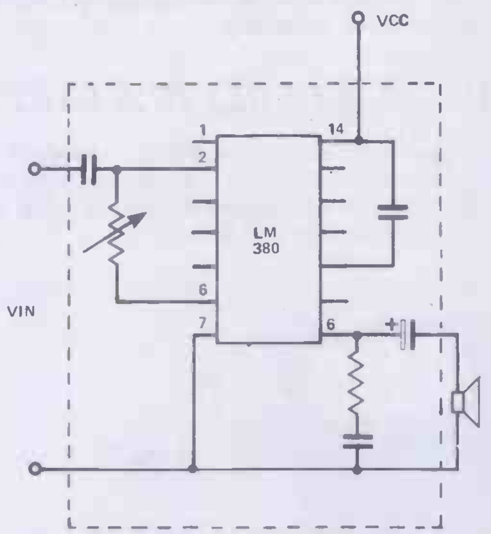


Fig. 1. The area inside the broken lines can be regarded as a 'Black Box' amplifier.

ALL BOXED UP

It can, however, be visualised in a much simpler fashion, the "black box". This term probably arises from the work of H. S. Black, who designated boxes into his circuit diagrams to represent complete amplifiers. In fact the modern representation of an operational amplifier in a circuit, as in figure 4, is really only a 'Black Box'. The area in broken lines in figbure 1 can be termed a black box and can be redrawn as in figure 2. In order for the black box amplifier to function correctly, certain connections obviously have to be made — power supply, volume control, i/p and o/p capacitors, etc, as shown in figure 1, although they are not shown in figure 2. But as long as we appreciate this then there is no reason why we can't think of an amplifier as a box. The same logic can be applied to literally any electronic circuit. As an aside, it is well worth remembering that a fault in a circuit using ICs, is much more likely to arise from these peripheral connections and components than from the main IC.

Fig. 2. A 'Black Box' amplifier. Note the complete lack of external circuitry.

LET YOUR MIND DO THE WORK

Try to reduce the whole circuit in your own mind to a number of black boxes, (as many as you need) say 2 or 3. Let us take for an example a typical mains to low voltage D.C. power supply as in figure 3.

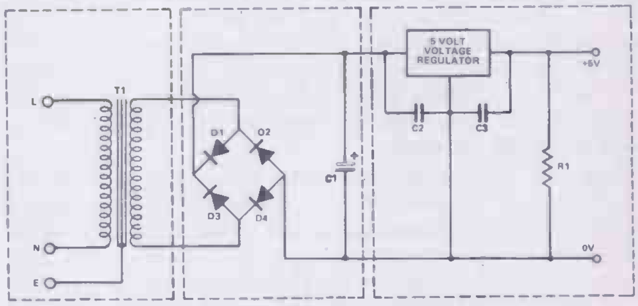


Fig. 3. Circuit diagram of a simple 5Vdc power supply.

Reducing the circuit diagram, which consists of ten components to black box symbols gives us something as in figure 4. The supply can be seen to have three main stages; a method of reducing the high voltage A.C. to low voltage, an A.C. to D.C. converter and a method of regulating the voltage. This is a much simpler representation of the supply than its corresponding circuit diagram but if we remember that there are certain peripherals to connect then it is every bit as accurate.

Fig. 4. Black box representation of mains power supply.

If the supply is malfunctioning then we should begin to check each individual black box in turn. It is wise to start at the first box and work to the last, because if the first box is not working then any following it won't either. In the example, therefore, we would look at the input to the transformer first (be careful — mains voltage can be lethal!). An A.C. voltmeter should give a reading of 240 V.C. If not, the fault is prior to this — perhaps a blown fuse?

Next, measure the output voltage of the transformer, which will depend on the transformer itself. In our theoretical example it should be about 6 volts. If all is correct so far we can move on to the next black box, the A.C. and D.C. coverter, whose output voltage should be approximately $\sqrt{2}$ x transformer output voltage = 8 volts D.C. After verifying the second black box is operational then we move to the final one and check this.

If you obtain any results at all from your project, for instance the power supply output might be 8 volts, then knowing this may help you to reduce the fault. In this example the problem is probably the IC voltage regulator itself, not functioning.

Remember, there may be more than one fault, in which case you will have to repair one at a time until the project fully works. The idea at this stage is to be as methodical as possible, isolating the area in which the fault lies and then finally pin-pointing the fault itself. The worst faults of all to find are intermittents. There one minute — gone the next. These were often caused in old valve circuits by rising temperature as the valves warmed up. Happily, a disappearing problem with the almost universal use of solid-state electronics.

TO (V)BE OR NOT TO (V)BE

In transistor circuits the voltage from base to emitter (Vbe) can be measured, giving a clue as to whether it works or not. In a silicon transistor this should be about 0.6 volts (see figure 5).

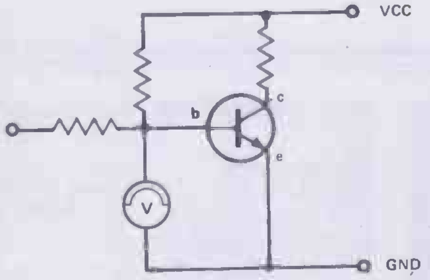


Fig. 5. The voltage from base to emitter for a silicon transistor should be 0.6 volts.

You can estimate unknown voltages, as in figure 6 and measure them to see if they correspond. Of course this is only an approximate method because the voltage depends on the resistance of the next stage after point A (which should if possible be taken into account in the voltage calculation).

With the use of a resistance meter, soldered joints can be checked in the vicinity of the fault by touching the probes onto component leads, which should be connected underneath the board by joints and copper track (see figure 7). If the meter shows zero resistance than all well and good, but it it shows a high resistance or even one of just a few ohms (probably due to dirt on the copper underneath the solder) then you have located a faulty joint.

If the fault still remains stubbornly hidden, the next step is to sub-divide the black boxes into smaller and smaller sections, checking each in turn, until finally you

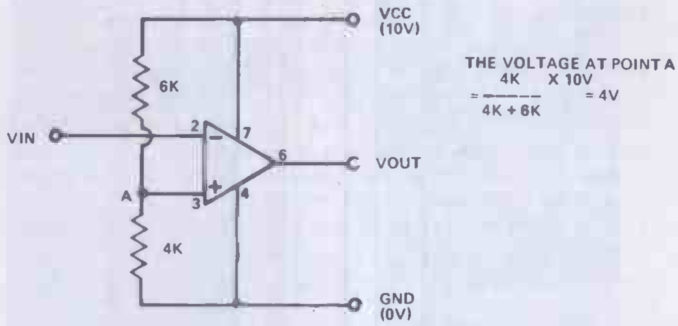
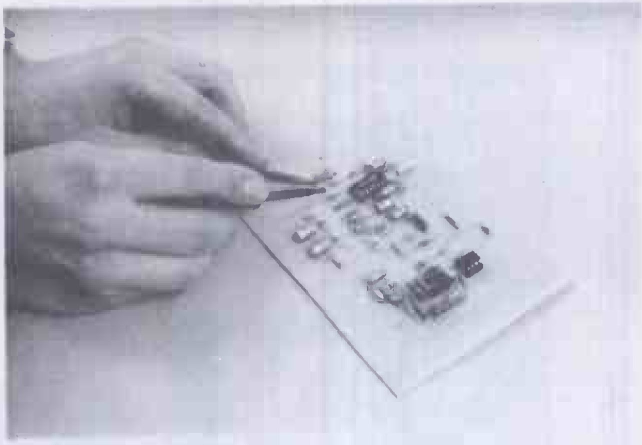


Fig. 6. Estimation of the voltage at point A. (With respect to 0 V.)

are considering individual components. These can be unsoldered and tested out of the printed circuit board if necessary.

Non electrolytic capacitors can be checked out of circuit with a resistance meter, they should have a high (almost infinite), resistance. Electrolytics, when measured, should normally appear to have a lower resistance then slowly increase to a high one lower values, 1-10uF will change considerably faster. This is because they charge up using the current available from the meter. Again, the ideal procedure is to check all of this before construction, in an attempt to reduce possible causes of faults. However, a component which seems perfect on insertion, can be damaged if there is a fault nearby, by high current, temperature etc. So testing of a component before use only reduces risks of faults and doesn't eliminate it.



Take care not to short any components with the test clips when probing your circuit.

THE LAST STRAW

Finding faults in a project can be a very difficult task, but one which every aspiring electronics genius will have to go through! There are no easy methods — although a logical approach to the symptoms is advisable. Remember also that fault finding can be very rewarding and great pride can be taken in the finished article.

However, if after all this time, energy and strenuous brain activity you still haven't got a working project — the alternative is still the bin! **HE**

Next Month

Hobby Electronics

How do we do it? Next month at great expense to life, limb and sanity we hope to present you, the loyal readers, with an issue yet to be surpassed in the history of magazine publishing. Extravagant claims? We think not, just feast your eyes on this little lot.

RADIO CONTROL

Do-it-yourself radio control systems always tend to be less attractive to build when confronted with hundreds of components, so for everyone that has ever promised themselves a system HE proudly present a Multi-Function digital R/C system using the latest 'dedicated' state-of-the-art ICs in both the decoder and encoder to make this system possibly the easiest and cheapest system yet published anywhere!

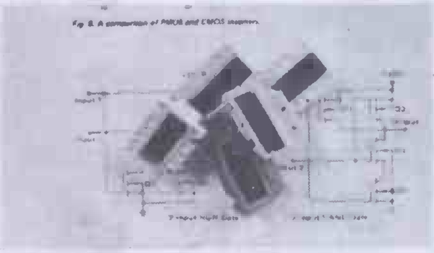
KIT REVIEW

Next month in conjunction with the Radio Control project we are reviewing a new servo kit. This easy to build kit is ideal for use in our project car and will not leave you broke. Before you start though it would be as well to arm yourself with a fine-point soldering iron and a new pair of glasses as this kit calls for some pretty accurate soldering.

MINIATURE TV SURVEY

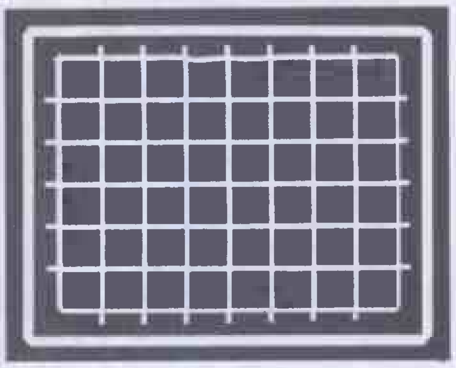
For people with very small eyes from people with very small brains (no offence meant) we have great pleasure in presenting this review of all of the latest titchy tellies on sale at the moment, from the miniscule Sinclair to the somewhat larger offerings from our Oriental cousins. We have drawn a limit at anything exceeding a screen size of five inches, you would be surprised what you can cram in such a small box, one model combines a TV with a FM/AM radio cassette recorder. The kitchen sink is an optional extra.

CMOS SPECIAL



Next month we present another in our very popular series highlighting a particular component or device. This time it's the turn of the CMOS IC. As usual we show lots of practical, buildable circuits with the accent on the functional and novel side of our hobby.

CROSSHATCH GENERATOR



To make this something of a TV special we have decided to include in this month's projects one of the most useful pieces of test gear available to the TV engineer. It will produce a grid pattern onto the screen of a TV set, this is particularly useful if you happen to be setting up the convergence on a colour set or the picture size and shape on a black and white set.

If you're very clever it can also be used as a TV game, how does multi-layer noughts and crosses sound?

SPACELAB

Look out for a major feature on one of the proposed payloads for the Shuttle, this new orbiting laboratory will enable scientists, rather than astronauts, to carry out their experiments in a near-Earth environment.

DIGITAL DICE

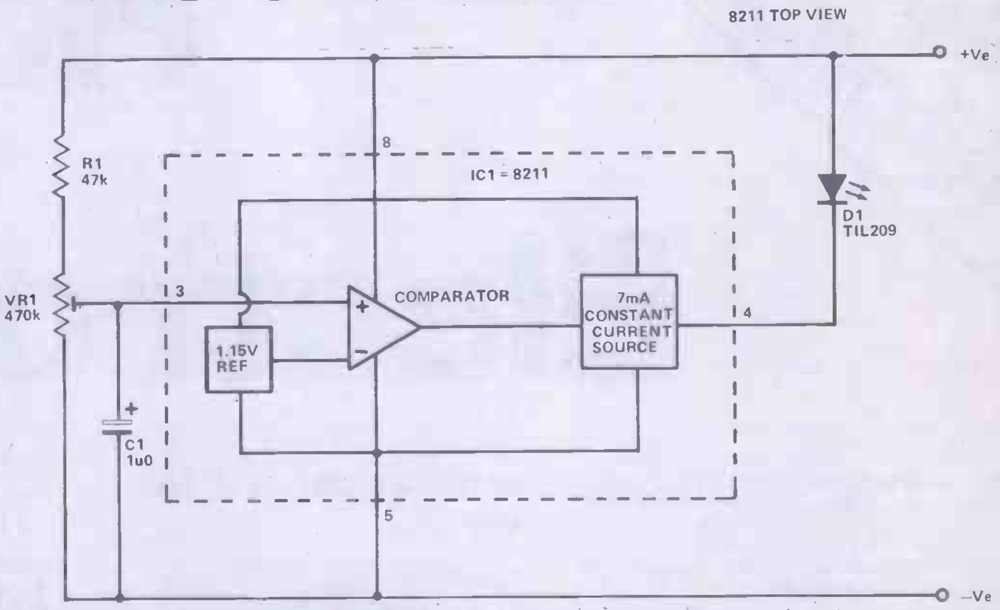
Groan, not another dice project, but wait, our researches have shown that dice projects are amongst the most popular electronic systems to build. Why? Simply because they are easy to build, ideal for a newcomer to electronics, easy to understand, and they work. They actually do something. Our project next month uses a rather novel circuit that will be of interest to beginners and 'old hands' alike.

The January issue will be on sale December 14th

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

Short Circuit

LOW BATTERY VOLTAGE INDICATOR



This circuit can be used to monitor a supply voltage of between about 5 and 25 volts (30 V absolute maximum) and will switch on a warning light if the supply falls below some predetermined threshold level.

Although only five components are used, the circuit is actually quite sophisticated, giving good reliability and precision. This is due to the use of an 8112 voltage detector IC. A comparator forms the heart of the device, and a highly stable internally generated reference voltage is fed to the inverting (—) input of the comparator. Its non-inverting (+) input is available at pin 3, and in this circuit it is fed from the supply lines via the potential divider circuit which consists of R1 and RV1. The output of the comparator is available at pin 4, but is obtained by way of a constant current generator which limits the output current to a nominal figure of 7 mA.

If the voltage at the non-inverting input exceeds the reference voltage, the output assumes the high state and LED indicator D1 is not switched on. If the non-inverting input voltage falls below the reference level, the output then goes low and power is applied to D1. The constant current source limits the LED current to a suitable level. In practice RV1 is adjusted so that with the supply voltage at its minimum acceptable level the non-inverting input is at a potential just marginally higher than the reference voltage. In other words it is adjusted for the lowest voltage that does not cause D1 to be switched on. A fall in supply voltage below the threshold level then takes the non-inverting input below the reference voltage and switches on the warning light. C1 decouples any stray pick-up which could otherwise cause spurious triggering of the circuit. The quiescent current consumption is typically only about 50 uA.

Ring Modulator

Enjoy SCI-FI from your HI-FI with HE's ring modulator audio effects unit.

