Hobby Electronics

MAY '82
ISSN 0142-6192
70p

Project Electronics For Everyone

Projects for all

HE CABLE TRACKER

Digital Thermometer▲

Audio Signal Generator▶

▲Cable Tracker

Echo-Reverb Unit▲

Scaling the Hi-fi Heights - the final installment

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•New Series•New Series•

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BC237/8/9	8p
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10MHz XTALS	£2
8 Pole 10.7MHz XTAL filters	£14.50
2GHz coax relay 150W	£10.95

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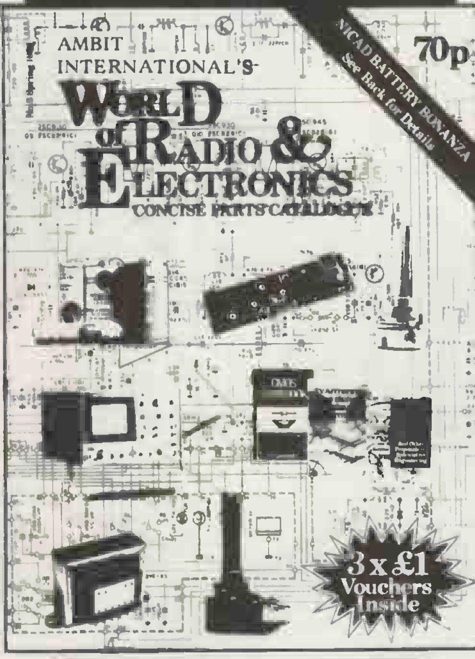
CAPACITY	TYPE	1-9	10-49
500 mAh	AA	80	74
2200 mAh	C	2.35	1.99
1200 mAh	D	2.14	2.06
4000 mAh	D	3.05	2.85
110 mAh	PP3	3.70	3.50

Price on the page



CMOS

4000	0.11
4001	0.11
4002	0.12
4007	0.13
4008	0.50
4008AE	0.80
4009	0.25
4010	0.30
4011AE	0.24
4011	0.11
4013	0.25
4015	0.50
4016	0.22
4017	0.40
4019	0.38
4020	0.55
4021	0.55
4022	0.55
4023	0.15
4024	0.33
4025	0.15
4026	1.05
4027	0.26
4028	0.50
4029	0.55
4030	0.35
4035	0.67
4040	0.50
4042	0.50
4043	0.50
4043AE	0.93
4044	0.60
4046	0.60
4047	0.66
4049	0.24
4050	0.24
4051	0.55
4052	0.55
4053	0.55
4054	1.30
4055	1.30
4056	1 30
4059	5 75
4060	0.75
4063	1.15
4066	0.30
4067	4 30
4068	0 16
4069AE	0.14
4070	0.16
4071	0.16
4072	0.16
4073	0 16
4075	0.16
4076	0.55
4077	0.18
4078	0.18
4081	0.12
4082	0.18
4093	0.30
4099	0.80
4175	0.80
4502	0.80
4503	0.50
4506	0.70
4507	0.37
4508	1.50
4510	0.55
4511	0.45
4512	0.55
4514	1.25
4515	1.25
4516	0.60
4518	0.35
4520	0.60
4521	1.30
4522	0.89
4527	0.80
4528	0.65
4529	0.70
4531	0.65
4532	0.80
4534	4.00
4536	2.50
4538	0.85
4539	0.80
4543	0.80
4549	3.50
4553	2.70
4554	1.20
4555	0.35
4556	0.40
4557	2 30
4558	0.80
4559	3.50
4560	2.50
4561	1.00
4562	2.50
4566	1.20
4568	1.45
4569	1.70
4572	0.22
4580	3.25
4581	1.40
4582	0.70
4583	0.80
4584	0.27
4585	0.45
4702	4 50
4703	4.48
4704	4.24
4705	4.24
4706	4.50
4720	4.00
4723	0 95
4724	0.95
4725	2.24
40014	0.54
40085	0.99
40098	0.54
40106	0.69
40160	1.05
40161	1.05
40162	1.05
40163	1.05
40174	1.05
40175	1.05
40192	1.08
40193	1.08
40194	1.08
40195	1.08

TTL N

7400N	0.10
7401N	0.10
7402N	0.20
7403N	0.11
7404N	0.12
7405N	0.12
7406N	0.22
7407N	0.22
7408N	0.15
7409N	0.15
7410N	0.12
7411N	0.18
7412N	0.19
7413N	0 27
7414N	0 51
7416N	0 27
7417N	0 27
7420N	0 13
7421N	0.28
7423N	0.22
7425N	0.22
7426N	0 22
7427N	0 22
7430N	0 13
7432N	0.23
7437N	0 22
7438N	0.22
7440N	0 14
7441N	0.54
7442N	0.42
7443N	0.62
7444N	0 62
7445N	0 62
7446N	0.62
7447N	0.62
7448N	0.56
7450	0.14
7451N	0.14
7453N	0.14
7454N	0.14
7460N	0 14
7470N	0.28
7472N	0 27
7473N	0.28
7474N	0.28
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7476N	0.30
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74104	0.62
74105	0.62
74107	0.26
74109N	0 35
74110N	0 54
74111N	0 68
74112N	1 70
74116N	1 98
74118N	0 85
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74120N	0 95
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74125N	0.40
74126N	0 40
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74142N	1 85
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74285N	3.50
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74293N	1.05
74297N	2 36
74298N	1.85
74365N	0.85
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74367N	0.85
74368N	0.85
74390N	1.85
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74490N	1.85

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74LS01N	0.10
74LS02N	0.11
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74LS367N	0.32
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74LS384N	2.50
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74LS396N	1 99
74LS398N	2 75
74LS399N	2.30
74LS445N	1 40
74LS447N	1 95
74LS490N	1 10
74LS668N	1 05
74LS669N	1 05
74LS670N	1 70

RAM

2102	1 70
2112	3 40
2114 2	1 49
4027	5 78
4116 2	1 59
4116 3	1 49
4864P	12 50
6116P 3	9.00
6116P 4	11 25
8264	12 50

74CXX

74C00	0.20
74C02	0.20
74C04	0.20
74C08	0.20
74C10	0.20
74C14	0.55
74C20	0.20
74C30	0.20
74C32	0.20
74C42	0.80
74C48	1.03
74C73	0.50
74C74	0.50
74C76	0.48
74C83	0.98
74C85	0.98
74C86	0.26
74C89	2.68
74C90	0.80
74C93	0.80
74C95	0.94
74C107	0.48
74C151	1.52
74C154	2.26
74C157	1.52
74C160	1.05
74C161	1.05
74C162	1.05
74C163	1.05
74C164	0.80
74C165	0.84
74C173	0.72
74C174	1.05
74C175	1.05
74C192	1.08
74C193	1.08
74C195	1.08
74C200	4 52
74C221	1 06
74C901	0 38
74C902	0 38
74C903	0 38
74C904	0 38
74C905	5 64
74C906	0 38
74C907	0 38
74C908	0 84
74C909	1 52
74C910	3 62
74C914	0 86
74C918	0 98
74C925	4 32
74C926	4 32
74C927	4 32

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MAY 1982
Vol 4 No 5

Hobby Electronics

PROJECTS

FEATURES

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Hobby Electronics is normally published on the second Friday of the month prior to the cover date.
Hobby Electronics, 145 Charing Cross Road, London WC2H 0EE, 01-437 1002. Telex No 8811896. Published by Argus Specialist Publications Ltd.
Distributed by Argus Press Sales & Distribution Ltd, 12-18 Paul St, London EC2A 4JS. Printed by QB Ltd, Colchester. Covers printed by Alabaster Passmore.
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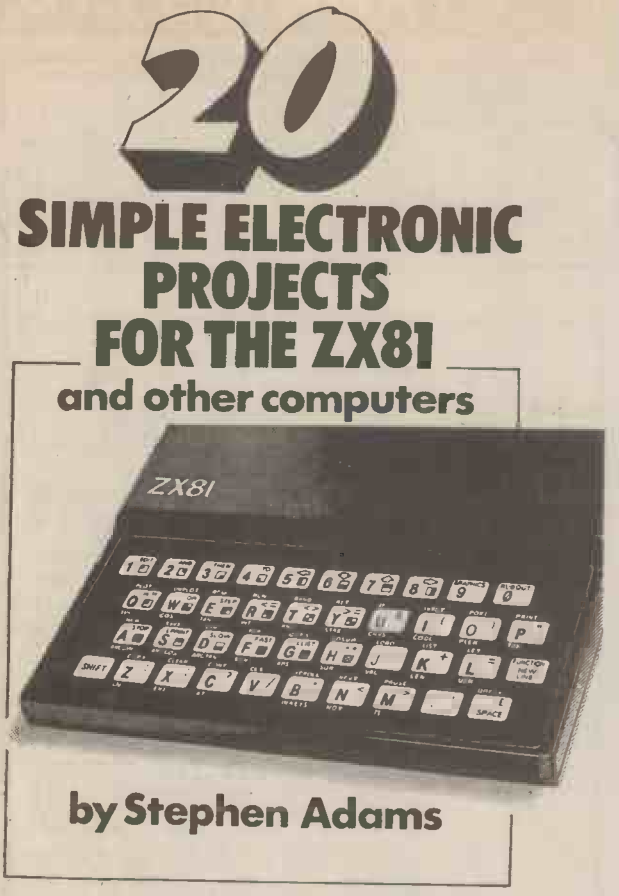

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AS FEATURED IN THIS ISSUE

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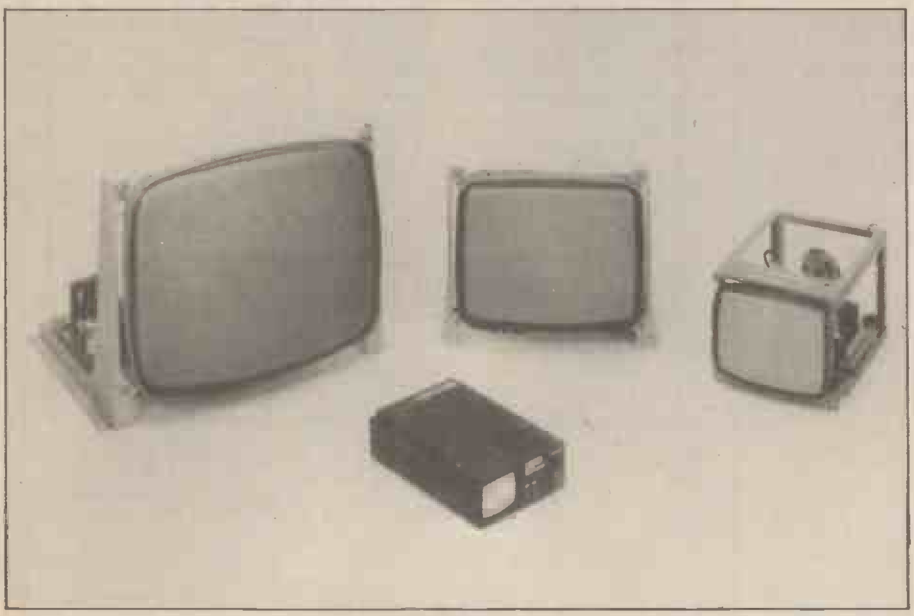
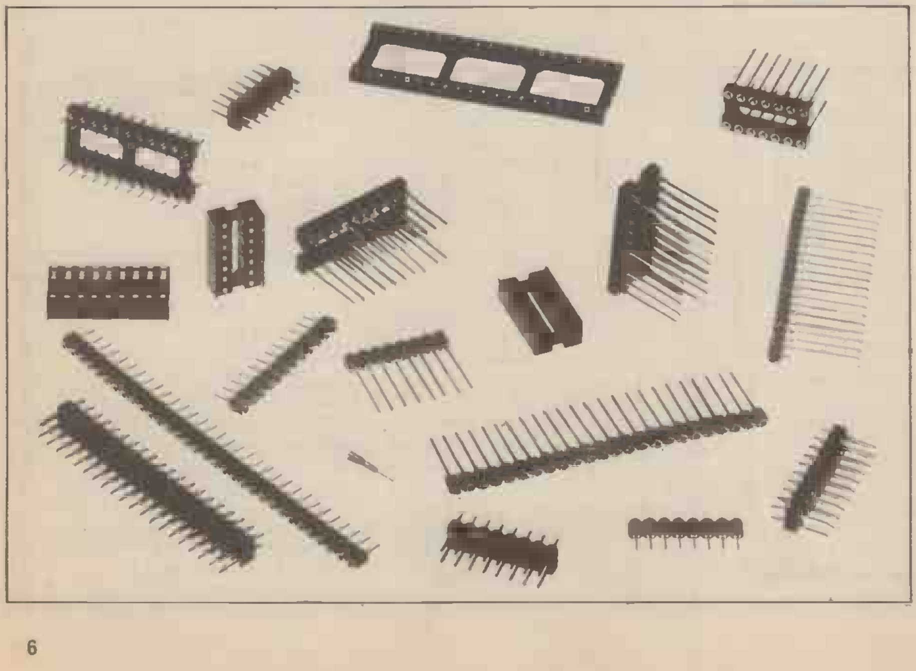
MONITOR





IT NEVER rains but it pours, quite often. This month's new releases include, for the first time, a selection of video monitors suitable for use as computer VDUs.

Most home computers are equipped with a 'video' output intended for use with ordinary domestic television sets. This output is, in fact, a frequency modulated RF signal which is tuned in on Channel Six. This system provides a cheap and convenient display, but the definition is not as good as it could be, due to lack of stability and bandwidth of most video modulators — and there is often a conflict over the use of the set! The simple solution to the second problem has been to buy or hire a monochrome TV which can be used solely as a VDU. Until now, however, there has been no easy, *safe* method of achieving improved display resolution (most domestic TVs cannot be safely modified to accept video input), so the appearence of a range of monitors designed for home computer users is especially welcome.

The most attractive of the new monitors is the 12" Monochrome Data Display Monitor **(above)** from **Chable Electronics Limited.** It operates from either 12 V DC or 240 V AC, measures a compact 370 x 290 x 30 mm and can be lifted with one hand; the display area is 24 x 80 characters. However, the DDM's most appealing feature, to the home computer user, is it's price — £85.68 including VAT and carriage. For further information contact **Chable Electronics Limited,** 3A Commercial Street, Batley, West Yorkshire WF17 5HJ or 'phone (0924) 441128.

The range of monitors from Thandar **(middle)** are intended for professional users, although they are also suitable for the home user. The range starts with the TV2S, a 2" model, and extends through 5", 9" to 12" types. They are supplied in chassis format, with a choice of B/W or green phosphor tubes and the option of standard or non-glare screens. Prices range from £119, including VAT, up to £155. Colour monitors, from 14" to 26", are also available on application. **Thandar Electronics Limited** are located at London Road, St. Ives, Huntingdon, Cambs PE17 4HJ; Tel. (0480) 64646.

Two new monitors **(below right)** from **Stotron Ltd.** are intermediate in price. The 12" model costs £99.50 and the 9" one, £92.75; both prices include VAT and carriage. The picture tubes are green phosphor, showing 1920 characters in 80 x 24 format and comply with DHEW regulations on X-radiation. Video input is via either RCA phono jack or SO-239 UHF connectors.

Another new product line from Stotron is a range of low-profile IC sockets **(left)**, featuring beryllium copper four-jaw gold plated contacts and insulation resistance of 10^{14} ohms. Full details of these and other new lines from Stotron appear in their 1982 catalogue, which is available from **Stotron Ltd**, Haywood House, Ivyhouse Lane, Hastings, East Sussex TN35 4PL; Tel. (0424) 442160.

MONITOR

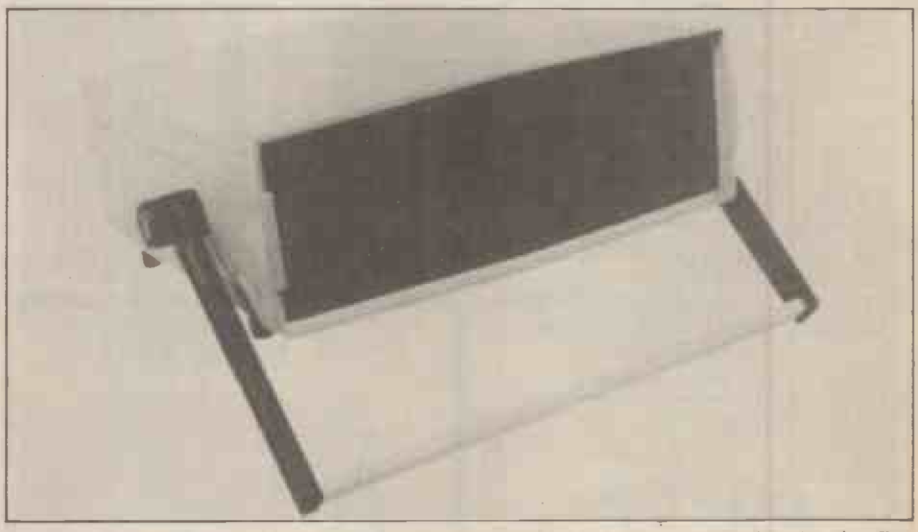
The best of the test equipment releases, this month, is a new hand-held digital multimeter (above) made by Sabtronics International Inc., of Tampa Florida (they don't just grow oranges there, you know) and marketed in the UK by **Black Star Ltd.** The **Model 2033** features 0.5% basic DC accuracy, a large 3½ digit LCD, push-button range and function switches and is powered by either a single PP3 battery or an optional AC adaptor. The 2033 will measure AC or DC voltages from 100 uV to 1000 V in five ranges, resistance from 1R0 to 20M in five ranges and AC or DC current from 10 uA to 2 Amps in three ranges. It is supplied complete with test leads for £42.26 including VAT; a high voltage probe is available as an optional accessory. The Sabtronics 2033 is available from various distributors around the country or directly from **Black StarLtd.**, 9A Crown Street, St, Ives, Huntingdon, Cambs PE17 4EB or 'phone (0480) 62440 for the location of our nearest dealer.

Readers of our new POPULAR COMPUTING section who are also owners of **Sharp, Casio** or similar pocket computers will be interested in a Manchester based mail order firm who specialise in pocket and portable computer systems. They are **Elkan Electronics** of 28, Bury New Road, Prestwich, Manchester M25 8LD. Their new catalogue, shortly to be released, will include the Sharp PC-1211 and PC-1500 and Casio's FX-702P, together with new software and books.

Obtaining the mechanical parts for a project is often more difficult than actually constructing the circuit, so new sources for hardware are always welcome. **Fieldtech Heathrow Limited** are marketing a new range of midget toggle switches, both single and double-pole, with switching from basic ON/OFF to variations of ON/OFF/ON through, various retailers, nationwide. The new range, called **Type 550**, is also available direct from Fieldtech Heathrow at prices ranging from 32 pence to 51 pence each. Data sheets will be supplied to interested readers who write to **Fieldtech Heathrow Limited**, Components Division, Huntavia House, 420 Bath Road, Longford, Middx UB7 OLL; Tel. (01) 897 6446.

Still on the subject of cases, **Adsum Ltd** have a range of standard instrument cases designed to suit a wide variety of applications. They are made from ABS plastic in standard colours (black or grey) and supplied blank, with internal fixing points. Two sizes are made, with external dimensions of 170 x 250 mm or 310 x 250 mm, and a range of heights. The maximum PCB size is, in each case, 10 mm less than each of the external dimensions. Details are available from **Adsum Ltd.**, Kiln Acre, Wickham Road, Fareham, Hants PO16 7ZH, Tel. (0329) 285858.

Latest news from the leading edge of technology concerns the introduction of stereo sound video machines. Leading the way will be Grundig, the West German manufacturers of almost everything electronic, with Philips and JVC not far behind. This long awaited (and long overdue) innovation will be welcomed by all — but particularly those who have been disappointed by the quality of sound on video cassettes of pop music or spectacular movies such as Flash Gordon, Superman or Star Trek. Already, producers of video-pop are preparing sound versions of popular tapes, as they will almost certainly benefit most from the improved quality of stereo.



Still on the subject of hardware, **OK Machine & Tool (UK) Ltd** have announced a new addition to their **PacTec** case range. The **Series CLH** (above) has a handle which doubles as a tilt-leg and is moulded from heavy weight ABS plastic. The basic size is 318 x 296 mm, with heights ranging from 115 to 146 mm. The cases accept a variety of mounting systems — PC card guides, mounting rails and other hardware — so allowing considerable flexibility for creating a number of internal configurations. The Series comes in four standard colours (blue, black, tan and grey) and can be supplied in kit form. The CLH Series is available direct from **OK Machine & Tool (UK) Ltd,** Dutton Lane, Eastleigh, Hants S05 4Aa (Tel. 0703 610944) or from **Watford Electronics.**

Grundig are also reported to be the first company ready to introduce stereo TV receivers to the UK. However, although stereo sound is broadcast in West Germany, it is unlikely to broadcast in the UK for some time, yet. True stereo TV will almost certainly come into general use when satellite television commences. Several European countries, notably West Germany and France, have their satellite TV systems well under way while, in the UK, a joint venture by three major companies, British Aerospace, British Telecom and Marconi Avionics, will put a UK satellite into orbit around 1986.

There are two possible methods by which satellite TV can be received — directly, by a small dish antenna on the roof, or via cable from a central receiving station. The Government appears to favour the idea of cable distribution, so it is likely that cable and satellite TV will be closely linked in this country. **HE**

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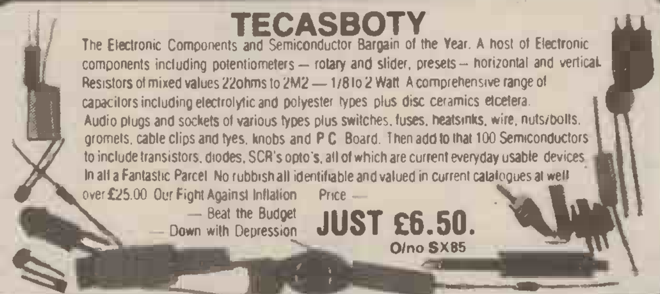

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Silicon General Purpose NPN Transitors TO-18 Case Lock fit leads — coded CV7644 Similar to BC147 — BC107 — ZT89 ALL NEW! VCE 70v IC500mA Hfe 75-250

	50 off	100 off	500 off	1000 off
PRICE	£2.00	£3.80	£17.50	£30.00

Order as CV7644

Silicon General Purpose PNP Transitors TO-5 Case Lock fit leads coded CV9507 similar 2N2905A to BFX30 VC 60 IC 600mA Min Hfe 50 ALL NEW!

	50 off	100 off	500 off	1000 off
PRICE:	£2.50	£4.00	£19.00	£35.00

Order as CV9507

Silicon NPN 'L' Type Transitors

TO-92 Plastic centre collector Like BC182L — 183L — 184L VCBO 45 VCEO 30 IC200mA Hfe 100-400

ALL perfect devices — uncoded ORDER AS SX183L

50 off	100 off	500 off	1000 off
£1.50	£2.50	£10.00	£17.00

PNP SILICON TRANSISTORS:

Similar ZTX500 — ZTX214 — E-Line VCEO 40 VCBO 35 Ic 300mA Hfe 50-400

Brand New — Uncoded — Pefect Devices

50 off	100 off	500 off	1000 off
£2.00	£3.50	£15.00	£25.00

Order as ZTXPNP

BI-PAK'S OPTO BARGAIN OF THE YEAR!

Valued at over £10—Normal Retail—we offer you a pack of 25 Opto devices to include LED's Large and Small in Red, Green, Yellow and Clear. 7 Segment Displays both Common Cathode and Common Anode PLUS bubble type displays—like DL-33. Photo Transistors—similar to OCP71 Photo Detectors—like MEL11-12. This whole pack of 25 devices will cost you just

£4·00

AND we guarantee your money back if you are not completely satisfied. FULL data etc included.

Order No. SX57.

The Third and Fourth Hand...

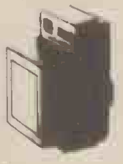
.... you always need but have never got 'until now'. This helpful unit with Rod mounted horizontally on Heavy Base Crocodile clips attached to rod ends. Six ball & socket joints give infinite variation and positions through 360° also available attached to Rod a 2½ diam magnifier giving 2.5 x magnification. Helping hand unit available with or without magnifier. Our Price with magnifier as illustrated ORDER NO T402 £5.50

Without magnifier ORDER NO T400 £4.75

MW398 NI-CAD CHARGER

Universal Ni-Cad battery charger. All plastic case with lift up lid. Charge/Test switch. LED indicators at each of the five charging points

Charges: —	Power —
PP3 (9V)	220-240V AC
U12 (1.5V penlite)	Dims —
U11 (1.5V "C")	210 x 100 x 50mm
U2 (1.5V "D")	£6.95



POWER SUPPLY OUR PRICE £3.25

Power supply fits directly into 13 amp socket. Fused for safety. Polarity reversing socket. Voltage switch. Lead with multi plug. Input — 240V AC 50HZ Output —3, 4.5, 6, 7.5, 9 & 12V DC Rating. — 300 ma MW88

5 watt (RMS) Audio Amp

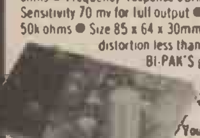
High Quality audio amplifier Module. Ideal for use in record players, tape recorders, stereo amps and cassette players, etc. Full data and back-up diagrams with each module

Specification

● Power Output 5 watts RMS ● Load Impedance 8-16 ohms ● Frequency response 50Hz to 25 KHz—3db ● Sensitivity 70 mv for full output ● Input Impedance 50k ohms ● Size 85 x 64 x 30mm ● Total Harmonic distortion less than 5%

BI-PAK'S give away price **£2.25**

You could not Build one for this price.



BI-PAK's COMPLETELY NEW CATALOGUE

Completely re-designed. Full of the type of components you require, plus some very interesting ones you will soon be using and of course, the largest range of semiconductors for the Amateur and Professional you could hope to find.

There are no wasted pages of useless information so often included in Catalogues published nowadays. Just solid facts i.e. price, description and individual features of what we have available. But remember, Bi-Pak's policy has always been to sell quality components at competitive prices and THAT WE STILL DO.

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8 Bit MICROPROCESSOR

National INS8080AN 40 Pin DIL N Channel Silicon GATE MOS TECHNOLOGY As used in Nationals N8080 Micro Computer Family Instruction Cycle Time 2 uS Supplied with functional Block Diagram BRAND NEW — NOT seconds or reclaims 100% perfect ORDER NO SX8080 **only**

Normal Sell price £4.50 each. Our BI-PAK Special Price **£2.00** SO HURRY — LIMITED STOCKS

40 Pin IC Socket to fit SX8080 ORDER NO 1609 Offer price **30p**

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Access

CAPACITORS

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

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

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

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

Ceramic. 22p-0-01u. 50V. 3p each.
★ Mullard Miniature ceramic plate.
★ 1.8pF to 100pF. 6p each.
Polystyrene. 5% tolerance.
10p-1000p 6p. 1500-4700p 8p. 6800-0.012 10p.
Trimmers. Mullard 808 Series.
2-10pF 22p. 2-22pF 30p. 5.5-65pF 35p.

CABLES

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

OPTO SPECIAL!

Special pack containing thirty 5mm LEDs. Ten red, ten green, ten yellow. Our normal price is 320p.
Special Offer price just 250p!
Offer expires 30th May 82.
Please note these are top quality grade 1 devices.

HARDWARE

PP3 Battery clips	6p
Red or black crocodile clips	6p
Black pointer control knob	15p
Pair Ultrasonics	350p
★ 6V Electronic buzzer	60p
★ 12V Electronic buzzer	65p
★ PB2720 Piezo transducer	75p
TO18 transistor socket	15p
64mm 64 ohm speaker	70p
64mm 8 ohm speaker	70p

PCB MATERIALS

Alfac PCB transfer sheets — please state type (e.g. DIL pads etc.)	45p
Dalo etch resist pen	100p
Fibre glass board 3.75" × 8"	75p
Ferric Chloride 250ml bottle	100p

COMPONENT KITS

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

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

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

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

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

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

25 6BA ¼" bolts	25 4BA ¼" bolts
25 6BA ½" bolts	25 4BA ½" bolts
50 6BA nuts	50 6BA nuts
50 6BA washers	50 6BA washers

ORDERING INFO

All prices exclude VAT. Please add to total order. Please add 50p carriage on all orders under £10 in value. Send cheque/PO or Access/Visa number with your order. Please note our new address. Callers most welcome — we are just 10 minutes from the centre of Colchester. Telephone orders welcome with Access and Visa. Official orders welcome from colleges and schools etc. Export orders no VAT but please add carriage.

POTENTIOMETERS

Rotary. Carbon track Log or Lin 1K-2M2.
Single 32p. Stereo 85p
Single switched 80p
Slide 60mm travel single Log or Lin 5K-500K. 63p.
Preset. Submin horiz. 100M-1M. 7p each.

BARCLAYCARD VISA

Access

TRIACS + SCRS

SCRs		TRIACs	
TIC45	28	400V 4A	60
C106D	30	400V 8A	70
400V 8A	70	400V 16A	105
400V 12A	99		

VERO

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

Just phone us on **0206 36412** with your order!