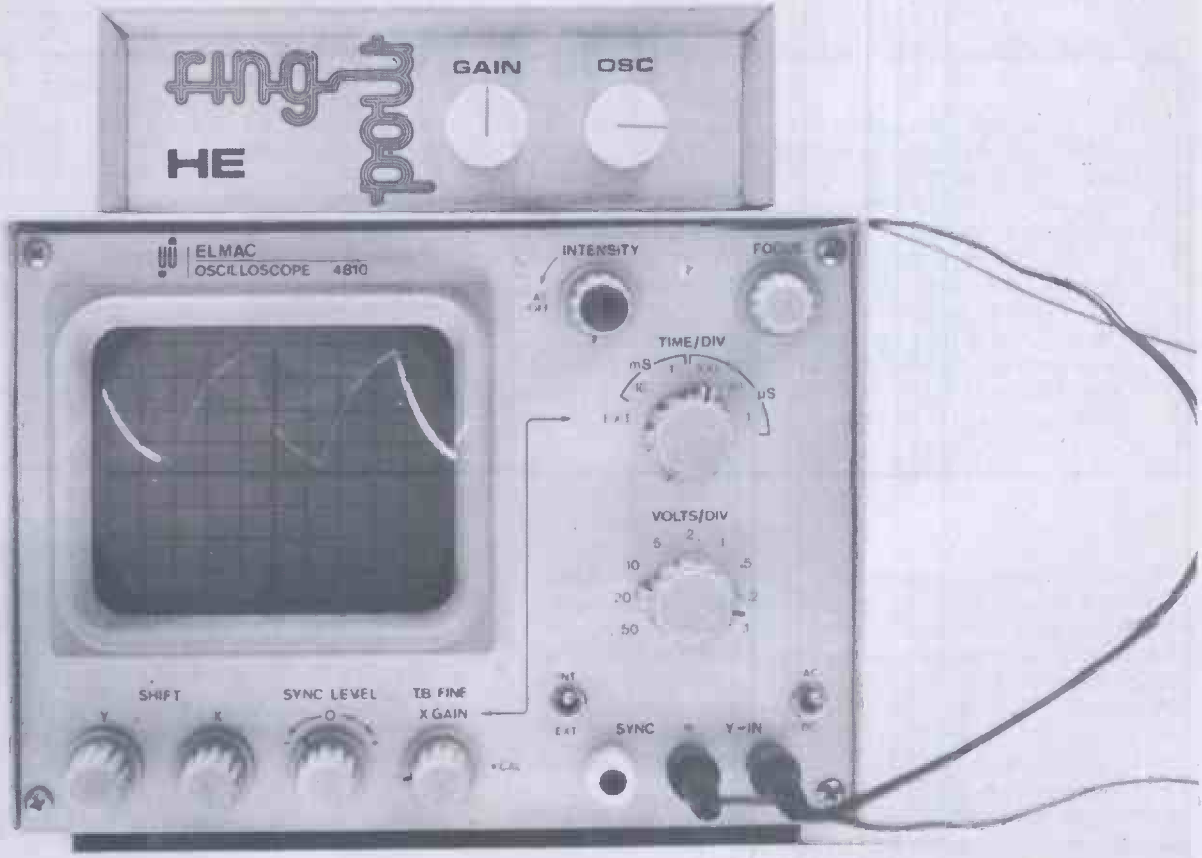
Now you can create the unique "Dalek" sound in the comfort and privacy of your own home. This is THE special effects unit that turns talk into squawk and mutter into stutter. With only two simple to operate controls and featuring a convenient built-in oscillator; the project is a cinch to build. Only four common IC's are used with a handful of passive components keeping the cost down without sacrificing performance.

GIGO

There is an old computing term, GIGO, which stands for garbage in — garbage out. This unit is a little different . . you get garbage out no matter what you put in!

There are two inputs and one output. Input signals should be between one and two volts peak to peak for satisfactory operation. The output level is variable by adjustment of RV2. To set up the unit, a signal is injected into the X input with the Y input disconnected, then RV1 should be adjusted until the output diminishes to a quiet hiss. It should be possible to completely null out the X input signal. If you cannot, then there is probably stray coupling between your connecting leads. We used screened cable for the audio signals and connected one end of each braid to a common earth point on the metal case. A metal case is recommended to reduce hum and noise pick up.

Once you have made this adjustment, a signal can be connected to the Y input and a modulated version of the



The oscillator in the Ring Modulator produces an approximate sawtooth waveform which can be simply modified to a square wave for further effects.

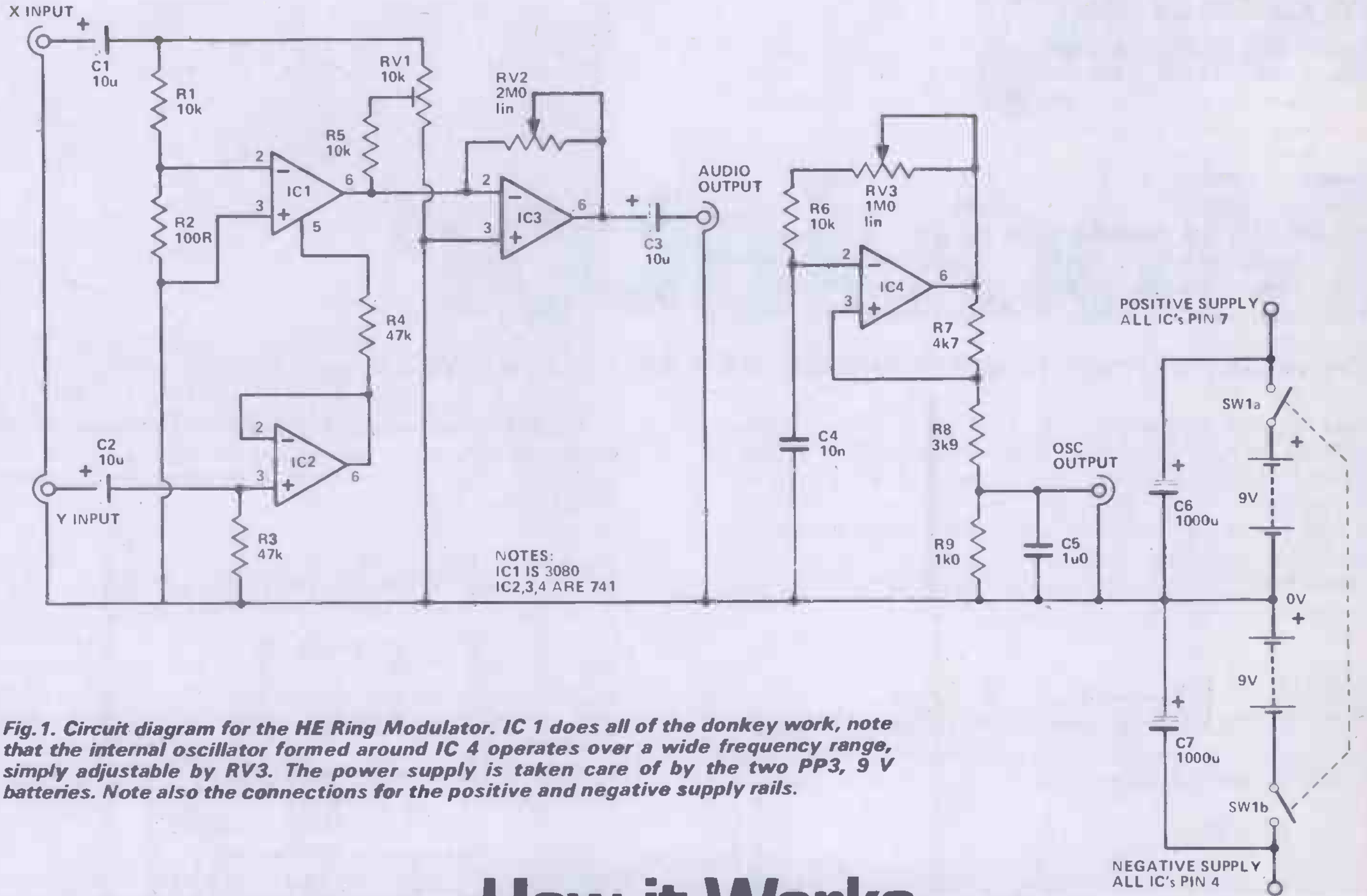


Fig. 1. Circuit diagram for the HE Ring Modulator. IC 1 does all of the donkey work, note that the internal oscillator formed around IC 4 operates over a wide frequency range, simply adjustable by RV3. The power supply is taken care of by the two PP3, 9 V batteries. Note also the connections for the positive and negative supply rails.

How it Works

The principal active element in this circuit is IC1, a 3080 operational transconductance amplifier whose gain is controlled by the current flowing into pin 5. This current flows through R4 and is determined by the voltage at the output of IC2, pin 6. When there is no signal at the Y input, a steady current flows through R4 giving IC1 a certain gain.

Any signal at the X input appears inverted at the output of IC1 as a varying current. It is converted to a voltage by IC3 whose gain is controlled by adjustment of RV2. With no signal at the Y input, RV1 is adjusted so that it feeds a portion of the non-inverted X input into IC3 exactly cancelling the inverted X signal from IC1. Any signal at the Y input will then modulate the gain of IC1 to produce the familiar 'ring modulator' sound.

An oscillator is built into the unit and comprises IC4 and associated components connected in a standard astable multivibrator configuration. A portion of the squarewave output is tapped off by potential divider R7, 8, 9. Capacitor C5 smooths the wave form to give an approximate sawtooth and frequency is variable by adjustment of RV3. Capacitors C6, 7 provide overall smoothing.

X input will appear at the output. The internal oscillator is a very simple affair consisting of one 741 op-amp connected in a standard astable oscillator circuit. Its output is an approximate sawtooth whose frequency is adjusted by RV3. Owing to the simple filtering employed, the output level falls as the frequency is increased. The output level can be increased by increasing the value of R9 and decreasing R8 keeping their total resistance to around five thousand ohms. By omitting or disconnecting C5, a squarewave output will be obtained. If you have a signal generator, you can experiment with different waveforms and amplitudes — or try connecting the Hobby Siren or Hobbytune to the unit!

The circuit is powered by two PP3 batteries. All of the inputs and outputs are available on the rear panel. They are from left to right: 'X', 'Y', OUT and OSC.

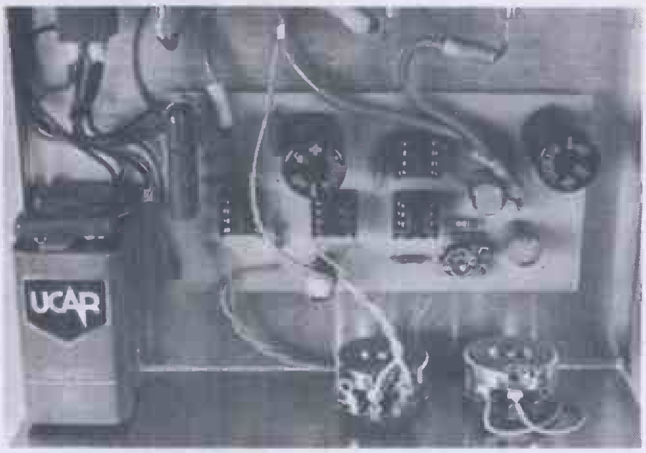
CONSTRUCTION

A metal box is the ideal enclosure and use of our PCB should prevent any problems with layout. However, the circuit is quite simple and Veroboard or other constructional techniques can be employed if desired.

Follow the usual practice when assembling the unit. Insert the wire link, resistors, capacitors and IC sockets before fitting the IC's. Use of sockets adds very little to the cost of the unit and greatly facilitates fault finding as well as enabling the chips to be easily removed for use in other projects. None of the chips used here are sensitive to static discharge and no special handling precautions are necessary.

When complete, the unit may be set up and tested. If you do not have a monitor amplifier, the output will drive a crystal earphone satisfactorily . . . the cheap eight ohm earphones will not work in this application. Suitable inputs include amplifier "line" outputs and transistor radio "earphone" outputs.

You will not put the Radiophonic workshop out of business probably; but you can create a winter-wonderland of effects for a cybernetic Christmas! **HE**



Keep all of the interconnecting leads short so as to prevent stray signal pick up. Note the use of screened cable to couple signal inputs and outputs.

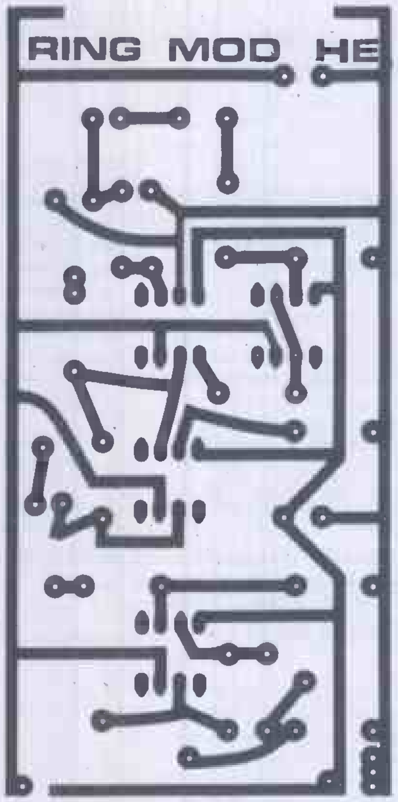


Fig.2. PCB foil pattern for the HE Ring Modulator.

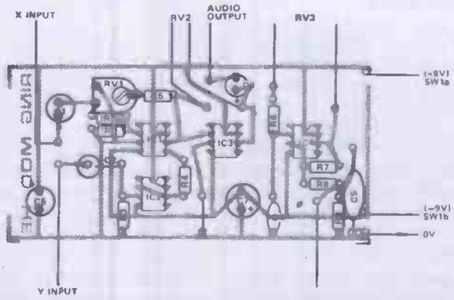


Fig.3. Overlay diagram for the Ring Modulator, as usual be sure to observe all of the rules when inserting polarised components, to avoid any headaches DOUBLE CHECK before switching on.

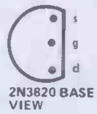
Parts List

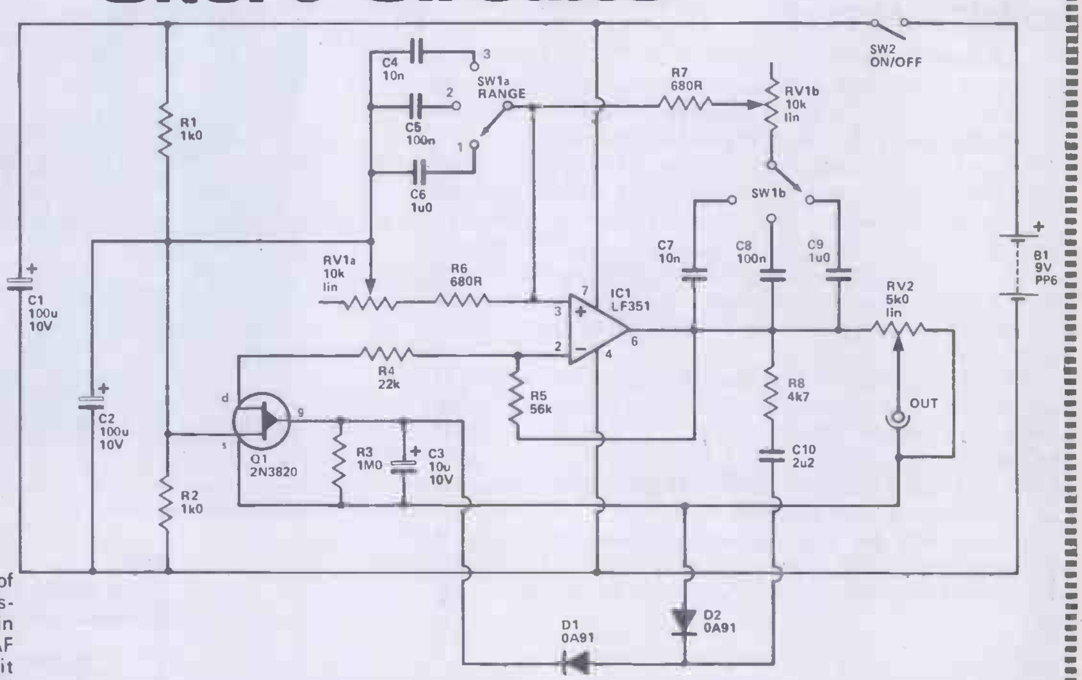
RESISTORS (All ¼W, 5%)	
R1, R5, R6	10k
R2	100R
R3, R4	47k
R7	4k7
R8	3k9
R9	1k0
POTENTIOMETERS	
RV1	10k min preset
RV2	2MO 1in
RV3	1MO 1in
CAPACITORS	
C1, C2, C3	10µ electrolytic
C4	10n polyester
C5	1µ0 polyester
C6, C7	1,000µ electrolytic
SEMICONDUCTORS	
IC1	3080
IC2, IC3, IC4	741
MISCELLANEOUS	
SW1 DPST connectors, PCB, 2 PP3 or equiv.	

Buylines

All the components should be readily available from the larger mail-order companies.

A.F. SIGNAL GENERATOR





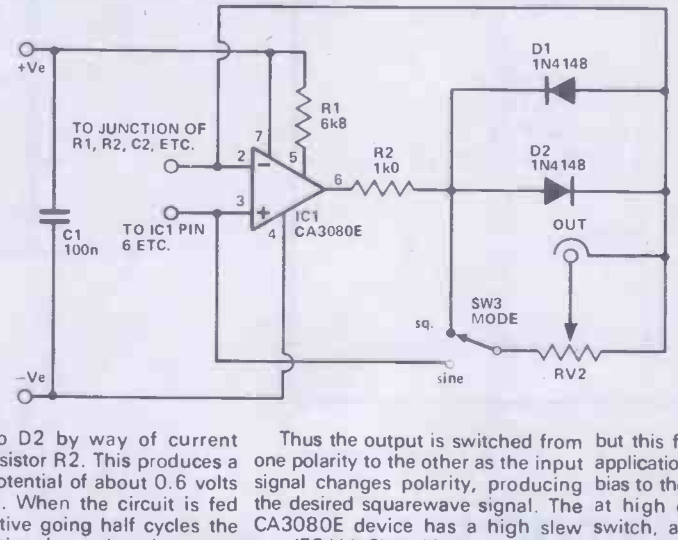
One of the most useful items of test equipment to have, especially if one has an interest in any type of audio gear, is an AF signal generator. The circuit shown here provides a good quality sinewave output over three continuously variable ranges (Range 1, below 20Hz to above 200Hz; Range 2, below 200Hz to over 2kHz; and Range 3, below 2kHz to over 20kHz) covering more than the entire audio frequency spectrum.