BRIDGE RECTIFIERS

1A 50V	22	18.0M	240
1A 400V	35	18.432M	220
2A 200V	40	19.968M	300
2A 400V	45	38.6667M	320
6A 100V	80	48.0M	220
6A 400V	95	116M	300
VM18 DIL 0.9A 200V	50		

SOCKETS

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

Soldercon pins 60p/100

DIL PLUGS

14 pin	45p
16 pin	50p
24 pin	90p

OPTO

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

Clips to suit 3p each

Rectangular		TIL32	40
★ red	12	TIL78	40
green	17	TIL111	60
yellow	17	ORP12	85
TIL38	40	TIL100	90

Seven Segment Displays

Com. cathode		Com. anode	
DL704 0.3"	95	DL707 0.3"	95
★ FND500 0.5"	80	FND507 0.5"	90
TIL313 0.3"	105	TIL312 0.3"	105
TIL322 0.5"	115	TIL321 0.5"	115

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

REGULATORS

Positive		Negative	
★ 78L05	25	79L05	65
78L12	30	79L12	65
78L15	30	79L15	65
★ 7805	45	★ 7905	45
★ 7812	45	★ 7912	45
7815	60	7915	60
LM309K	130	LM723	40
LM317K	320	LM338K	475
LM317T	120	78H05	
LM323K	350	5A 5V	550

DIODES

BY127	12	★ 1N4001	3
DA47	10	1N4002	5
OA90	8	1N4006	7
OA91	7	1N4007	7
OA200	8	1N5401	15
OA202	8	1N5404	16
1N914	4	1N5406	17
★ 1N4148	2	400mW zen. 6p	

★ BZX61 Series zeners.
★ 1.3W. 4V7-39V 15p each.

SOLDERING IRONS

Antex CX 17W Soldering Iron	420p
2.3mm and 4.7mm bits to suit	55p
CX 17W element	190p
Antex X25 25W Soldering Iron	440p
3.3mm and 4.7mm bits to suit	55p
X25 25W element	190p
Solder pump desoldering tool	480p
Spare nozzle for above	70p
10 metres 22 swg solder	100p

CRYSTALS

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

BOXES

Dimensions in inches. Aluminium.

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

Plastic Project Boxes
Complete with lid and screws.
3 × 2 × 1in. 55p
4½ × 3 × 1½in. 88p
7 × 4 × 2in. 160p.

SWITCHES

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

TRANSISTORS

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

LINEAR

		CA3189E	290	★ LM380	65	LM3900	50	NE566	150	TLO71	45
★ 709	25	ICL7106	790	★ LM381	120	LM3909	70	★ NE567	100	TLO72	75
★ 741	14	ICL8038	320	LM382	120	LM3911	120	NE571	425	TLO81	30
748	35	ICM7555	80	★ LM386	65	★ LM3914	200	RC4136	65	TLO82	70
AY-3-1270	840	★ LF351	45	LM387	120	★ LM3915	220	SN76018	150	TLO84	95
AY-3-8910	700	LF353	85	LM393	100	LM13600	120	★ SN76477	250	★ XR2206	300
★ AY-3-8912	625	LF356	90			MC1310	150	TBA800	80	ZN414	100
		LM10	395	★ LM709	25	MC3302	150	TBA810	95	ZN423	195
CA3046	60	★ LM301A	25	LM710	50	MC3340	135	TBA820	80	ZN424	135
CA3080	65	LM311	70	LM725	350	NE515	270	TBA950	290	ZN425E	390
CA3089	215	LM318	120	LM733	75	NE529	225	TCA940	170	ZN426E	330
CA3090AQ	375	★ LM324	40	★ LM741	14	NE531	150	TDA1004	300	ZN427E	650
CA3130E	90	LM339	50	LM747	75	NE544	185	TDA1008	320	ZN428E	480
CA3140E	45	LM348	65	LM748	35	★ NE555	16	TDA1010	225	ZN1034E	200
CA3160E	100	LM358	50	LM1458	40	★ NE556	45	TDA1022	560		
CA3161E	140	LM377	150	LM2917	200	NE565	120	TAD1024	125		

CMOS

		★ 4017	43	4036	285	4055	115	4082	20	4502	70	4529	150
		4018	60	4039	295	4059	480	4085	65	4503	50	4532	95
4000	14	4019	35	4040	55	4060	85	4086	65	4507	38	4534	495
★ 4001	12	★ 4020	55	4041	75	4063	90	4089	140	4508	200	4538	110
4002	14	4021	65	4042	55	4066	35	★ 4093	33	4510	65	4543	110
4006	65	4022	70	4043	60	4067	395	4094	14	★ 4511	50	4549	380
4007	17	4023	18	4044	65	★ 4068	15	4095	90	4512	70	4553	295
4008	58	4024	40	4046	70	4069	18	4097	340	4514	180	4555	45
4009	30	4025	18	4047	70	4070	18	4098	85	4515	180	4556	48
4010	35	★ 4026	96	4048	55	4071	18	4099	95	4516	75	4559	390
★ 4011	13	4027	30	★ 4049	28	4072	18	40106	50	★ 4518	45	4560	180
4012	17	4028	55	4050	28	4073	20	40109	100	4520	70	4584	45
★ 4013	26	4029	75	4051	60	4075	20	40163	100	4521	200	4585	99
4014	60	4030	35	4052	70	4076	60	40173	100	4526	80	4724	140
4015	60	4031	170	4053	60	4077	25	40175	100	4527	90		
★ 4016	26	4034	170	4054	110	4081	18	40193	120	★ 4528	75		

TTL

		7413	24	7442	40	7480	45	74107	30	74155	60	74177	75
		7414	35	7444	85	7482	70	74109	32	74156	60	74179	65
7400	11	7416	25	7446	60	7483	50	74121	28	74157	43	74180	65
7401	11	7417	25	7447	48	7485	75	74122	45	74160	60	74181	135
7402	12	7420	15	7448	50	7486	25	74123	48	74161	60	74182	75
7403	14	7421	20	7450	16	7489	180	74125	40	74162	60	74190	70
7404	14	7422	20	7451	16	7490	28	74126	40	74163	60	74191	70
7405	17	7427	28	7453	16	7491	40	74132	40	74164	60	74192	70
7406	26	7428	28	7454	16	7492	45	74141	65	74165	60	74193	65
7407	26	7430	15	7460	16	7493	30	74165	65	74167	180	74194	70
7408	15	7432	25	7472	25	7494	35	74147	100	74170	165	74195	63
7409	16	7433	27	7473	28	7495	50	74148	75	74173	60	74196	63
7410	14	7438	27	7474	25	7496	45	74150	75	74174	65	74197	63
7411	20	7437	27	7475	38	7497	120	74153	45	74175	70	74198	95
7412	20	7440	17	7476	30	74100	80	74154	75	74176	55	74199	95

LS TTL

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

CONNECTORS

DIN	Plug	Skt	Jack	Plug	Skt
2 pin	9p	9p	2.5mm	10p	10p
3 pin	12p	10p	3.5mm	★ 8p	★ 8p
5 pin	13p	11p	Standard	16p	20p
Phono	10p	12p	Stereo	24p	25p
1mm	13p	13p	4mm	18p	17p

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

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

TRANSFORMERS

Please add carriage charges to our normal post charges

Miniature mains.
606V, 909V, 12012V all @ 100mA 100p each

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

RESISTORS

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

PANEL METERS

Sixe 60 × 46 × 35mm.

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

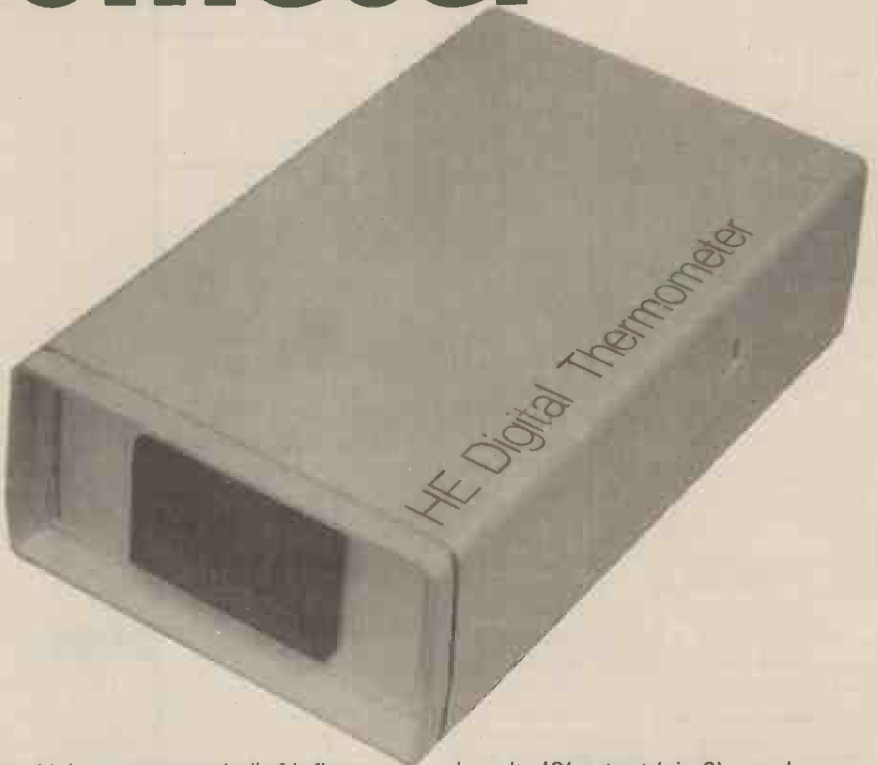
495p each.

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

Digital Thermometer

Owen Bishop

A neat, compact project for indoor or outdoor use.



THIS PROJECT was designed as a battery-powered, digital thermometer giving a readout on a seven-segment LED display. Its neat appearance makes it equally at home in the study or the living-room, or it can be used for remote temperature sensing.

The sensor is an IC which generates a current proportional to the temperature of its surroundings. One useful feature of this IC is that the current is completely unaffected by the length of the wire connecting the sensor to the rest of the circuit. Changes in resistance of the connecting wire have no effect either. The project, therefore,is suitable for remote sensing of temperature. The sensor could easily be situated in the greenhouse, for example, allowing you to monitor the temperature from indoors and warning of the risk of overheating in summer, or of frost in winter.

Although weather forecasts, nowadays, are given in degrees Celsius (some people wrongly persist in calling it Centigrade — why not pay our respects to Celsius, the man who invented this scale?), many people still think in terms of degrees Fahrenheit, so this circuit can be built to measure temperature in either scale.

The Circuit

IC1 is a constant-current generator, the current being determined by the value of R1 and by the ambient temperature. The current flowing to R2 is given by:

$$I = 227 \times T/R,$$

where I is in microamperes, R is the value of R1 in ohms, and T is the absolute temperature, in Kelvin. Absolute Zero, on the Kelvin scale is approximately equal to -273°C or -459°F. A room temperature of 20°C is, therefore, 273 + 20 = 293 K. Thus at room temperature, I = 227 x 293/220 = 302 uA. As this current flows through R2 it generates a potential of 3V02 across it. Note that if IC1 is to be used as a remote sensor, R1 must be mounted as close to it as possible; the leads to V+ and V- may be as long as necessary. Current flowing from V- is constant and *all* of it flows to R2. Hence the length of the lead and its resistance do not affect the voltage across R2.

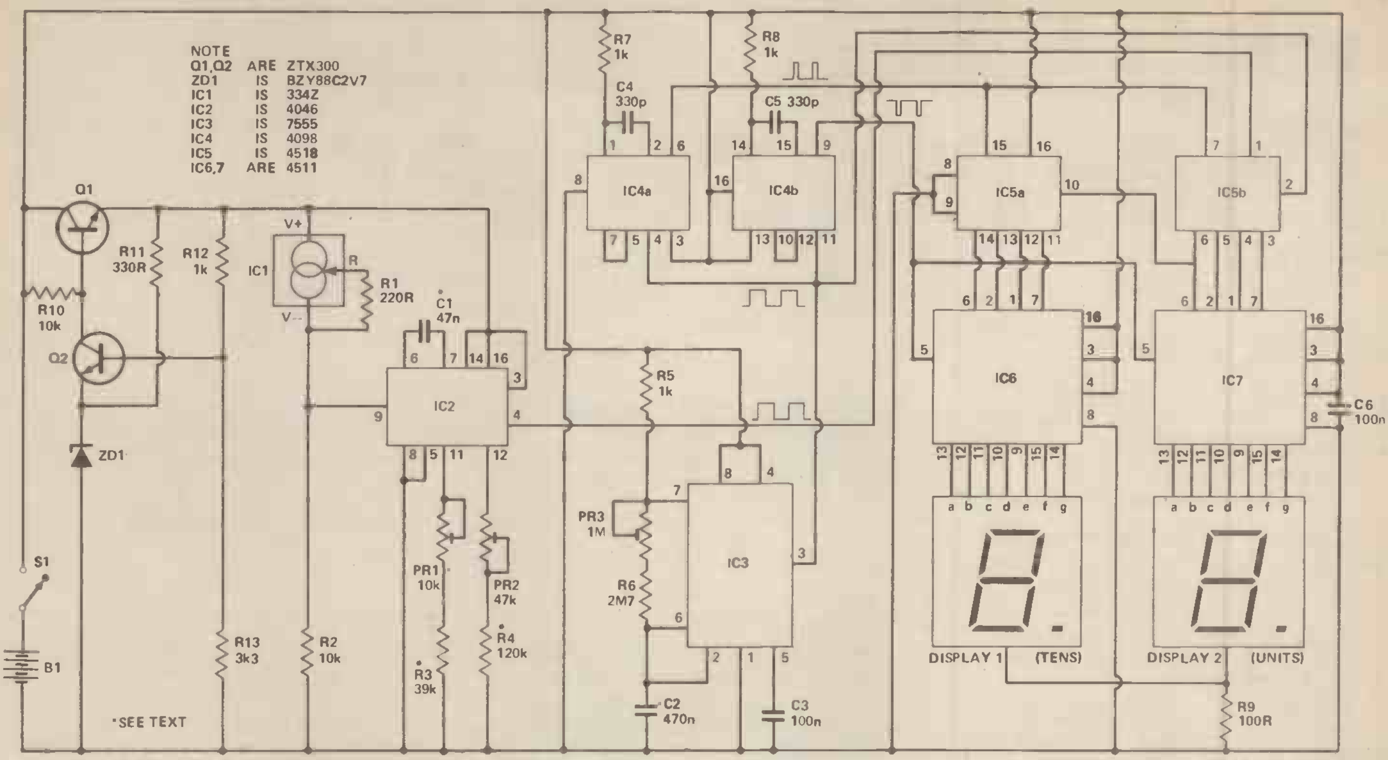
IC2 is a CMOS phase-locked-loop IC, which is used because of the VCO it contains (among other functions). With a fixed capacitance across pins 6 and 7, the rate of oscillation at any given voltage is determined by the resistance at pin 11. The resistor at pin 12 determines the minimum (or offset) frequency. With no resistor at pin 12, the rate is 0 Hz at 0 V. We choose minimum (offset) and maximum frequencies which correspond to the correct temperatures when the 'hundreds' digit is omitted. The scale maximum is, in practice, only 799 (99°F) for Fahrenheit.

Timing for the system is under the control of IC3, a CMOS timer wired as an astable, operating at 0.5Hz. The dual monostable (IC4) is wired to generate a short pulse at the beginning and end of each pulse from IC3. The count is 'enabled' as the output of IC3 goes high and the counter is reset to zero, by the pulse from IC4a. When the high pulse from IC3 ends, the counter is disabled; simultaneously, the low-going pulse from IC4b to the drivers (ICs 6 and 7) stores the resulting count, which is then decoded and displayed.

IC5 contains two decade counters; the units counter (IC5b) is enabled whenever input 'EN' (pin 2) is taken low. Its '8' output (pin 6) goes low whenever the count changes from 9 back to 0; this low-going edge triggers the other counter (IC5a) which is incremented and counts 'tens'. Enabling or disabling IC5 automatically has the same effect on IC5a. Note that the input to IC5b is the clock input (pin 1), which triggers a count on a positive-going edge; the input to IC5a is at its 'enable' input (pin 10) which is negative-triggered; its clock input (pin 9) is wired to 0 V to hold it permanently low.

To ensure that all the digits are equally bright, there should be a resistor in each lead between ICs 6 and 7 and the displays. We have economised by using only a single resistor (R9) in the common cathode line. When the displayed value alters, there is a small change in brightness because the number of illuminated segments has changed. In practice this is not worth bothering about, since the display does not change often.

The regulator circuit is fairly conventional. A constant voltage of 2V7 is maintained at the junction of Q2 and D1; with the forward voltage drop across the base-emitter junction of Q2, the voltage at R12/R13 must be 2.7 + 0.6 = 3V3. Since R12/R13 is a potential divider across the output, the circuit is only stable when the output voltage is 4V5, giving 3V3 at the base of Q2. As the supply voltage or load varies, the negative feedback through



▲Figure 1. The complete Digital Thermometer circuit. Although it uses quite a few chips, all except the displays are mounted on one board. The sensor IC may be taken off-board for remote sensing of temperature.

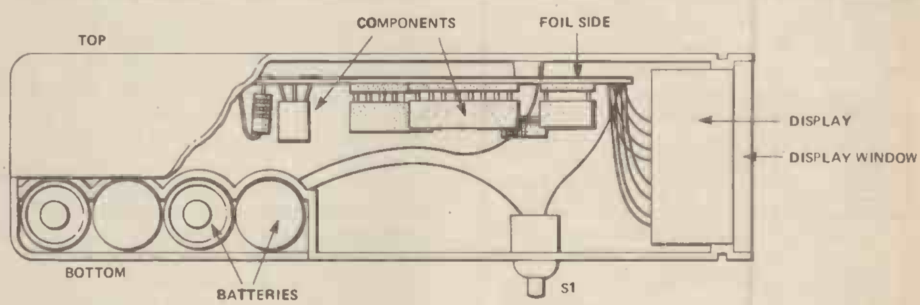
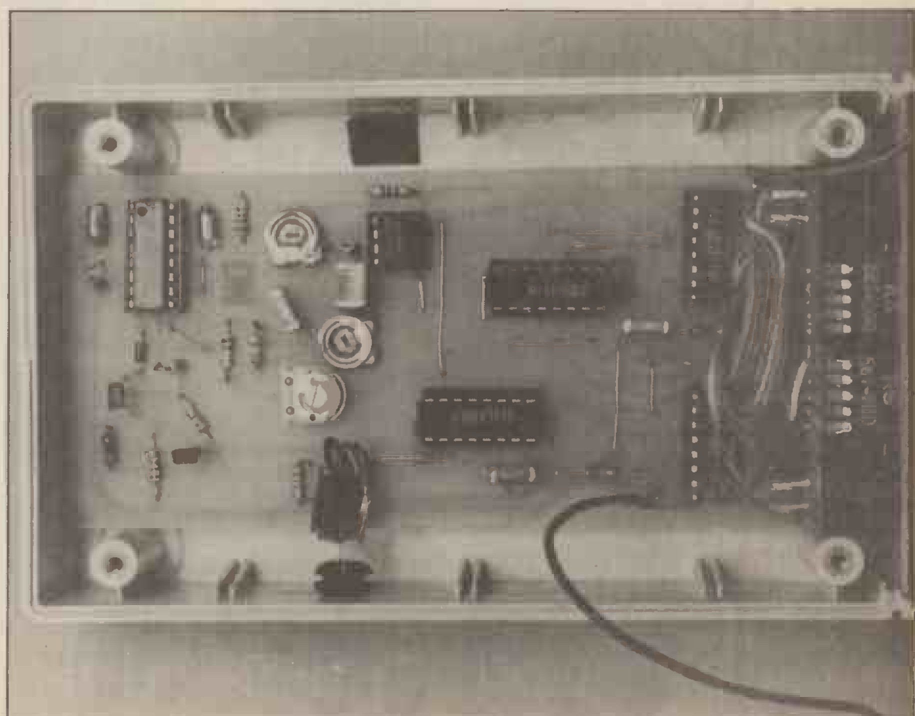


Figure 2. Cut-away view of internal ▶ layout, showing the PCB mounted upside down.



Q2 (via R12, 13) will either turn Q1 on harder or turn it off slightly, to maintain an output of 4V5. This circuit gives good regulation over the voltage range to be expected from batteries, as they gradually discharge.

Construction

The thermometer circuit is built on a single PCB mounted *upside down* in the top section of the case. The case we used has a built-in battery compartment, holding the four HP7 cells which provide the power supply of 6 V. The circuit will work directly from the batteries, but it is affected by falling voltage, as the cells age, as mentioned For this reason the simple voltage regulator is included, though it is not essential if you are willing to renew the cells fairly frequently. The regulator is mounted at the rear of the PCB, away from the sensor. It supplies only the sensor and oscillator, the remainder of the circuit being supplied directly from the battery.

The switch is a push-on/push-off type, mounted on the bottom of the case, near the front; It also acts as a tilting leg, giving a better view of the display. To switch the thermometer on or off, simply place your hand on top of the case and press down!

Parts List

RESISTORS
(All ¼ W, 5%)

R1 . . . . 220R
R2 . . . . 10k
R3* 3k9
R4* 120k
R5 . . . . 1k
R6 . . . . 2M7
R7 . . . . 1k
R8 . . . . 1k
R9 . . . . 100R
R10 . . . . 10k
R11 . . . . 330R
R12 . . . . 1k
R13 . . . . 3k3

* . . . . See Text

POTENTIOMETERS
(All sub-miniature horizontal presets)

PR1 . . . . 10k
PR2 . . . . 47k
PR3 . . . . 1M

CAPACITORS
(All polyester, except where indicated)

C1* . . . . 47n polycarbonate
C2 . . . . 470n polycarbonate
C3 . . . . 100n polycarbonate
C4 . . . . 330p polystyrene
C5 . . . . 330p polystyrene
C6 . . . . 100n polycarbonate

SEMICONDUCTORS

IC1 . . . . 334Z constant current generator
IC2 . . . . 4046B phase -locked loop
IC3 . . . . 7555 CMOS timer
IC4 . . . . 4098B or 4528B dual monostable
IC5 . . . . . 4518B dual BCD counter
IC6,7 . . . . 4511B BCD-to-7-segment latch/decoder/driver
Q1, 2 . . . . ZXT300 NPN transistor
ZD1 . . . . Zener diode, 2V7

MISCELLANEOUS

DISP1, DISP2 . . . . 7-segment LED display (2 off)
SW1 . Push-to-make/push-to-break switch, SPST

Battery instrument case (Vero type 2) 2.5 mm matrix stripboard, 127 mm x 63 mm main board, 63 mm x 25 mm for regulator, 55 mm x 28 mm (20 strips x 11 holes) for displays; 1.0 mm terminal pins, (7 off); Small angle bracket, 4BA bolt and nut set (2 off); Self-tapping screws for 2 mm holes (4 off).

BUYLINES . . . . page 68

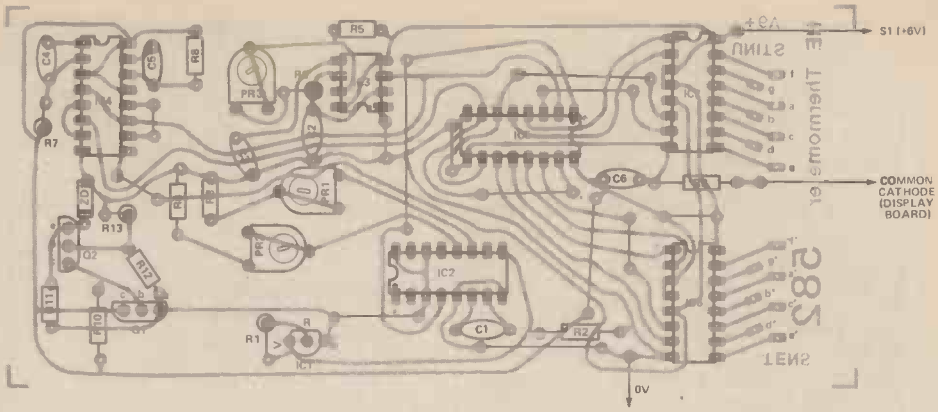
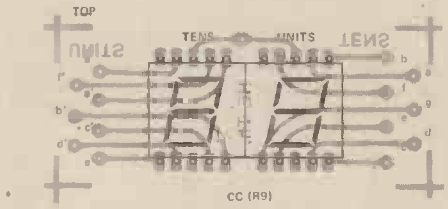


Figure 3. The component layout. Be careful to make the correct connections between the display board (right) and the main board.



It is more convenient if you leave mounting the board and wiring the switch until the thermometer board is complete and working. We strongly advise that sockets are used for the ICs, as this allows them to be removed, if necessary, when attempting to locate faults. Soldercon pins were used to mount IC1 and proved perfectly satisfactory. Since the circuit uses CMOS ICs, take the usual precautions to avoid static charges and wire up all the connections to each IC before inserting it.

Begin by building the regulator board; this is very simple so there should be no problems. When the regulator is connected to the 6 V supply, its output voltage should be about 4V5. Continue with IC1 and its resistors (R1, R2); use a heat sink when soldering this IC to the board. Test this section by switching on the power and measuring the voltage across R2. This should be about 3 V, whether you are using the 4V5 supply or the direct 6 V supply. Hold the IC between your finger-tips for a minute or two (or hold a warm soldering iron *near* it, but don't actually touch it); the voltage should rise. When the heat source is removed, the voltage should fall back to its original level.

Next, wire up IC3 (the CMOS timer), together with R5, R6, RV3, C2 and C3. To test this section you will need to take out IC1. The output of IC3 (pin 3) should rise and fall at approximately 0.5 Hz (2 seconds between successive pulses). Run it for one minute, counting the pulses. Use a 'scope', if you have one; if not, connect a high impedance earphone or audio probe between pin 3 and O V; you should hear a 'click' each time the edge of a pulse rises or falls. Adjust RV5 for 30 pulses per minute (60 clicks per minute); the pulses should have a 50% mark-space ratio ie, 1 Sec high, 1 Sec low.

Now you are ready to fit IC2, the voltage-controlled oscillator (VCO). At this stage, you need to decide whether the thermometer is to read degrees Fahrenheit or Celsius, and to choose the appropriate values for C1, R3 and R4. Those given in the Parts List are for degrees Fahrenheit; for Celsius, change these to 100n, 10k and 56k, respectively.

Next, mount PR1 and PR2 and, with IC1 still out of the circuit *and* IC3 removed, look at pin 4 of IC2. A 'scope is preferable but, if you do not have one, the frequencies can be adjusted by matching them against audio tones from an accurately calibrated audio oscillator or, if you have a musical ear, from a piano or organ, using a high impedance earphone or probe, as before.

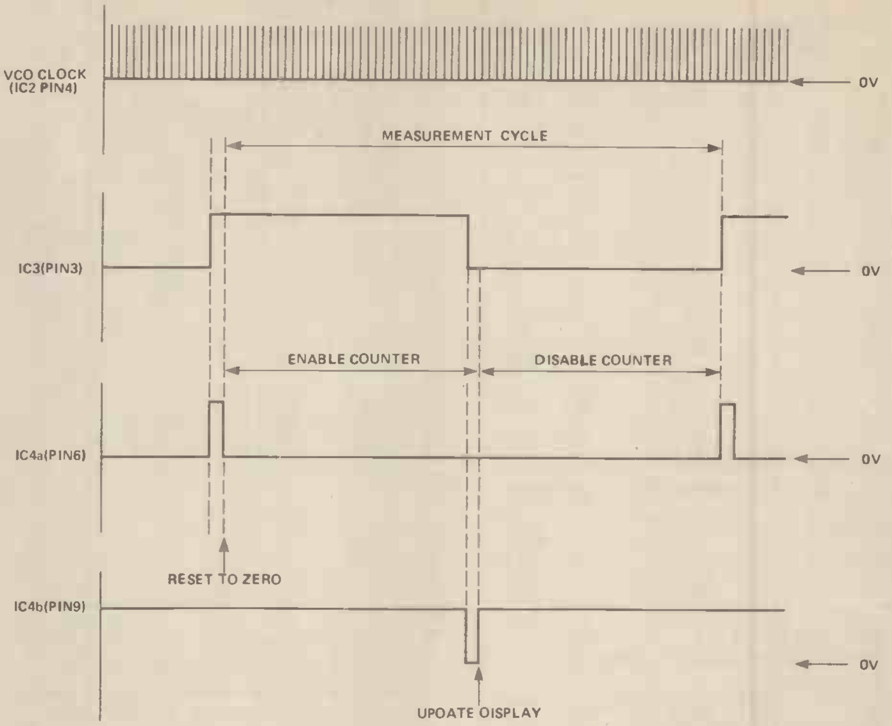
The 'offset' frequency of IC2, pin 4 should be 241 Hz (about B below Middle C) for the Fahrenheit scale or 127 Hz (C below Middle C) for reading Celsius; adjust PR2 for the correct frequency (PR1 is not adjusted at this stage). If you find it impossible to obtain the frequency, replace R4 with a higher or lower value, to reduce or increase the frequency accordingly.

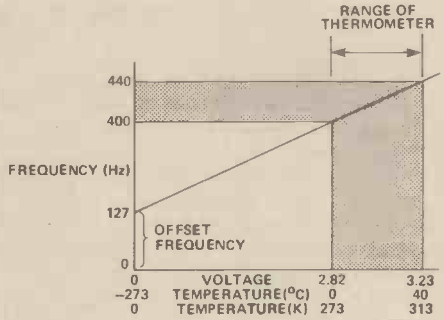
Before going on to wire up the counting and display circuits we must put together the pulse generators of IC4. The output of the leading-edge pulse generator (pin 6) is normally low (0 V), with a very brief (250 nS) high -going pulse as the output from IC3 goes low. If you have doubts that IC4 is working, connect a 100n capacitor in parallel with C4 or C5, to stretch the pulses.