The circuit uses the usual Wien Bridge type circuit, and this form of oscillator consists of an amplifier having frequency selective positive feedback provided via a C-R network. The capacitive elements of this network are whichever two capacitors are selected by SW1, the three sets of capacitors giving the unit its three ranges. The resistive elements are R6, R7 and RV1, the latter permitting the unit to be tuned over the ranges quoted above. This network provides positive feedback over operational amplifier IC1, which is a FET type giving low noise and distortion levels. VR1a and R6 also bias the non-inverting input of IC1 to a central tapping on the supply produced by R1, R2 and C2.

The closed loop gain of IC1 must be maintained at precisely the correct level if good results are to be attained. Insufficient gain would lead to less than full compensation for the losses through the C-R Wien network, with insufficient feedback and consequent violent oscillation with the output signal becoming clipped and seriously distorted. An automatic gain control (AGC) circuit is used to maintain stable operating conditions and a constant output level. R5, R4 and the drain to source resistance of Q1 form a negative feedback network which controls the closed loop gain of IC1. Initially Q1 is forward biased by R3 so that there is enough gain to give strong oscillation. Some of the output from IC1 is coupled by R8 and C10 to a rectifier and smoothing network comprised of D1, D2 and C3. These produce a positive bias which tends to cut off Q1, producing reduced circuit gain. The stronger the circuit oscillates, the larger the bias, and the lower the gain becaomes. Lack of oscillation produces reduced bias, more gain, and stronger oscillation. The required stabilising action is thus obtained.

Variable attenuator VR2 enables the output to be adjusted from zero up to about 1.5V RMS. The current consumption of the circuit is about 7 mA.

SINE TO SQUARE CONVERTER



This circuit provides an optional squarewave of about 1.2 volts peak to peak when used with the signal generator circuit described above. The above circuit requires no modification, other than the omission of output attenuator potentiometer RV2 which is included in this section of the unit instead.

The squaring circuit is based on operational transconductance amplifier IC1. This device is in some ways similar to an ordinary operational amplifier, but it is the output current rather than the output voltage that is a function of the input voltages. The inverting input of the device is biased to the central tapping on the supply lines, and the non-inverting input is fed with the sinewave output from the main signal generator circuit. When fed with positive going half cycles, the non-inverting input is taken to a higher voltage than the inverting one, resulting in a forward bias being applied to D2 by way of current limiting resistor R2. This produces a positive potential of about 0.6 volts across D2. When the circuit is fed with negative going half cycles the non-inverting input is taken to a lower potential than the investing one, causing a forward bias to be applied to D1, and producing a negative output potential of about 0.6 volts.

Thus the output is switched from one polarity to the other as the input signal changes polarity, producing the desired squarewave signal. The CA3080E device has a high slew rate (50 V/uS) and is therefore capable of producing a high quality squarewave signal even at the higher frequencies covered by the unit. The gain of the CA3080E can be varied by altering the bias fed to its pin 5, but this feature is of no use in this application and R1 provides a strong bias to the device so that it operates at high gain. SW3 is the mode switch, and merely connects RV2 and the output socket to the output of the sinewave generator or squaring circuit, as required.

The squaring circuitry only adds about 3 mA or so to the current consumption of the unit.

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Shown next to each issue is the relevent code letter to use when ordering Hobbyprints. (See Hobbyprints ad. elsewhere in this issue.)

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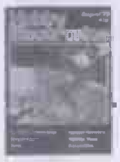

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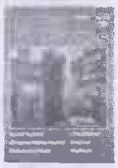

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Hobby Chit~Chat

In this month's 'Chit-Chat' Ray Marston takes an in-depth look at the LM3914 IC and shows a variety of ways of using it as an indicating instrument in the car and the workshop.

IF YOU LOOK at this month's 'Car Voltmeter' project you'll notice that it is based on the LM3914 Dot/Bar Display Driver IC from National Semiconductors. We've used this IC in several projects in HE and ETI (our sister magazine) over the last few months and are greatly impressed with the dèvice. We regard it as a very important new tool in the field of amateur and professional electronics.

The LM3914 is a highly versatile IC that is designed to sense an analogue input voltage and drive a line of 10 LEDs to give a visual analogue display of that voltage. The unit can give either a 'Dot' or 'Bar' display of the voltage. Figure 1 illustrates the appearance of the two alternative display modes when used to indicate 5 volts on a 10 volt scale. The unit acts as an inexpensive and superior alternative to the conventional analogue-indicating moving-coil meter. It does not suffer from 'sticking' problems, is unaffected by vibration and can be used in any attitude.

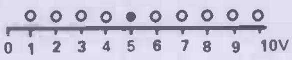

Fig. 1a. 'Dot' indication of 5 volts on a 10 volt LED scale.

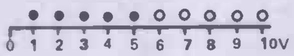

Fig. 1b. 'Bar' indication of 5 volts on a 10 volt LED scale.

The LM3914 can readily be used as the basis of a wide variety of 'indicator' and instrumentation projects in the home, the car, the workshop and in miscellaneous audio and musical projects. One of the great attractions of the device is that it is very easy to understand and use. You don't need to be a BA or MSc to be able to fully comprehend its operating principle and learn to adapt it to suit your own particular circuit requirement. We explain the essential details of the device and show several practical ways of using it in the next few pages.

THE LM3914: BASIC PRINCIPLES

Figure 2 shows the equivalent internal circuit of the LM3914 IC, together with the connections for making it

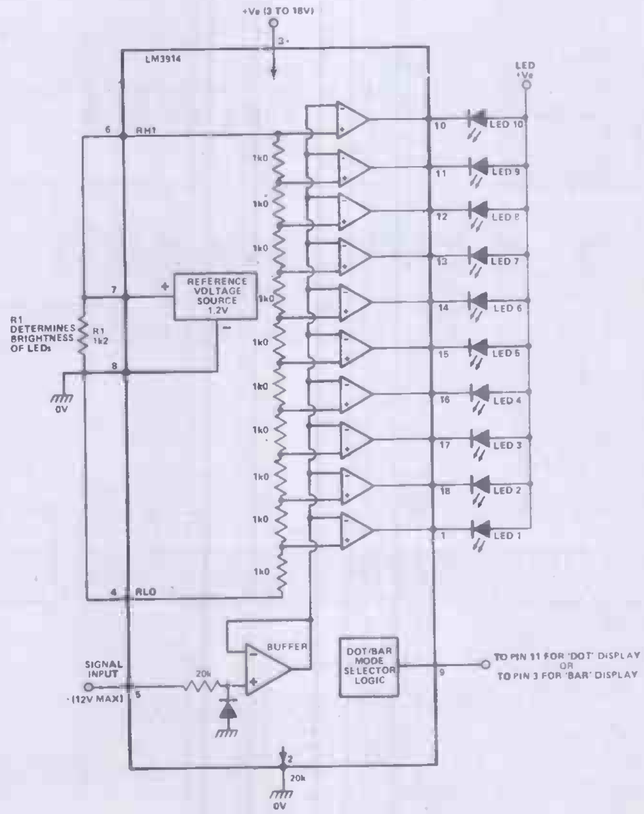

Fig.2. Equivalent internal circuit of the LM 3914 with connections for making a 0-12 volt dot or bar meter.

act as a 10-LED voltmeter with a full-scale sensitivity of 1.2 volts.

The first point to note about the IC is that it contains a 10-resistor potential divider, wired between pins 4 and 6. The IC also contains ten voltage comparator circuits, each with its non-inverting (+) terminal taken to its own particular tap on the potential divider, but with all inverting (-) terminals of the comparators joined together and taken to the output of an input buffer amplifier. This buffer amplifier gives an output that is, for all practical purposes, identical to the voltage applied to input terminal 5 of the IC. The output of each one of the ten voltage comparators is individually available on one of the pins of the IC (pin 1 and pins 10 to 18) and is capable of 'sinking' a current of up to 30 mA.

The next point to notice is that the IC contains a built-in reference voltage source that provides a highly stable potential of 1.2 volts between pins 7 and 8. This source is of the 'floating' type, so that 1.2 volts is developed between pins 7 and 8 irrespective of whether pin 8 is tied to ground or is held at some voltage above ground. In the diagram of Fig 2 we've shown pins 7 and 8 externally connected to potential divider pins 6 and 4 respectively, so in this particular case 1.2 volts is developed across the 10-resistor potential divider network of the IC.

The final point to notice about the IC is that it contains an internal logic network that can be externally programmed to give either a 'dot' or a 'bar' display or action from the outputs of the ten voltage comparators. In the 'dot' mode, only one of the ten outputs is enabled at any one time. In the 'bar' mode all outputs below and including the highest 'energised' output are enabled at any one time.

At this point, let's put together the basic information that we have already learned about the LM3914 and the circuit of Fig 2, and see how the entire circuit functions. Let's assume that the logic is set for 'bar' mode operation.

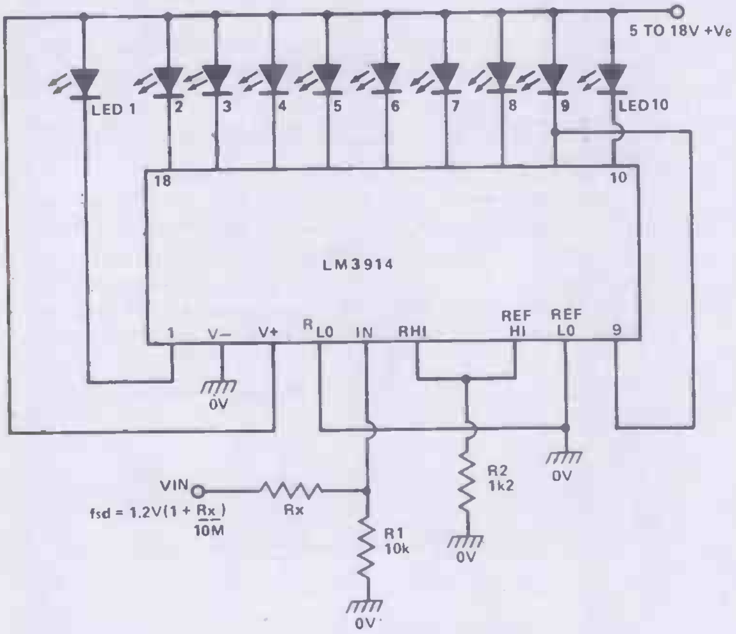

Fig.3. 1.2 V to 1000 V FSD 'Dot' mode voltmeter.

We already know that a reference of 1.2 volts has been set up across the 10-resistor divider, with the low (pin 4) end of the divider tied to ground (zero) volts. Consequently, 0.12 V is applied to the '+' input of the lowest voltage comparator, 0.24 V to the next, 0.36 V to the next and so on. If we now apply a slowly rising voltage to input pin 5 of the IC, the following sequence of events takes place:

When the input voltage is zero, the outputs of all ten voltage comparators are high and none of the external LEDs are turned on. As the input voltage is slowly increased it eventually reaches and then rises above the 'reference' 0.12 volts value of the first comparator, which then turns on (it's output conducts) and energises LED 1. As the input is further increased it eventually reaches the 0.24 V of the second comparator, which then also turns on and energises LED 2. At this stage both LED 1 and LED 2 are on. As the input voltage is further increased progressively more and more comparators and LEDs are turned on, until eventually, when the input rises to and then exceeds 1.2 volts, the last comparator and LED 10 turn on, at which stage all ten LEDs are illuminated.

A similar kind of action is obtained when the LM3914 logic is set for 'dot' mode operation, except that only one LED turns on at any given time. At zero volts, none of the LEDs are on. At voltages above 1.2 (or whatever reference value is applied to the last comparator) only LED 10 is turned on.

At this stage, then, you can see that the LM3914 is a reasonably easy device to understand. Let's move on, then, and look at some of the finer details of its operation.

THE LM3914: A CLOSER LOOK

There is one component in Fig 2 that we have not yet mentioned and that is R1. This resistor is wired between the pin 7 and pin 8 output terminals of the reference voltage source and determines or 'programmes' the ON currents of the LEDs. The on current of each LED in fact approximates ten times the output current of the reference voltage source. The reference can supply up to 3 mA of current, so the LEDs can be programmed to pass currents up to 30 mA.

Remembering that the reference develops 1.2 V, you can see that if a total resistance of 1k2 is placed across the pin 7 — pin 8 terminals the reference will pass 1 mA and each LED will pass 10 mA in the ON mode. In Fig 2 the total resistance across the reference terminals is equal to the 1k2 of R1 shunted by the 10k of the ICs internal potential divider, so the reference actually passes about 1.1 mA and the LEDs conduct 11 mA. If R1 were removed from the circuit the LEDs would still pass 1.2 mA due to the resistance loading of the internal potential divider on pins 7 and 8.

You'll notice from the above description that the IC can pass total currents up to 300 mA when it is used in the 'bar' mode with all ten LEDs on. The IC has a maximum power rating of only 660 mW, so there is a danger of exceeding this rating when the IC is used in the 'bar' mode. We'll return to this point later.

The LM3914 IC can be powered from any d.c. supply in the range 3 to 25 volts. The LEDs can use the same supply as the IC or can be independently powered from supplies with voltages up to a maximum of 25 V. The voltage across the internal potential divider can have any value up to 25 volts maximum.

The internal reference amplifier produces a basic nominal output of 1.28 volts (limits are 1.2 V to 1.32 V), but can be externally 'programmed' to produce effective reference values up to 12 V (we'll show how later).

The input buffer of the IC has integral overload protection and can withstand inputs of up to plus or minus 35 V without damage.

The IC can be made to give either a 'dot' display by wiring pin 9 to pin 11, or a 'bar' display by wiring pin 9 to positive-supply pin 3.

PRACTICAL CIRCUITS: SIMPLE 'DOT' mode voltmeters

The basic circuit of Fig 2 acts as a voltmeter that reads full-scale at an input of 1.2 volts. The range of the circuit can be changed in a variety of ways. The sensitivity can be increased, for example, by either interposing a d.c. amplifier between the input signal and pin 5 of the IC, or by reducing the reference voltage that is applied to the pin 4 — pin 6 terminals of the IC: in this latter case the IC will operate quite well with a reference voltage down to a couple of hundred mV.

The easiest and best way to reduce the sensitivity of the meter is to use the connections shown in Fig 3. Here, the basic circuit is that of a 1.2 V meter, but the input signal is applied to the IC via a potential divider formed by Rx and R1. Thus, the circuit can be made to read 12 volts full scale by giving Rx a value of 90k, so that Rx-R1 act as a 10:1 divider. This circuit can be used to read full scale voltages from 1.2 V up to about 1000V.

An alternative connection is shown in Fig 4. In this case the input voltage is applied directly to pin 5 of the IC, but the reference voltage on the internal devider is made variable from 1.2 V to 10 V via RV1. You'll remember that the 'reference voltage' develops 1.2 V between pins 7 and 8, but this voltage is fully floating. By wiring RV1 between pin 8 and ground we can ensure that the output current of the reference flows to ground via RV1, thus providing a voltage that raises the pin 8 (and also pin 7) value considerably above zero volts. This increased voltage is applied to the top (pin 6) end of the internal potential divider, which has its low end (pin 4) grounded, and determines the full scale sensitivity of the circuit. This circuit has a useful voltage range of only 1.2 V to 10V. The IC supply voltage must be greater than the required full scale voltage.

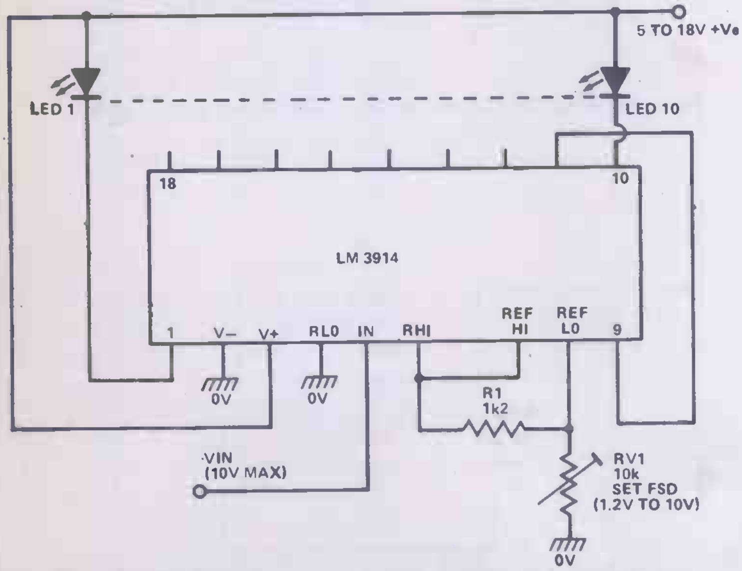

Fig.4. An alternative 1.2 to 10 V FSD 'Dot' mode voltmeter.