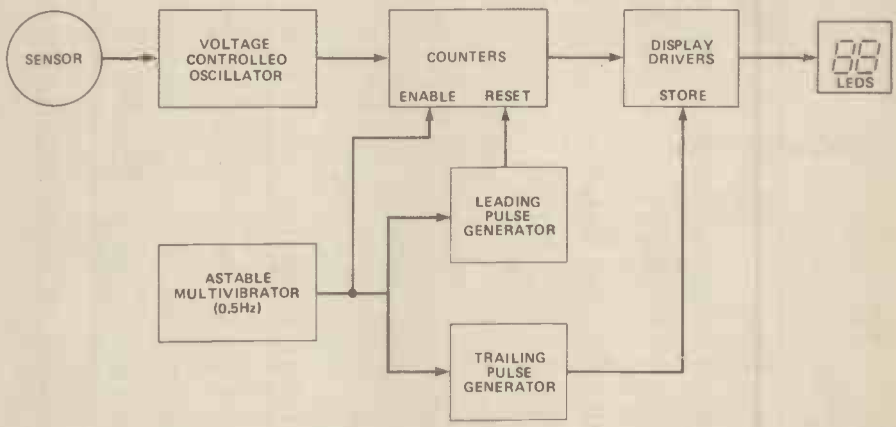
Now, replace all the ICs in their sockets and mount ICs 5, 6 and 7. The two LED digits are mounted on a small, separate PCB, plugged in to Soldercon pins. Run wires from the display board to the pins beside ICs 6 and 7, being careful to follow the wiring diagram (a goes to a, b' goes to b' and so on). Remember that the main board will be mounted upside down in the top of the case; the displays *must* be mounted with their upper edges nearest the main board. Securing the display board is

How It Works

The sensor produces a voltage which is proportional to its temperature and this is fed to a voltage controlled oscillator; the frequency of the VCO is therefore, proportional to temperature. When switched on, the counter is reset to zero, then allowed to count for a fixed length of time (approximately 1 second). At 0°C it counts to 400, and at 40°C it counts to 440 — or, if the device has been built to operate on the Fahrenheit scale, it counts to 732 at 32°F and to 804 at 104°F. The counter has only two stages, for units and tens; hundreds are ignored, so the counter actually shows '00' at 0°C and '40' at 40°C (or '32' at 32°F and '04' at 104°F). The astable multivibrator is a slow oscillator which controls the timing of events in the system. It turns the counter on (enables it) for one second in every two. It is also connected to two pulse generators. One gives a rising pulse (high) to reset the counter, the other gives a falling pulse (low) to store the result, as counting finishes.







easy if you use the bolts on the LED bezel; if your budget can't afford these, you will have to mount the display board to the main board using small L-shaped angle brackets.

Assuming that all connections have been correctly made, and the ICs plugged in the display should show '00' when first switched on. About one second later it should change to a number between '00' and '99'. It will then remain at that number, or change by one or two as the temperature changes. To begin with, you will probably obtain a nonsensical reading, but don't panic — here are some things which may be wrong:

1) Both displays blank — check the power supply and the display connections.
2) Some segments never light — faulty wiring between the display and IC6 or IC7.
3) Peculiar symbols — wires between IC6 and 7 and the display are crossed or shorted; you may have wired in the decimal point instead of one of the segments.
4) Certain figures never displayed but a blank occasionally appears on one (possibly both) displays — wires crossed between IC5 and ICs 6-7.

When the display is working properly, all that remains is to set the device to indicate the correct temperature. At average room temperature, the frequency from IC2 should be about 768 Hz (G in the octave above Middle C) for the Fahrenheit scale or 420 Hz (Ab above Middle C) for Celsius. Adjust PR1 to obtain this, but on no account re-adjust PR2. It is possible, though unlikely, that you may need to replace R3 at this stage, if the correct frequency cannot be obtained. The display should now be within range of the correct temperature, but could be as much as 30 or 40 degrees out, in either direction. Now adjust RV1 to bring the display reading to its correct value, using an ordinary room thermometer as reference. Both thermometers will take several minutes to acquire the temperature of their surroundings — do not attempt this calibration until both have been at steady temperature for at least 10 minutes.

Before mounting the boards, drill the case to take the switch. Also drill plenty of ventilation holes to allow air to circulate to the sensor or, for greater accuracy and rapid response, drill a hole large enough to accept the package of the sensor IC and attach some leads so that it protrudes slightly out of the hole, into the air outside.

Secure the main board in the top half of the case, using self-tapping screws or 'Sticky Fixers'. Cut a rectangular opening in the front panel, level with the displays and slip the panel into its slots. If you're using the display bezel, drill two holes to take the mounting bolts. Before closing the case, read the display to check that PR1 and PR2 have not accidentally been altered. The HE Digital Thermometer is then complete! **HE**

TTLs	
7400	11p
7401	11p
7402	12p
7403	12p
7404	12p
7405	18p
7406	25p
7407	25p
7408	14p
7409	15p
7410	15p
7411	20p
7412	20p
7413	22p
7414	35p
7416	25p
7417	25p
7420	17p
7421	30p
7422	20p
7423	22p
7425	28p
7426	30p
7427	25p
7428	30p
7430	15p
7432	25p
7433	27p
7437	27p
7438	30p
7440	17p
7441	70p
7442A	36p
7443	90p
7445	60p
7446A	93p
7448	45p
7450	17p
7451	17p
7453	17p
7454	17p
7460	17p
7470	36p
7472	30p
7473	30p
7474	30p
7475	30p
7476	30p
7480	50p
7481	100p
7482	70p
7483A	45p
7484	100p
7485	90p
7486	20p
7489	210p
7490A	25p
7491	60p
7492A	30p
7493A	30p
7494	50p
7495A	50p
7496	45p
7497	120p
74100	85p
74107	22p
74109	40p
74116	90p
74118	75p
74119	90p
74120	70p
74121	25p
74122	45p
74123	48p
74125	40p
74126	40p
74128	40p
74132	45p
74136	32p
74141	65p
74142	200p
74145	70p
74147	100p
74148	75p
74150	80p
74151A	45p
74153	45p
74154	70p
74155	50p
74156	50p
74157	50p
74159	100p
74160	60p
74161	60p
74162	60p
74163	60p
74164	50p
74165	55p
74166	70p
74170	140p
74172	300p
74173	65p
74174	60p
74175	60p
74176	50p
74177	70p
74178	100p
74180	50p
74181	160p
74182	90p
74184A	90p
74185	120p
74186	500p
74188	325p
74190	50p
74191	50p
74192	50p
74193	50p
74194	70p
74195	60p
74196	70p
74197	60p
74198	100p
74199	100p
74221	60p
74251	70p
74278	150p
74279	80p
74283	75p
74284	200p
74285	200p
74290	100p
74293	100p
74298	100p
74365	55p
74366	55p
74368	55p
74390	100p
74393	100p
74490	120p

74LS SERIES	
74LS00	12p
74LS01	14p
74LS02	14p
74LS03	14p
74LS04	15p
74LS05	15p
74LS08	16p
74LS09	15p
74LS10	15p
74LS11	15p
74LS13	25p
74LS14	40p
74LS20	15p
74LS21	15p
74LS22	16p
74LS26	16p
74LS27	16p
74LS30	15p
74LS32	16p
74LS37	16p
74LS38	16p
74LS42	36p
74LS47	40p
74LS51	15p
74LS55	30p
74LS73	25p
74LS74	16p
74LS75	24p
74LS76	20p
74LS83	45p
74LS85	65p
74LS86	20p
74LS90	28p
74LS92	40p
74LS93	30p
74LS95	45p
74LA96	100p
74LS107	45p
74LS109	30p
74LS112	34p
74LS113	30p
74LS114	30p
74LS122	42p
74LS123	50p
74LS124	120p
74LS125	30p
74LS126	30p
74LS132	45p
74LS133	30p
74LS136	30p
74LS138	34p
74LS139	36p
74LS145	75p
74LS147	160p
74LS148	90p
74LS151	70p
74LS153	60p
74LS154	90p
74LS155	40p
74LS156	40p
74LS157	35p
74LS158	35p
74LS160	40p
74LS161	40p
74LS162	40p
74LS163	40p
74LS164	48p
74LS165	100p
74LS166	90p
74LS170	120p
74LS173	70p
74LS174	45p
74LS175	40p
74LS181	140p
74LS190	50p
74LS191	50p
74LS192	50p
74LS193	48p
74LS194	40p
74LS195	48p
74LS196	60p
74LS197	65p
74LS221	60p
74LS240	70p
74LS241	70p
74LS242	80p
74LS243	80p
74LS244	65p
74LS245	90p
74LS251	40p
74LS253	40p
74LS257	45p
74LS258	40p
74LS259	90p
74LS260	24p
74LS266	25p
74LS273	70p
74LS279	45p
74LS283	45p
74LS298	160p
74LS323	250p
74LS324	150p
74LS348	150p
74LS352	100p
74LS353	100p
74LS363	160p
74LS364	160p
74LS365	36p
74LS367	36p
74LS268	36p
74LS373	70p
74LS374	70p
74LS375	50p
74LS377	70p
74LS378	60p
74LS390	55p
74LS393	70p
74LS399	200p
74LS540	135p
74LS541	135p
74LS670	170p

4000 SERIES	
4000	12p
4001	14p
4002	15p
4006	65p
4007	16p
4008	60p
4009	35p
4010	40p
4011	14p
4012	16p
4013	35p
4014	60p
4015	60p
4016	30p
4017	45p
4018	60p
4019	32p
4020	60p
4021	65p
4022	70p
4023	20p
4024	40p
4025	20p
4026	130p
4027	32p
4028	60p
4029	75p
4030	40p
4031	170p
4034	160p
4035	80p
4036	295p
4039	295p
4040	55p
4041	70p
4042	55p
4043	60p
4044	70p
4046	70p
4047	75p
4048	55p
4049	27p
4050	27p
4051	60p
4052	80p
4053	60p
4054	130p
4055	125p
4056	120p
4059	500p
4060	90p
4063	100p
4066	35p
4067	400p
4068	18p
4069	18p
4070	18p
4071	18p
4072	18p
4073	20p
4075	20p
4076	60p
4081	16p
4082	20p
4086	72p
4089	150p
4093	40p
4094	150p
4095	95p
4096	95p
4097	340p
4098	90p
4099	120p
40085	90p
40097	£120p
40098	120p
40102	180p
40103	180p
40106	45p
40109	100p
40163	100p
40173	120p
40174	90p
40175	100p
40193	120p
40257	160p
4502	70p
4503	50p
4507	40p
4508	200p
4510	65p
4511	50p
4512	65p
4514	150p
4515	150p
4516	75p
4518	45p
4520	70p
4521	150p
4526	75p
4527	90p
4528	75p
4532	90p
4534	500p
4536	300p
4538	120p
4539	110p
4543	100p
4553	290p
4555	50p
4556	60p
4560	180p
4568	300p
4569	180p
4572	30p
4583	90p
4584	45p
4585	100p
14495	400p

74S SERIES	
74S00	60p
74S04	60p
74S08	75p
74S30	60p
74S32	90p
74S74	90p
74S85	300p
74S86	180p
74S124	300p
74S132	160p
74S133	75p
74S138	225p
74S139	225p
74S157	250p
74S163	300p
74S174	250p
74S175	320p
74S194	350p
74S241	400p

LINEAR I.Cs	
AN103	200p
AY1-0212	600p
AY1-1313	668p
AY1-1320	320p
AY1-5050	140p
AY3-8910	600p
AY3-8912	650p
AY5-1224A	240p
AY5-1315	600p
AY5-4007D	520p
CA3028A	120p
CA3019	80p
CA3046	70p
CA3048	225p
CA3059	300p
CA3080E	72p
CA3086	48p
CA3089	225p
CA3090AQ	375p
CA3130E	90p
CA3140	50p
CA3160E	100p
CA3161E	190p
CA3162	450p
CA3189E	300p
CA3240	120p
CA3280G	200p
DAC1408-8	200p
HA1366	195p
HA1388	270p
ICL7106	850p
ICL8038	300p
ICM7555	80p
LC7120	325p
LC7130	325p
LF347	160p
LF351	48p
LF353	100p
LF356P	95p
LF357	120p
LM10C	425p
LM301A	27p
LM310	120p
LM318	200p
LM319	225p
LM324	45p
LM335Z	140p
LM339	65p
LM348	75p
LM358P	75p
LM377	175p
LM380	75p
LM381AN	180p
LM382	120p
LM386	95p
LM387	120p
LM389	95p
LM393	100p
LM394	350p
LM709	36p
LM710	50p
LM711	70p
LM733	100p
LM741	18p
LM747	70p
LM748	35p
LM2917	200p
LM3302	140p
LM3900	55p
LM3909	95p
LM3911	130p
LM3914	210p
LM3915	225p
LM3916	225p
LM13600	125p
M51513L	300p
M51516L	500p
MB3712	225p
MC1310P	150p
MC1458	40p
MC1495L	350p
MC1496	70p
MC3340P	120p
MC3401	90p
MC3403	120p
MK50398	750p
ML920	800p
MM57160	620p
MN6221A	£6
NE531	150p
NE555	20p
NE556	50p
NE564	420p
NE565	130p
NE566	155p
NE567	140p
NE570	425p
NE571	425p
NE5534A	150p
PLL02A	500p
RC4136	70p
RC4151	200p
RC4558	60p
S566B	260p
SAD1024A	1250p
SFF96364	800p
SL490	350p
SN76477	175p
SP8515	750p
TA7120	165p
TA7204	195p
TA7205	125p
TA7222	160p
TA7310	160p
TBA651	200p
TBA800	90p
TBA810	100p
TBA820	90p
TBA950	300p
TCA220	350p
TCA940	200p
TDA1004A	300p
TDA1008	320p
TDA1010	225p
TDA1022	550p
TDA1024	120p
TDA1034B	250p
TDA1170	300p
TDA2002V	325p
TDA2020	320p
TL071/81	45p
TL072/82	75p
TL074	130p
TL084	110p
TL094	200p
TL170	50p
TL430C	70p
UAA170	170p
UA2240	300p
UDN6118	320p
UDN6184	320p
ULN2003	100p
UPC575	275p
UPC592H	200p
UPC1156H	275p
XR2206	300p
ZN414	90p
ZN419C	225p
ZN423E	150p
ZN424E	135p
ZN425E	350p
ZN427E	625p
ZN1034E	200p
ZN1040E	700p

VOLTAGE REGULATORS

FIXED PLASTIC

1A	+ ve		− ve	
5V 1A	7805	50p	7905	55p
12V 1A	7812	50p	7912	55p
15V 1A	7815	55p	7915	60p
18V 1A	7818	55p	7918	60p
24V 1A	7824	55p	7924	60p
5V 100mA	78L05	30p	79L05	65p
12V 100mA	78L12	30p	79L12	70p
15V 100mA	78L15	30p	79L15	70p

OTHER REGULATORS

LM309K 1A 5V	135p	78HGKC	600p
LM317K	325p	78HO5KC	550p
LM317T 1A Adj	200p	78MGT2C	140p
LM337T	225p	78GUIC	200p
LM323K 3A 5V	500p	79GUIC	225p
LM723 150mA Adj	37p	79HGKC	700p
TL494	400p	TL497	300p
78S40	300p	LM305AH	250p

OPTO-ELECTRONICS

2N5777	45p	ORP60	120p
OCP71	180p	ORP61	120p
ORP12	120p	TIL78	55p

OPTO-ISOLATORS

ILD74	130p	TIL111	90p
MCT26	100p	TIL112	90p
MCS2400	190p	TIL113	90p
ILQ74	240p	TIL116	90p

LEDS

0.125"		0.2"	
TIL32	55p	TIL220 Red	12p
TIL209 Red	11p	TIL222 Gr	15p
TIL211 Gr	16p	TIL228 Yel	22p
TIL212 Ye	18p	Rectangular LEDs (R, G, Y)	30p
TIL216 Red	18p	NSB5881	570p
		TIL311	600p

DISPLAYS

3015F	200p	TIL312/3	110p
DL704	140p	TIL321/2	130p
DL707 Red	140p	TIL330	140p
FND357	120p	7750/60	200p
FND500	90p	**DRIVERS**	
FND507	90p	9368	250p
MAN3640	175p	9370	300p
MAN4640	200p	UDN6118	323p
		UDN6184	320p

* SPECIAL OFFER *

	1-24	25-99
2114L-2	90p	85p
2716	210p	200p
2532	400p	375p
4116-200nS	70p	65p

COMPUTER COMPONENTS

CPUs

1802CE	700p
2650A	£12
6502	450p
6502A	600p
6800	370p
6802	425p
6809	£10
6809E	£15
8035	750p
8039	850p
8080A	350p
8085A	550p
INS8060	£11
TMS9980	£20
Z80	370p
Z80A	450p
Z80B	£16
8088	£19

SUPPORT DEVICES

3242	800p
3245	450p
6522	500p
6532	775p
6821	160p
6551	650p
6821	160p
6845	£10
6847	£10
6850	160p
6852	250p
6875	600p
8154	950p
8155	800p
8205	220p
8212	160p
8216	160p
8224	250p
8226	250p
8228	250p
8243	450p
8250	850p
8251	350p
8253	800p
8255	350p
8257	800p
8259	800p
8279	950p
Z80PIO	300p
Z80APIO	350p
Z80CTC	300p
Z80ACTC	350p
Z80ADART	800p
Z80ADMA	£12
Z80S101	£12

CRT CONTROLLER

COM5037	£18
SFF96364	£8
TMS9927	£18
6845	£10
6847	£10
9365	£60

MEMORIES

2101A	400p
2102-3L	120p
2107B	500p
2111A	300p
2112-A	300p
2114-2L	95p
2114-4L	90p
2147	450p
4027-3	300p
4044-45	450p
4116-15	90p
4116-20	75p
4118-3	500p
4118-4	450p
4164-2	600p
4816AP-3	500p
5101	300p
6116P-3	530p
6514-45	300p
6810	200p
7489	210p
74S189	325p
74S201	350p
74S289	325p

ROMs/PROMs

74S188	325p
74S287	308p
74S288	226p
74S387	325p
74S471	650p
74S473	850p
74S474	650p
74S570	650p
74S571	650p
74S573	950p

EPROMs

1702A	500p
2708	300p
2716 (+6V)	300p
2564	£25
2516 (+5V)	300p
2532	400p
2732	400p
2716-300nS	500p
2732-300nS	750p

UARTs

AY-3-1015P	300p
AY-5-1013P	300p
IM6402	450p
TR1602	300p
COM8017	300p

CHARACTER GENERATORS

RO-3-2513UC	750p
RO-3-2513LC	700p
SN74S262AN	£10

INTERFACE ICs

AD558CJ	775p
AD561J	£14
AM25S10	350p
AM26LS31	160p
AM26LS32	190p
DAC80	£20
DM8131	375p
DP8304	450p
DS8832	250p
DS8833	225p
DS8836	150p
DS8838	225p
LF13201	450p
MC1488	55p
MC1489	55p
MC3418	950p
MC3446	300p
MC3480	850p
MC3486	500p
MC4024	325p
MC4044	325p
MC14411	700p
MC14412	900p
MC4044	325p
MM58174	£12
ULN2003A	100p
ULN2004A	100p
75017	160p
75110	160p
75112	160p
75114	160p
75115	160p
75150P	140p
75154	140p
75182	230p
75324	375p
75361	150p
75363	150p
75365	150p
75461/2	72p
75453/4	72p
75491/2	70p
8T26	120p
8T28	120p
8T95	120p
8T97	120p
81LS95	90p
81LS96	120p
81LS97	90p
81LS98	120p
9602	220p
9637AP	160p
ZN425E-8	350p
ZN426E-8	350p
ZN427E-8	650p
ZN428E-8	500p

DISC CONTROL

FD1771	£20
FD1791	£30
FD1793	£32
FD1795	£35
FD1797	£37
WD1691	£15
WD2143	550p

CRYSTALS

32.768KHz	180p
100KHz	300p
200KHz	300p
1.0MHz	320p
1.008MHz	350p
1.5MHz	450p
1.8432MHz	250p
2.0MHz	250p
2.45760MHz	250p
2.5MHz	250p
3.276MHz	150p
3.5795MHz	100p
3.686MHz	300p
4.00MHz	150p
4.194MHz	200p
4.43MHz	150p
5.00MHz	175p
4.43MHz	150p
5.00MHz	175p
6.0MHz	150p
6.144MHz	250p
7.0MHz	150p
7.168MHz	175p
8.00MHz	175p
8.86MHz	175p
10.00MHz	250p
10.7MHz	150p
12MHz	250p
13MHz	350p
14.318MHz	175p
15MHz	200p
16.00MHz	250p
18.00MHz	200p
18.432	150p
19.968MHz	150p
24MHz	175p
26.690MHz	150p
27.145MHz	200p
38.6667MHz	175p
48.0MHz	175p
55.5MHz	400p
116.0MHz	300p

KEYBOARD ENCODER

AY-5-2376	700p
74C922	500p

MODULATORS

6MHz UHF	375p
8MHz UHF	450p

BAUD RATE GENERATOR

COM 8116	£8
MC 14411	£7

TELETEXT ICs

SAA5020	£6
SAA5030	£9
SAA5041	£16
SAA5050	£9

CONNECTION SYSTEMS

JUMPER LEADS

24" Cable with Headers

	14pin	16pin	24pin	40pin
Single end	145p	165p	240p	380p
Double end	210p	230p	345p	540p

Cable with Sockets

	20pin	26pin	34pin	40pin
Single end (24")	160p	210p	270p	300p
Double end (18")	290p	385p	490p	540p

34 Way Edge Conn (36") One End £5.50
D. Conn 25W 24" M: £5. F: £5.50

ID CONNECTORS

(Speed block) Type	10 Way	26 Way	34 Way	40 Way
Header plug	90p	200p	240p	270p
Receptacle	90p	200p	240p	270p

EUROCONNECTORS

	Plug	Skt
DIN 41612 2 × 32 Way	300p	350p
Angled 2 × 32 Way	350p	400p
3 × 32 Way	370p	430p
Angled 3 × 32 Way		450p
DIN 41617 31 Way	200p	200p

(for 2 × 32 Way please specify A + B or A + C type)

DIL HEADER PLUGS

	14pin	16pin	24pin	40pin
Solder type	50p	60p	100p	275p
IDC type	130p	140p	200p	285p

MIN D CONNECTORS

	9	15	25	37
MALE				
solder	95p	135p	200p	280p
angled	160p	230p	265p	425p
FEMALE				
solder	125p	190p	345p	375p
angled	175p	240p	310p	500p
Hoods	100p	100p	100	150p

DIL SWITCHES

4 way	110p
8 way	140p
6 way	125p
10 way	160p

ZIF SKTS

24 pin £6
28 pin £8
40 pin £10

EDGE CONNECTORS

	0.1"	0.156"
2 × 18 Way		150p
2 × 22 Way	310p	170p
2 × 23 Way	335p	—
2 × 25 Way	210p	200p
1 × 43 Way	260p	—
2 × 43 Way	350p	—
1 × 77 Way	700p	—

ACORN ATOM

Basic Kit £120 Built £135
Fully Expanded 12K + 12K £188
p&p £2.50/unit
SEE APRIL PE FOR
ATOM VISION
Phone for details on Atom Accessories

LOW PROFILE DIL SOCKETS BY TEXAS

8 pin	9p	18 pin	16p	24 pin	24p
14 pin	10p	20 pin	18p	28 pin	26p
16 pin	11p	22 pin	22p	40 pin	30p

WIRE WRAP SOCKETS BY TEXAS

8 pin	25p	18 pin	50p	24 pin	70p
14 pin	35p	20 pin	60p	28 pin	80p
16 pin	40p	22 pin	65p	40 pin	100p

TRANSISTORS

AD161/2	45p
BC107/8	13p
BC109C	14p
BC117	20p
BC147/8	9p
BC149	10p
BC157/8	10p
BC159	11p
BC169C	12p
BC172	12p
BC177/8	17p
BC179	18p
BC182/3	10p
BC184	11p
BC187	30p
BC212/3	11p
BC214	12p
BC237	15p
BC327	16p
BC337	16p
BC338	16p
BC461	25p
BC477/8	30p
BC516/7	40p
BC547B	14p
BC548C	12p
BC549C	16p
BC557KB	14p
BC559C	16p
BCY70	18p
BCY71/2	22p
BD131/2	50p
BD135/6	40p
BD139	40p
BD140	40p
BD189	60p
BD232	60p
BD233	75p
BD235	85p
BD241	60p
BD242	60p
BD677	40p
BF244B	35p
BF256B	50p
BF257/8	32p
BF337	30p
BFR39	25p
BFR40/1	25p
BFR79	25p
BFR80/1	25p
BFR96	180p
BFX29	40p
BFX30	27p
BFX84/5	40p
BFX86/7	27p
BFX88	27p
BFX89	180p
BFY50	24p
BFY51/2	24p
BFY56	33p
BFY90	80p
BRY39	45p
BSX19/20	24p
BU104	225p
BU105	190p
BU108	250p
BU109	225p
BU126	150p
BU180A	120p
BU205	200p
BU208	200p
BU406	145p
BUX80	£6
BUY69C	350p
E310	50p
MJ802	£4
MJ2501	225p
MJ2955	90p
MJ3001	225p
MJ4502	£4
MJE340	60p
MJE2955	100p
MJE3055	70p
MPF102	40p
MPF103/4	30p
MPF105	30p
MPSA06	30p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	32p
MPSA70	50p
MPSA93	40p
MPSU06	63p
MPSU07	60p
MPSU45	90p
MPSU65	78p
TIP29A	35p
TIP29C	40p
TIP30A	35p
TIP30C	40p
TIP31A	40p
TIP31C	45p
TIP32A	45p
TIP32C	40p
TIP33A	70p
TIP33C	80p
TIP34A	90p
TIP34C	120p
TIP35A	120p
TIP35C	140p
TIP36A	140p
TIP36C	150p
TIP41A	50p
TIP41C	55p
TIP42A	60p
TIP42C	65p
TIP54	160p
TIP120	75p
TIP121	75p
TIP122	80p
TIP142	130p
TIP147	130p
TIP2955	78p
TIP4055	70p
TIS93	30p
ZTX108	12p
ZTX300	13p
ZTX452	45p
ZTX500	15p
ZTX502	16p
ZTX504	18p
ZTX552	55p
ZTX652	60p
ZTX752	70p
VN66AF	72p
VN10KM	60p
VN66	80p
2N697	25p
2N698	45p
2N706A	30p
2N708	30p
2N918	45p
2N930	18p
2N1131/2	36p
2N1613	25p
2N1711	25p
2N2102	70p
2N2160	350p
2N2219A	25p
2N2222A	25p
2N2369A	25p
2N2484	30p
2N2646	45p
2N2904/5	25p
2N2906A	25p
2N2907A	25p
2N2926	9p
2N3053	30p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
2N3584	250p
2N3643/4	48p
2N3702/3	12p
2N3704/5	12p
2N3706/7	14p
2N3708/9	12p
2N3773	300p
2N3819	25p
2N3820	40p
2N3823	50p
2N3866	90p
2N3902	700p
2N3903/4	16p
2N3905/6	16p
2N4037	65p
2N4123/4	27p
2N4125/6	27p
2N4401/3	27p
2N4427	90p
2N4871	60p
2N5087	27p
2N5089	27p
2N5172	27p
2N5191	90p
2N5194	90p
2N5245	40p
2N5298	65p
2N5401	60p
2N5457/8	40p
2N5459	40p
2N5460	60p
2N5485	44p
2N5875	250p
2N6027	48p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2SC1172	150p
2SC1306	100p
2SC1307	150p
2SC1957	90p
2SC1969	150p
2SC2028	95p
2SC2029	250p
2SC2078	200p
2SC2335	250p
2SC2612	250p
3N128	120p
3N140	120p
3N141	110p
3N201	110p
3N204	120p
40290	260p
40361/2	75p
40408	90p
40409	100p
40410	100p
40411	300p
40594	120p
40595	120p
40673	75p
40871/2	100p

DIODES

BY127	12p
BYX36.300	20p
OA47	8p
OA90/91	9p
OA95	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	5p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5401/3	14p
1N5404/7	19p
1S920	9p

BRIDGE RECTIFIERS

1A 50V	19p
1A 100V	20p
1A 400V	25p
1A 600V	30p
2A 50V	30p
2A 100V	35p
2A 400V	45p
3A 200V	60p
3A 600V	72p
4A 100V	95p
4A 400V	100p
6A 50V	80p
6A 100V	100p
6A 400V	120p
10A 400V	200p
25A 400V	400p

ZENERS

2.7V-33V	
400mW	9p
1W	15p

TRIACS

PLASTIC

3A 400V	60p
6A 400V	70p
6A 500V	88p
8A 400V	75p
8A 500V	95p
12A 400V	85p
12A 500V	105p
16A 400V	110p
16A 500V	130p
T2800D	130p

THYRISTORS

3A 400V	100p
8A 600V	140p
12A 400V	160p
16A 100V	180p
16A 400V	180p
C106D	45p
MCR101	36p
TIC44	27p
2N3525	130p
2N4444	180p
2N5060	30p
2N5064	35p

PCB MOUNTING RELAYS

6 or 12V DC Coil
SPDT 2A 24V DC 160p
6 or 12V DC coil
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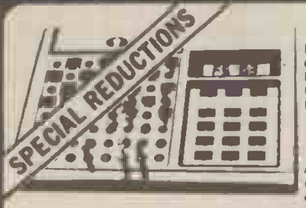

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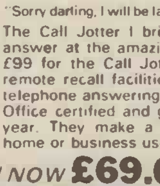

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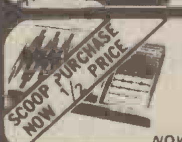

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POINTS OF VIEW

Clubbing Together

Dear Sir,
I became interested in electronics a few years ago, just before your first issue came out, so I was pleased to see it appear on the shelves. Since then I have come a long way, with your help. I have every copy from Issue one on my bookshelf, although I must admit that some of the earlier ones are becoming a bit tatty, now. I also attended night school for two years and, between night school and your magazine, I have been able to build a lot of my own test equipment.

I sometimes pick out a couple of old issues and read through them. In September 1980 you printed a letter from a Mr. George Edwards, who asked about clubs. You replied that you would mention any clubs that wrote to you but, as you have not printed any (apart from the one mentioned in the reply), I take it that either no other clubs exist or that they are very secretive about their existence.

There must be thousands of people who're interested in electronics and who are pursuing the subject on their own, like myself. I would be very interested in contacting anyone in my area so that we can share ideas and help one another. Perhaps people interested in forming a club could write to you. Then others in the area, whether they live in London or Edinburgh, would be able to contact them. Electronics is a fast-growing industry, but the hobbyist seems to be left out, to fend for himself.

I think the potential for this is endless — who knows what might be developed through the sharing of equipment and ideas? Perhaps you could spare a page of HE to be used for Club News and similar ideas?

Just one other thing — what happened to 'Short Circuits'? I used to enjoy experimenting with them.
R. Mitchell,
Portslade,
Sussex.

Mr. Mitchell is apparently correct in his assumption that no other electronics clubs exist — certainly, none have contacted us. The club mentioned in the September 1980 issue is still going strong, however. They are the British Amateur Electronics Club and interested readers should contact the Chairman, Mr. Cyril Bogod, at the BAEC, 'Dickens', 26 Forrest Road, Penarth, South Glamorgan. Tel: 0222 707813. The BAEC is a national organisation and they should be able to put you in touch with other electronics hobbyists in your area.

We will shortly be re-introducing a new series of circuits for experimenters under the title "Breadboards". Look out for them in the June issue!

Reactions Tested

Dear Sir,
I have just completed the Reaction Tester (September '81 issue) and it doesn't work. The bottom LED lights up when switched on but pressing the 'go' button has no effect whatsoever. I have checked everything I can think of, including the PCB and the two ICs.

Maplin recommended a C106 thyristor instead of the C103 — could they have different gate voltages and therefore be the cause? The 4017 I bought has CD4017 printed on it — could this be the fault?

The only other thing I can think of is that there is a mistake in the instructions. If there is, could you please advise me?
A. Bricknell,
Leigh-on-Sea,
Essex.
PS Keep up the good mag.

The 'CD' is simply the maker's code name for the IC — the type or 'generic' as it is sometimes called, is 4017; that's what counts. Since it appears that either the 555 IC is not oscillating, or the 4017 is not counting, indicated by the fact that is 'stuck' in reset condition (zero count), it's unlikely that the thyristor is at fault (the gate voltages are the same, anyway).

The circuit has no errors, other than that the IC types are interchanged (which should be immediately obvious), and the PCB layout seems correct. Having eliminated all those possibilities, we can only suggest that you check, very carefully, all the circuitry associated with the 555 astable and the input to pin 14 of the 4017.

Mast Head Amplification

Dear Sir,
I purchased your magazine this month for the first time and I find it excellent, but for one thing; no information on where to buy the kit for the TV Mast Head Amplifier (February '82 issue). Who and where are RS Components, please?
Yours,
(signature indecipherable)
South Wigston

We're not even sure about the address, but hopefully the writer will recognise his own letter! Our misplaced comments about RS Components continue to haunt us — RS Components will accept orders only from "Full time industrial, educational and trade users..", however the mail order firm Crewe Allen, of 51 Scrutton Street, London EC2A 4PJ (Tel: 01 739 4846) can supply components from the RS catalogue.

The TV Mast Head Amplifier is not available as a kit, as such, but Magenta Electronics can supply all of the parts, including the double-sided PCB. Would Oliver Davis of Co. Donegal, Ireland and G. Inchbald in Manchester please copy!

Delay Time

Dear Sir,
I have been trying, without success, to obtain a circuit diagram for a solid state echo unit using Bucket Brigade Delay technology.

Can you suggest where I might obtain such a circuit?
D. Vanderwolf
Torpoint,
Cornwall.

This is one letter we are happy to answer without delay. Look no further, Mr. Vanderwolf! The circuit you seek is on page 41 — the HE Echo-Reverb project.

Overseas Mail

Dear Editor,
I have read with great interest your magazine, Hobby Electronics.

I am particularly interested in books about trouble-shooting in electronics — these are particularly lacking on the HE Bookshelf. I will be very glad if you could suggest any suitable books. I am very interested in regulators, audio, radio and test equipment.
R. Kimura,
Swaziland,
Southern Africa.

Trouble-shooting (fault-finding) is a very interesting topic — one that we will be giving detailed attention to, in the near future. However, Mr. Kimura and other interested readers might also like to read Ian Sinclair's book, "Electronics Fault Diagnosis", published by Keith Dickson (Publishing) Ltd., 17, Hendon Lane, London N3 1RT.

Satisfaction Guaranteed.

Dear Sir,
I own a stereo radio/cassette player which is still under guarantee and it has a very annoying defect; when recording from FM, especially from stereo FM, the motor causes definite distortion to the recording.

I have isolated the motor as the source of the interference by playing a tape while in the FM radio mode. While the motor was running the interference could be heard distinctly and as soon as it was stopped, the interference stopped. Obviously this should not happen, as it means I cannot get satisfactory recordings from the radio and this defeats my purpose in buying the machine. I wondered if there is anything I could do to remedy the situation or whether I should return it

under guarantee. I would be very grateful if you could give me your opinion.
E. Weeks,
Godalming,
Surrey.

We do not, normally, advise on anything to do with commercial equipment but this case is so clear that we decided to make an exception — also, it is an excellent example of fault-finding technique! Our opinion is: do not even think about fiddling with it — return it at once.

Specifically Speaking

Dear Sir,
Recently I have been thinking of building your power amplifier from the March 1980 issue of Hobby Electronics, the System 5080A. The amplifier seems excellent but you did not supply the specifications — power output, distortion, frequency response, etc. I should be grateful to receive a copy of the specifications and, in future, I suggest that you supply them with the projects, as I am sure many people would be interested.
Yours,
P. Upton,
Salisbury,
Zimbabwe.

To the best of our knowledge, a set of specification figures for the 5080A was never produced — or if they were, they are now lost! However, the following information can be extracted from the text: the power output is 25 W per channel; distortion is "so low as to be inaudible" and the frequency response is "well above and below the human hearing range". As you say, it seems pretty good. Nevertheless, your suggestion is a good one, and in future we'll certainly publish the full specification figures for any quality audio project.

Famous Names

Dear Sir,
The article Famous Names (HE, December 1981) paying tribute to the visionary Campbell-Swinton, contained a serious error. We read: "The unanimous rejection of Baird's 30-line system in favour of Schoenberg's 405-line system, in 1936, proved how right Campbell-Swinton was." In fact, no such choice was ever made.

The Baird 30-line system was started as early as 1929 and, by 1930, had become fairly refined. In 1931 the BBC took over all responsibility for the daily broadcasts as a light entertainment programme on the medium waveband, receivable nationwide. This left Baird with time to develop his 120 and 180 line systems, which he broadcast on the seven meter band. Later, he developed a 240-line system.

So the contest of the two rival systems in 1936 (transmitted on alternate weeks) was between the Schoenberg 405-line system and the Baird 240-line system. The BBC (30-line) transmissions had actually ceased the previous year. The number 240 has been chosen, not by Baird directly, but by the Postmaster General's Television Committee, under the chairmanship of Lord Selsdon, which commenced sitting in May 1934 and gave its decision on recommended standards in February 1935. The choice may well have been influenced by the choice of 240 lines by RCA, in the United States of America, which was trying to develop Zworykin's Iconoscope camera, without much success.

J.L. Baird was not only the first person to demonstrate true television (ie, moving half-tone portraits of live subjects) anywhere in the world, but one of the quite small number of pioneers in the field of high-definition television.
D.B. Pitt,
Chairman,
Narrow Bandwidth TeleVision Association,
Nottingham.

Ian Sinclair, the author of the Famous Names series, replies:
I regret that my efforts to compress a lot of information into a short phrase was the cause of a serious error of fact. As you rightly point out, the old experimental 30-line system had ceased by the time the dual broadcasts started. The Baird system had moved to higher definition and also to a more electronic system. Whether this would have been done but for the determined work of Schoenberg, Blumlien and McGee, on the completely electronic system, is a moot point.

At one time, in fact, the only way in which live TV could be transmitted on the Baird high-resolution system was by scanning the light source and, even by the time of the experimental broadcast, the Baird system could not cope well with live working. For that reason, he developed a fast film processor and it was usual to film each programme, then transmit from a flying-spot scanner a few minutes after the end of the show. It was extremely dangerous to stand in the corridor after a concert because the whole orchestra, brandishing instruments, would come running from the studio to the processing rooms to see themselves on film as the programme was being transmitted. Some of this film was preserved, but the short processing cycle made most of it useless after a few months.

Thank you for your comments. This series has aroused a lot of interest and some most interesting personal recollections.

We certainly agree and would be most interested to hear from any other readers with personal knowledge of the pioneers or recollections of the early days of electronics.

Kit Fever

Dear Sir,
Please could you tell me if you can do a kit of the Bicycle Speedometer (March '81 issue)? I intend to build this as part of my course at Technical College.
A.E. Davis,
Weston-Super-Mare,
Avon.

M.A. Elatta, of Portsmouth and P. Longman, from Hull also wrote in with similar requests.

It seems to be a common misunderstanding, among some of our readers, that we supply kits for our projects; we don't. Kits are available for some projects, true, but not from us. If you have a copy of the issue in which the project appears, the Buylines make it clear whether or not there is a kit and, if so, who is supplying it and the cost.

Dear Sir,
I have been buying Hobby Electronics since the first issue and I am generally very impressed.

I was, therefore, annoyed to find that two projects in the December 1981 issue (Drum Synthesiser and Guitar Graphic Equaliser) had no PCB foil patterns printed in the magazine. They do seem to be available, but only as part of a full kit.

I stopped buying another electronics magazine a few years ago because it was becoming a 'kit catalogue' and I hope Hobby Electronics is not on the same downhill path.
Yours sincerely,
D. Squibb,
Weymouth, Dorset.

The issue of the PCBs for these projects has been dealt with in previous issues, but to clear up this matter once and for all:

We try to present, in Hobby Electronics, projects that are useful, interesting or instructive. To achieve this, we accept material from a number of sources; many of our contributors are private individuals, but some are small companies, designing and making up circuits for industry and private sale, as well as for magazines such as ours. In the past, several of these contributors have wished to retain the copyright acknowledgement to the relevant company. We also attempt to persuade the kit supplier to make PCBs — and any other special components — available separately.

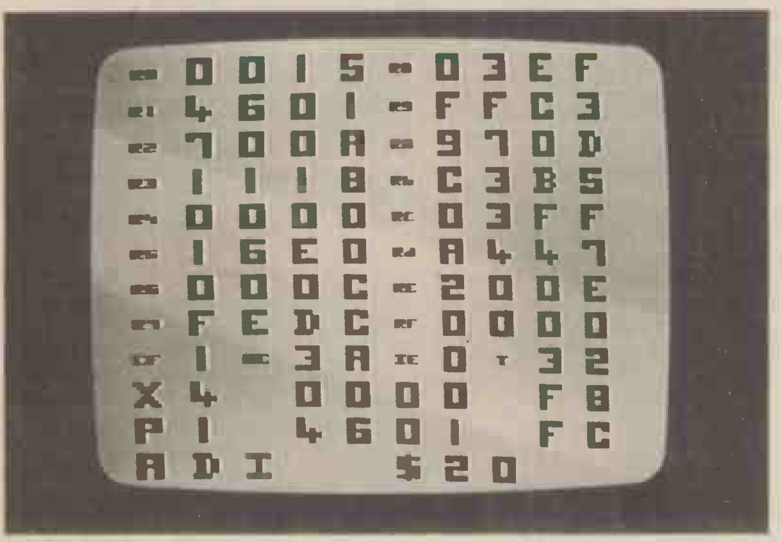
While we would prefer no restrictions whatsoever attached to our projects, the continual and difficult search for new, innovative ideas the kit supplier to make PCBs — and any other special components — available separately.

While we would prefer no restrictions whatsoever attached to our projects, the continual and difficult search for new, innovative projects demands that we accept such projects whenever they become available, from whatever source. This new arrangement, while less than ideal, at least permits the individual at home to make a project from the PCB upwards, as many of our readers prefer.

We hope that this long-winded explanation closes the subject! **HE**

WHAT'S ON NEXT?

POPULAR COMPUTING



The HE MicroTrainer.

Next month we begin a brand new computer hardware project, the HE MicroTrainer. Based on the 1802 microprocessor, it is simple to construct and easy to operate, the perfect machine to introduce the 'nuts and bolts' of microcomputer technology. The MicroTrainer has been designed specifically for Hobby Electronics' readers, and offers a number of distinct advantages over other development systems:

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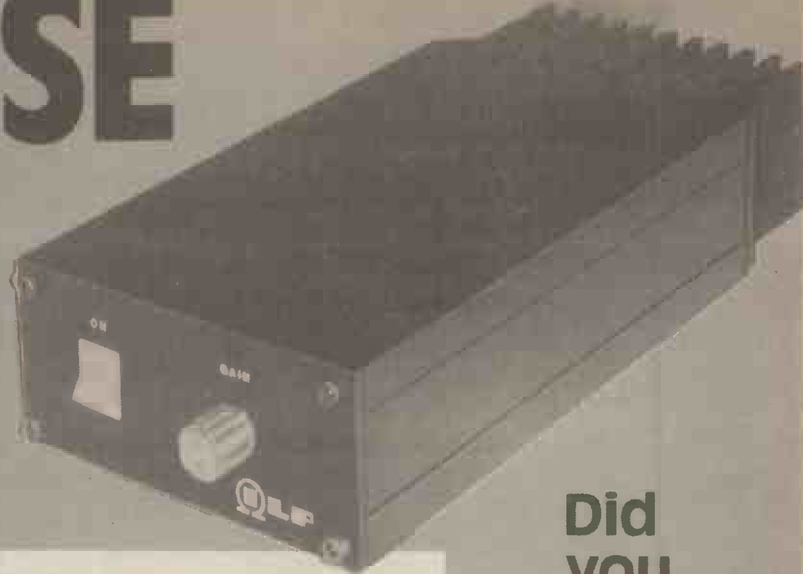

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Phil Cohen

I REMEMBER from my adolescence (I'm not as old as I feel) the first of the Sinclair devices to hit the British market. These included a matchbox sized radio, a calculator (which hit *before* the Japanese ones), a digital watch kit at a fraction of the cost of competitive ones, and so on.

Although these may raise a yawn nowadays, at the time they were at the forefront of the market. Imagine the reaction of the public to the *first* digital watch, the *first* calculator — real 'Boys' Own Paper' stuff.

Sinclair entered the computer market with a little development kit based on the SC/MP processor, then moved very quickly up-market with the ZX80 (the forerunner of the ZX81).

I remember my reaction on first seeing the *ZX80* advertised — I looked at the date of the magazine to see whether it was an April edition. I really believed that it was a joke! I didn't think anyone could put so much into so small a package at so low a price.

The ZX80 had a couple of dozen chips and primitive BASIC capabilities. The ZX81 has as powerful a BASIC as many other machines on the market, and has five ICs (ignoring the three-terminal regulator).

Amazing!

To look at, the ZX81 seems to be a mock-up of itself — it weighs about as much as a paperback book, it has no moving parts, it has no trailing wires, its case is plastic.

The keyboard looks as if it has simply been printed onto the front of the case. In fact, it's 'elastometric', made up of a conductive rubber sheet over a set of printed circuit contacts. When you press the sheet down, it makes contact with the circuit board. It's just difficult to believe that it is what it's claimed to be.

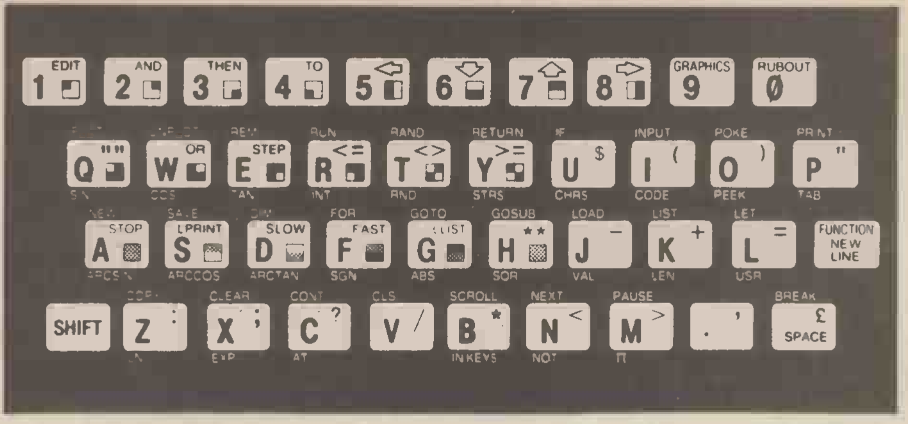
Hardware

Input and output for the ZX81 could not be simpler — literally. Output is direct to a TV set (not a monitor), and there are a couple of sockets for connection of a cassette recorder for program and data storage.

The power for the ZX81 comes from 9 V DC and that's it! Unless you want to add peripherals.

There is an exposed section of edge connector pads at the rear of the machine designed for the addition of the two peripherals so far released. One is a RAM pack which brings the total memory from its existing, rather limited, 1K up to a more sensible 16K. The other peripheral available is a printer. It features full alphanumerics plus graphics and prints 32 characters to the line, nine lines every 25 mm.

The processor used in the ZX81 is a version of the ubiquitous Z-80. The keyboard is laid out in the normal typewriter 'QWERTY' manner — although *much* smaller than a typewriter



The ZX81's multi-function keyboard supports a very large number of operations. Graphics characters are called up by the GRAPHICS key (SHIFT/9); alternate characters (+, =, etc) by holding down the SHIFT key; functions (AND, etc) or any of the words printed beneath the keys are called by FUNCTION (SHIFT/NEWLINE) while program keywords are entered automatically after entering a program line number. If all this sounds confusing — don't worry. The keys are all colour-coded (eg, SHIFT and SHIFTed keys are red) and the input mode is indicated by the cursor character.

keyboard. One user I heard from (he's ten) said it was just the right size.

I, unfortunately, have normal sized adult hands, so it's a bit small for me. In fact, that's one of the few criticisms I have of the ZX81 — you can't type on it, you have to use it like a calculator.

In fact, there's no 'feedback' to tell you that you've pressed a key — so you have to keep moving your eyes from the screen to the keyboard and back again. After a while (particularly during program entry) this gets very tedious indeed, but I suppose that most of the buyers (myself included, if I'd bought one instead of being loaned one for review) would rather have the cash than a better keyboard. It's very tempting for reviewers to catalogue the facilities that are missing from a device while at the same time forgetting that if they had been included, the buyer would inevitably have to pay. The incredibly low price of the ZX81 is one of its main attractions.

The other difference between ZX81 keyboard and those normally found on computers is the fact that the key function don't stop at the letters of the alphabet.

Statement Entry

This 'doubling up' of function is due to the extremely clever way in which Sinclair have arranged their program entry.

Say you want to enter the line "10 PRINT A". In most computers, you would press the '1' key, then the '0' key . . . through to the 'A' key at the end of the line. On the ZX81 you start with the line number, then simply press the 'P' key. Up on the screen comes "10 PRINT". There's no need to type the rest of the word in. Then you press the 'A' key (no need for a space — the computer supplies that).

The ZX81 BASIC is arranged so that the first word on each line is a keyword (like PRINT, FOR etc). So when you press the 'P' key, the machine *knows* that you mean PRINT, because the next entry *must* be a keyword. On the keyboard, the word PRINT appears over the 'P' key.

A ZX81 disassembled.

In fact, nearly all of the keys have a keyword associated with them. One consequence of using this system is that the old 'LET' statement (introduced in the very first version of BASIC, nearly 20 years ago) is resurrected. Most systems these days allow you to miss out the word LET in an assignment statement.

Another consequence of the system is that the software doesn't have to check the spelling to see if it's a keyword. Each of the keywords is entered and stored as a single character (although it appears spelt out on the screen). This is not only faster, it also saves memory.

There is also a SHIFT key, and a combination of other keys (FUNCTION and GRAPHICS) to select other options from the same letter key. In fact, some of the letter keys have *five* different functions crammed onto their ultra-small face!

The ZX81 is not for those who have trouble with small print!

Display

The display on the screen is rather unusual for two reasons: the first is that all characters are shown normally black on white. I found this a rather pleasant, and less of a strain on the eye than the normal white-on-black.

The second rather unusual feature is that there is no automatic scrolling of the display. In most systems, when the PRINT statements in the program have put enough lines out to fill the available space, the screen 'scrolls' up one leaving a blank line at the bottom for the next line of output. The ZX81 does not have this feature — and in fact, if the PRINT statements try to put too much onto the screen, an error will result and the program will halt!

There are two ways to get round this. One is a SCROLL statement, which moves the screen up one line. The second is the CLS statement, which clears the screen.

It is rather surprising that Sinclair have chosen not to implement the automatic scroll — perhaps they have some good reason. I can't think of one.

The character set consists of uppercase letters, numbers, and the very minimum of other symbols. In fact Sinclair have kept the character set so small that I think some users may run into problems. For example, the symbol for mulitplication is an asterisk '*', and the symbol for exponentiation (ie raising to a higher power) is two asterisks '**'. Now, it is quite possible to put two of the multiplication symbols into line side by side. However, this is not interpreted by the computer as exponentiation. That has to be the special '**' symbol. Unfortunately, there is no easy way that the user can tell the difference between the two on the screen. So it is quite possible to do as I did — to type two multiplication symbols to mean exponentiation, and then wonder why it didn't work.

Syntax Checking

Each line of the program is checked for syntax as it is entered. Not only does this mean that problems will be shown up as they occur, but also that the machine doesn't have to check the syntax again as it runs the program.

The graphics symbols are fairly complete — allowing each character position to be split into four segments each of which can be black or white.

There are also symbols which allow shading of each character position, split horizontally into two segments (see photo of the keyboard). Each of the symbols in the alphanumeric set can be shown 'reversed', also.

As each line of program is entered, it appears on the screen in its correct position. So the normal method of looking at the program — a LIST command which scrolls the listing onto the screen — is not used.

Instead, the bottom couple of lines of the screen are an 'entry area', where the cursor appears. The top part of the screen then shows whatever part of the program the last line was entered into.

In fact, this method of entry is very much easier to sue than the normal 'scroll' method. It means that you can actually see the program change as you enter lines — this is very useful for beginners, who sometimes have trouble visualising what is happening inside the machine.

There is also an EDIT facility — one of the already-entered lines can be called into the bottom part of the screen and modified, before being replaced in the main part of the program.

The operating system has a couple of features which are unique to the ZX81 — one of these is the ability to run in two modes — SLOW and FAST.

In the SLOW mode, the machine gives a 'flicker-free' display — the screen display is constant while calculations are in progress.

In the FAST mode (about four times as fast), the screen blanks while the machine is calculating, only coming on when it is paused for input (or during execution of the PAUSE command). This is because Sinclair are using the *CPU* to output the display!

The cassette saving routines have the ability to label the programs with an alphanumeric string, and to search for that string when the program is read off tape, only starting to load when they find the right program.

Another unusual feature is that when a program is saved, all the current variable values are saved, too. This is nice for fitting very 'tight' programs into the machine — the data initialisations do not need to take up *any* memory. The only space they need would already be used by the variables themselves.

Manual

The documentation that comes with the ZX81 is really excellent — the author, has taken a very down-to-earth approach, and the whole thing (over 200 pages of it) hangs together very nicely indeed. It is well peppered with explanatory examples, and is written in an easy style that will not confuse or frighten anyone. It's also spiral bound, so that it will lie flat while you copy programs from it!

The manual for a machine like the ZX81 is almost as important as the hardware itself — it is, after all, primarily a teaching machine.

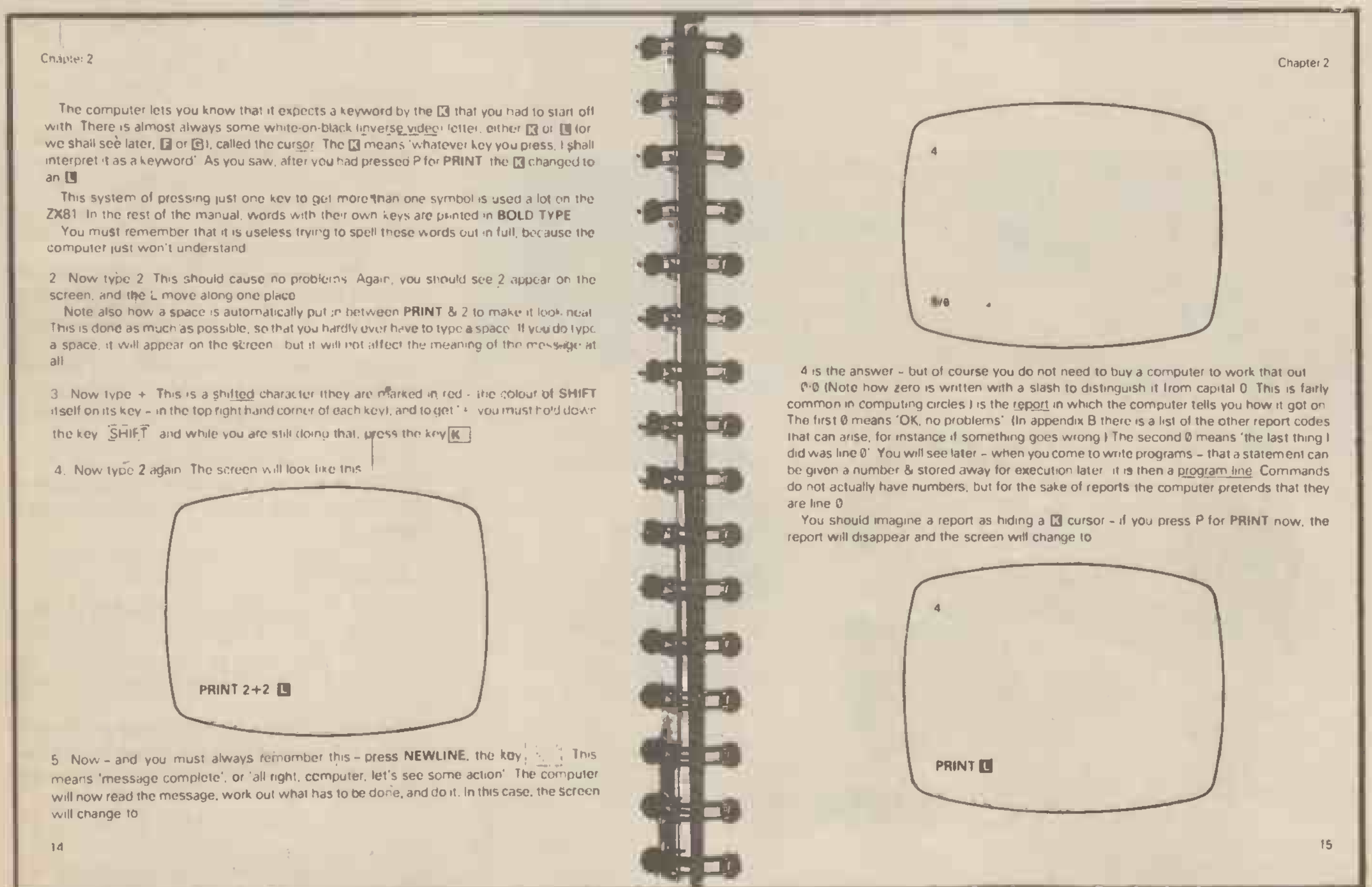
The only thing that's missing from the manual is any sort of comprehensive hardware details. I suppose, though, that given the probable audience this would not be worthwhile.

The manual not only describes the ZX81 BASIC in loving detail, it also goes on to describe the internal software in some depth, including a full listing of the system variables and their interpretation, and a section on how to use machine code programs with BASIC.

Using it

Now we come to the most important part — how the machine performs.

I didn't try any 'benchmark' programs on the ZX81 — there's not much point, because all they would show is that the



Chapter 2

The computer lets you know that it expects a keyword by the K that you had to start off with. There is almost always some white-on-black (inverse video) letter, either K or L (or we shall see later, F or G), called the cursor. The K means 'whatever key you press, I shall interpret it as a keyword'. As you saw, after you had pressed P for PRINT, the K changed to an L.

This system of pressing just one key to get more than one symbol is used a lot on the ZX81. In the rest of the manual, words with their own keys are printed in **BOLD TYPE**.

You must remember that it is useless trying to spell these words out in full, because the computer just won't understand.

2. Now type 2. This should cause no problems. Again, you should see 2 appear on the screen, and the L move along one place.

Note also how a space is automatically put in between **PRINT** & 2 to make it look neat. This is done as much as possible, so that you hardly ever have to type a space. If you do type a space, it will appear on the screen, but it will not affect the meaning of the message at all.

3. Now type +. This is a shifted character (they are marked in red - the colour of **SHIFT** itself on its key - in the top right hand corner of each key), and to get '+' you must hold down the key SHIFT and while you are still doing that, press the key K.

4. Now type 2 again. The screen will look like this

PRINT 2+2 L

5. Now - and you must always remember this - press **NEWLINE**, the key. This means 'message complete', or 'all right, computer, let's see some action'. The computer will now read the message, work out what has to be done, and do it. In this case, the screen will change to

14

Chapter 2

4

0/0

4 is the answer - but of course you do not need to buy a computer to work that out.

0/0 (Note how zero is written with a slash to distinguish it from capital O. This is fairly common in computing circles.) is the report in which the computer tells you how it got on. The first 0 means 'OK, no problems'. (In appendix B there is a list of the other report codes that can arise, for instance if something goes wrong.) The second 0 means 'the last thing I did was line 0'. You will see later - when you come to write programs - that a statement can be given a number & stored away for execution later: it is then a program line. Commands do not actually have numbers, but for the sake of reports the computer pretends that they are line 0.