Figure 5 shows how the LM3914 can be used as an expanded scale voltmeter that reads (say) 10V at minimum scale but 15 V at full scale. The secret of this circuit is that both the top and bottom ends of the internal potential divider (pins 6 and 4) of the IC are externally available, so the top and bottom limits of the scale can be individually set. In the diagram the top of the divider is fed from the 1.2 V reference, but the bottom is fed from

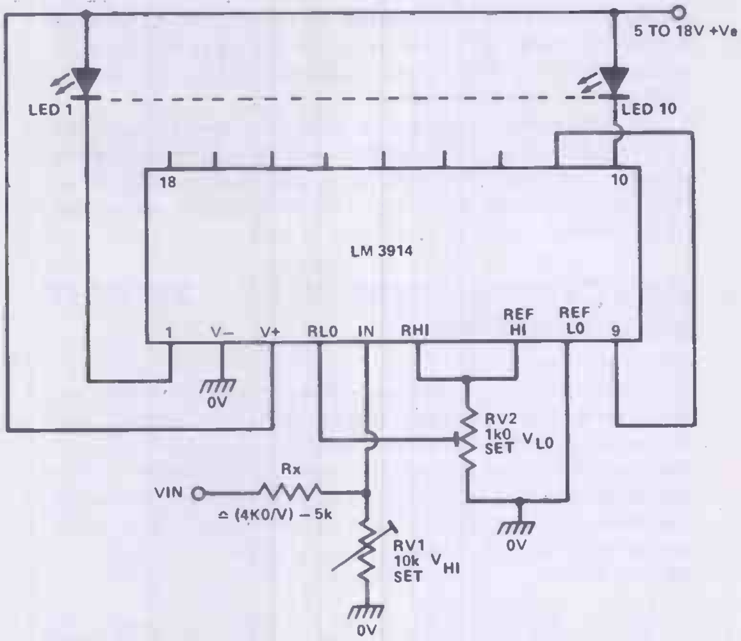

Fig.5. Expanded scale (10 V-15 V etc) 'Dot' mode voltmeter.

the slider of RV2. The external input signal is applied to the IC via the Rx-RV1 potential divider. Thus, if 1.2V is set to the top of the divider and 0.8 V is set to the bottom and the input divider has a ratio of 20:1, the circuit will read 24 V at full scale and 16 V at minimum scale.

PRACTICAL CIRCUITS: 'BAR' MODE OPERATION

The three basic voltmeter circuits of Figs 3 to 5 can be used with the IC connected in either the 'dot' or the 'bar' mode. When using the bar mode, however, it must be remembered that the power rating of the IC can easily be exceeded when all ten LEDs are on if an excessive voltage is allowed to develop across the output terminals

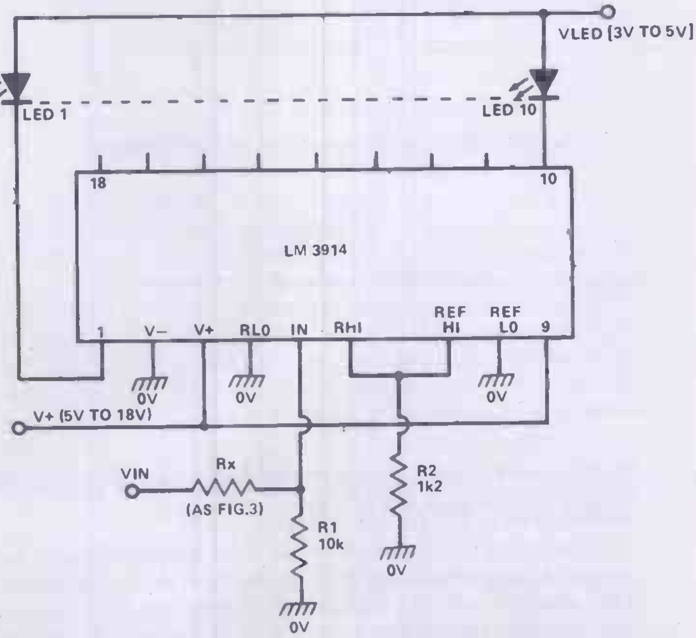

Fig.6. Bar-display voltmeter with separate LED supply.

of the IC. LEDs normally 'drop' about 2 volts when they are conducting, so one way around this problem is to power the LEDs from their own low-voltage (3 to 5 V) supply, as shown in Fig 6.

An alternative solution is to power the IC and the LEDs from the same source but to wire a current-limiting resistor in series with each LED, as shown in Fig 7, so that the output terminals of the IC saturate when the LEDs are on.

PRACTICAL CIRCUITS: 20-LED VOLTMETERS

Figure 8 shows how two LM3914s can be interconnected to make a 20-LED dot mode voltmeter. Here, the input terminals of the two ICs are wired in parallel, but IC1 is configured so that it reads 0 to 1.2 volts and IC2 is configured so that it reads 1.2 volts to 2.4 volts. In the latter case, the low end of the IC2 internal potential divider is coupled to the 1.2 V reference of IC1 and the top of the divider is taken to the 'top' of the 1.2 V reference of IC2, which is raised 1.2 V above that of IC1.

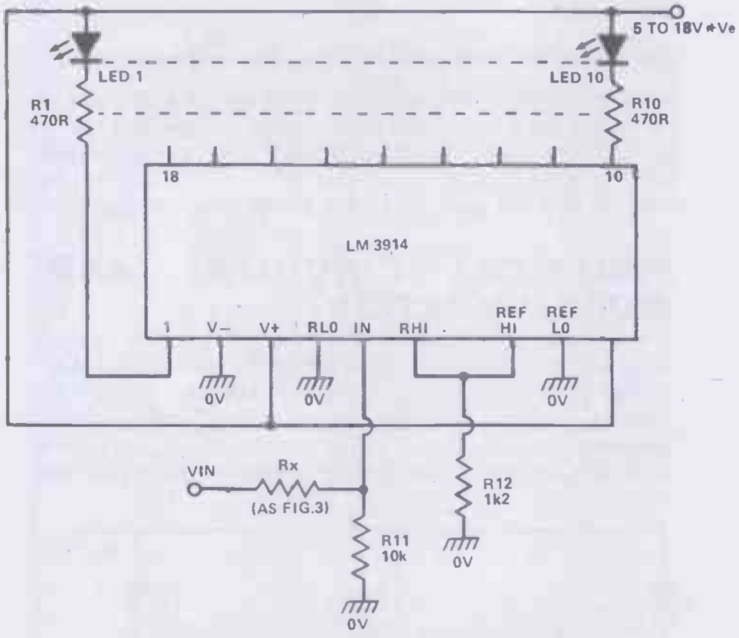

Fig.7. Bar-display voltmeter with common LED supply.

The Fig 8 circuit is wired for 'dot' mode operation. In this case pin 9 of IC1 is wired to pin 1 of IC2 and pin 9 of IC2 is wired to pin 11 of IC2. Note that a 22k resistor is wired in parallel with LED 9 of IC1 in this mode.

Fig 9 shows the connections for making a 20-LED 'bar' mode voltmeter. The connections are similar to those of Fig 8, except that pin 9 is taken to pin 3 on each IC, and a 470R current limiting resistor is wired in series with each LED to reduce the power dissipation of the ICs.

PRACTICAL CIRCUITS: A 20-LED CAR TACHOMETER

The LM3914 can be made to act as a car tachometer by simply wiring a frequency-to-voltage converter between the vehicles contact breaker points and the input pin of the IC. Fig 10 shows the practical circuit of such a converter, designed to interface with either of the 20-LED voltmeter circuits of Figs 8 or 9. Note the LM2917 IC used in this circuit is a 14-pin device. The C2 value of 22n is the 'optimum' value for a full scale range of approximately 10 000 RPM on a 4-cylinder 4-stroke engine. For substantially lower full scale RPM values, the value of C2 may have to be increased. The value may have to be reduced on vehicles with 6 or more cylinders.

A more detailed description of this particular circuit is given in the August '79 issue of Hobby Electronics.

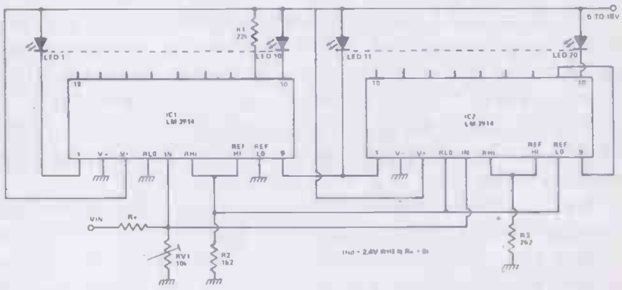

Fig.8. Dot-mode 20 LED voltmeter. (FSD = 2.4 V when $R_x = 0$).

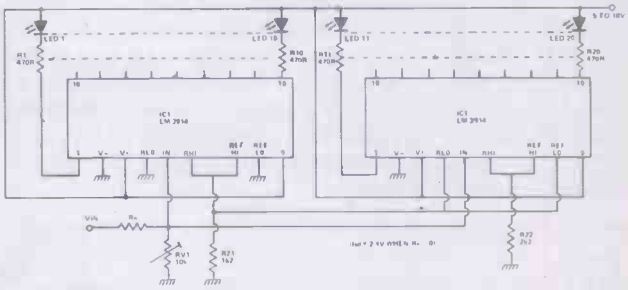

Fig.9. Bar-mode 20-LED voltmeter. (FSD = 2.4 V when $R_x = 0$).

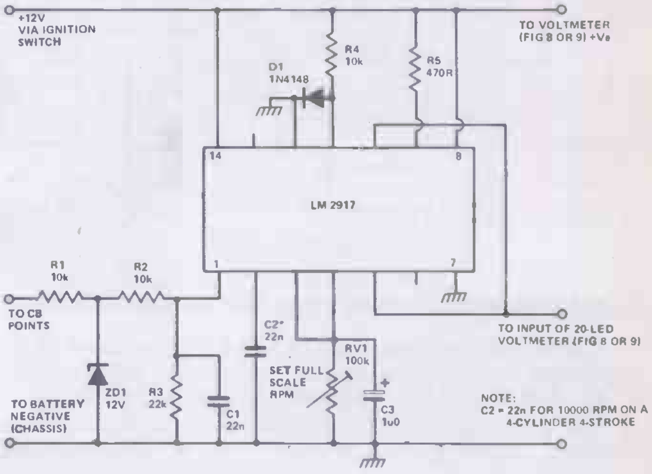

Fig.10. Car tachometer conversion circuit for use with a 20 LED voltmeter. (Fig. 8 or 9).

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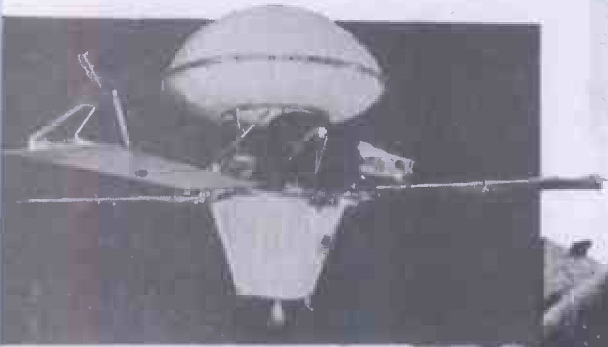
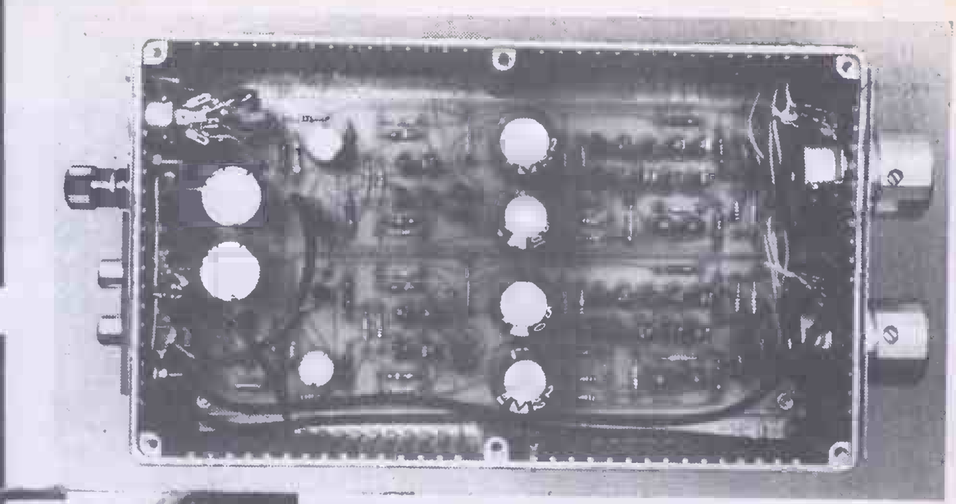
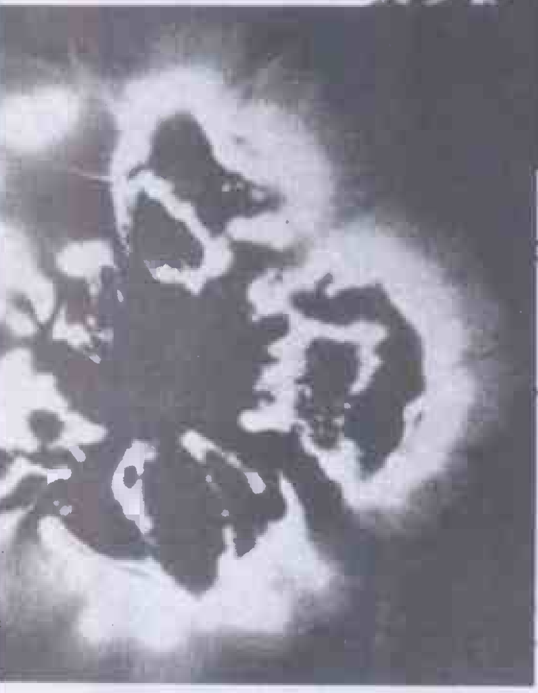
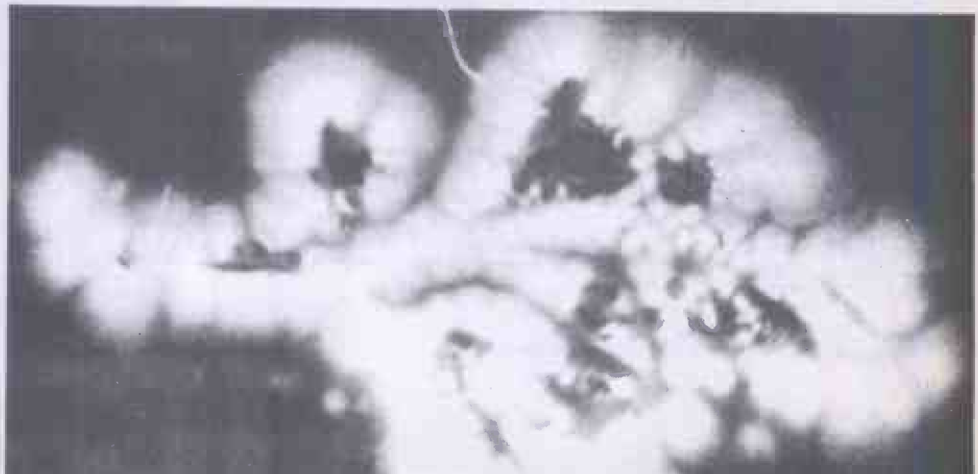


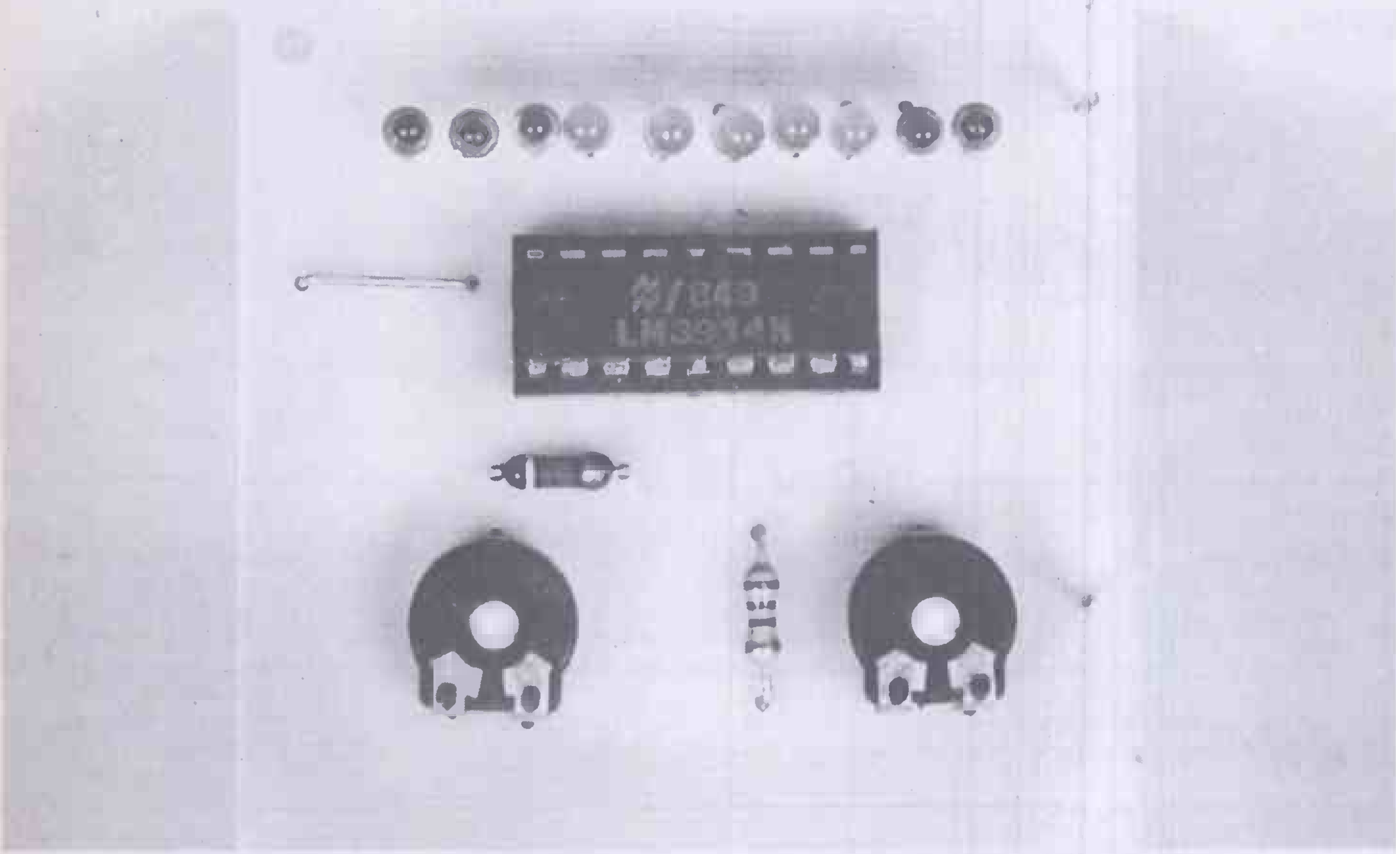






Bargraph Car Voltmeter

A 'must' for the motoring enthusiast. An all solid-state 10-LED expanded-scale car voltmeter or battery-condition indicator.



A VOLTMETER IS A USEFUL accessory to have fitted to a car, since it can, when properly used, give the owner an excellent indication of the state of the battery and it's charging circuit. Under no-load conditions, with the engine turned off, a sound and well charged battery will give a reading of 12 to 13 volts. Any value lower than 12 volts indicates a defective battery.

With the engine turned off and all lights switched on, the battery reading should fall to 11 to 12 volts. Again, any reading lower than this indicates a faulty battery.

With the engine running at a fast idle and the electrical system lightly loaded, the battery reading should rise to between 13 and 14 volts. A reading below the lower value indicates a faulty dynamo / alternator or a defective regulator. A reading above the upper value indicates a defective regulator.

You'll notice from the above statement that the range of voltmeter readings that are of interest span only a very limited range, from say 10.5 volts minimum to 15 volts maximum, so a special type of 'suppressed zero' voltmeter should ideally be used in the car.

Our HE car voltmeter is very special. It is an all solid-state design that gives a readout on a two-coloured line of ten LEDs (light emitting diodes). The unit has excellent long-term and thermal accuracy once it has been initially calibrated to span the range 10.5 to 15 volts. The unit is very easy to install in the vehicle and has a total building cost of only three or four pounds. The unit gives a 'dot' display in which only one of the ten LEDs is illuminated at any one time.

CONSTRUCTION AND USE

The entire circuit, including the ten LEDs, is built up on a small PCB and construction should present very few problems. Note that IC1 is an 18-pin device and also that it should be fitted to the PCB via a suitable holder. We

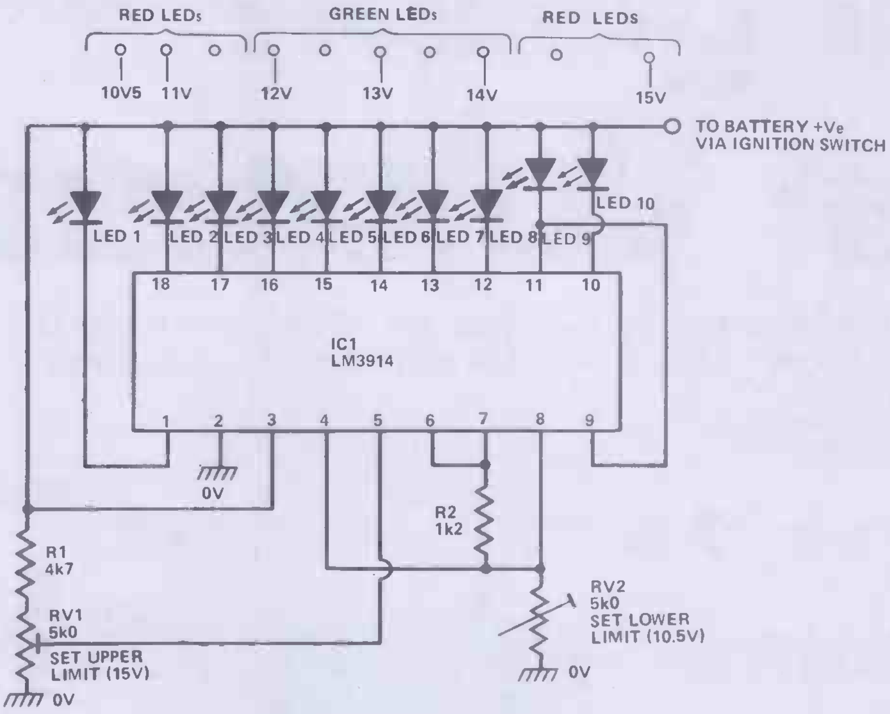


Fig. 1. Circuit diagram of the HE Bargraph Car Voltmeter, the choice of a box is decided by the type of installation required.

How It Works

There is little we can say other than the IC1 acts as a LED-driving voltometer that has its basic maximum and minimum readings determined by the values of R2 and RV2. When correctly adjusted, the unit actually spans the approximate range 2.5 volts to 3.6 volts, but is made to read a supply voltage span of 10-10.5 volts to 15 volts by interposing potential divider R1-RV1 between the supply line and the pin-5 input terminal of the IC.

The IC is configured to give a 'dot' display, in which only one of the ten LEDs is illuminated at any given time. If the supply voltage is below 10.5 volts none of the LEDs illuminate. If the supply equals or exceeds 15 volts, LED 10 illuminates.

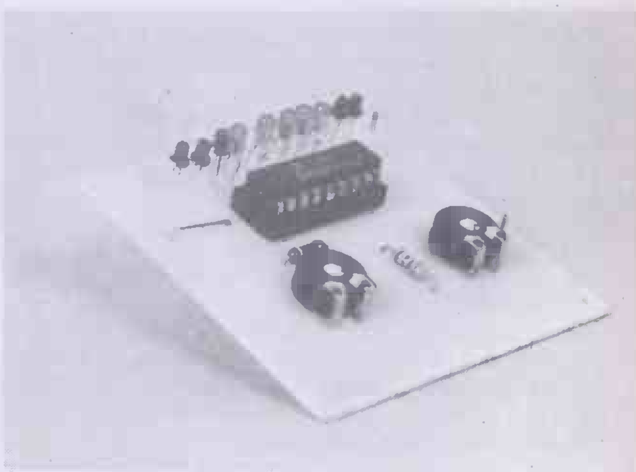
A comprehensive description of the functioning of the LM3914 IC is given in this month's 'Hobby Chit-Chat' feature.

advise testing each one of the LEDs, to confirm it's functioning and polarity, before fitting it to the PCB.

To check each LED, connect it in series with a 470R resistor and then connect the combination across a 12-volt supply. If necessary switch the LED connections until the LED illuminates, under which condition the lead closest to the positive supply rail is the anode.

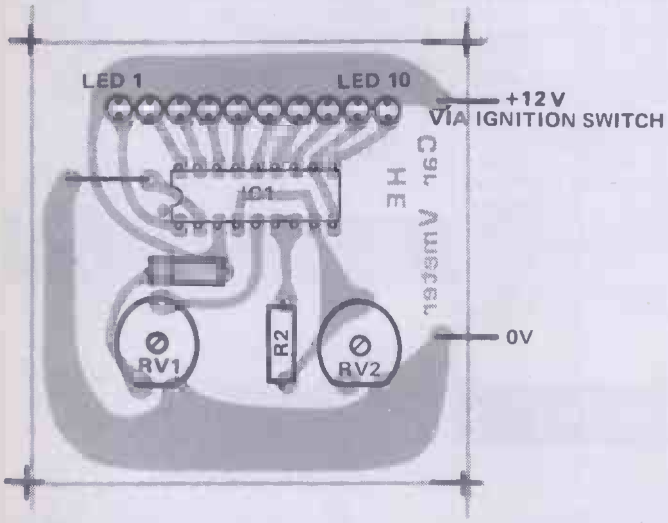
When construction is complete, double-check the circuit wiring and connect the unit to a variable voltage DC supply that can span the 10-15 volt range. Monitor the supply voltage with a reasonably accurate meter and calibrate the unit as follows.

Set the supply to 15 volts and adjust RV1 so that LED 10 just turns on. Reduce the supply to 10 volts and adjust RV2 so that LED 1 just turns on. Recheck the settings of RV1 and RV2. The calibration is then complete and the unit can be installed in the vehicle by taking the 'O' volt lead to chassis and the '+12 volt' lead to the vehicles battery via the ignition switch. HE



The HE LED Voltmeter, see text for the setting-up procedure.

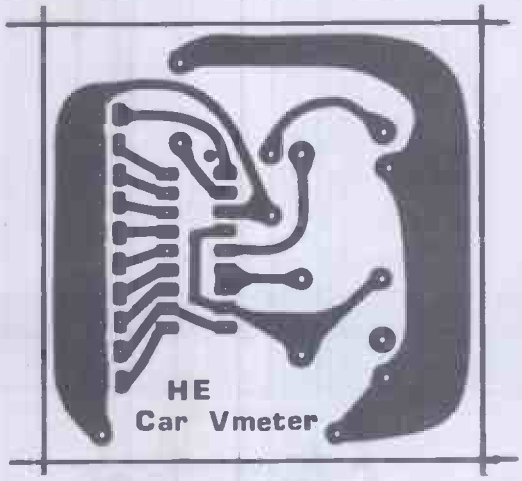
Bargraph Car Voltmeter



PCB overlay for the Voltmeter, note the position of IC1. Right (lower) PCB foil pattern, take care to avoid solder splashes.

Parts List

RESISTORS (all ¼W 5%)	
R1	4x7
R2	1x2
POTENTIOMETERS	
RV1, 2	4x7 preset
SEMICONDUCTORS	
IC1	LM3914
LEDs 1, 2, 3, 9, 10	TIL 209
LEDs 4, 5, 6, 7 8	TIL 211

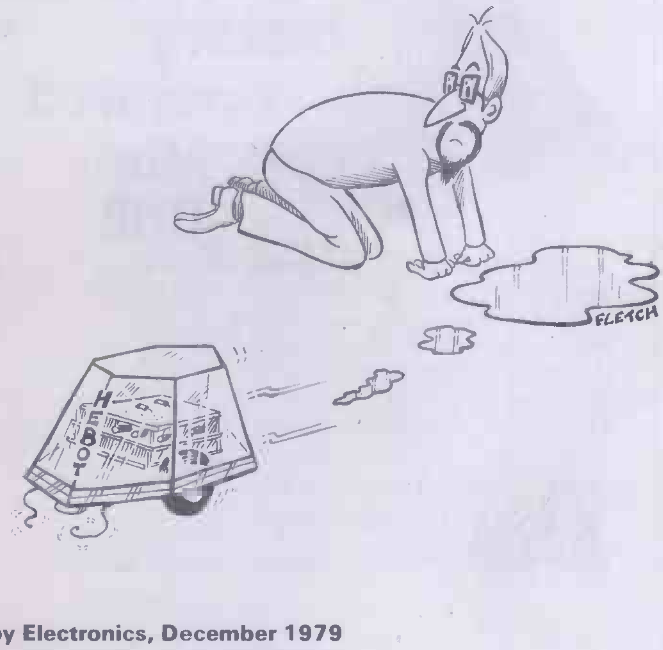


Buylines

None of the components should be difficult to obtain. As is usual practice with HE all of the components should be available from most of the larger mail-order-houses, ie Maplin, Watford, Stevenson etc.

Tee-Hee-bot

Well, you've got to laugh, did you see HEBOT on BBC's Blue Peter.



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Green	**12p**
Yellow	**12p**
Square Red	
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Red **70p**
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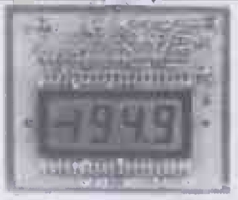
DIGITAL VOLTMETER/ THERMOMETER KIT



Based on the ICL7106. This kit contains a PCB resistor, presets, capacitors, diodes, IC and 0.5" liquid crystal display. Components are also included to enable the basic DV kit to be modified to a Digital Thermometer, using a single diode as the sensor. Requires a 3mA 9V supply (PP3 battery) **£20.75**

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TRIACS

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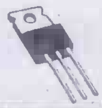

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Breaker One-Four

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This month Breaker-One-Four comes from the USA where our roving reporter Rick Maybury has been looking at CB in the land of its birth.

THE FIRST THING that struck me about America was the fact that everybody (well, nearly everybody) has some kind of personal radio. Of course they're not all CB but for a country with such dense population centres they can still find room for even the most humble bus conductor or street cleaner (yes, even street cleaners in New York have two-way radios).

CB itself has been going through something of a recession in the last few years, that doesn't mean it's died out, far from it, it just means that people that had only a fringe interest, the loonies etc have now given it up and the dedicated hard core continue to use CB in a responsible and intelligent way.

My first indication that CB was alive and well was in the shape of advertisement hoardings for hotels and restaurants, many had displays to the effect that they would monitor a particular channel so that any road-weary traveller could book a room or order a meal several miles before they reached their destination — now isn't that a good idea?

Listening to CB on the road revealed that the 'Truckers' channel-19 was particularly busy, you could hear evidence of actual 'convoys' being formed, reports of police activity, although I didn't actually hear any emergencies being reported I was reliably informed by some American friends that it does indeed save lives, several to their knowledge in the past year.

This particular aspect of CB is one of the most contentious subjects on British CB, people claim that in our small over-populated island the need for such a service does not exist, well, that is just not true, accidents happen everywhere, a telephone is not always at hand (or working) and these days with the improvements in medical care, seconds, not minutes can and do count when it comes to saving lives and we can all remember the winter of 78/79 and all of the stranded motorists and elderly people who lost their lives. Enough of the propaganda, I think we all know the arguments by now.

I was told that during the 'boom' of 76-78 CBs were so popular and in demand that they were literally ripped out of cars, leaving other valuables untouched, indeed, the car itself, probably a lot easier to steal was safer than a CB in the car. The situation has settled down now, almost 75% of all cars on the road sport some kind of CB antenna, and that doesn't include all of the 'disguised' or 'Hidden Ears' that are used.

Buying rigs couldn't be easier or cheaper, most shops and that includes food stores, sell CB equipment, the most amusing retailer of CB was good old Woolies, they offered a quite creditable range in most of their stores, the one oddity was the cost of aerials, they were in many cases up to 50% of the cost of the rig. An average rig, 40 channel, 4 watts with a digital readout, the type that sells over here for around £100 on the black market could be seen almost everywhere for about £20-25. The largest chain of CB stores was our old friend Tandy or Radio Shack as they are known in the US. A typical Radio Shack rig would go for about 69 dollars or about £34. Antennas tended to be quite expensive in Radio Shack, around £10-30 for mobiles and £25-50 for base stations. This, however, was not representative as many 'local' shops would quite readily undercut Radio Shack.

The latest trend would seem to be the 'scanner'. This is a cunning type of tuner that offers several advantages over a manually tuned rig. A typical scanner can be programmed to look for vacant channels, monitor certain channels, ie 9 for emergencies, go to a particular channel at a particular time or just scan up and down the spectrum looking for a nearby contact. All of this is usually looked after by the ubiquitous Microprocessor and will typically sell for around £100-150 for a mobile rig.

Another development of CB has been the upsurge of mobile telephones, in the US you can connect a wide range of devices to your phone without incurring the wrath of the telephone company, so small pocket transceivers with a full dialling capability can be kept in the pocket in constant touch with a base station connected to the phone. The pocket TX/RX can both receive incoming calls and make outgoing calls within about a quarter-mile radius, the transceiver is put into a Charger/holder at night ready for the next day, all for around £75-£150.

SIDEBANNED

Perhaps one of the more surprising aspects of American CB was the almost total disinterest in Sideband operation. I was unable to discover any concrete reason, after all Sideband rigs don't cost significantly more than straight AM rigs, the only reason I could see was the lack of convenience in operation, the almost continual twiddling of clarifiers and the difficulty in holding three or more conversations simultaneously. However, if the rather poor American CB magazines are to be believed rigs with automatic clarifiers are on the way.

INTERFERENCE

From my brief visit I learned that the Americans are almost obsessed with communications, their 'Phone system must surely be one of the most sophisticated, anywhere you go within the States you can always receive at least a dozen radio and a similar number of TV stations. Granted that they are a much larger country but America has cities much larger and more densely populated than our own. I saw absolutely no evidence of frequency overcrowding, no-one I spoke to had any complaints, although to be fair I was told that TVI was a problem some years ago but all modern TV sets are fitted with high pass filters, literally adding a few pennies tc the cost of a set and this problem has completely disappeared.

In conclusion I have seen CB working and working well, I saw no evidence of the widespread chaos and abuse that exists in the States, or so we are told by people that for reasons best known to themselves do not want CB. America isn't that different from us, just bigger.