You should imagine a report as hiding a K cursor - if you press P for **PRINT** now, the report will disappear and the screen will change to

4

PRINT L

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A sample page from the excellent manual which is supplied with the machine.

machine is significantly slower than almost any other on the market.

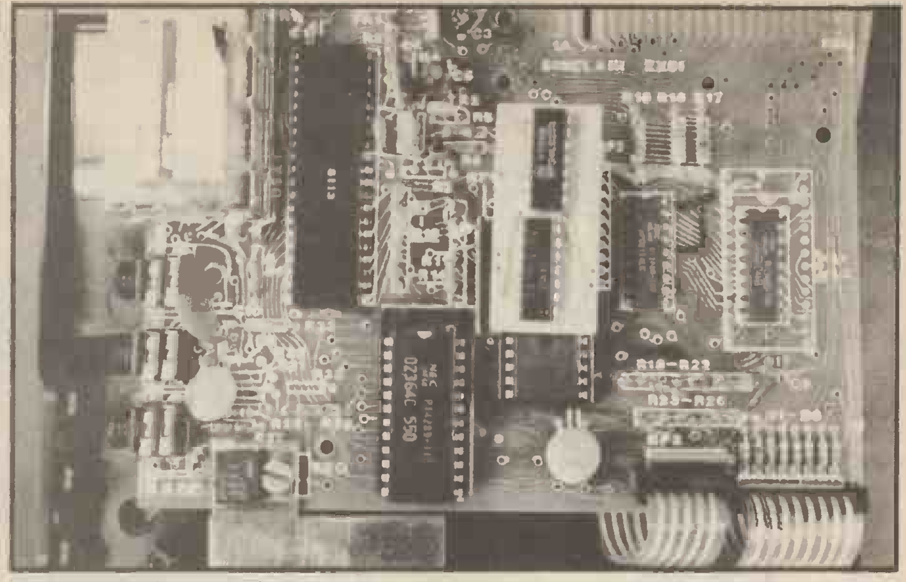
I say again — it's a teaching machine. So the speed doesn't *really* matter.

I wouldn't recommend the ZX81 to someone who wants to do a lot of number-crunching, though — you'd be better off with a programmable calculator.

The display is sharp enough to be read without too much strain — even on my little portable. The characters are a little 'blocky', but not outrageously so.

Apart from the problem I mentioned earlier about the keyboard having no feedback, the only other major trouble in using the ZX81 is that 1K of RAM is really rather small — even with one character per keyword.

Then again — if it's the only computer that you can afford, and it's the first one that you've used, then it's not likely to trouble you.



The inside. That's all — true!

ZX81 Basic

Finally, I've included a list of the commands and features of the ZX81 BASIC so that you can see that the ZX81's language is every bit as comprehensive as that of other machines on the market.

Variables may have an alphanumeric name of any length, starting with a letter continuing with letters and numbers — and *spaces!* This is due to the unique keyword entry method.

Values are stored to 9 digits, with a range between about 10^{-38} and 10^{38}.

Array names are a single letter, and arrays may have any number of dimensions of any size.

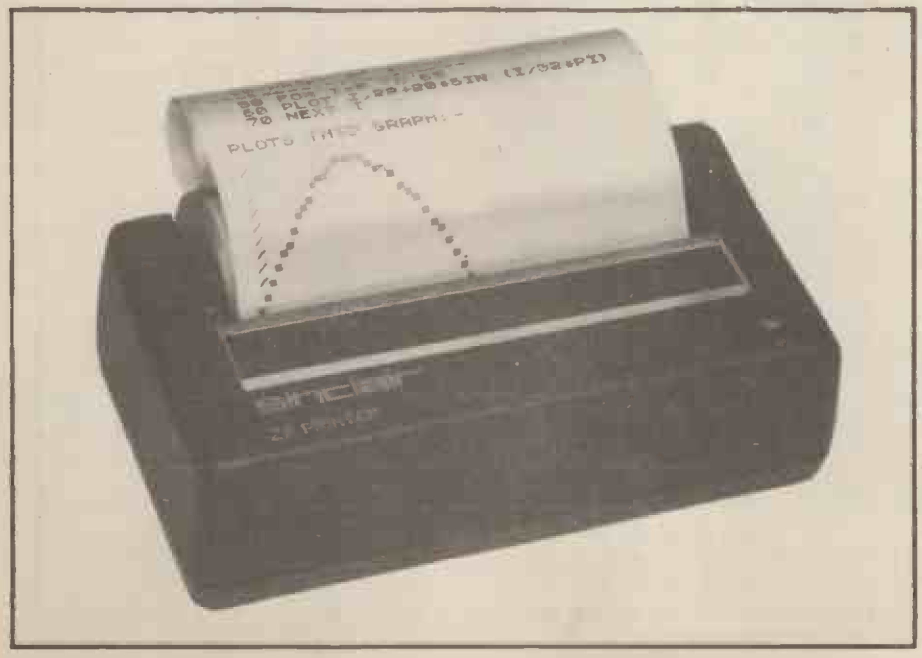
String arrays are allowed — but all of the strings in the array are the same length.

String variables are any length, but the string name is only a single letter.

Functions supported include: absolute value, arccos, AND, arcsin, arctan, CHR$, CODE (the same as ASC in other BASICs — but it's not ASCII), cos, X^e, INKEY$ (gets a key press from the keyboard), integer part of a numC in other BAISCS — but it's not ASCII), cos, X^e, INKEY$ (gets a key press from the keyboard), integer part of a number length of a string, NOT, OR, PEEK, pi, random number, sign of a number, sin,square root, STR$ tan, user machine code routine call, and VAL.

Statement types are:

CLEAR deletes all variables
CLS clears the screen
CONT after 'break', continues execution
COPY sends a copy of the screen contents to the printer
DIM dimensions arrays
FAST sets machine into fast mode (see text)
FOR . . . TO . . . STEP forms a loop (the variable used must have only one letter in its name)
GOSUB sends program to a line number (line number may be expressed as an expression)
IF . . . THEN allows changes in program flow — but multiple statements per line are not supported
INPUT allows the user to input a string or numeric characters
LET is required for assignment statements
LIST allows the user to call up any part of the program on the screen's display area
LLIST sends it to the printer
LOAD searches for the program name on the tape, then loads it
LPRINT sends output to the printer
NEW initialises the whole system
NEXT ends a FOR loop
PAUSE stops the program for a set period from 1/50 of a second to about 10 minutes
PLOT makes one quarter of a character print in the position specified
POKE allows the program to alter memory directly
PRINT puts information onto the screen. Features supported are: comma (giving fixed tab), semi-colon (at the end of the statement, preventing line feed and carriage return) and TAB
RAND allows randomisation
RND variable sequence
REM for remarks
RETURN ends subroutine
RUN runs a program. RUN (line number) starts the program from the line number
SAVE puts the program onto tape, with a name of any length
SCROLL moves all the lines in the display area up one
SLO puts the machine into slow mode (see text)
STOP halts execution
UNPLOT turns off one quarter of a character position, in the position specified



Summary

The ZX81 is a very high value-for-money machine. It's designed as a teaching machine, and at a price of £49.95 for the kit or £69.95, ready assembled it is very well targeted.

It is not a machine for those who have number-crunching applications in mind. For that is rather slow and a bit awkward.

It does, however, have almost all the advanced features found on other BASIC systems. Having mastered the ZX81, you will be able to drive almost any other machine after a couple of days. **HE**

Sinclair ZX81 Personal Comp
the heart of a system that grows with you.

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. Not surprisingly, over 50,000 were sold.

In March 1981, the Sinclair lead increased dramatically. For just £69.95 the Sinclair ZX81 offers even more advanced facilities at an even lower price. Initially, even we were surprised by the demand – over 50,000 in the first 3 months!

Today, the Sinclair ZX81 is the heart of a computer system. You can add 16-times more memory with the ZX RAM pack. The ZX Printer offers an unbeatable combination of performance and price. And the ZX Software library is growing every day.

Lower price: higher capability
With the ZX81, it's still very simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

It uses the same micro-processor, but incorporates a new, more powerful 8K BASIC ROM – the 'trained intelligence' of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays.

And the ZX81 incorporates other operation refinements – the facility to load and save named programs on cassette, for example, *and* to drive the new ZX Printer.

New BASIC manual

Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BASIC programming, from first principles to complex programs.

Kit: £49.95

Higher specification, lower price – how's it done?
Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4!

The secret lies in a totally new master chip. Designed by Sinclair and custom-built in Britain, this unique chip replaces 18 chips from the ZX80!

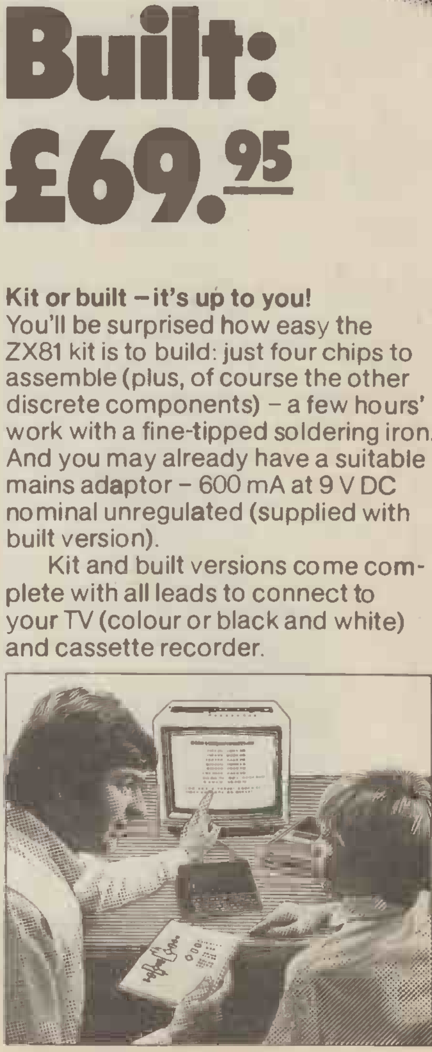
New, improved specification

- Z80A micro-processor – new faster version of the famous Z80 chip, widely recognised as the best ever made.
- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (RUN, LIST, PRINT, etc.) have their own single-key entry.
- Unique syntax-check and report codes identify programming errors immediately.
- Full range of mathematical and scientific functions accurate to eight decimal places.
- Graph-drawing and animated-display facilities.
- Multi-dimensional string and numerical arrays.
- Up to 26 FOR/NEXT loops.
- Randomise function – useful for games as well as serious applications.
- Cassette LOAD and SAVE with named programs.
- 1K-byte RAM expandable to 16K bytes with Sinclair RAM pack.
- Able to drive the new Sinclair printer.
- Advanced 4-chip design: micro-processor, ROM, RAM, plus master chip – unique, custom-built chip replacing 18 ZX80 chips.

Built: £69.95

Kit or built – it's up to you!
You'll be surprised how easy the ZX81 kit is to build: just four chips to assemble (plus, of course the other discrete components) – a few hours' work with a fine-tipped soldering iron. And you may already have a suitable mains adaptor – 600 mA at 9 V DC nominal unregulated (supplied with built version).

Kit and built versions come complete with all leads to connect to your TV (colour or black and white) and cassette recorder.



uter-

Available now- the ZX Printer for only £49.95

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alphanumerics *and* highly sophisticated graphics.

A special feature is COPY, which prints out exactly what is on the whole TV screen without the need for further intructions.

At last you can have a hard copy of your program listings – particularly useful when writing or editing programs.

And of course you can print out your results for permanent records or sending to a friend.

Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The ZX Printer connects to the rear of your computer – using a stackable connector so you *can* plug in a RAM pack as well. A roll of paper (65 ft long x 4 in wide) is supplied, along with full instructions.

16K-byte RAM pack for massive add-on memory.

Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.

With the RAM pack, you can also run some of the more sophisticated ZX Software – the Business & Household management systems for example.

How to order your ZX81

BY PHONE – Access, Barclaycard or Trustcard holders can call 01-200 0200 for personal attention 24 hours a day, every day.

BY FREEPOST – use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access, Barclaycard or Trustcard.

EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

To: Sinclair Research Ltd, FREEPOST, Camberley, Surrey, GU15 3BR. Order

Qty	Item	Code	Item price £	Total £
	Sinclair ZX81 Personal Computer kit(s). Price includes ZX81 BASIC manual, excludes mains adaptor.	12	49.95	
	Ready-assembled Sinclair ZX81 Personal Computer(s). Price includes ZX81 BASIC manual and mains adaptor.	11	69.95	
	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	10	8.95	
	16K-BYTE RAM pack.	18	49.95	
	Sinclair ZX Printer.	27	49.95	
	8K BASIC ROM to fit ZX80.	17	19.95	
	Post and Packing.			2.95

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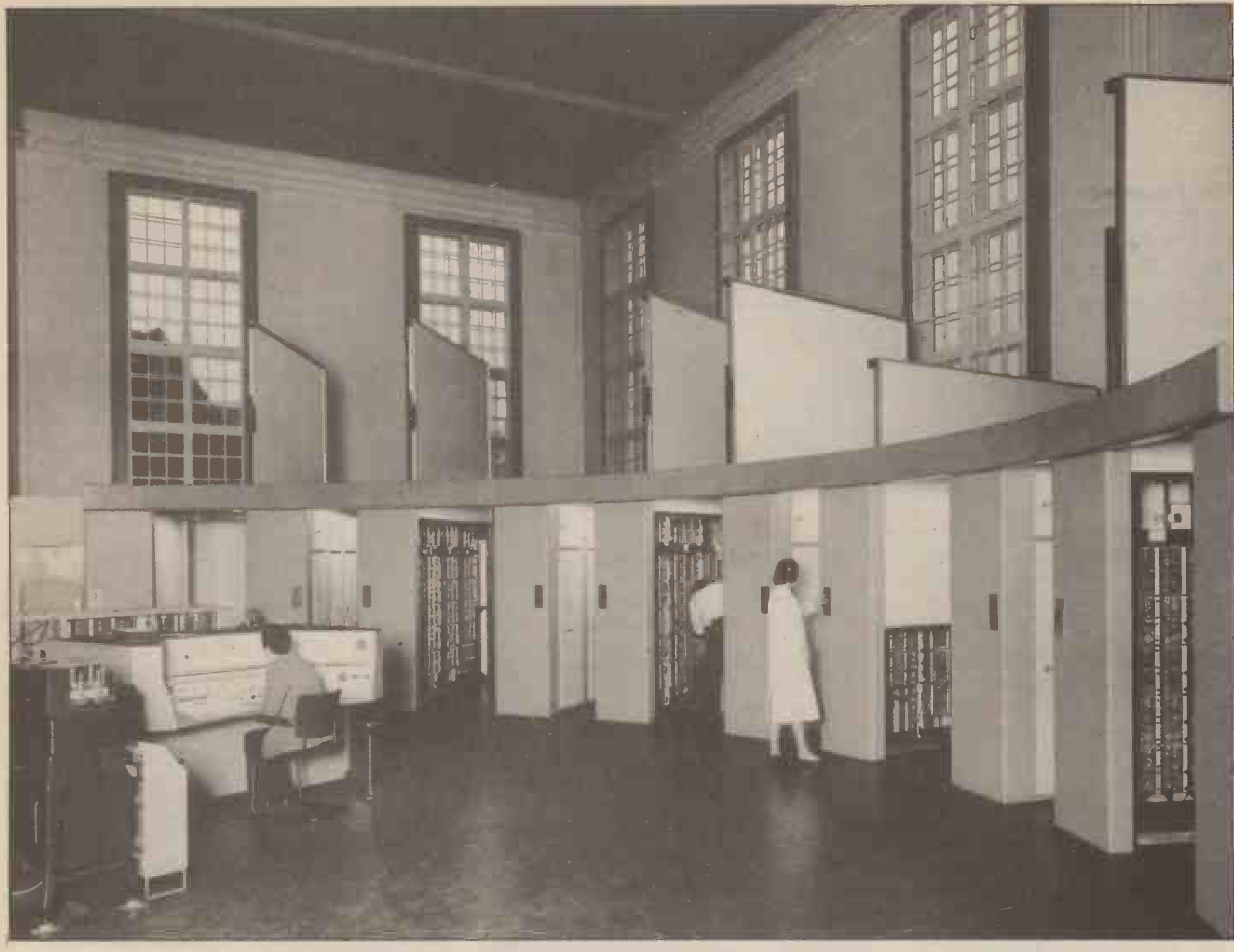


Pictured above is ACE, the National Physical Laboratory's first computer. The vertical sliding panels are to allow access for maintainance — and also to provide better cooling for the racks of valves. (Courtesy NPL, Crown Copyright).

MICRO-HISTORY

A slice through the years, as we look at some of the men and machines that preceeded today's powerful computers.

ALMOST every day, we read in the national press, or in other publications, that the age of computers is upon us. This is undoubtably true, but it is nevertheless worthwhile looking back at some of the developments which have led to the current 'state of the art', before the technology overwhelms us! In writing about computers, there is often a temptation to baffle readers with science — the jargon looks good, and sounds authoratative. In fact, we should be trying to do the opposite; explain exactly what computers are and how they effect our lives, in plain, simple language. So, let's start at the beginning, and get the whole thing in perspective.

Looking at the names associated with early computers, three stand out as beacons of foresight and understanding.

Taking them in chronological order, which is logical, we first meet Blaise Pascal.

Born in France, in the Seventeenth Century, he was best known as a mathematician. His father was a tax collector, an unpopular occupation, even then, and the sight of his father spending long hours over columns of figures was young Blaise's first inspiration; he produced a mechanical engine that removed the drudgery of the work. The basic design was a success, which was a considerable feat of purely mechanical engineering, and it enjoyed a limited commercial success, too. The main disadvantage was that it was only capable of either addition or subtraction — one operation at a time.

This machine was called the 'Pascalline' and it is still, surprisingly, in use today, recording the mileage that your car has covered. Its improved successor, which was capable of multiplication, survived for nearly as long. Only the first electronic calculators sent it to the Science Museum. If you should see it there, it's worth remembering that it was invented when the Inducalculators sent it to the Science Museum. If you should see it there, it's worth remembering that it was invented when the Industrial Revolution was still to come and that even simple mechanical parts could not be manufactured accurately. It was this difficulty that caused the failure of the next innovator in computer science.

The Difference Engine

Charles Babbage (who is the subject of this month's Famous Names), also began life as a child prodigy and it was his early interest in tables of logarithms that inspired his life's work. His first achievement was to produce a machine for calculating log tables which were more accurate than those previously published. His next task, the construction of the Difference Engine, was more challenging, but after eleven years' work and a Government grant of £17,000 (an enormous amount of money, in those days), the mechanical problems finally defeated him.

Despite this failure, he conceived an even more spectacular device, the great Analytical Engine, which incorporated all of the concepts of the Difference Engine but was, in addition, programmable; it was intended to carry out mathematical operations as required, on whatever data was available. This was the first visualisation of the computer as we understand it today — it actually included most of the features incorporated in modern microcomputers. Once more, though, the inability to make presicion parts spelled the doom of the Analytical Engine. Babbage died, aged 80, with not much left to his name except a pile of cogs and gear wheels. His son finally managed to put together a working model, which can be seen in the Science Museum.

Herman the Wise

Less than twenty years later, the third great inventor in the history of computers, Herman Hollerith, made the final link in the chain of innovations that led to modern computers. His 'Tabulator' was designed as an entry in a competition to develop a system to analyse the mass of information collected for the 1890 American Census. It was an electromechanical device and completed the Census results in record time, making Hollerith a very rich man. Indeed, the company he founded (International Business Machines — IBM) is still one of the largest mainframe computer manufacturers and it is only recently that its dominance of the business has been challenged.

Hollerith's Tabulator was by no means an ideal computer; it was designed to do just one specific job and its 'programming' could not easily be changed. This was not the flexible, all-purpose machine conceived by Babbage. However, it is interesting to note that, following Babbage's adaptation of the punched cards used to control weaving machinery, Hollerith used similar cards to enter the Census data. These cards are still in use in many computer systems, today — some things never seem to change!

The breakthrough was made shortly after World War II. The development of ballistic computers and code-breaking machines during the War produced some extremely sophisticated electromechanical devices but, like all such devices, they were 'dedicated' machines limited to a specific application. The first true electronic computer was, in fact, developed in Britain, in 1948 by a Manchester University team.

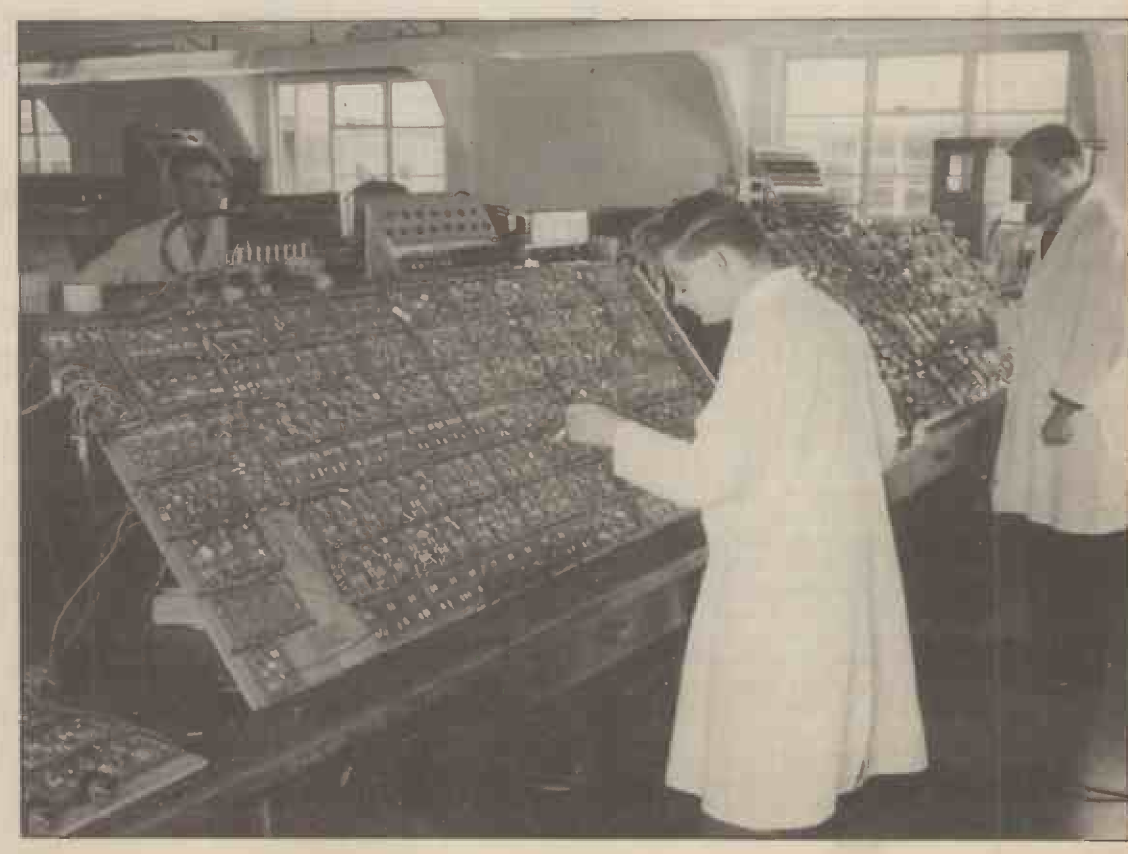
The development of the true electronic computer rested largely on the work of two mathematicians; Alan Turing, a Britain whose work on code-breaking laid the foundations and the American, John Von Neumann. Another vital step was the introduction of the binary numbering system. If Pascal or Babbage had designed their systems to use binary numbers they would have simplifed their problems by a factor of nine and it is possible that the world would have had steam-powered computers before it had electricity.

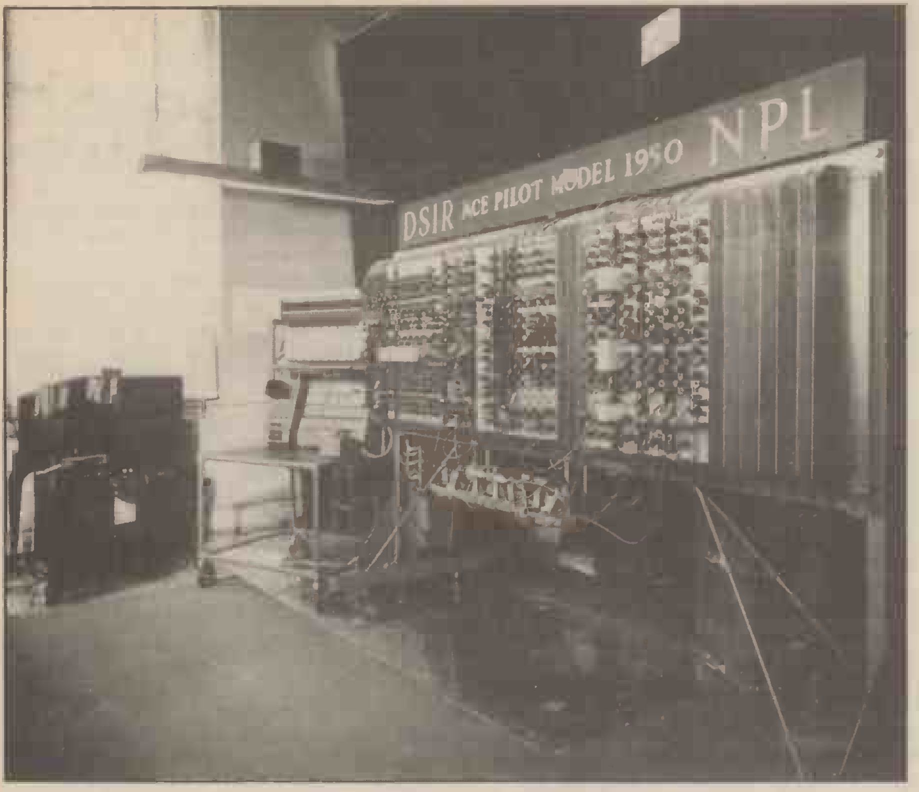
Having made the key evolutionary leap, computers went from strength to strength. The first ones were monsters, its true (Ferranti's first commmercial computer stood 32 feet long, eight feet high and four feet deep, used 3,500 valves, 2,500 capacitors, 15,000 resistors and six miles of wire) and rejoiced in names such as UNIVAC, ENIAC and ACE, but they were true general-purpose, programmable computers, consisting of the same basic elements as are found in today's computers.

The growth of computers, since then has been by a series of steady refinements, rather than by revolutionary developments. The thermionic valve was a notoriously unreliable device, slow and costly in terms of power consumption and space and they were soon replaced

A first generation computer — thousands of circuit cards and transistors beyond counting!

(Courtesy NPL, Crown Copyright).





Pilot model of the NPL's ACE. (Courtesy NPL, Crown Copyright).

by the newly invented transistor. However, the replacement of valves by transistors did not involve any change in the basic design of computers.

The introduction of the transistor produced the 'second generation' of computers. A 'generation' in computer terms is loosely defined as a tenfold decrease in size with a tenfold increase in processing power at a tenth of the original cost. As the translstor became the descendent of the valve, so the chip or integrated circuit became the descendent of the transistor. In those days (some ten to twelve years ago), the first integrated devices consisted of perhaps a half dozen transistors on a single chip of silicon. Rapid advances were made and soon a new kind of computer was born.

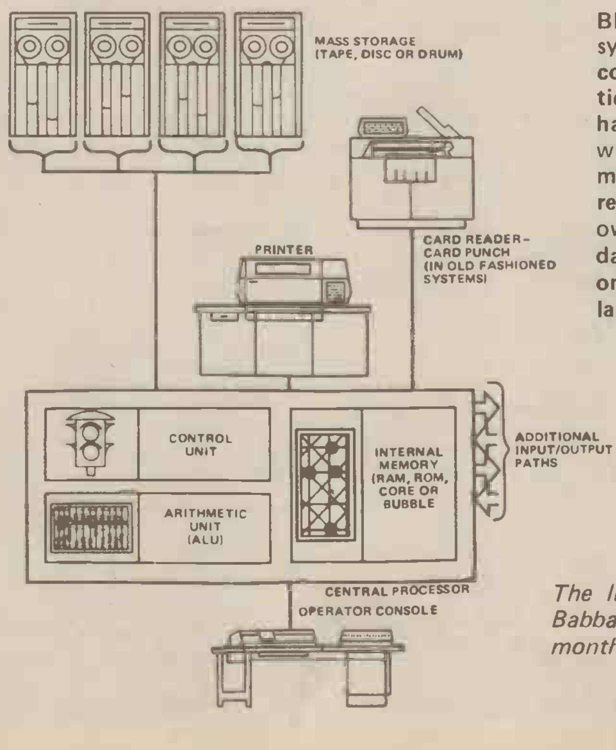
The Minis

Just as the Mini car revolutionised the way the world looked at motoring, so the minicomputer changed the face of computers. Up till the advent of the integrated circuitry there had been only 'computers'; now there were 'mainframes' and 'minis'. These were rigidly divided into sectors of operation — the mainframes were used for serious purposes, the minis were 'toys' used in research. Among the names of companies who were to make their fortunes producing minis was DEC who are, probably, still the world leader. Soon, the mini was to be found everywhere from research labs to classrooms and their spread was due simply to the fact that they were small, cheap and relatively easy to use. They were even built into pieces of equipment, such as machine tools. Indeed, it is fair to say that the mini paved the way for the micro, although the actual distinctions between them have been rapidly eroded.