BACK HOME

By the time you read this there's a very good chance that the Government will have made some kind of announcement regarding CB. We at HE believe that should a statement be made it will be to the effect that a two-way radio system similar to CB but operating on a much higher frequency may be introduced within the next six months. What this means (if we are right) is that you the readers of BOF, those of you that took the trouble to fill out our petition and wrote to your MP or the Home Secretary have helped change the law. If we're wrong it wasn't for the want of trying and we shouldn't give up.

Back to more mundane matters now. Thanks to all concerned at the Guardian newspaper for their excellent article (incidentally BOF made quite a considerable contribution to that story). We've had to hold over entries for the slang competition till next month due to pressure of space. The long awaited Tape competition should make a welcome appearance next month courtesy of our old friend Dave Mills.

BITS AND PIECES

Another dealer to add to your list. This tine it's RP Autombile Engineers Ltd, who claim that they can sell you just about everything legal related to CB. That includes SWR bridges, connectors and aerials as well as a couple of other things that are best not mentioned. They can be found lurking at Dept CB, 25 Rosebery Crescent, Kingfield, Woking, Surrey. Call Andy Marshall on Woking 20024 for more details.

GET TOGETHER

At last something seems to be happening after that letter from Keith Townsend last month. A meeting will be held on Sunday 25th November at the Woodhayes pub (good choice) in Woodhayes Lane, 1 mile from junction 11 on the M1/M6 (turn left if you're coming from the south). Two or three members of each club are invited to attend (around lunchtime) to thrash out some common policy. Members of the press, media are also invited to attend and with a bit of luck Breaker One Four will be there too.

CB CLUBS

Still more club information keeps arriving. Before we get down to this month's selection, we've had quite a few enquiries from the northern end of the country asking if we knew of any clubs, so if there are any clubs in Manchester, Tyne and Weir and Newcastle areas please let us know.

United Breakers Association (UBA)
Chairman: Andy Donovan,
c/o 50 Gaskell Street,
Clapham, SW4.

UBA (Essex)
Chairman: Ted Cheneler,
24 Bryony Close,
Witham, Essex.

Steel City CB Club.
Chairman Alan Taylor
SSCBC, CBA.
PO Box 123.
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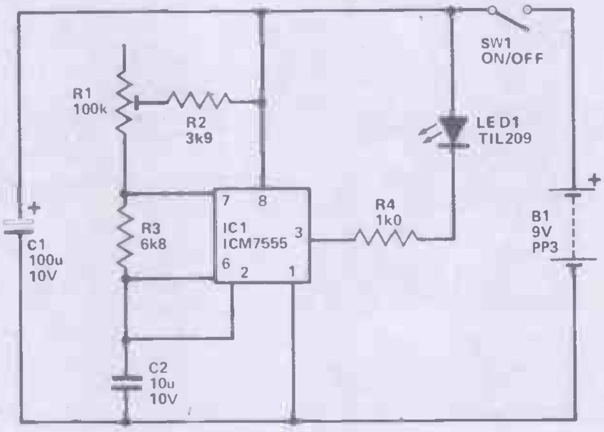

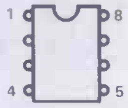

ICM7555 TOP VIEW

SIMPLE PHOTOGRAPHIC TIMER

Although this timing device may seem to be rather unsophisticated, it is a handy little gadget for timing darkroom exposures, or time exposures, or time exposures made on a camera with the shutter set to the "B" position. The unit simply flashes a LED indicator briefly at 1 second intervals. If, for example, one wishes to make a ten second time exposure, then the shutter is opened during any convenient flash produced by the unit, and then closed after a further ten flashes have been produced. Adequate accuracy for normal requirements can be obtained in this way.

The circuit is based on the CMOS version of the well known 555 timer device. The CMOS version has the advantage of having a current consumption which is only about one hundredth of that taken by the conventional version, and this is obviously beneficial in a battery powered piece of equipment such as this one. The average current consumption of the unit is actually less than 1mA., giving an extremely long battery life.

The CMOS version of the 555 operates in the same basic manner as the ordinary version, with timing capacitor C2 first charging up to ⅔ V+ by way of the timing resistors — R1 — R2 — R3. The device is then triggered into the discharge mode, resulting in C2 being discharged through R4 to a potential of ⅓ V+ whereupon the circuit reverts to its original state with C2 charging up once again. Contuous oscillation thus results. The frequency of operation is adjusted to 1 HZ by adjusting R1, and in practice this is adjusted by trial and error to obtain (say) 60 flashes in a one minute period. Longer calibration periods can be used if better accuracy is required.

The output of IC1 assumes the high state while C2 is charging, and the low state while it is discharging. As C2 charges via R1, R2 and R3, but only discharges through R4, the discharge time is therefore much shorter than the charge time. By connecting LED indicator D1 and its current limiting resistor R4 between the output of the IC1 and the positive supply the required brief flashes are thus obtained.

Into Linear ICs

By Ian Sinclair Part 6

With only one more episode to go Ian Sinclair takes a long hard look a the world of the IC amplifier and suggests a few more practical circuits for you to experiment with.

THE 741 OPERATIONAL AMPLIFIER is useful, as we've seen, for several audio-frequency projects, but specially designed audio amplifier ICs are usually superior, particularly as far as noise is concerned. Amplifier noise is the rushing sound which you hear from the loudspeaker when the volume control of an amplifier is turned all the way up with no signal coming in. The noise comes from an unwanted electrical signal which is generated in all conductors, but particularly in transistors and ICs. The 741 was originally designed for uses (in computers) in which the electrical noise signals are not a serious problem, and it generates too much noise to be of much use at the input of a high-quality amplifier. Several ICs have therefore been designed to replace the 741 in audio amplifiers, so that in this part we're going to take a look at four preamplifier ICs, each with its own particular advantages. Later on in this part we'll also look at ICs which give a power output suitable for driving a loudspeaker directly.

THE MC1303L STEREO PREAMPLIFIER

As the MC letters proclaim, this linear IC is manufactured by Motorola, and the package contains two identical preamplifiers on a single fourteen-pin chip, so making it ideal for stereo preamplifiers. Unlike most audio ICs, the MC1303 (the L means the package style) needs a dual power supply of +12 V and −12 V in addition to a common earth connection. In common with most modern audio amplifier ICs, the MC1303 has internal protection against short circuits at the outputs. Unusually for such an IC, loudspeakers can be driven directly at power levels.

The circuitry which is needed is shown in Fig. 6.1, assuming that the inputs are from a stereo magnetic cartridge which will be designed to feed into a resistance of around 47k. The capacitor C1 isolated this input from the bias at the input of the IC; this bias comes from R2. Feedback is applied at pin 8 through the network consisting of R4,C3,R5,C4 and C2,R3. Some explanation of this little lot is needed if you're not familiar with preamplifier circuits.

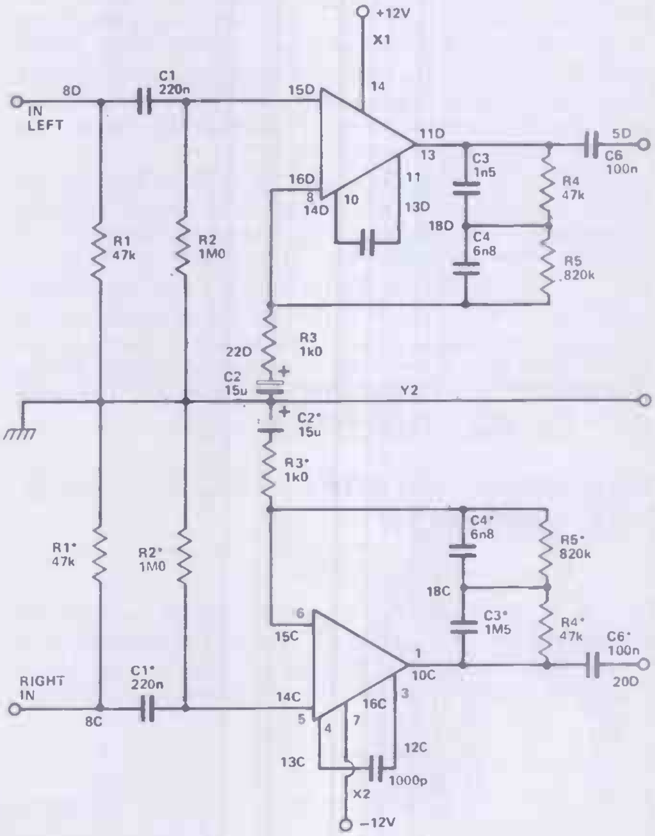

Fig. 6.1 MC1303L stereo preamplifier circuit. The complete Eurobreadboard layout is shown. Note that pin 1 of the IC is on line 10C.

When discs are recorded, we find that we can't just record the signals from the microphone by amplifying them and using them to drive the disc cutter. There are two problems. One is that the low bass frequencies cause excessive cutting width, so that one groove cuts through into the next. The other problem is that the uncut groove will still cause a signal, a noise signal, if it's played, and this noise signal can be louder than some of the high notes that we're trying to record.

Recording engineers get round these problems by a technique called pre-emphasis and equalisation. Before recording, the signal is deliberately distorted, so that the low frequencies are attenuated (their amplitudes reduced) and the high frequencies boosted (amplitudes increased) leaving the middle frequencies unaffected. This isn't done any old how, but by using filter networks whose values are internationally specified. To recover the original signal, then, we must reverse this process, using an equalising network.

C4 and R5 in parallel ensure that the gain is very high at low frequencies around 30 Hz, but the gain decreases at higher frequencies because C4 offers less impedance to feedback signal than does R5. The gain at a frequency of around 500 Hz is the "normal" gain of the amplifier; but at higher frequencies the combination of C3 and R4 causes the gain to decrease. The combined effect of the network is to reverse the attenuation and boosting processes that were carried out during recording, so restoring the signal to the correct amplitude at each frequency — we hope. The values which are shown in the circuit are those used for the signals from magnetic pick-up cartridges, since other types of cartridges are much less common, even on low-quality equipment. No values for tape or cassette signals have been given because the equalising values have to be matched to the type of replay head which is used, and there is much less international agreement about the amounts of boost and the frequencies at which they start.

C6 has been included in case the preamplifier is to be used to drive an amplifying stage which has a DC bias voltage present at the input. The voltage at the output of the MC1303, as used in this circuit, will normally be earth voltage, so that this preamplifier can be directly coupled to most of the output stages illustrated later in this part. There aren't many components needed to try out the MC1303, so it doesn't take very long to knock up the circuit on the Eurobreadboard, and it will operate with +9 V and —9 V supplies.

THE LM381 STEREO PREAMPLIFIER

The letters LM reveal that this chip is made by National Semiconductors, and this particular one is another dual preamplifier which is intended for stereo use. Once again, the circuit arrangements for a magnetic pickup cartridge have been illustrated (Fig. 6.2), with R1 set at 47 k to match most popular types of magnetic cartridge. This particular IC, however, differs from the Motorola one in several ways, not least in using a single supply which may be of anything from 9 V to 40 V, making battery or mains use simple. The bias is set by R3 and R4 applied to the input on pin 2 (pin 13 on the other part of the circuit), and the equalisation is carried out by R5,C3,C4 and R4 feeding back a fraction of the output signal across R2. Note that R2 does not affect the bias, since C2 is connected in series so as not to block DC though it passes signals. The circuit, incidentally, needs twice as many components as are shown if it's going to be used for stereo. Since the two parts are identical, there isn't much point in showing both parts. The Eurobreadboard numbers are shown for one part, with the numbers for the other section in brackets. The output signal from each section is taken through a capacitor (C5) which has to be used because the output pins (7 and 8) are not at earth voltage.

This chip has a low-noise input stage, claimed as the equivalent of 0.5 μV of noise signal, as compared to about 1 mV of normal signal from the cartridge, so that its noise performance is a lot better than that of the 741. The 381 is not sensitive to hum on the supply, so that mains supplies which are not too well smoothed can still be used.

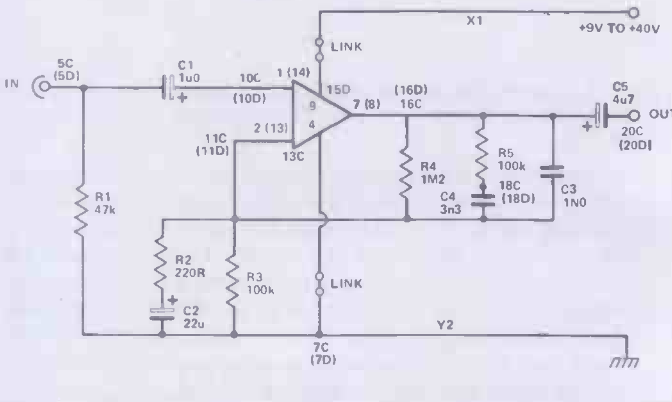

Fig. 6.2 Circuit and Eurobreadboard layout for the LM381 preamp. The layout is shown mainly for one channel, figures in brackets are the corresponding points for the other channel.

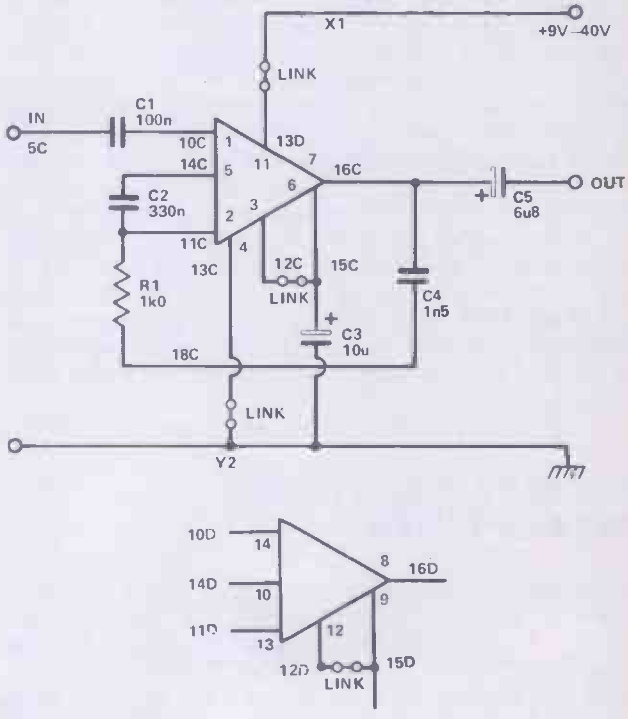

Fig. 6.3 Circuit and layout for one half of the LM382 stereo preamplifier. The pin numbers and Eurobreadboard layout for the second half are also shown.

THE LM382 PREAMPLIFIER

This IC is a design which is intended for simple record-players, using the smallest possible number of components. Like its stable-companion, the LM381, it uses a single power supply line which may be anything from 9

V to 40 V. The simplicity of the circuit makes it particularly suitable for low voltage operation from a single 9 V battery. No external bias components are needed, so that the circuit shows only the equalising and coupling components. C1 is the input coupling capacitor and C5 the output coupling capacitor.

Equalisation is carried out by C2, R1 and C4, with C3 used to decouple unwanted signals from the internal circuits. The claimed noise signal at the input is slightly higher than that of the 381 at 0.8 μV, but the same excellent standard of mains hum rejection allows the chip to be used with poorly-smoothed mains supplies. Like its companion, the 382 is internally protected against short circuits at its output, so that it isn't easy to burn out the IC because of such accidental short-circuits.

TREBLE TROUBLE AND BASS BASE?

Amplifiers and loudspeakers which might sound good out in a field somewhere often sound a bit peculiar in your own room. The reason is the way that sound waves bounce off the hard surfaces, like walls and windows, inside a room, and are absorbed by curtains and soft furnishings (no, not her!). To restore things back to something which pleases us more, though not necessarily like the original sound, we use tone controls.

A tone control reduces (cuts) or increases (boosts) the gain of the amplifier for a chosen range of frequencies. Most tone controls leave the "mid-range" frequencies of 400 Hz to around 1.5 kHz alone, and boost or cut the bass frequencies below 200 Hz or the treble frequencies above about 4 kHz. What about the ones in between, I hear you ask? They are affected to some extent by the tone controls, but not so much as the intended frequencies.

Tone controls come in two basic types, active or passive. Passive tone controls can never increase the amplitude of a signal, and are best suited to a part of a circuit where you have a fairly large signal voltage, a volt or so, to play with. Fig. 6.4 shows an example which

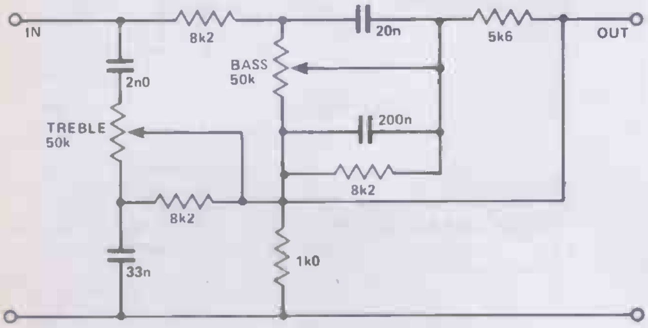

Fig. 6.4 One form of a passive tone-control circuit.

uses four capacitors, five resistors and two potentiometers — the reason for the complicated circuit is to try to ensure that the controls don't affect each other. It's a bit of a nuisance if twiddling the bass control changes the treble, just to take one example.