Firms involved in the business of integrated circuit production tend to follow a natural progression in the devices that they make. First off the production line come the standard logic elements, the AND/OR type gates and, once the production of these is running at a profitable level, they attempt to squeeze a little more onto the slab of silicon. As soon as this stage is proved they take another leap forward and so on. In the terminology of the business, this is a progression from SSI (Small Scale Intergration) with about 10-20 actual devices on the 'chip' through MSI (Medium Scale Integration), which has a dozen or so gates (rather than discrete elements) up to LSI (Large Scale Integration), which is taken as being greater than 100 gates on the chip. At this stage of the game we are still talking about, complex TTL type packages, the next jump is to VLSI which, believe it or not, stands for Very Large Scale Integration. We are now in the realm of memory devices and microprocessors.

If we take a look at **Figure 1** we can see a generalised block diagram of a computer; what kind of computer is not important because they all have the same functional blocks within them, be they micro or mainframe. The common misconception is that the 'mighty chip' is a computer — far from it. Your average microprocessor still needs all the memory circuits, control circuits, mass storage devices and other components that even the old valve machines needed; they are merely smaller. The very first microprocessor came about in 1971 simply because it was realised that it would be possible to make a device of that complexity on a single chip. The device was called the 4004 and the company that made it was Intel . The next device they produced was the 8008 and that was followed by the microprocessor chip which, ten years after its initial introduction, still dominates the microcomputers of the world — ubiquitous 8080.

The rest of the story is not history; since the 8080, new chips have been introduced almost every year and so the future is still wide open. Indeed, the future probably holds as many new and exciting developments as the past and another revolution in computer technology is still possible, considering the work currently being done on the 'biological computer'. We may yet see computing 'brains' which more closely live up to the description!



Block diagram of a computer system. A modern microcomputer is essentially identical — mass storage (usually hard disc) is quite possible with larger, more powerful microcomputers. Card readers, however, are a holdover from the very earliest days of computing. They are only used, now, with very large mainframe systems.

The life and career of Charles Babbage is the subject of this month's Famous Names feature.

HE

Lack of ZX81 memory giving you headaches..?

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The growth of interest in computer use caused by the introduction of the Sinclair ZX81 has made new and exciting demands on the ingenuity of electronic engineers. At Memotech we have focused our attention on the design of an inexpensive, reliable memory extension.

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Clever Dick

Who is this mysterious person? Did Charles Dickens discover Hovis? Did Robert the Bruce discover Australia?

OK. Lets get it out of the way.

Dear CD,
I am writing to you about your reply to Mr Belfield's letter in the March '82 issue of HE. You said that you would award next month's binder to anyone who could politely and in one sentence explain what chocolate digestives have to do with you.

I believe I have the answer — here goes. Chocolate digestives have the initials CD and C.D. = Clever Dick. I hope it is the right answer.
Paul Procter,
Chester.

PS Your mag is the best one out.

Dear CD,
I write to you claiming a binder, with no grovelling whatsoever. You offered a binder to anyone who could explain D. Belfield's PPS; well, here is the explanation.

Clever Dick (CD) and chocolate digestives (cd) both have the same initials, so by saying that his sister likes chocolate digestives, he is implying that she also likes you — is this grovelling?

Was that polite enough?
In expectation of a binder,
R. Hart,
Mansfield,
Notts.

PS Charles Dickens also has the intials CD — any relation?

Dear CD,
In the March issue (we know that by now, thanks all the same) *you asked for the connection between yourself and Mr Belfield's sister's craving for chocolate digestives.*

Well, firstly you should be honoured to have the same initials as a Chocolate Digestive and, secondly, it is a clue to your real identity.

If you remove all the letters from Clever Dick that also occur in Chocolate Digestive, you are left with the letters R, K. This would therefore, suggest that you are in fact Ron Keeley, the Esteemed Editor.

I hope this answers your question and you wil keep your promise of an award?
I.M.A. Bruce.

PS I have been reading HE for almost three years and in that time have not only developed a warped sense of humour but also a very warped stock of HEs.

Dear Chocolate Digestives,
Isn't Mr Belfield's PPS obvious? He thinks that CD stands for Chocolate Digestives and his sister has fallen in love with you (but then, which girl wouldn't).

Anyhow, down to business. Why are all these people complaining about the few mistakes made in HE? Don't they know that it is all done on purpose to keep us hobbyists on our toes? After all, how can two whole diagrams (Figures 9 and 10, page 43) in the ocilloscope article in the March issue be misplaced and then merely attributed to 'gremlins'.

I'm sure that the HE team, in their ultimate wisdom, know exactly what they are doing.
Yours, Canlhaveabinderpleasingly,
J. Sylvester,
Ilkeston,
Derbyshire.

PS Why is it that, in some project component lists, it says, for example, ''50k — 5 off'' instead of ''5 off''?
PPS I wouldn't mind a binder.
PPPS If you send a binder, I might just get back in from this three-stories-high window ledge.
PPPPS Remember, if I do accidentally fall off (of?) this ledge, I won't be able to buy HE anymore!

Oh what clever, witty readers you are. I should have known that the question was far too easy for such erudite, intelligent and perspicacious people. Never mind. You can't win them all — nor can all win. So.

Paul Procter is straight to the point, even blunt, one might say — but is that polite? G. Adamson, I'm afraid, loses immediately. What a dreadful pun!

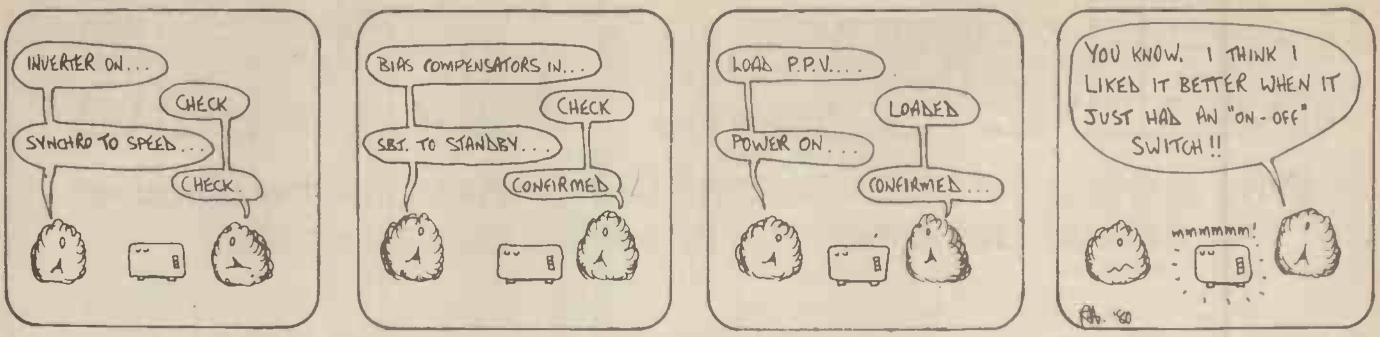
Mr R. Hart has a strong claim, but loses points for subdued grovelling — if your going to do it, lad, do it properly, like. Besides, Charles Dickens is older than I am. I.M.A. Bruce came up with a very clever answer (although his 'name' is another dreadful pun) which, unfortunately for HIM, has nothing to do with ME. My real identity, sir, is the most closely guarded secret since Superman fell out of the 'phone box. Not even the Editor knows who I really am — and sometimes I'm not too sure myself.

That leaves J.Sylvester (any relation to Victor?), who has probably jumped by now. Just in case he's still hanging about, a binder is on its way to Him, awarded for the most concise answer to the question; his salutation was plain enough. A belated binder is also awarded to D. Belfield, together with a packet of Chocolate Digestives for his sister (but he'll have to write again, with his full address this time).

This late reply seems to have missed the point, though he's quick enough to claim the reward.

Dear CD,
In reply to D. Belfield's letter, the SAB0600 is, in fact, the IC used in the Doorchime project (December 81) and can be obtained from TK Electronics.

Now a suggestion for a project; how about a Flanger? I am interested in making electronic music — December's HE was excellent and I have built the Graphic Equaliser and the Drum Synth (with modifications) and they worked extremely well.



Don't forget the binder, thank you.
S.C. Bonnell,
Wolverhampton.
PS Keep up the good work.

Right! The Doorchime! I knew I'd seen is somewhere. This is a good as time as any to remind you all that I can only give detailed replies to exact questions — the IC referred to could have been in any project published anytime in the past four years and I certainly don't have time to check them all!

The Flanger project is a good idea, which follows naturally from the HE Echo-Reverb in this issue. I'll see what I can do to push it, OK? As for the binder — sorry, you're too late.

It's always nice to receive 'love letters', but this one is just slightly dubious.

Dear CD,
I often buy decent magazines on electronics from my newsagent and often have a laugh at HE. Most of the projects are, to say the least, pathetic tea-break rejects.

But what was this I saw in the April '82 issue? A useful project! Amazing! I must congratulate you for the Digital Capacitance Meter (usually, any sensible projects are to be found in ETI). I actually bought the magazine and the last three pages weren't on CB!
M. Garton,
Purveyor of Messy Writing,
(Address illegible).

He's right about the writing, if nothing else. All Hobby Electronics projects are designed to be useful for some purpose, even if the aim is only to instruct — we do have a number of readers who are just getting into electronics for the first time, you know.

The next letter raises a most interesting question — is it 1984, already?

Dear Dick,
I remember reading, some time ago, that a Japanese camera company fitted their remote control cameras with infra red control so they could get around the Wireless Telegraphy Act of 1947/1969. But, after reading the 1969 Act, I noticed that any form of transmission, including infra red, could only be considered legal if used by the Post Office or by people with licenses.

It seems that they do not yet have control over shouting or singing, but I expect that they're working on it. Is it true, Dick? Are these infra red cameras and remote control units against the law?
M.Scholes,
Telford,
Salop.

PS Why do all these people waste time buying or grovelling for binders? Have they no floors on which to pile their HEs? I keep mine in suitcases and old box files under the bed!

The implication, here, is that anyone who uses an infra red remote control system for any purpose (changing TV channels, for example), is breaking the law. That is not the case. The Act referred to defines Wireless Telegraphy (for which a license is required) as follows:

Wirelss Telegraphy means the emitting or receiving, over paths which are not provided by any material substance constructed or arranged for that purpose, of electromagnetic energy of a frequency not exceeding 3 x 10^6 Megahertz.

Fortunately for all of us, the infra-red band *starts* at 3 x 10^6 MHz and, therefore, operating an infra-red remote system does not require a license, under the Act. Imagine the trouble Buzby would have, if IR was illegal! He'd probably lose all his feathers from over-work.

Now here's a classic plea for HELP.

Dear CD,
I have built the Power Pack (September '81) and — lo and behold — it worked. Yesterday I put in the fuse holder and, instead of 5 to 15 volts, I now get 7V5 to 23 V and sparks jump between the carbon track and the connector. What have I done wrong?
C. Basnett,
Quarry Bank,
West Midlands.

See what I mean? On the face of it, this project is so simple that nothing should go wrong (so what do you mean, "lo and behold"?). The only answer that occurs to me is that you've got a solder bridge between — or nearly between — the PCB tracks and the mains voltage is arcing across. Check the board carefully for lumps of solder.

Sometimes, it seems, people just don't read the magazine — we go to an awful lot of trouble to get all this information in. Why, of why won't you just READ IT!

Dear CD,
Please can you answer my simple question; where do you get the boxes for projects, ie Bike Alarm and Digital Capacitance Meter (April '82). Do you have to build them yourself?
C. Mathews,
Egham,
Surrey.

No, I certainly don't — and neither do you. The Buylines page is there to let you know where to obtain components and parts for all our projects — but you must read it, you know. If you had, you'd know that cases for both these projects are available from BICC Vero. OK?

Then, reading does not always lead to understanding.

Dear CD,
After reading Ian Sinclair's Into Digital Electronics, I'm hooked on digital circuits and displays. The only thing is, I'd like to be able to check IC pins with a logic probe, for fault finding, but I'm not sure what the logic state of the pins should be in the first place. I wonder if you could help me?
K. Goonan,
Preston,
Lancs.

You may be beyond all help, buy I'll try. Without repeating the series, the simple answer is that the logic state is a given IC pin will usually be either a 1 (high voltage) or a 0 (low voltage), but exactly which state the pin assumes depends on the type of IC (AND gate? OR gate? Timer? Counter?) and how it is connected. For example, a 555 may be wired as an astable multivibrator or as a monostable, to choose two common circuit configurations. Before you can know what the logic state of a pin *should* be, therefore, you must understand the circuit. I believe that a very special logic probe is being designed and will be published in the near future. Perhaps you will be able to use it to gain a better understanding of digital logic. In the meantime I can only suggest that you go back and read Ian Sinclair's series from the beginning! **HE**

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160V: 10nF, 12n, 100n 11p; 150n, 220n 17p; 330n, 470n 30p; 680n, 38p; 1µF 42p; 1µ5 45p; 2µ2 48p.
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POLYESTER RADIAL LEAD CAPACITORS: 250V:
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TAG-END TYPE: 70V: 4700, 245p; 64V: 3300 198p; 2200 139p; 50V: 3300 154p; 2200 110p; 40V: 4700 160p; 25V: 10,000 320p; 15,000 345p.

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

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0.25W 200 M—4.7 M M vert.	10p

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

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15V	7815	145p		—	
18V	7818	145p		—	
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5V	7805	45p	7905	55p	
12V	7812	50p	7912	55p	
15V	7815	50p	7915	55p	
18V	7818	50p	7918	55p	
24V	7824	50p	7924	55p	
100mA	TO92 Plastic Casing				
5V	78L05	30p	79L05	60p	
6V	78L62	30p			
8V	78L82	30p			
12V	78L12	30p	79L12	60p	
15V	78L15	30p	79L15	60p	

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LM305H	140p	LM723	35p	78HO5	550p
LM309K	135p	TAA550	50p	78HG5	550p
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DPDT Standard	44	½AA DPDT	13
SUB-MIN TOGGLE		1A DPDT	14
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SPDT (c/over)	60		
DPDT 6 tags	75	PUSH BUTTON	
DPDT c/off	80	Push-Make	15
DPDT Biased	145	Push-Break	18

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ROCKER: DPDT 10A/250V 70
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16 pin	10p	42p
18 pin	16p	52p
20 pin	22p	60p
22 pin	25p	70p
24 pin	27p	70p
28 pin	28p	80p
40 pin	30p	99p

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6-7 B-Y-R	110p	13; 14; 15; 16; 17	120p
1.5 Green	150p	18/1.6	135p
'T' type 1 to 5, BI, Rd. Wht. YI	150p	18/465	152p
B9A Valve Holder	42p	TOC 1	124p
		MW5FR	122p
RDT2	145p	MW/LW SFR	154p

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2½ x 5"	83p	—
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4¾ x 17	426p	—
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OA70	12
OA79	15
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OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
IN914	4
IN916	5
IN4001/2	5
IN4003	6
IN4004/5	6
IN4006/7	7
IN4148	4
IN5401/2	15
IN5404	16
IN5406	17
IN5408	19
IS44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	65

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2A/600V	65
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	350
25A/200V	240
25A/600V	395
BY164	56
VM18	50

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

TRIACS

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

7400 TTL

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

74151	45
74153	45
74154	75
74156	75
74157	45
74159	99
74160	60
74161	60
74162	62
74163	64
74164	64
74165	62
74166	65
74167	185
74170	168
74172	290
74173	65
74174	72
74175	72
74176	55
74177	75
74178	95
74180	65
74181	140
74182	75
74184	99
74185	99
74188	290
74190	70
74191	70
74192	70
74193	65
74194	75
74195	65
74196	65
74197	65
74198	99
74221	80
74246	150
74247	150
74248	150

74LS

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

CMOS

4000	14	4048	55	4408	790
4001	14	4049	30	4409	790
4002	14	4050	30	4410	725
4006	66	4051	78	4411	695
4007	18	4052	78	4412	800
4008	62	4053	78	4415	480
4009	35	4054	125	4419	280
4010	40	4055	125	4440	999
4011	15	4056	120	4450	350
4012	18	4057	1915	4451	350
4013	34	4059	480	4490	350
4014	75	4060	90	4500	675
4015	66	4061	1225	4501	28
4016	32	4062	995	4502	90
4017	48	4063	99	4503	50
4018	68	4066	36	4504	105
4019	42	4067	399	4506	65
4020	61	4068	22	4507	40
4021	70	4069	20	4508	265
4022	66	4070	26	4510	68
4023	20	4071	20	4511	68
4024	45	4072	20	4512	75
4025	19	4073	20		
4026	130	4075	20		
4027	38	4076	60		
4028	58	4077	26		
4029	77	4078	26		
4030	50	4081	26		
4031	170	4082	21		
4032	125	4085	65		
4033	165	4086	70		
4034	195	4089	140		
4035	95	4093	43		
4036	275	4094	168		
4037	115	4095	90		
4038	110	4096	90		
4039	290	4097	320		
4040	59	4098	88		
4041	78	4099	95		
4042	60	4160	95		
4043	70	4161	99		
4044	65	4162	99		
4045	170	4163	99		
4046	75	4174	99		
4047	75	4175	105		
		4194	105		

ICs

2114L-3	87
2708	185
2716	210
4116	80
6502	399
6522	350
6800	300
709C 8 pin	35
710	48
733	100
741 8 pin	74
747C	65
748C	36
753	185
810	159
81LS95	90
81LS96	90
81LS97	90
9400CJ	350
AY-1-1313A	660
AY-1-1320	225
AY-1-5050	99
AY-1-5051	160

AY-3-8500	390	MC1495	350
AY-3-8910	600	MC1496	70
AY-5-1224A	235	MC1496	70
AY-5-1230	450	MC1596	225
CA3011	130	MC1648	290
CA3018	86	MC1709G	90
CA3020	210	MC1710	79
CA3023	210	MC3302	150
CA3028A	95	MC3340P	120
CA3035	255	MC3360P	120
CAA3045	365	MC3401	65
CA3046	70	MC3403	65
CA3048	220	MC3403	110
CA3059	285	MFC6040	97
CAA3075	213	MK50398	635
CA3080E	70	ML924	250
CA3081	190	MM5303	635
CAAA3085	95	MM5307	1275
CAA3089E	200	MM5387	47
CA3090AQ	375	NE529	225
CA3123E	150	NE531	14
CA3130	90	NE543	225
CA3140	48	NE544	210
CA3160	95	NE555	16
CA3189	295	NE556	45
HA1336W	240	NE560	325
ICL7106E	750	NE561	398
ICL7107	975	NE562	410
ICL8038CC	300	NE564	420
ICM7204	550	NE565	120
ICM7205	1150	NE566	155
ICM7216A	1950	NE567	140
ICM7217A	790	NE570	425
ICM7224	785	NE571	420
ICM7555	80	NE5534	15
ICM7556	150	RC4136	69
LA3350	250	S566B	245
LAAA4031	340	SAB3209	425
LA4032	295	SAB3210	295
LAAA4400	440	SAB3271	485
LC7120	300	SAB4209	595
LC7130	340	SN76013	350
LF347	150	SN76023	350
LF351	48	SN76477	175
LF353	50	SN76488	480
LF355	85	SN76660	120
LF356	90	SL490	350
LF357	110	SP8629	299
LM301A	26	TAAA621	295
LM308	95	TAA7120	150
LM311	70	TA7130	160
LM318	200	TA7204	225
LM319	215	TA7205A	225
LM324	30	TA7222	175
LM339	54	TAD100	159
LM348	64	TBA120	70
LM349	116	TBA641	275
LM358	65	TBA800	80
LM377	175	TBA810	95
LM379	480	TBA820	80
LM380	75	TCA965	120
LM381	145	TDA1004	290
LM382	125	TDA1008	310
LM384	140	TDA1022	525
LM386	90	TDA1024	105
LM387	120	TDA1490	290
LM389	95	TDA2020	320
LM393	100	TLO61	40
LM394	290	TLO63	80
LM733	100	TLO71CP	30
LM1458	40	TLO74	100
LM2917	195	TLO81	25
LM3900	50	TLO82	45
LM3302	95	TLO83	75
LM3900	50	TLO84	95
LM3909	85	UAA170	170
LM3911	125	UAA180	170
LM3914	210	UA2240	245
LM3915	220	XR2206	300
LM3916	220	XR2211	575
LS7220	280	Z80CPU	350
M252	625	Z80AACPU	385
M253AA	1150	Z80AACTC	325
MC1303	88	Z80CIC	300
MC1304P	260	Z80P10	290
MC1310	150	Z80AAP10	320
MC1455	150	ZN424E	130
MC1458	40	ZN425E	345
MC1488	55	ZN426E	300
MC1458	40	ZN427	600
MC1469	300	ZN428	478
MC1488	40	ZN429	210
MC1489	55	ZN1034E	200
		ZN1040E	675

TRANSISTORS

AC125	35	BC307B	14	BFY52	23	TIP35A	160	2N1306/7	65	2N5191	75
AC126/7	35	BC328	95	BRY39	40	TIP35C	185	2N1671B	120	2N5305	24
AC128	30	BC338	15	BSX20	20	TIP36A	170	2N2160	350	2N5457/8	30
AC141/2	30	BC441	34	BSY65	35	TIP36C	199	2N2219A	28	2N5459	30
AC176/87	30	BC461	34	BSY95A	25	TIP41A	55	2N2220A	23	2N5485	30
AC188	30	BC477	40	BU105	170	TIP41B	60	2N2222	25	2N5777	45
ACY17/18	70	BC516/7	40	BU205	190	TIP42A	60	2N2369A	18	2N6027	32
ACY20/1	75	BC547/B	12	BU208	200	TIP42B	75	2N2476	50	2SA715	60
ACY22	60	BC549	14	E113	45	TIP120	90	2N2483	27	2SC495	70
AD140	120	BC556/7	15	E176	50	TIP121/2	99	2N2497	63	2SC496	70
AD149	79	BC558/9	15	E421	250	TIP142	120	2N2646	45	2SC1096	85
AD161/2	42	BCY70	16	MJ2955	90	TIP147	120	2N2894	30	2SC1173	125
AF115	60	BCY71	18	MJE340	54	TIP2955	60	2N2904	28	2SC1306	100
AF139	40	BCY72	20	MJE370	100	TIP3055	60	2N2905A	26	2SC1307	150
AF178	75	BD131/2	48	MJE371	100	TIS43	32	2N2906/7	26	2SC1449	85
AF180/6	70	BD133	60	MJE520/1	95	TIS44	45	2N2926G	10	2SC1923	50
AF239	78	BD135	45	MJE2955	99	TIS88A	50	2N3053	26	2SC1945	225
BC107/8	10	BD136/7	40	MJE3055	70	TIS90	30	2N3054	58	2SC1953	90
BC108B	12	BD138/9	40	MPF102	40	TIS91	32	2N3055	48	2SC1957	90
BC108C	12	BD140	40	MPF103	30	VK1010	80	2N3121	30	2SC1969	140
BC109	10	BD695A	85	MPF104	30	VN10KM	45	2N3133	45	2SC2028	85
BC109B	12	BD696A	85	MPF105	30	VN46AF	78	2N3135	30	2SC2029	210
BC109C	12	BDY17	195	MPF106	40	VN66AF	85	2N3252	46	2SC2078	170
BC117	24	BOY60	160	MPSA05/6	25	VN88AF	94	2N3442	140	2SC2091	85
BC119	38	BOY61	160	MPSA12	30	ZTX107/8	11	2N3568	25	2SC2314	85
BC137	40	BF115	35	MPSA55	30	ZTX109	12	2N3663	15	2SC2166	165
BC140/3	30	BF167	29	MPSA56	30	ZTX300	13	2N3702/3	10	2SC1679	190
BC147/8	9	BF173	27	MPSU06	55	ZTX301/2	16	2N3704/5	10	3N128	112
BC149	9	BF177	25	MRSU56	60	ZTX303	25	2N3706/7	10	3N140	112
BC153/4	27	BF178	30	OC35	125	ZTX304	17	2N3708/9	10	40311	60
BC157/8	10	BF179	35	OC36	120	ZTX314	25	2N3710/11	10	40313	130
BC159	11	BF180	38	OC41/2	75	ZTX326	30	2N3713	140	40316	95
BC160	45	BF194/5	10	OC44	75	ZTX341	30	2N3771	179	40317	80
BC167A	10	BF196/7	12	OC45/70	40	ZTX500	14	2N3772	195	40324	100
BC168C	10	BF198	16	OC71/2	40	ZTX501/2	15	2N3773	270	40326	60
BC169C	10	BF200	30	OC76	50	ZTX503	18	2N3819	22	40327	70
BC170	15	BF224A	25	OC81/2	50	ZTX504	25	2N3820	38	40347	90
BC171/2	11	BF244	28	OC83/4	40	ZTX531	25	2N3822/3	50	40348	120
BC177/8	16	BF256	35	OC170/1	50	ZTX550	25	2N3866	90	40360	60
BC179	20	BF257/8	32	TIP29	34	2N526	58	2N3903/4	15	40361/2	70
BC182/2L	10	BF259	35	TIP29C	60	2N696	30	2N3905/6	15	4047	60
BC183/L	10	BF594/5	40	TIP30	48	2N697	23	2N4037	46	4048	70
BC184	10	BFR39/40	23	TIP30A	48	2N698	40	2N4058	10	40411	285
BC184L	10	BFR41/79	23	TIP30C	58	2N699	48	2N4061/2	10	40412	90
BC187	26	BFR80/81	25	TIP31A	45	2N706	19	2N4069	45	40467	130
BC212	10	BFX29	28	TIP31C	55	2N918	35	2N4859	78	40468	85
BC212L	10	BFX81	45	TIP32A	46	2N930	20	2N4871	55	40594	105
BC213	10	BFX84	26	TIP32C	60	2N961	65	2N5135/6	20	40595	110
BC213L	10	BFX85/6	28	TIP33A	65	2N1131/2	24	2N5138	18	40603	110
BC214	10	BFX87/8	28	TIP33C	78	2N1304	65	2N5179	45	40636	175
BC214L	10	BFY50/1	23	TIP34A	74	2N1305	60	2N5180	45	40673	85
				TIP34C	88						

HE Echo-Reverb Unit

A superb project for creative musicians and audiophiles.

AN ECHO-REVERB unit is an accessory that can be added to virtually any existing audio or electronic music system and used to impart new life to existing sounds. In any audio system, the unit is simply interposed between the output of the preamp and the input of the main amplifier, so that the audio signals have to pass through the echo-reverb unit on their way to the main amplifier.

Some modestly-priced echo-reverb units use a crude mechanical spring-line to create the time-delayed echo-reverb and provide only a single, fixed delay time. Commercial (all electronic) echo-reverb units can be rather expensive, but provide fully-variable delay times. Many use clocked CCD (charge-coupled device) analogue ICs to implement the delays (see **How It Works**). The best commercial units use digital techniques to implement the delays, but these are extremely expensive!

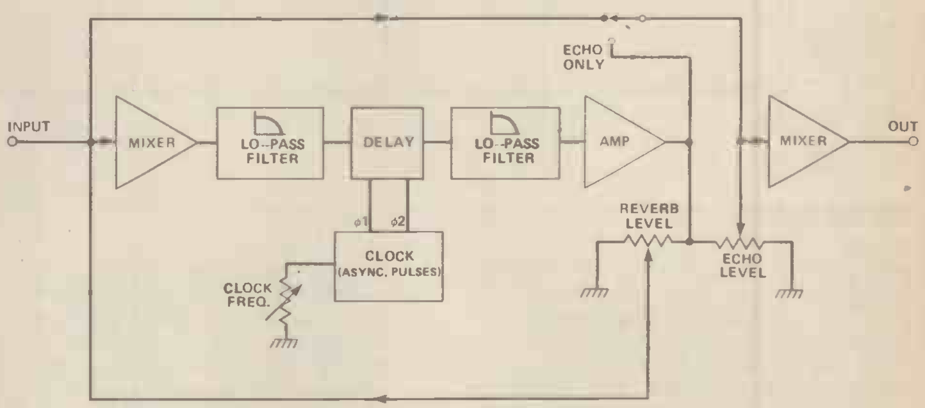
We have used the analogue CCD technique to implement the time delays and the HE Echo-Reverb gives a performance that is at least as good as some commercial units using CCDs. The important thing about our unit, however, is that the design uses some cunning techniques to reduce the hardware costs of its circuitry, while at the same time enhancing the overall performance and facilities.

Echo-Reverb

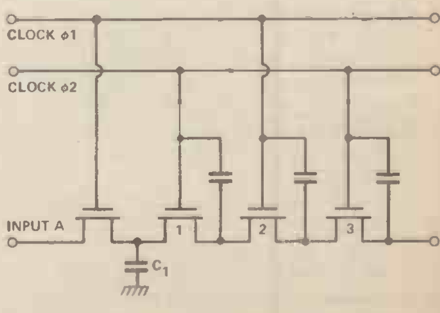
As the audio signals enter the echo-reverb unit they spilt into two paths, which are re-united again near the output of of the unit via a built-in low-distortion audio mixer. One of these

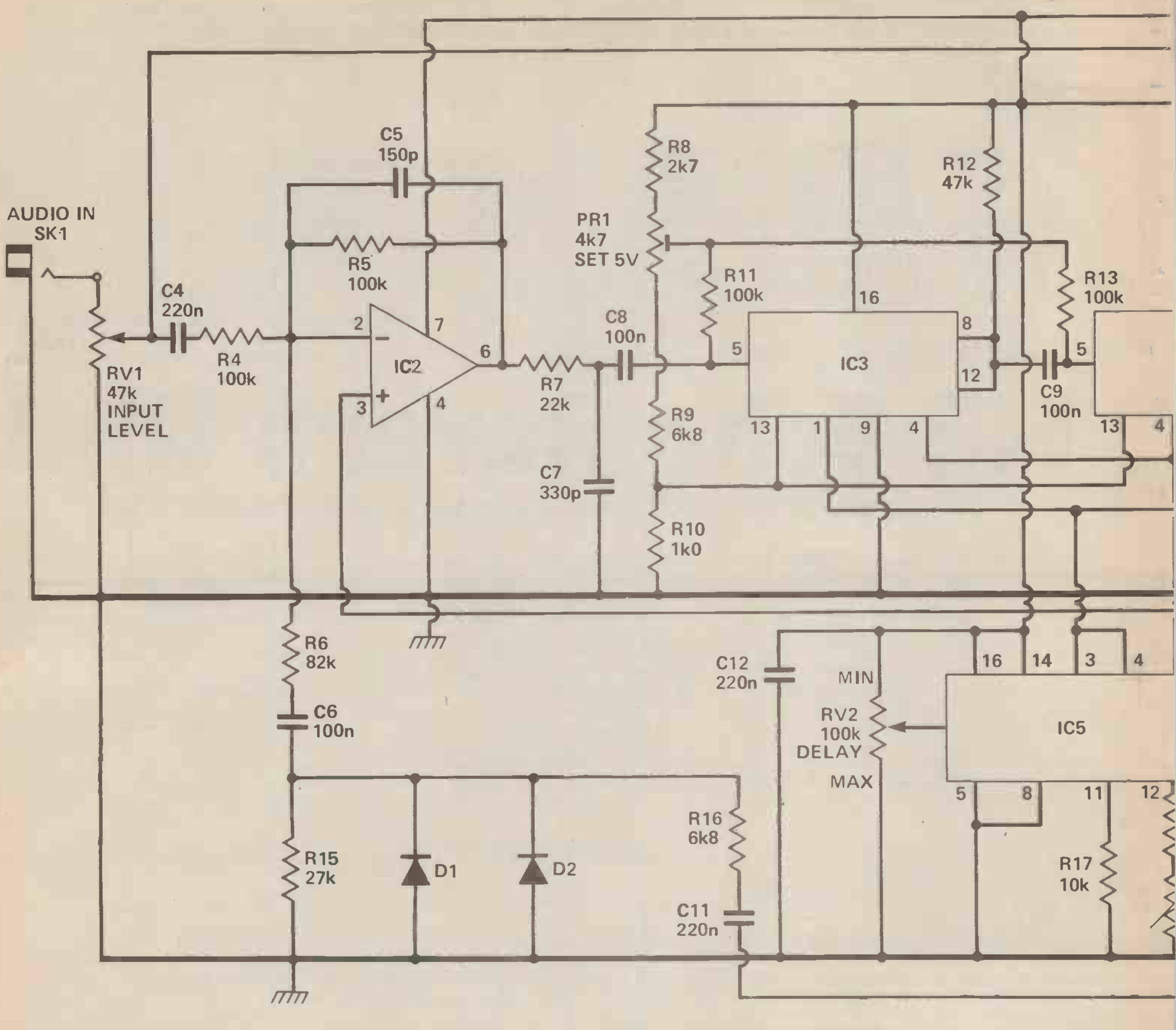
How It Works

THE STAGES for producing the various reverb effects from the HE Echo-Reverb, are shown in the block diagram. The main signal path comes from the output of the first mixer and through a 7 kHz low-pass filter. This filter is necessary to limit the audio bandwidth to less than half the clock frequency, because the audio input is being *sampled* at the clock frequency (variable, to change the length of delay), and it is a fundamental principle of sampling (Shannon's Law) that the sampling frequency must be at least twice the maximum input frequency. The filtered signal then passes through the delay line to a second low pass filter (at 15 kHz), which removes any clock signal residuals. This second filter includes a buffer amplifier to give the unit an overall gain of one. The output then splits into two paths; one is sent back to the input, to provide the reverb effect, the other goes to a final mixer via a switch. In the other position, the final mix can be varied from 'straight through' to full reverberation.'



The delay circuitry comprises two charge coupled devices (CCD's) with 1024 delay stages. The diagram right shows an example of the internal structure of a MOS CCD IC. The principle may be compared to a line of firemen passing buckets of water from one end to the other — hence the name 'bucket brigade'. In electrical terms the 'buckets' are capacitors and the 'water' is an electric charge which is proportional to an instantaneous value of the input waveform — a sample. Each sample is stored briefly, then passed on to the next stage at the time of a clock pulse. Although each sample is stored for a very short time, at each stage, the time taken to 'clock' a sample from input to output can be as much as 50 mS.





paths is a direct link from the input of the echo-reverb to the input of the mixer stage; the other path is via a variable signal-delay network. By varying the signal delay and then the mixture of direct and delayed signals, a variety of interesting effects can be obtained. Here are a few ideas to try:

(1). With equal levels of direct and delayed signals, and a few milliseconds of delay, a 'double-tracking' or 'mini-chorus' effect is obtained. This makes a single input sound like a pair of independent but time-synchronised outputs. Thus, a single violin can be made to sound like a duet and a duet is made to sound like a quartet.

(2). With a reduced level of delayed signal in the mix, and with a delay time of tens of milliseconds, a simple echo effect is obtained. The audio sounds as if it were being played in a softly furnished room where there is a single hard wall or reflective surface, facing the sound source. The apparent size of this room is directly proportional to the milliseconds delay time of the echo unit, and is fully variable up to 50 feet (50 mS delay).

A standard feature of most echo units (including ours) is a Reverb facility. This allows a fraction of the output signal from the delay line to be fed back and added to the delay line *input,* so that you end up getting echoes of the echoes of echoes. By using only small amounts of feedback (often called 'Recirculation' or 'Regeneration' on commercial units), you get 'soft' reverb or, by adding lots of feedback you get 'hard' reverb. A variety of impressive effects can be obtained from the reverb facility, as follows:

(3). When equal levels of mixing are used with maximum (50 mS) delay and maximum feedback, the sounds seem as if they are being played in a large hard-faced cave or chamber. The apparent dimensions of this 'chamber' can be varied via the delay-time control, while the apparent 'hardness' of the chamber can be varied by altering either the mixing or reverb level controls. Thus, the apparent sounds can be varied from those of a hard cave, to a small church, or down to a large but softly furnished lounge.

(4). When equal levels of mixing are used with short (a few mS) delays and a large amount of feedback, all

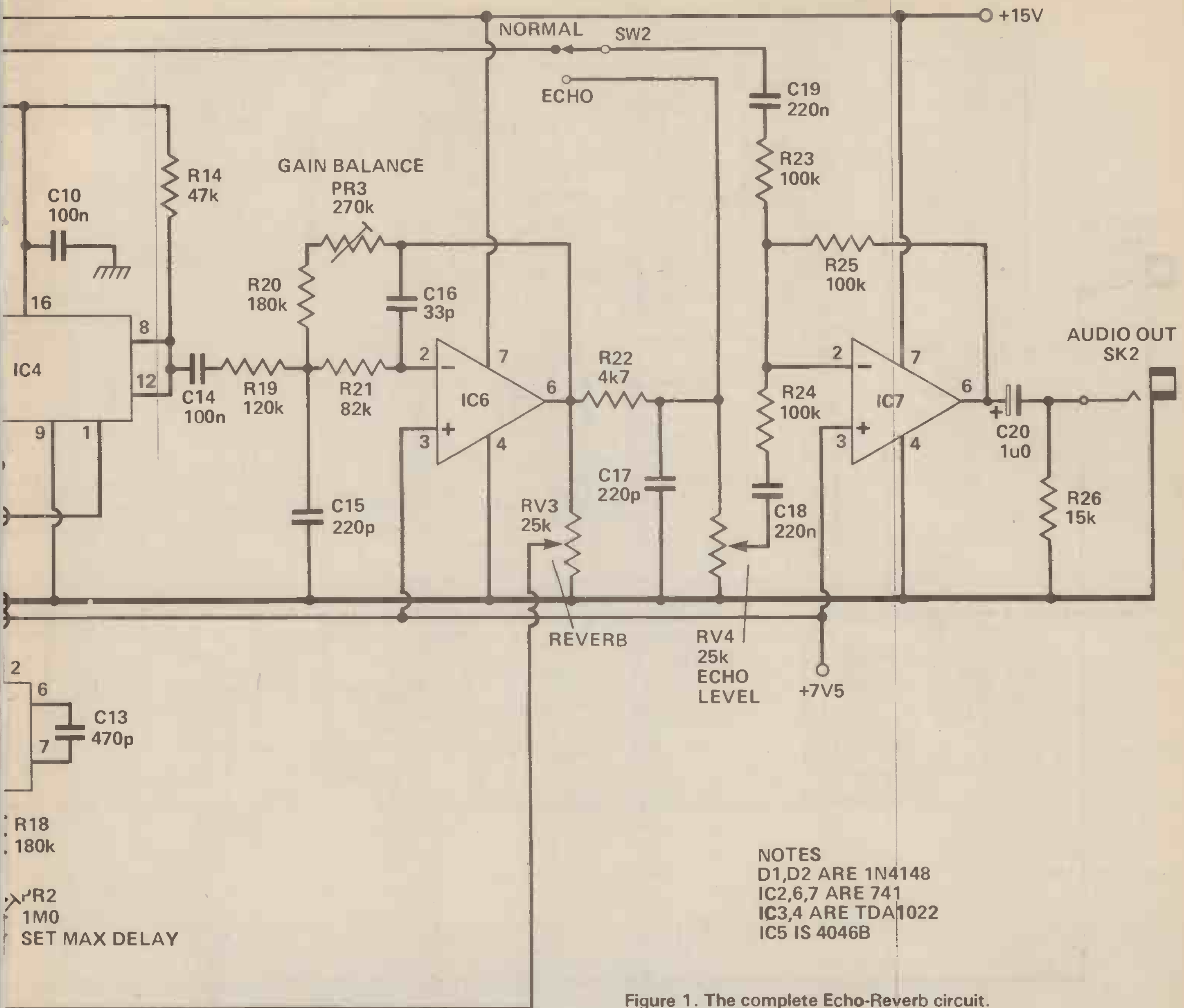


Figure 1. The complete Echo-Reverb circuit.

audio signals sound as if they are being played inside a small-diameter hard-faced pipe or drum. The apparent dimensions of the 'pipe' are variable via the time-delay controls and the apparent hardness of the 'pipe' is variable via the mixing or reverb controls. The sounds can therefore be varied from those of, say, a sewer pipe, to a dustbin or bucket!

The Circuit

The principle of the echo-reverb unit is described in How It Works. Audio signals enter the unit via RV1 and split into two paths which are re-united again, near the output, via a low-distortion audio mixer (IC7). One of these paths is virtually a direct link from the input of the unit (RV1 wiper) to one input of the IC7 mixer, via level control RV4. Thus, by varying the delay time and the setting of RV4, a range of different echo times and characteristics can be added to the original audio signals.

A fraction of the buffered output of the delay line can be tapped of via RV3 and fed back to the input of the delay line via the IC2 mixer stage. This produces echoes of echoes of echoes, etc ('regeneration' or 'recirculation'), and is the standard characteristic of a reverb sound. The quality of the sound depends on the setting of RV3 (Reverb) and the delay time.

The delay line is formed by IC3 and IC4, a pair of series-connected TDA 1022 CCD (Charge-Coupled Device) "bucket-brigade" analogue ICs. They are clocked by a two-phase variable frequency oscillator formed by IC5, a 4046B phase-locked-loop chip. The TDA 1022s are 512-stage delay lines, so our circuit uses a total of 1024 CCD stages. The delay time available from these chips is:

$$D = \frac{P}{2} \times S$$

where P is the clock-cycle period and S is the total number of delay stages in the line. Our prototype is set up so that the clock periods are fully variable (via RV2) from a minimum of 2.5 uS (400 kHz) to a maximum of 60 uS (16.6 kHz), thus giving a delay range of 1.28 mS to 30.7 mS. In practice, however, the delay times can be extended to 50 mS by adjusting PR2 to give a maximum clock period of 97.6 uS (10.24 kHz) if some clock-signal breakthrough is acceptable

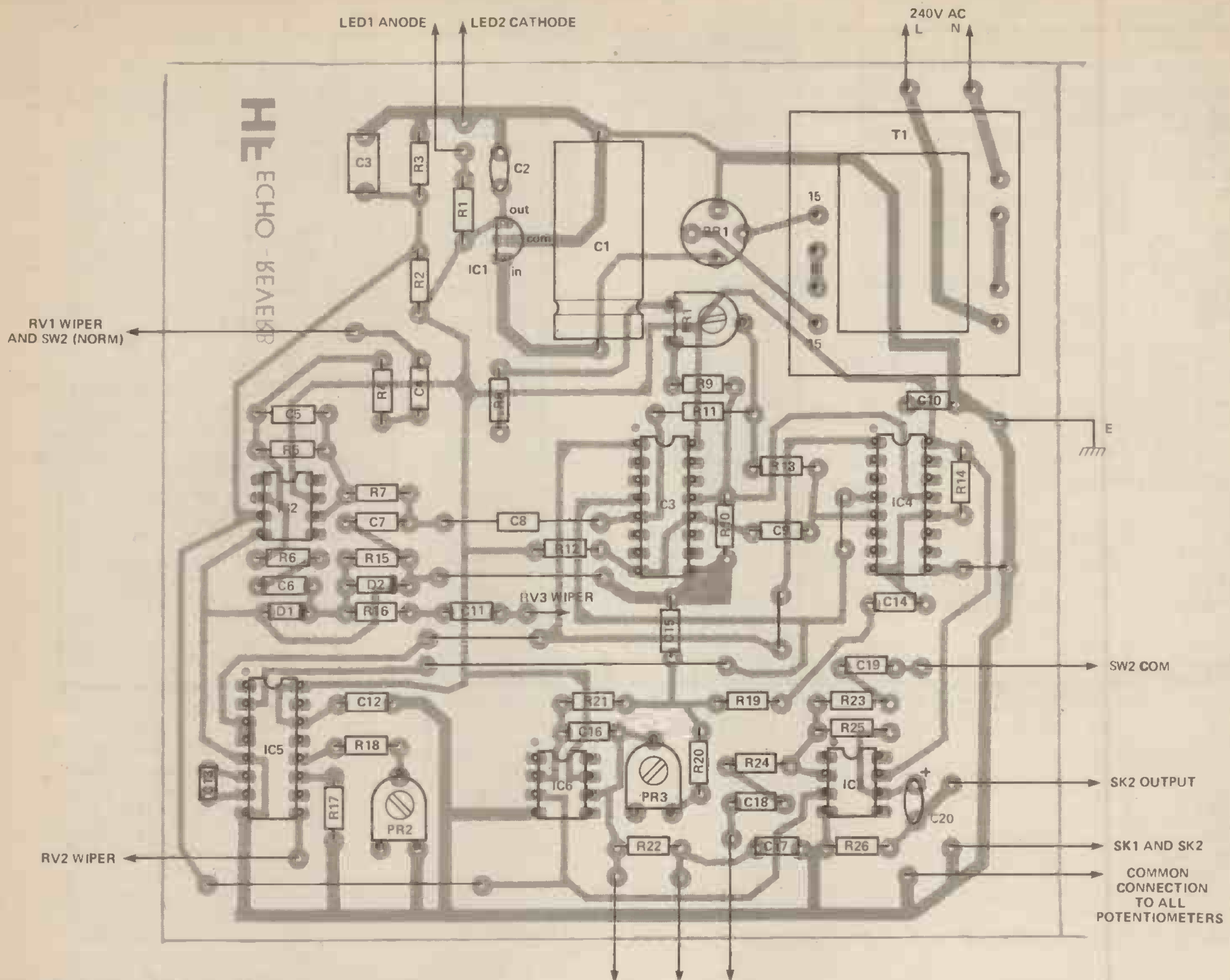
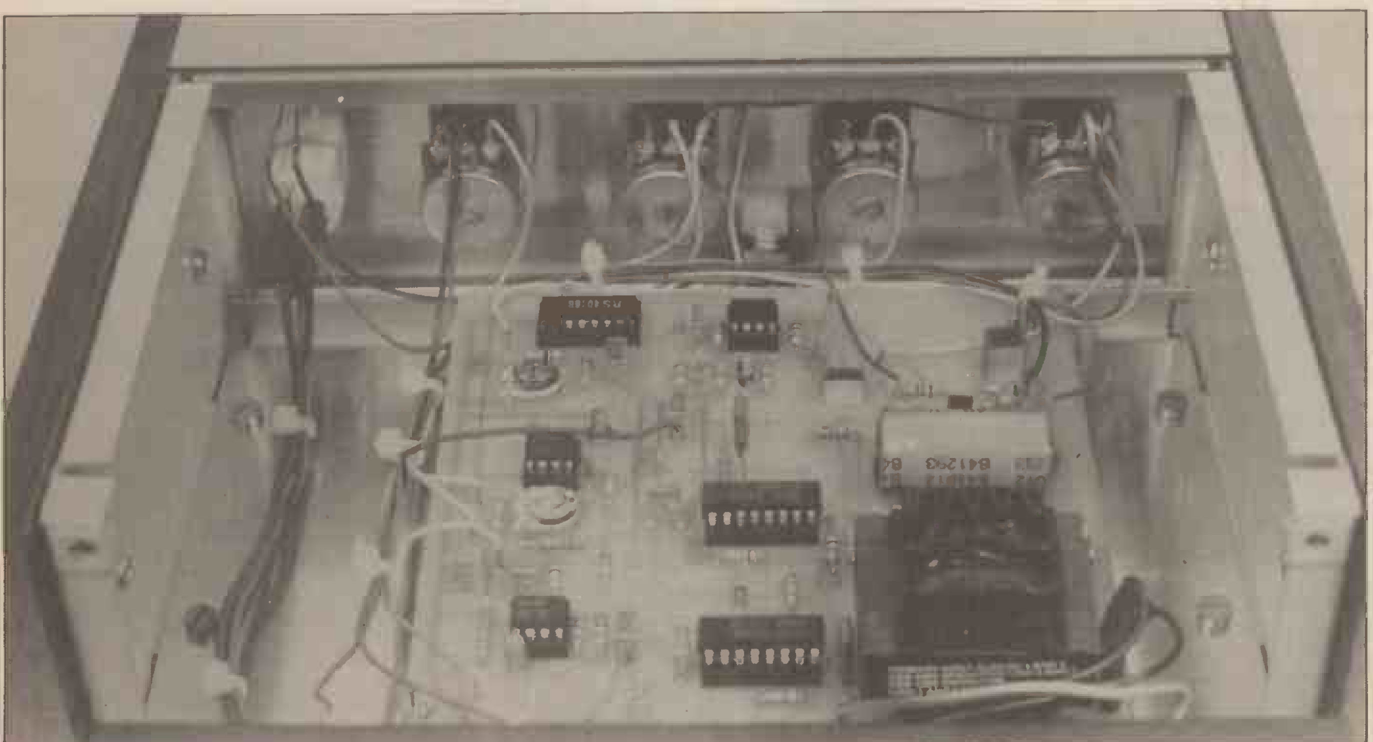


Figure 2. The view from the component side.



Parts List

RESISTORS
(all ¼ W 5% carbon)

R1	1k5
R2,3	1k2
R4,5,11,13,23,24,25	100k
R6,21	82k
R7	22k
R8	2k7
R9,16	6k8
R10	1k0
R12,14	47k
R15	7k
R17	10k
R18, 20	180k
R19	120k
R22	4k7
R26	15k

POTENTIOMETERS

RV1	47 linear carbon
RV2	100k linear carbon
RV3,4	22k linear carbon
PR1	4k7 miniature pre-set
PR2	1M0 miniature pre-set
PR3	220k miniature pre-set

CAPACITORS

C1	1000u 40V electrolytic (axial)
C2	10u 35v tantalum
C3	680n polycarbonate
C4,11,12,18,19	220n polycarbonate
C5	150p ceramic
C6,9,14	100n
C7	330p polystyrene
C8,10	100n polyester C280
C13	470p ceramic
C15,17	220p ceramic
C16	33p ceramic
C20	1u0 35V tantalum

SEMICONDUCTORS

IC1	78L15 voltage regulator
IC2,6,7	741 op-amp
IC3,4	TDA1022 bucket bridge delay line
IC5	4046B CMOS phase locked loop
BR1	50V 1A bridge rectifier
D1,2	1n4148 signal diode

MISCELLANEOUS

T1	15–0–15V 3VA PCB mounting transformer
SW1	DPDT miniature mains rocker switch
SW2	SPDT miniature toggle switch
Sk1,2	Phono Sockets

Case, PCB, fixing bolts, knobs etc.

BUYLINES . . . . page 68

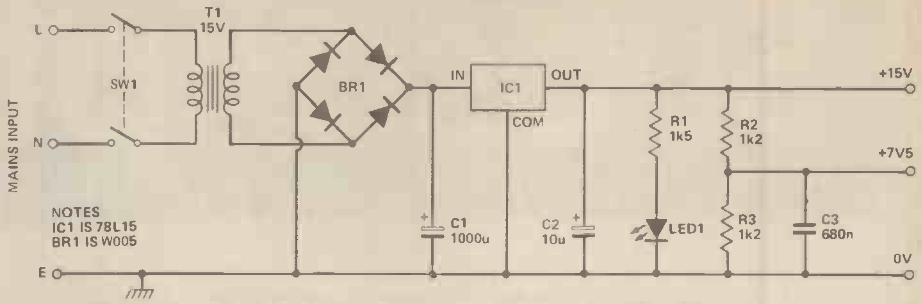


Figure 3. Circuit diagram of the regulated power supply.

on the output signal (see setting-up instructions, Max Delay Time).

When using CCD delay lines it is important that the clock frequency must be at least *double* the maximum audio signal frequency that will be used. The delay line output signal must be well filtered to cancel residual clock signals and the input to the delay line must be low-pass filtered, to avoid intermodulation problems by ensuring that the maximum input frequency is no higher than half the clock frequency. With these points in mind, the mixer IC2 with R7 and C7 are configured to give a 12 dB/octave slope, rolling off at 7kHz at the front of the delay line. IC6 acts as a 12 dB/octave, 15 kHz low-pass filter at the output of the line.

Final points to note about the circuit are that D1 – D2 – R15 – R16 are configured to give a degree of self-limiting on the reverb signals. This protects the delay line against destructive reverb overloads. The entire circuit is powered from a regulated mains-derived 15 volt supply via IC1 (**Figure 3 above**).

Construction

Most of the circuitry for this project is built on a single PCB, and construction should, therefore present very few problems. Before you start, however, a word of warning: the circuit includes a high frequency clock generator which tends to produce a fair amount of RFI (Radio Frequency Interference). Consequently, you should build it into a metal box and take lots of care over RF screening.

Begin construction by fitting the seven wire links and the PCB-mounting mains transformer. Then proceed with the assembly of the remaining components, taking the usual care to observe component polarities, etc. Use sockets to mount the two delay-line chips (IC3 and IC4) and IC5; handle the chips with care, when fitting them into place.

When the PCB is complete, temporarily wire the unit to all control pots, switches and sockets, then set-up the pre-sets.

Setting Up Procedure

The HE Echo-Reverb unit contains three pre-set pots which must be correctly adjusted to make the unit fit for use; once these have been set correctly initially, they require no further adjustment. The pre-sets (PR1, PR3 and PR2) control the delay line biasing, the delay line loop gain and the maximum delay time, respectively. The setting up procedure is as follows:

Delay Line Biasing: With no input signal present, set all three pre-sets to zero, set SW2 to Echo Only, RV4 (Echo Level) to maximum and RV2 (Delay) to mid value. Connect a DC voltmeter between the + 15 V line (+ ve) and the wiper of PR1 (– ve). Then adjust PR1 for a reading of precisely 5 volts. Remove the meter. Now connect an audio (voice or music) signal to the input and check that it can be played through the unit without excessive audible distortion (ie the sound never becomes harsh).

Delay Line Loop Gain: With RV2 (Delay) set to mid-range but with RV3 (Reveb) and RV4 (Echo Level) set to zero, connect a voice-range (350 Hz — 3k5 Hz) input signal of about 1 V peak-to-peak and monitor the output signal. Switch SW2 between the Normal and Echo Only positions, adjusting PR3 so that equal output levels are obtained in both positons (this test can be done with test gear or simply 'by ear', using a tape or disc signal source). When this adjustment is complete, set SW2 to the Echo Only position. Pass a music/voice signal through the system and use RV2 to check the Reverb sound is satisfactory.

Max Delay Time: Set SW2 to Normal, RV3 (Reverb) to zero, RV4 (Echo Level) to maximum (wiper at zero volts). Adjust PR2 while monitoring the output of the unit and note that high-pitched tone (whistle) is produced when PR2 is turned beyond a certain point. Now pass a voice signal through the unit; note that the echo effect is obtained, then trim PR2 to find a compromise setting at which a good delay (echo) is obtained with minimum acceptable intrusion from the 'whistle' sound. Finally, check that the delay can be varied over a wide range (roughly 2 mS to 50 mS) via RV2 and the reverb can be varied with RV3.

The setting-up procedure is now complete and the unit can be cased and made ready for use, as already described.

HE

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ELECTRONIC REVOLUTION

Part One of our new bi-monthly series following the history of the Electric Society — from Volta to Video.

IF you had to name the great, central pillar of modern society, the one technological aid it couldn't do without, it would have to be electricity. Coal had its day back in the 19th Century and, though it seems to be having something of a renaissance now, this is only as a means of generating electricity. Oil rules the world's economy, but only because so few hands have the power to turn the taps off. Nuclear power is the coming force we are told, but it has been coming for the past quarter-century without showing much sign of actually arriving. Electricity is the great common thread which binds together the various primary sources of power. The world might survive an oil embargo, but just try to imagine the darkness and confusion that would fall on the face of the land if some genius hit upon a way of turning off the electricity worldwide: no lighting, very little heat, (even North Sea gas is driven by electric pumps), no radio, no TV, no computers, no telephones, no industry and very little agriculture. You only have to look at the few large *partial* supply failures of the past two decades to see the sort of chaos which would descend as the generators slowed down and stopped: the famous New York blackout one night in 1965, or the power cuts of February 1974 during the Miner's strike. Or, if you want a practical demonstration, try reading the rest of this article by the light of an unpressurised paraffin lamp, which is the best you would have had in most English villages until the late 1940s.

Cooke and Wheatstone's five-needle telegraph, first installed alongside the Euston-Camden railway and later used by the Great Western Railway for communications between Paddington and West Drayton.

Try as they might, no one has come up with a cheaper, cleaner and more easily handled form of power transmission for applications other than road and air transport. Now, as we get towards the end of electricity's second century, the silicon chip and the society it is creating looks set to make us more, rather than less, dependent on the movements of electrons — invisible to all and still rather mysterious to most.

Few people these days, it is true, would go as far as James Thurber's aunt, who used to roam around the house sticking light-bulbs into empty sockets in case the electricity dripping out of them formed dangerous, invisible puddles on the floor. Nor are there quite as many people, as there once were, who replace fuses with stout copper wire saying that they can't understand why folk use that inferior silvery stuff you buy in Woolworths! But even if electricity is not regarded by people at large with the same superstitious horror as nuclear energy (though the author did once see a poster saying "Ban Electricity NOW") it is still a rather strange and unfathomable force — which makes you realise just how strange it must all have seemed when the first serious experimenters began their work, back at the beginning of the 19th Century.

Electricity has been with us, now, for just over a century as a public utility. But, it took a hundred years of trial and error and laborious experimentation before that to turn it from a useless scientific curiosity into the driving force of the second Industrial Revolution. That movement, beginning in the 1880s, turned the USA and Germany into great industrial powers because they hitched themselves to it but began Britain's long, slow decline because she took it up only half-heartedly and late. The century before 1880 produced some remarkably far-sighted inventions, projects far ahead of their time like Davidson's electric locomotive or the transatlantic telegraph of 1858. But, on the whole, progress was slow, a hesitant, haphazard clearing of the runway for the great electrical take-off at the end of the century.

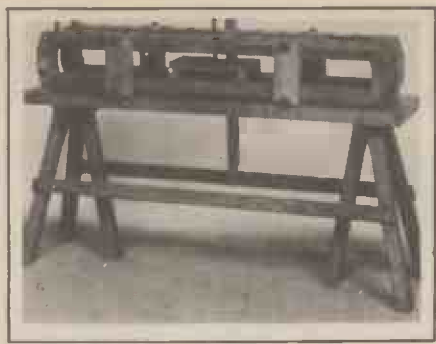
Myth and Magic

Ever since men first began to wonder

about the world around them, they had noticed some inexplicable happenings which could best be put down to witchcraft or angry gods. Lightning was the most spectacular, of course, but the first Stone Age settlers in South America must soon have learnt to steer clear of a certain clumsy-looking, sluggish river-fish. As early as 321 BC, the Greek natural philosopher Theophrastus remarked on the strange attractive properties of amber — though he couldn't explain them. The Chinese seem to have used lodestone compasses about 800 AD and, by the 1560s, scientists were familiar enough with large artificially-made permanent magnets for the surgeon Ambroise Pare to have had the brainwave of using one to extract a steel splinter from a patient's eye. It was, presumably, about this time, as seagoing ships grew larger, that shipwrights learnt the inadvisability of using copper fastenings near iron nails. But it was left to Elizabeth I's Court Physician, William Gilbert, to tie some of these phenomena together in his treatise "De Magnete" of 1600 in which he coins the word "electricity", associates static electricity with magnetism and divines that the Earth is a huge magnet. It also seems that Gilbert constructed the first recorded static generator, direct ancestor of the 50-foot diameter Van der Graaf machine currently used in nuclear research at Harwell.