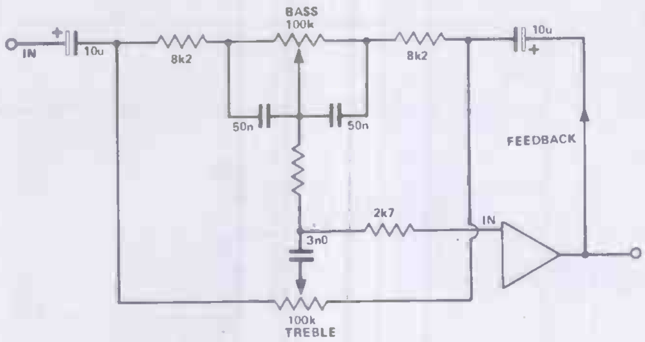

Fig. 6.5 The Baxendall tone-control circuit.

Fig. 6.5 shows the most famous of active tone control, the Baxendall circuit. This little lot is always operated as a feedback network, and can permit amplification, unlike the passive type of circuit.

THE TBA 231 PREAMPLIFIER

The previous preamplifiers have been intended as low-noise mono or stereo preamplifier stages which amplify and equalise an input signal from a magnetic cartridge to the level at which volume and tone controls can be used and a power amplifier driven.

This circuit (Fig. 6.6) uses its two stages to provide pre-amplification and tone/volume controls of the type used in Hi-Fi amplifiers, so that two chips of this type with corresponding power stages would be needed to perform creditably along with efficient good-quality speakers. That word efficient is important — most high quality speaker units are anything but efficient. A single power supply is used, but the inputs of each half of the chip have to be biased to half of the supply voltage.

Resistors R2 and R4 supply this bias voltage, with C2 decoupling the bias supply. R1 then supplies bias to the input pin (9) of the first half of the chip, and R5 supplies bias to the input pin (5) of the second half. The input signal is applied through C1, and equalisation is carried out by R7, R8, C6, C7 and R9 feeding pin 8, with a signal return to earth through R3, C3. The network made up from R6, C4 and C5 is a correction network designed to keep the circuit stable when feedback is applied. The output from this first stage is at pin 13, and a coupling capacitor C8 is needed because the DC level at pin 13 is approximately half of the supply voltage.

The signal through C8 feeds the volume control RV1, and the amount of signal which is selected by this potentiometer is passed through coupling capacitor C9 into pin 5, the input pin for the second section of the preamplifier. Only five pins are used in this stage, with C10 acting as a correction capacitor to assist stability. The feedback circuit which is connected between pins 1 (output) and 6 is a type of Baxandall tone control circuit, with RV2 acting as the bass control and RV3 as the treble control. This type of tone control is very widely used in high quality preamplifier designs because the two controls do not interact. In addition, both boost and cut of treble or bass can be obtained. This control network is always connected as a feedback loop, which makes it ideal for use with IC preamplifiers. The final

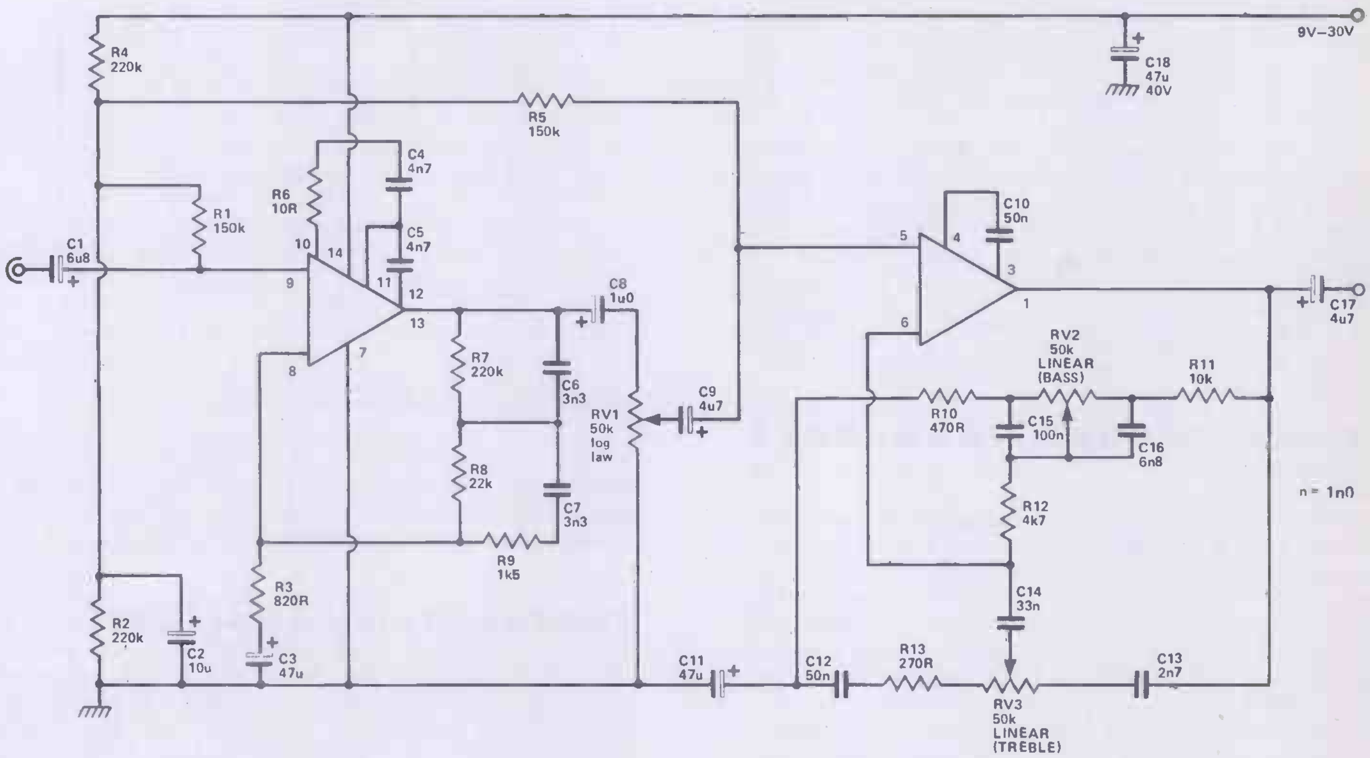

Fig. 6.6 The TBA231 preamplifier circuit, including volume and tone controls. No layout has been shown for this much more complicated circuit.

output signal is then coupled by C17 to the power output IC.

POWER OUTPUT ICs

Power output stages present the linear IC designer with his most difficult problem. Any power output stage must pass much larger signal currents than a pre-amplifier stage, so that much more heat is generated inside the IC. Unless this heat can be removed, the temperature inside the material of the IC will rise so high that the chip will be destroyed, and no repair is possible. At very low output power levels of a watt or less, we can make use of the air around the chip to remove the heat, along with the small amount of heat which flows from the pins to the printed circuit board. For higher power outputs, some sort of metal contact to the silicon of the IC is needed so that some power ICs are fitted with thick metal "wings" which can be used to dissipate heat, or which can be bolted to metal sheets or fins to create a large area to expose to the cool air. Other ICs are fitted with threaded studs so that fins can be bolted directly to the ICs. Both of these methods rely on attaching a larger area of metal to the semiconductor, so that the air has a better chance to cool the IC.

Whatever method of cooling is used, high temperatures inside the chip must be avoided, so that most power output ICs have also built-in thermal protection circuits which act to bias-off the final stages of the IC when the temperature is too high. This type of circuit is very often combined with a short-circuit protection as well, so that the IC is very well protected against all likely forms of overload.

All IC power output circuits use Class B, meaning that the output signal is shared between two transistors, with each transistor conducting for only half the signal wave time. Fig. 6.7 shows a typical circuit of this type using separate transistors so as to show the action.

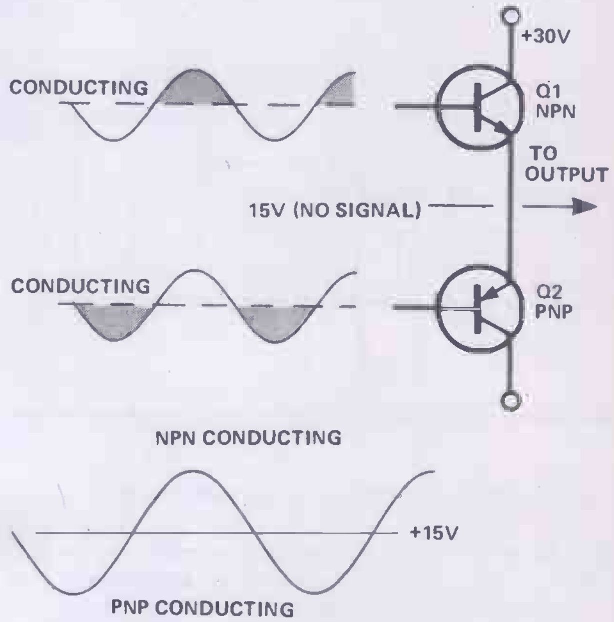

Fig. 6.7 The Class B principle for power amplifiers.

The PNP transistor conducts when its base voltage is about 0.5 V less than its emitter voltage, and the NPN transistor conducts when its base voltage is about 0.5 V more (positive) than its emitter voltage, so that Q1 passes current during the positive half of the cycle, and Q2 passes current during the negative half of the cycle. In theory, this circuit could be arranged so that neither transistor passed current when there was no input signal, but an unbiased stage of this type causes considerable distortion, called cross-over distortion, which cannot be completely corrected by the use of negative feedback. For this reason, a small amount of bias is always applied. The feature of the Class B circuit which makes it so attractive for IC power amplifiers is that its efficiency is high — the amount of power delivered to the loudspeaker is almost as much as is taken from the power supply, and up to five times the amount of power which is wasted in heating each output transistor. Unlike a separate-transistor (discrete) output stage, though, both of the output transistors of the IC are on one block of silicon, so that they can't be connected to separate heat-radiating fins.

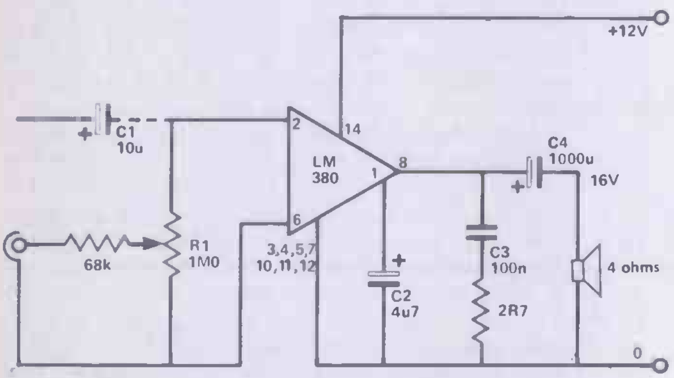

Fig. 6.8 The LM380 output IC. A volume control is shown, but if this is already incorporated in a preamplifier circuit, the dotted input circuit can be used and the 25k potentiometer replaced by a 22k fixed resistor.

USING THE LM380

The National Semiconductor LM380 power output IC is a particularly simple device which nevertheless gives a 2W output to a 4-ohm loudspeaker. A single-ended power supply is used, whose voltage has to be matched to the resistance of the loudspeaker which is used. A 12 V supply is used for a 4-ohm loudspeaker, a 14 V supply for an 8-ohm loudspeaker, and an 18 V supply for a 16-ohm loudspeaker. The maximum power output is 2W in each case, but will be less if lower voltage power supplies are used for a given loudspeaker resistance. If a higher voltage power supply is used, however, the power output will not be noticably increased, because the chip has current limiting and heating overload protection circuits.

With no signal input, the IC takes only 7 mA total current, so that this IC is ideal for battery operation, though its output on the 6 V batteries which are used for cassette recorders is a bit low. The voltage gain is around 50 times, so that, typically, for a 2 W output into a 4 ohm loudspeaker, the signal input is about 0.16 V peak-to-peak. This is an amount which can be supplied easily by any of the pre-amplifiers discussed earlier in this part, even when we allow for some losses in volume and tone controls. In the circuit of Fig. 6.8 the signal input is through the isolating capacitor C1 to pin 2 of the IC, with R1 acting as the earth return resistor. C2 is a frequency correcting capacitor which is needed to prevent oscillation, and C4 is the coupling capacitor for the loudspeaker. The DC level at pin 8, with no signal input, is about half of the supply voltage. The very small number of components makes this a particularly attractive output IC to use and it forms the basis of a useful utility amplifier, needing only a volume control for bench use and general test purposes. Note that seven of the pins of the IC are earthed. The positive feedback input connection comes into its own when the IC is used in cassette recorders, when the output stage is used as an oscillator during recording.

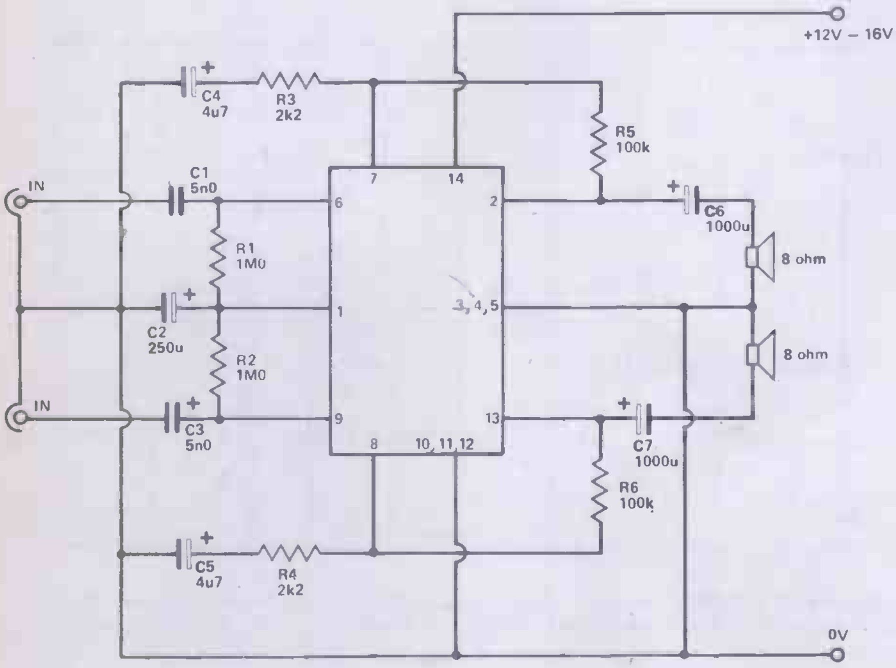

Fig. 6.9 The circuit diagram for the LM377 dual audio output IC.

STEREO POWER AMPLIFIER IC LM377

This is a 2 x 2W stereo IC output chip which is useful for small stereo amplifiers or even for adding a headphone output to a cassette deck. It's yet another National Semiconductor IC, and contains two power amplifier stages each with a claimed low distortion figure of 0.1% at 2W output. The power supply is single-ended and can have voltage levels of 12 V to 16 V, the best results are obtained at the higher voltage. Like its stablemates, the LM3777 is internally protected against overheating or accidental short-circuits on the output leads. The voltage gain of each channel is fixed by the feedback to pins 7 and 8, and is 45 times in the circuit of Fig. 6.9. Once again, this is adequate to allow the unit to be driven by any of the preamplifiers which were described earlier. The current taken from the power supply, with no input signal, is 15 mA.

In the circuit of Fig. 6.9, the input signals are taken through coupling capacitors C1 and C2, which can be of low values because the input resistance of the IC is high. R1 and R2 are load resistors, 1M each, and the signal common pin is earthed through C2 — note that this pin must not be earthed directly since to do so would upset the bias voltages inside the IC. Feedback is applied from each output to the feedback pin for each channel. For the stereo channel whose input is at pin 6, feedback is from pin 8 through R5 to pin 7, and the gain is set by the ratio of R5 to R3. R3 is returned to earth through C4 to avoid upsetting the bias. Similarly for the other channel whose input is on pin 9, the output from pin 13 is fed back through R6 to pin 8 with R4, C5 to earth. A loudspeaker resistance of 8 ohms gives the best results, and no special heat-dissipating arrangements are needed despite the comparatively high total power output. The IC should be placed, however, where air can circulate freely around it.

THE PLESSEY SL415

This one is a home-grown chip, a complete preamplifier and power amplifier IC. The maximum power output is 5W, with an 8-ohm speaker, and a single-ended 24 V power supply. As shown in Fig. 6.10 the circuit is for a single-channel (mono) amplifier. A simpler version, omitting the tone controls, can also be built. Two SL415's make a useful small stereo amplifier, and with a reasonably small number of components, construction is not too difficult. It's usually an advantage when you're making up a soldered version to have the control potentiometer separate, and some constructors prefer to have all the tone-control components on a separate piece of board.

The input (Fig. 6.10) is taken directly to RV1, the volume control, so that this input is suitable only for signals which have already been equalised by a preamplifier. C1 is a coupling capacitor and C2 a high-frequency decoupling capacitor which prevents oscillation. The input signal is taken to pin 6, and the output from pin 5 is used for DC feedback through R2 and RV2 to the inputs. RV2 is used to adjust the bias on pin 7, with C3 decoupling any signal from this point. RV2 is adjusted so that the steady voltage on pin 10 (the final output) with no signal input is exactly half of the supply voltage.

In the final stage, C9 is used to prevent oscillations, along with the network C11,R8. Another essential aid to stability is the connection of C13 between pins 9 and 1 as close to the IC as possible. Pins 1 and 3 are both directly earthed, but pin 1 is the earth for the output stage and should be connected directly to the supply negative. Pin 3 should then be connected to pin 1 with as short a lead as possible. This is important, as connecting the negative supply line to pin 3 can cause oscillation. Heat-sink fins can be connected to the SL415 by making use of the stud which makes contact to the silicon of the chip, and several manufacturers offer printed circuit boards ready-made for this IC and its surrounding components. **HE**

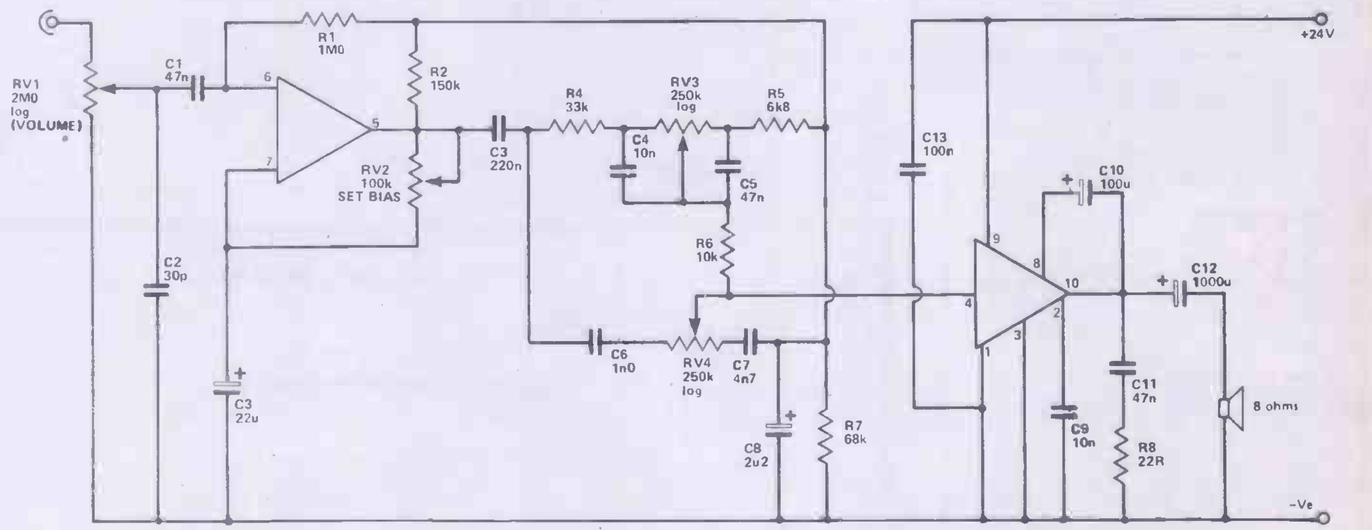

Fig. 6.10 The circuit diagram for a complete amplifier using a SL415. The maximum output power is 5W. No Eurobreadboard layout is shown, because the arrangement of components is critical, and a ready-made PCB is preferable except for experimental purposes.

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15 pence per word (minimum 25 words)
Box number £1.00 extra.

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CLASSIFIED ADS, HOBBY ELECTRONICS
145 Charing Cross Road, London WC2H 0EE
(Telephone: 01-437 1002)

AD. INDEX

INTRODUCTION TO MICROPROCESSORS AND COMPUTING. 50 pages of diagrams and explanation to get you started. Price £2.30 + 45p postage.
EDUCATIONAL DATA AND TECHNICAL SERVICES
59 Station Road, Cogenhoe, Northampton NN7 1LU

1000 MIXED RESISTORS (5% carbon film) for £3. 1N4148 SPECIFICATION DIODES on bandolier: 50, 150, 500, 1000 for 50p, £1, £3, £5. NYLON KNOBS, 20mm diameter for ¼" shafts, 30p for five. Post free from D. Johnston, 12 Balgillo Road, Dundee DD5 3LU.

Until April 1st this month's p.c.b.s to which Hobby Electronics have the copyright may be purchased for only 10p per square inch (incl. VAT, P&P).

E.G. A board the size of this ad = 110p (take to nearest sq. inch)

MAIL ORDER ONLY — CASH WITH ORDER TO:

S&G SERVICES (HULL)
43 Wheeler Street, Hull, North Humberside

QUARTZ LCD 5 Function

Hours, mins, secs, month, date, auto calendar, back light, fully adjustable bracelet to fit all wrists.

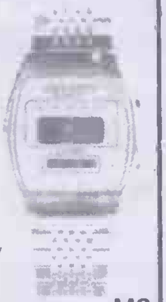
£6.65

Guaranteed same day despatch.

Very slim, only 6mm thick

M1

SOLAR QUARTZ LCD 5 Function



Genuine solar panel with battery back-up.
Hours, mins, secs.
Day/date.
Fully adjustable bracelet.
Back-light.
Only 7mm thick.

£8.65

Guaranteed same day dispatch.

M2

QUARTZ LCD 11 Function SLIM CHRONO

6 digit, 11 functions.
Hours, mins., secs., day, date, day of week.
1/100th, 1/10th, secs.;
10X secs., mins.
Split and lap modes.
Back-light, auto calendar. Only 8mm thick.
Stainless steel bracelet and back.
Adjustable bracelet.

Metac Price

£10.65 Thousands sold!

Guaranteed same day dispatch

M3

QUARTZ LCD ALARM 7 Function

Alarm
Hours, mins., secs.
Month, date, day.
6 digits, 3 flags plus continuous display of day and date or seconds.
Back-light.
Only 9mm thick

£12.65

Guaranteed same day dispatch

M4

MULTI ALARM 6 Digits 10 Functions

* Hours, mins., secs.
* Month, date, day
* Basic alarm
* Memory date alarm
* Timer alarm with dual time and 5 country zone.
* Back light.
* 8mm thick.

£18.65

M5

FRONT-BUTTON ALARM Chrono Dual Time

6 digits, 5 flags, 22 functions.
Constant display of hours and mins. plus optional seconds or date display.
AM/PM indication.
Month, date.
Continuous display of day.
Stop-watch to 12 hours 59.9 secs. in 1/10 second steps.
Split and lap timing modes.
Dual time zones.
Only 8mm thick.
Back-light.

Fully adjustable open bracelet.

£22.65

Guaranteed same day dispatch.

M6

SOLAR QUARTZ LCD Chronograph with Alarm Dual Time Zone Facility

6 digits, 5 flags, 22 functions.
Solar panel with battery back-up.
6 basic functions stop-watch to 12 hours 59.9 secs. in 1/10 sec. steps.
Split and lap timing modes.
Dual time zones.
Alarm.
9mm thick.
Back-light.
Fully adjustable bracelet.

£27.95

M7

ALARM CHRONO with 9 World Time Zones

* 6 digits, 5 flags
* 6 basic functions.
* 8 further time zones.
* Count-down alarm
* Stop-watch to 12 hours 59.9 secs. in 1/10 sec. steps.
* Split and lap timing modes.
* Alarm
* 9mm thick.
* Back-light
* Fully adjustable bracelet.

£29.65

M8

SOLAR QUARTZ LCD Chronograph

Powered from solar panel with battery back-up
6 digit, 11 functions.
Hours, mins., secs., day date, day of week
1/100th, 1/10th secs.
10X secs., mins
Split and lap modes.
Back light Auto calendar Only 8mm thick
Stainless steel bracelet and back
Adjustable bracelet.

Metac Price

£13.65 Guaranteed same day dispatch

M9

LADIES DAY WATCH
QUARTZ LCD

Ladies Day Watch only 25×20mm and 6mm thick.
Hours, minutes, seconds, day, date, backlight and auto calendar.
Elegant metal bracelet in silver or gold fully adjustable to suit very slim wrists.
State colour preference.

£9.95 Guaranteed same day despatch

M15

LADIES FASHION WATCH
QUARTZ LCD

Lady's Fashion Watch. Elegant bracelet in bronze/gold finish or silver colour. Hours, minutes, seconds, day, date, backlight and auto calendar. Adjustable for the slimmest of wrists.

State colour preference.

£14.95

Guaranteed same day despatch

M17

LADIES COCKTAIL WATCH
QUARTZ LCD

Lady's Cocktail Watch
Highly functional watch which also suits those special occasions. Beautifully designed with a very thin bracelet which retains strength as well as elegance. Hours, mins., secs., day, date, backlight and autocalendar.
Bracelet fully adjustable to suit slim wrists.
State gold or silver finish.

£19.95

Guaranteed same day despatch

M18

HANIMEX Electronic LED Alarm Clock

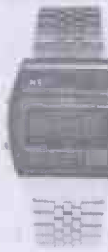
Features and Specification
Hour minute display. Large LED display with p.m. and alarm on indicator. 24 Hours alarm with on off control. Display flashing for power loss indication. Repeatable 9-minute snooze. Display bright dim modes control. Size: 5.15" x 3.93" x 2.36" (131mm x 11mm x 60mm)
Weight 1.43 lbs (0.65 kg)

£10.20 Thousands sold!
Mains operated

Guaranteed same day despatch.

M13

EXECUTIVE ALARM WATCH



6 functions plus alarm: Conference signal, 5 minute snooze alarm. Conference signal sounds 4 secs. before main alarm to give advance warning and option to cancel. Snooze sounds 5 mins. after main alarm and is always preceded by the conference signal.

£14.95

M60

MACY QUARTZ ANALOGUE

Automatic calendar day and date, infinite bracelet. This man's watch has elegance as well as the robust appearance provided by a watch with traditional features. Accuracy is provided by a quartz crystal powered by a long life miniature battery.

£24.95

M21

Metac price breakthrough for an Alarm Chronograph with Dual Time
Only £16.95

OUTSTANDING FEATURES

* **DUAL TIME.** Local time always visible and you can set and recall any other time zone (such as GMT).
  Also has a light for night viewing
* **CALENDAR FUNCTIONS** include the date and day in each time zone.
* **CHRONOGRAPH/STOPWATCH** displays up to 12 hours, 59 minutes and 59.9 seconds.
  On command, stopwatch display freezes to show intermediate (split/lap) time while stopwatch continues to run. Can also switch to and from timekeeping and stopwatch modes without affecting either's operation.
* **ALARM** can be set to any time within a 24-hour period. At the designated time, a pleasant, but effective buzzer sounds to remind or awaken you!

Guaranteed same day despatch **M16**

HOW TO ORDER

Payment can be made by sending cheque, postal order, Barclay, Access or American Express card numbers. Write your name, address and order details clearly, enclose 40 pence per single item for post and packing or the amount stated in the advert. All products carry 1 year written guarantee and full money-back 10 day reassurance. Battery fitting and electronic calibration service is available to customers at any Metac shop. All prices include VAT currently at 15%.

Metac Wholesale:
Trade enquiries — send for a complete list of prices for all the goods advertised plus many more not shown, also minimum order details.
Telephone orders: Credit card customers can telephone orders direct to Daventry (03272) 76545 or Edgware Road 01-723 4753 24 hours a day.

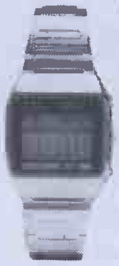
Service Enquiries: 03272-77659
CALLERS WELCOME. Shops open 9.30am-6.00pm.

Metac ELECTRONICS & TIME CENTRES

North & Midlands
67 High Street, DAVENTRY
Northamptonshire
Telephone: 03272 76545

South of England
327 Edgware Road
LONDON W.2
Telephone: (01) 723 4753

SEIKO MEMORY BANK



Calendar watch M354
Hours, mins., secs.
Month, day, date in 12 or 24 hour format all indicated continuously.
Monthly calendar display month, year and all dates or any selected month over 80 year period.
Memory bank function.
Any desired dates up to 11 can be stored in advance.
2 year battery life.
Water resistant.

Metac Price **£79.50** **M11**

SEIKO ALARM CHRONOGRAPH

With WEEKLY Alarm.
Hours, mins, Secs, month, date, day, am/pm.
Weekly alarm — can be set for every day at designated time, e.g. 6.30am on Mon., Wed. and Friday.
Alarm set time displayed above time of day.
Full stopwatch functions, laptime, split, etc.

Price **£89.95** **M10**

SEIKO MELODY ALARM CHRONOGRAPH

Chiming Alarm, plus chrono. Hours, mins, secs, date, day, 24-hour alarm, 12 hour chronograph, 1/10th secs, laptime, back light, stainless steel, mineral glass.

Metac Price **£92.95** **M19**

SEIKO CALCULATOR WATCH

Full specification calculator with memory, plus multi function watch.
Hours, mins, secs, day, date, backlight.
Automatic calendar.
Long-life battery.

Price **£96.20** **M27**

CASIO CHRONO 95QS-3LB

Stainless steel case, water resistant to 66 feet. Hours, mins, secs, am/pm, year, month, date, day. Auto-calendar pre-programmed until year 2029. 12/24 hour stopwatch function. Range 7 hours, 1/100 sec. (Mode). Net time/lap-time/1st-2nd place times. Dual time function. Accuracy 15secs. per month. Battery life approx. 4 years.

Price **£22.95** **M22**

CASIO LADIES 86CL-23B-1

Elegant slim line stainless steel bracelet, fully adjustable. Hours, mins, 10 sec. symbol second by flash, am/pm. Month, date, day. Auto-calendar pre-programmed for 28th day in Feb. Accuracy per month 15 secs., battery life approx. 15 months.

Price **£29.95** **M23**

CASIO F-200 SPORTS CHRONO

Attractive man's watch in black resin with mineral glass. Hours, mins, secs, am/pm. Month, date, alpha-numeric day. Auto-calendar set 28th Feb. Stopwatch working range 1 hour units 1/100 sec. Mode. Net time/lap time/1st-2nd place times. Accuracy approx. 15 secs. per month. Battery 12 months.

Price **£14.95** **M24**

CASIO ALARM CHRONO 81CS-36B

Hours, mins, secs, day, and also day, month and year perpetual automatic calendar. 100th sec. chronograph to 7 hours. Net time/lap time/1st and 2nd place times. User optional 12/24 hr. display. 24 Alarm. User optional, hourly chime. Backlight, mineral glass, stainless steel. Water resistant to 100ft. Battery life approx. 4 years.

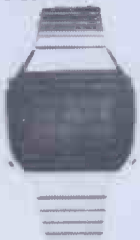
Price **£34.95** **M25**

BELTIME CHRONOGRAPH

9 Functions
Hours, mins, secs, day, date, month, interchange feature, automatic calendar, backlight, net time/lap time. Stainless steel bracelet. Battery life 1 year.

Price **£14.95** **M34**

BELTIME MULTI ALARM



29 Functions
Hours, mins, secs, date, day. Alarm, chronograph, light. Watch 8 functions, Alarm 4 functions, chronograph 17 functions. Stainless steel bracelet.

Price **£29.95** **M35**

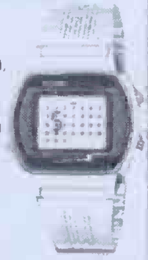
CASIO F-8C

3 Year Battery Life

Hours, mins, secs, am/pm, date, day. Auto calendar set. 28th Feb. Stopwatch function. Accuracy 15 secs. per month. Battery life approx. 3 years.

Price **£9.95** **M36**

CASIO CALENDAR 200



47CS-23B-1Black
Stainless steel. Hours, mins, 10 second symbol, second (by flash), am/pm. Month, day, date. Auto calendar set from1901 to 2009. Full month calendar display, dual time function. Accuracy 10 secs. per month. Battery life approx. 15 months.

Price **£59.95** **M37**

MELODY MULTI-ALARM CHRONOGRAPH

Hours, mins, secs, day, date, countdown alarm, dual time zone, 1/100th sec. stopwatch. Lap/split time, 1st and 2nd place times. Melody test function.

Price **£26.95** **M30**

DUAL TIME-ALARM CHRONOGRAPH

Incorporating module of world-famous Japanese watch manufacture. Hours, mins, secs, day of week, month, day and date, 24 hour alarm, 12 hour chronograph, 1/10th secs, lap time, backlight, stainless steel case and bracelet, mineral glass, battery hatch, long life battery.

Price **£35.00** **M12**

PICOQUARTZ MICROPROCESSOR ALARM CHRONOGRAPH

Multi-language — day of the week can be set to English, French, German, Italian or Spanish. Chime — every full hour combined with a response signal, beebing at every pressing of the functions. Can be switched off. 12-24 hour format, backlight, Chrono — 1 full-scale chrono with lap, counting hours, up to 24 hours. Minutes, secs, 1/100th secs. Two Alarm systems. Two time zones.

Price **£37.95** **M32**

SEIKO CHRONOGRAPH

Hours, mins, secs and day of the week. Month, date and day of the week. Stopwatch display. Hours, mins, secs up to 12 hours (minutes, secs, 1/100 secs up to 20 minutes). Lap timing, continuous time measurement of two competitors. Stainless steel, mineral glass.

Price **£56.00** **M33**

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& TIME CENTRES

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