Speculation about the nature of electricity — or rather, "the electricities", since no one had yet linked static, magnetism and lightning conclusively together as aspects of the same thing — went on in a desultory way for the next two centuries. It was not until the last two decades of the 18th Century that serious investigation was able to begin and the Electric Machine became something more than a toy for amusing the ladies at a philosophical society lecture. Franklin made his famous kite-flying experiment to investigate lightning — and his less famous, inspired but incorrect guess at polarities, which has bedevilled electronics ever since. In Italy, the two Professors Galvani — the frog's legs man — and Count Volta worked away at the problem of chemical electricity until, in 1800, Volta was able to produce his first pile battery. The world's men of learning now had their first controllable, storable, measurable source of electricity and the experiments began in earnest.

Sir Humphry Davy gave his famous arc-light demonstration in 1809 and, eleven years later, in 1820, Professor Oersted of Copenhagen made the momentous discovery that a compass needle could be deflected by an electric current passing through a wire. It was left to Michael Faraday, in the summer and autumn of 1831, to make the imaginative leap by standing Oersted's 'current + wire + magnet + movement = current'. It may seem obvious, now, but it was a stroke of genius at the time and Faraday's demonstration of a crude magneto-electric generator to the Royal Institution on 24 November 1831 marks the birth of the electronic age.


Part of the Gauss and Weber telegraph system.

The child was born, perhaps, but it was remarkably slow a-growing during the half-century after Faraday's discovery. An increasingly powerful range of magneto generators were built in Europe and the USA during the 1830s and 1840s, but the trouble was that nobody really had much idea of what to do with the current they produced. Arc lighting developed slowly during the middle decades of the century and a breed of wandering electricity generators grew up (Samuel Crompton was one of the first), roaming Europe with mobile steam-driven apparatus to illuminate railway tunnelling work, circuses and fairgrounds. But arc lighting was too harsh and too expensive to rival colza oil or kerosene as a source of domestic illumination. A few avant-garde scrap-metal dealers invested in electro-magnets for lifting and Birmingham factory proprietors found electro-plating an excellent way of poshing up cheap and nasty tableware, while rheumatism sufferers were made momentarily forgetful of their aches by the even worse pains resulting from patent Therapeutic Electrical Machines (which could still be seen at country fairs in the 1930s) Of course, the demand for lighthouses pushed forward the development of large generators, like Clarkes 2 kW machine which supplied the one at the South Foreland, near Dover, in 1858, but it was all a primitive, haphazard business, this early public electricity supply.

The men of science were still only beginning to grope their way towards an understanding of this mysterious force, so it is hardly surprising that theoretical knowledge among the early practitioners was sketchy in the extreme. It was not until the 1860s, for instance, that any idea began to emerge of there being a distinction between force and current — the power of the early generators was reckoned by the size of the spark, or the loudness of the howls, which they produced. Power requirements were judged, rule-of-thumb fashion, by the number of acid-cell batteries needed to make the thing work. Ammeters, where they existed, were simply calibrated by the man who built them without any reference to a common scale. As we have seen, it took a very long time to dispose of the notion of several different, independent kinds of electricity. Electricity supply was plagued well into the 1890s by a persistent folk-belief that direct current was not only less dangerous than alternating but, in some curious way, a different kind of power altogether, a belief which led to all the early generators being fitted with commutators to convert their output to DC. In fact, some historians go so far as to say that the obsession with DC over AC held back the development of industry by a good half-century.

All the same, there were some remarkably far-sighted experiments made in these early days, projects like Davidson's battery-powered electric railway locomotive of 1842 which managed to reach 40 mph on a run between Edinburgh and Glasgow, only to be smashed up at the end of the journey by enraged steam-engine drivers who were frightened that it would take away their living. They need not have worried, though. Old King Coal was to remain unchallenged on his throne for another fifty years as the main source of power for the railways and factories. It was not until the self-taught Serbian inventor Nikolai Tesla developed phase-induction, at the end of the 1880s, that electric motors were able to start up under their own power and drive the tramcars which were to do so much to change the geography of European and American cities, around the turn of the century.

First Light

If a public electricity supply industry was to develop, in the way gas had developed early in the 19th Century, it would have to find itself some simple domestic service which it could perform more cheaply than any of the alternative forms of energy then on offer. Domestic lighting was the obvious candidate and, throughout the late 1870s, Crompton and Swan, in Britain, and Edison in the United States worked feverishly to develop a cheap, mass-produceable incandescent light bulb. They fiddled about with filaments of paper, horse-hair, silk, bamboo and platinum until — just about simultaneously, in the autumn of 1879 — both Swan and Edison hit upon the trick of making a bulb which would last more than a few hours — exhausting the air in the bulb while the filament was hot, in order to get rid of the combustion gases. A vicious patents battle ensued — Edison was a devil for litigation — but from 1880 onwards, progress was as rapid as it had been sluggish over the previous fifty years. Edison, being a most unusual combination of inventive genius and shrewd businessman, set up his first public supply power station at Pearl Street, New York City, in September 1882. It served 85 buildings at first but, by the end of 1884, no less than 60,000 lamps were connected up to the supply.

In Britain, things were done more haphazardly and Godalming, rather than London, had the honour of being the first town to go electric, in September 1881. The local gas company had attempted an early OPEC — unilateral price-hike. The town council demurred and turned, instead, to a pair of wandering electrical entrepreneurs, Messrs. Calder and Barrett, who undertook to light the streets from a mobile steam generator and, later on, from an old water mill. The new arrangement was not a technical success. The lights were connected in series, like those on a Christmas tree, with the result that those nearest the generator were noticeably brighter than those further away, while a single blown bulb plunged the whole town into darkness. Nor was it much better off financially and in May 1884, it closed down, the brothers Siemens (who had taken over the contract) having been unable to find the 500 domestic subscribers, at £3 per annum, who were necessary to make the project break even. Later, town supply systems were more successful. London got its Grovesnor Gallery, Holborn and Kensington Court Power stations in the early 1880s, each with an output of about 60 kW and equipped with standby batteries to provide off-peak power in the small hours, so that the machinery could be oiled and cleaned.

Despite gas lighting's new lease of life, thanks to the invention of the incandescent mantle in 1880, electric lighting caught on rapidly with the better-off and from the early 1880s onwards, there appeared a succession of gadgets to make use of this new, clean, convenient form of power: kettles, flatirons, hotplates, and heaters, all ornately decorated in the fashion of the time and all guaranteed to cause today's BEAB safety inspectors a collective heart attack. True, with the power supply pitched at 110 volts, in most cases, the danger wasn't too great, but a cavalier attitude to safety lasted well into the 240 volt era, in many countries. Most of Eastern Europe still does without earthing, which keeps the fire brigades busy, if nothing else, and the French were long famous for the nonchalance with which they stapled bare wires around the attics of their houses. Only a few years ago, a British engineer working on an Anglo-French joint construction project in the Middle East was watching a French electrician wiring up a street lamp. Horrified by what he saw, he remarked that if anyone broke into the control box they would be killed for sure. "Ah M'sieur" said the electrician, "You do not understand. In France, it is forbid the public to open these boxes."

AC/DC

By the end of the 1880s in Europe and the USA, demand for electricity was fast outstripping what the small, city-centre power stations were able to supply. The answer was to build out-of-town, but this meant high transmission voltages, if the method was to be economically worthwhile. High voltage meant transformers, to step it down to domestic supply level, and transformers — unfortunately for Edison and the other champions of direct current — meant AC, unless they wished to tinker with alternators and commutators on either side of the iron core. The result was de Ferranti's Deptford power station, in 1891, which drove 10,000 volts an unprecedented 8 miles along underground cables to London's centre. Edison published pamphlets to warn the public that AC and DC were different things, the former being "fit only to power the electric chair", but the battle was lost, especially as Parsons steam turbines came to replace the inefficient and failure-prone reciprocating engines in the power stations, making accurate frequency regulation possible for the first time. However, this all took time and, in the mid-1920s when the Government was trying to unify the electricity supply system, the UK still had over 200 DC town supply systems plus no less than 17 different AC frequencies. At the start of the First World War, only one British home in ten was on the mains and by the outbreak of World War Two the figure had barely reached one household in two.

So it was not in the area of public service supply that electricity established itself in the public consciousness during the 19th Century. Although the power used was much smaller, it was the telegraph and its younger near-cousin, the telephone, that made the Victorian man-in-the-street familiar with electricity and built up the manufacturing and operating skills which were to be drawn upon by power engineering at the end of the century. Where would the electricity supply companies have been in the 1880s, for instance, if the telegraphs hadn't first inspired the factories which specialised in cables, insulated with that now-forgotten 19th Century wonder material, gutta-percha?

Where electric power supply was concerned, the trouble in the early 1830s was that, while people knew more or less *how* to do it, they couldn't find any really convincing reason *why*, a question which would be answered only when Swan and Edison came along with the electric light bulb. But with the telegraph, things were very different; the need was there, ready-made, just waiting for electricity to come its way.

Long Distance Information

Telegraphing information over long distances had excited a great deal of interest since the late 18th Century. In France, a semaphore telegraph system, developed by one M. Chappe, had been crucial during 1792-93 in enabling the Revolutionary government in Paris to move its raggle-taggle armies about the country to beat back the invading Allies. As is so often the case with inventors, they were so grateful to M. Chappe afterwards, that the poor man cut his throat in despair. However, the British Admiralty was more appreciative and soon set up its own chain of telegraph towers which, on one famous occasion, got a message to Portsmouth and back in three minutes flat. But these telegraph systems were slow, useless in fog or at night and so expensive to man — one from Warsaw to Moscow needed 1,300 men on duty at any one moment — that only the most urgent government business could justify them. They never really caught on though the Admiralty, conservative as ever, kept its semaphore network going well into the 1850s on the ground that fiddling about with copper wires was damned un-seamanlike.

It had been known for some time that, among its many other properties, electricity travelled at amazing speeds. A French *savant* had proved as much in the 1760s, by connecting a circle of 200 Carthusian monks holding hands to a static generator (what a pity that photography had not been invented). So it is scarcely surprising that, by 1830, some 30-40 different electric telegraph systems had been invented; some were merely ingenious, like Soemmering's electrolytic telegraph of 1810 (the operator watched the lettered electrodes in a glass tank of water to see where the bubbles formed) and some very promising, like the Russian diplomat Baron Schilling's electo-magnetic telegraph of 1825, the first to use a simple code. What the telegraph needed, in order to become a practicable system, was a large-scale non-governmental user to furnish the sort of market which would make it worthwhile for someone to develop a cheap, fast, simple method. That customer materialised in the shape of the railways, which were spreading across Britain and the Eastern USA in the mid-1830s. They had soon found that they would need some quick and reliable method for all-weather, 24-hour long-distance signalling if the countryside wasn't to resound with the crunch of colliding locomotives. They also needed (people often forget) common time for their trains to run to, something which simply hadn't existed in the pre-telegraph days when every time for their trains to run to, something which simply hadn't existed in the pre-telegraph days when every town set its clocks to its own midday, with the result that noon at Plymouth was 12.20 GMT. In Britain, the answer was provided by an invalided Indian Army subaltern and half-hearted medical student named William Cooke, who saw Schilling's telegraph at Munich and rushed home to team up with the scientist Charles Wheatstone in developing an electric telegraph to sell to the railways.

Though slow by later standards, their alphabetic needle-deflection apparatus could be used by an untrained operator. It was installed between Euston and Camden stations, in June 1937, and two years later a line was rigged up alongside the Great Western Railway between Paddington and West Drayton. Cooke and Wheatstone soon parted company amid great bitterness, but the idea of the electric telegraph remained, first coming into the headlines in January 1845, when a notorious murderer was arrested at Paddington after a message from the booking office at Slough station — "hanged by a copper wire" they said. The real breakthrough came, also in 1845, when the minor portrait painter Samuel Morse invented his code-based key telegraph which, in the end, did as much to open up the American West as the railways themselves (though you can't help wondering whether all the operators did, in fact, wear eyeshields and sleeve-bands as the TV Westerns portray them).

Baron Schilling's magnetic needle detector.

The first telegraph line was laid across the English Channel at the end of August 1850. So, the age of international telecommunications began — though it was cut off rather abruptly the next morning, when a fisherman hauled up the fragile unarmoured wire that was fouling his anchor and hacked off a length of this queer, gold-filled seaweed for a souvenir. Later attempts were more successful and in 1855, the line laid beneath the Black Sea from the Allied HQ in the Crimea to link up with the overland cable at Constantinople provided dramatic proof of the advantages of electric telegraphy. The British could get a message from Sebastopol to London in a couple of hours while the War Ministry in St. Petersburg had to wait weeks for news to come on horseback, across the steppes. In fact it is said that they ordered the London "Times" to find out what was going on at the front. It was only a matter of time before someone attempted a transatlantic link and, after several frustrating failures, the American entrepreneur Cyrus Field succeeded in laying a cable between Ireland and Newfoundland in August 1858 — almost a miracle in view of the primitive technology and crude theoretical knowledge available to him. The link failed after less than a month of garbled, fitful operation, probably because the project's scientific adviser had insisted on using 2.000 volt spark coils to try to ram messages along the thin wire, thus burning out the insulation.

Further attempts were made, as business got back to normal after the American Civil War, and success was finally and permanently achieved on 27 July 1866, when the end of the cable was brought ashore from the vast, redundant passenger vessel the "Great Eastern" — the only ship in the world large enough to carry the amount of cable necessary for the job. From then on, it was merely a question of extending the telegraph around the world. Technical improvements were few, until the advent of Frederick Creed and the telex machine in the early 1900s. In 1902, Creed found telegraph paper-tape messages being prepared, exactly as they had been in 1860, by the operator pouding three metal plungers with a rubber-tipped stick held in each fist, a process which led to a crippling occupational illness called Telegraphist's Wrist.

Dirty Deeds

The possibilities of the copper wire were not exhausted (for the time being) until the late 1870s when two inventors arrived — once again simultaneously — at a solution to the problem of transmitting human speech down the wire. This time it was a real photo-finish with Alexander Graham Bell and Elisha Gray registering their reed-and-electro magnet telephone systems at the US Patents Office within hours of each other, on 14 February 1876. The result was a long and nasty lawsuit which was only resolved by the indefagitable Thomas Edison stealing both partys clothes with his carbon diaphragm mouthpiece, the ancestor of the modern telephone. The Strowger automatic telephone exchange was invented, some twenty years later, by a New York undertaker who had been brought to the verge of bankruptcy by an unscrupulous rival, who had bribed an exchange girl to route calls to Strowger through to his firm instead! With that, the telephone and telegraph systems had achieved very much the shape they still have, eighty years later, on the verge of the digital telecoms era.

The telegraph brought about drastic changes in the world. Newspapers, as we know them today, were built up around the telegraph office; the "Daily Telegraph" acknowledged as much in its title, when it was founded in 1855. In international relations, crises grew more difficult to handle, if anything, as the ambassador declined from being a minor potentate, acting on his own initiative, into a kind of decorative monkey at the end of a wire. The world grew a smaller place, but it still comes as something of a shock to remember that in September 1914, Admiral vonSpees German Pacific squadron could be warmly greeted and sold supplies by the French community in the Marquesas Islands who, being hundreds of miles from the telegraph lines, were unaware that France and Germany had been at war for nearly two months. It was not until wireless telegraphy came along that instant worldwide communication began to make the Global Village, and Global Village Idiots, a possibility. **HE**

SUPER HI-FI SPEAKER CABINETS

Made for an expensive Hi-Fi outfit – will suit any decor. Resonance free. Cut-outs for 6½" woofer and 2½" tweeter. The front material is Dacron. The completed unit is most pleasing. Supplied in pairs, price £6.90 per pair (this is probably less than the original cost of one cabinet) carriage £3.00 the pair.

GOODMANS SPEAKERS

6½" 8 ohm 25 watt £4.50. 2½" 8 ohm tweeter. £2.50. No extra for postage if ordered with cabinets. Xover £1.50.

UNIVAC KEYBOARD BARGAIN

50 keys, together with 5 miniature toggle switches all mounted on a p.c.b. together with 12 i.c.'s, many transistors and other parts.
£13 50 + £2.00 post.
This is far less than the value of the switches alone. Diagram of this keyboard is available separately for £1.

SOLENOID WITH PLUNGER

Mains operated £1.99
10 – 12 volts DC operated £1.50.

POPULAR KITS

3 - 30v VARIABLE VOLTAGE POWER SUPPLY UNIT
With 1 amp DC output, for use on the bench, students, inventors, service engineers, etc. Automatic short circuit and overload protection. In case with a volt meter on the front panel. Complete kit £13.80

IONISER KIT
Refresh your home, office, shop, work room, etc. with a negative ION generator. Makes you feel better and work harder – complete mains operated kit, case
£11.95 post £2.00

MORSE TRAINER
Complete kit £2.99.

DRILL SPEED CONTROLLER
Complete kit £3.95.

MAINS POWER SUPPLY
Gives any voltage from 3v to 16v at up to 300mA.
Complete kit less case £1.95. Case 90p.

OUR CAR STARTER AND CHARGER KIT has no doubt saved many motorists from embarrassment in an emergency you can start car off mains or bring your battery up to full charge in a couple of hours. The kit comprises: 250w mains transformer, two 10 amp bridge rectifiers, start/charge switch and full instructions. You can assemble this in the evening, box it up or leave it on the shelf in the garage whichever suits you best. Price £12.50 + £3.00 post.

BUMPER BARGAIN PARCEL

10 kilo of unused parts. Minimum 1000 items. Includes – relays, switches, motors, drills, taps and dies, thermostats, neons, i.f. coils, oscillator coils, variable condensers, variable resistors and at least one each of the following: panel meter, timer, thermal trip, and other expensive items. Individually would cost well over £100. Yours for only £11.50 + £3.00 post.

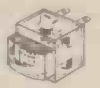
MILLIONS OF HOMES WILL BE BURGLED THIS SUMMER – SAY THE EXPERTS

Don't let yours be one of them. Install our burgar alarm. Install our burglar alarm. Complete kit includes 6" external alarm bell, mains power unit control box with key switch 10 window/door switches 100 yards of wire. With instructions £29.50.

TINIEST MICROPHONE

Not much bigger than a pea, 600 ohm condenser type. Ideal for bugging and similar applications. 50p each or 10 for £4.50.

LEVEL METER

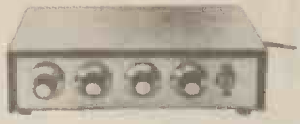


Size approximately ¾" square, scaled signal and power but cover easily removable for rescaling. Sensitivity 200 uA. 75p.

THERMOSTAT ASSORTMENT

10 different thermostats. 7 bi-metal types and 3 liquid types. There are the current stats which will open the switch to protect devices against overload, short circuits, etc., or when fitted say in front of the element of a blow heater, the heat would trip the stat if the blower fuses; appliance stats, one for high temperatures, others adjustable over a range of temperatures which could include 0 – 100°C. There is also a thermostatic pod which can be immersed, an oven stat, a calibrated boiler stat, finally an ice stat which, fitted to our waterproof heater element, up in the loft could protect your pipes from freezing. Separately, these thermostats could cost around £15.00 – however, you can have the parcel for £2.50.

3 CHANNEL SOUND TO LIGHT KIT



Complete kit of parts for a three-channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two-tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four-pin plug and socket facilitate ease of connecting lamps. Special snip price is £14.95 in kit form or £25.00 assembled and tested.

ULTRA SMALL 12v RELAYS

Single pole gold plated contacts. Tubular construction, 17mm long 10mm dia. Ideal for models. PCB or freemounting. £2.30 ea.

MINAITURE PLUG IN RELAYS

12v operated. 3 changeover. £2.45, base 45p.
12v operated. 2 changeover. £1.87, base 35p.

THIS MONTH'S SNIP

ROTARY WAFER SWITCHES

5 amp silver plated contacts. ¼" shaft, 1" dia. wafer.
Single wafer types, 29p each, as follows:

1 pole 12 way	2 pole 6 way	3 pole 4 way
4 pole 3 way	6 pole 2 way	4 pole 3 way

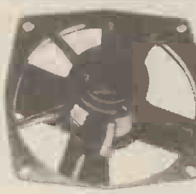
Two wafer type, 59p each, as follows

2 pole 12 way	4 pole 5 way	4 pole 6 way
6 pole 2 way	8 pole 3 way	12 pole 2 way

3 wafer types 99p each,

3 pole 12 way	6 pole 5 way	6 pole 6 way
9 pole 4 way	12p 3 way	18p 2 way

EXTRACTOR FAN



Mains operated – ex-computer
5" Woods extractor
£5.75, Post £1.25.
5" Plannair extractor
£6.50. Post £1.25
4" x 4" Muffin 115v.
£4.50. Post 75p.
4" x 4" Muffin 230v.
£5.75. Post 75p.

8 POWERFUL BATTERY MOTORS

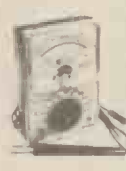
For models, maccanos, drills, remote control planes, boats, etc. £2.95.

TAPE PUNCH & READER

For controlling machine tools, etc, motorised 8 bit punch with matching tape reader. Ex-computers, believed in good working order, any not so would be exchanged. £17.50 pair. Post £4.00.

MINI-MULTI TESTER

Deluxe pocket size precision moving coil instrument, Jewelled bearings - 2000 o.p.v. mirrored scale.
11 instant range measures: DC volts 10, 50, 250, 1000.
AC volts 10, 50, 250, 1000.
DC amps 0 – 100 mA.



Continuity and resistance 0 - 1 meg ohms in two ranges. Complete with test prods and instruction book showing how to measure capacity and inductance as well. Unbelievable value at only £6.75 + 60p post and insurance.

FREE Amps range kit to enble you to read DC current from 0 - 10 amps, directly on the 0 - 10 scale. It's free if you purchase quickly, but of you already own a Mini-Tester and would like one, send £2.50.

12V FLUORESCENT LIGHTING

For camping – car repairing – emergeny lighting from a 12v battery you can't beat fluorescent lighting. It will offer plenty of well distributed light and is economical. We offer an inverter for 21" 13 watt miniature fluorescent tube. £3.45. (tube not supplied).

FREE OUR CURRENT BARGAIN LIST WILL BE ENCLOSED WITH ALL ORDERS.

TRANSMITTER SURVEILLANCE

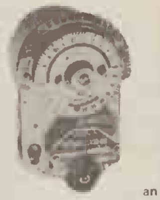
Tiny, easily hidden but which will enable conversation to be picked up with FM radio. Can be made in a matchbox – all electronic parts and circuit. £2.30. (not licenceable in the U.K.)

RADIO MIKE

Ideal for discos and garden parties, allows complete freedom of movement. Play through FM radio or tuner amp. £6.90 comp. kit. (not licenceable in the U.K.).

FM RECEIVER

Made up and working, complete with scale and pointer needs only headphones, ideal for use with our surveillance transmitter or radio mike. £5.85.

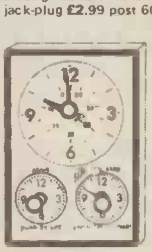


VENNER TIME SWITCH

Mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only £2.95. These are without case but we can supply a plastic base £1.75 or metal case with window £2.95. Also available is adaptor kit to convert this into a normal 24 hr. time switch but with the added advantage of up to 12 on/offs per 24 hrs. This makes an ideal controllerfor the immersion heater. Price of adaptor kit is £2.30.

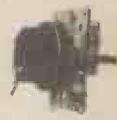
STEREO HEADPHONES

Very good quality, 8 ohm impedance, padded, terminating with standard ¼" jack-plug £2.99 post 60p.



TIME SWITCH BARGAIN
Large clear mains frequency controlled clock, which will always show you the correct time + start and stop switches with dials. Complete with knobs. £2.50.

DELAY SWITCH



Mains operated – delay can be accurately set with pointers knob for periods of up to 2½hrs. 2 contacts suitable to switch 10 amps – second contact opens a few minutes after 1st contact. £1.95.

MOTORS FOR ROBOTICS

If its a toy robot you are making then one of our eight battery motors (see centre column) may do. If its a bigger one, however, then see below If still not big enough then enquire – we have larger motors but these are usually mains driven.

12v MOTOR BY SMITHS

Made for use in cars, these are series wound and they become more powerful as load increases. Size 3½" long by 3" dia. These have a good length of ¼" spindle – price £3.45.
Ditto, but double ended £4.25.

EXTRA POWERFUL 12v MOTOR

Made to work battery lawnmower, this probably develops up to ¼ h.p., so it could be used to power a go-kart or to drive a compressor, etc. etc. £6.90 + £1.50 post.
(This is easily reversible with our reversible switch - Price £1.15).

SPIT MOTORS

These are powerful mains operated Induction motors with gear box attached. The final shaft is a ¼" rod with square hole, so you have alternative couplingmethods – final speed is approx. 5 revs/min, price £5.50. – Similar motors with final speeds of 80, 100, 160 & 200r.p.m. same price.

REVERSIBLE MOTOR WITH CONTROL GEAR

Made by the famous Framco Company this is a very robust motor, size approximately 7½" long, 3½" dia. 3/8" shaft, Tremendously powerful motor, almost impossible to stop. Ideal for operating stage curtains, sliding doors, ventilators etc., even garage doors If adequately counter-balanced. We offer the motor complete with control gear as follows:

1 Framco motor with gear box
1 manual reversing and on/off switch
1 push to start switch
1 x 100w auto transformer
2 limit stop switches
1 circuit diag. of connections.
£19.50 plus postage £2.50.

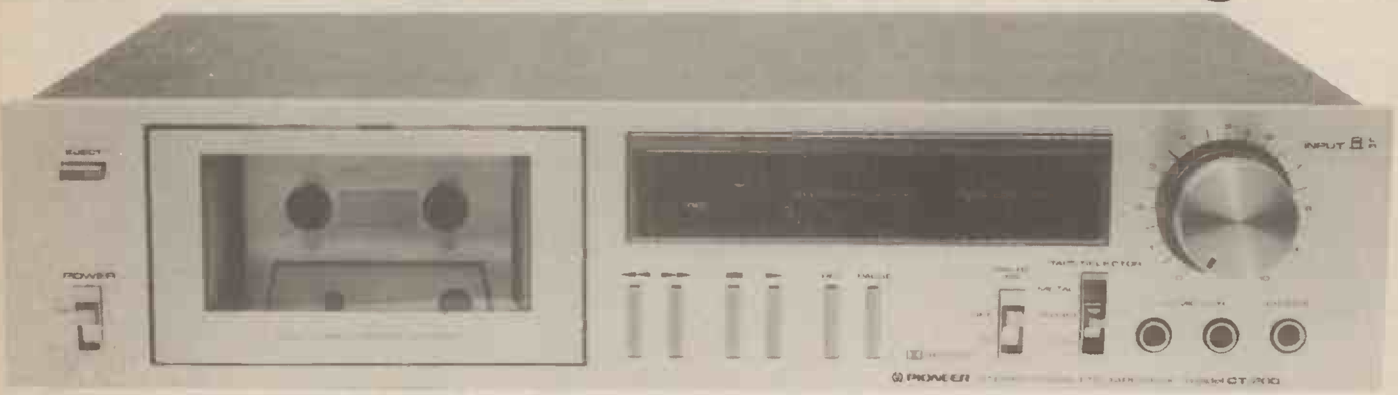
J. BULL (Electrical) Ltd.

(Dept. HE), 34 - 36 AMERICA LANE, HAYWARDS HEATH, SUSSEX RH16 3QU.

Established 30 YEARS

MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £10, add 60p service charge. Monthly account orders accepted from schools and public companies. Access & Barclaycard orders phone Haywards Heath (0444) 454563. Bulk Orders: Write for quote. Delivery by return.

SCALING the Hi-Fi HEIGHTS Part 5



The final installment looks at adding a cassette deck to a basic system.

CASSETTE RECORDERS appear in just about all rack systems, these days, and continue to outsell tuners as the most popular addition to a record player system. Home recording of LPs and singles (with the appropriate license of course!) is a widespread and popular method of enlarging a music collection; in addition there is the advantage of taping an LP-length selection of the best tracks of several records or artists. Miss out the boring bits, to order!

Reel-to-reel tape recorders have all but faded from the home hi-fi scene. There are only a handful of models remaining and these tend to be at the 'top-end' of the market, with prices in the £500+ bracket. They are outside our scope at present, as they are an unlikely addition to a first system.

Basic Theory

A music signal is recorded on to tape by the process of magnetisation. It is mixed with a high-frequency sinewave, at around 100-170 kHz, and fed to a coil and magnetic pole-piece arrangement, past which travels a magnetically coated plastic strip — the tape! The high-frequency signal is referred to as the 'bias', while the coil and poles form the 'recording head'.

Bias is required to ensure that the amount of magnetisation of the tape particles is directly proportional to the audio signal strength.

Even so, the music has to be passed through an equalisation stage, both before and after recording, to get a 'flat' response. This compensates for the varying sensitivity of the tape at different frequencies and — in theory, anyway — the equalisation circuitry produces the same result in all tape recorders, regardless of manufacture. Tapes recorded on one machine should be able to be replayed satisfactorily on another!

Years ago, the equalisation was set to produce large amounts of bass cut (7 dB at 50 Hz) but, with the ever increasing quality of tape and improved noise reduction systems, this has been substantially modified to suit the new, better quality tapes.

Biased View

Too little bias, for a given tape, results in lacking of frequency extremes ,ie bass and treble. As the amount of bias is increased, treble response improves rapidly followed by the bass, some dBs of bias strength later. Unfortunately, there is not a single level which optimises both HF and LF. To compound matters still further, distortion and some noise effects are also highly dependent upon bias level.

A compromise level is usually selected, but this still results in a considerably reduced HF level, a problem which is overcome by boosting the top end of the signal before recording (pre-equalisation).

Reducing Noise

Partially because of this high frequency boost, signal-to-noise levels (ie, how much louder the music appears above the unwanted hiss and hum, etc) would be unacceptable by hi-fi standards without some method to control tape hiss.

The most popular system is the Dolby 'B' noise reduction system, which is to be found on 99% of all cassette machines sold today. It operates by 'sloping' the frequency response to a degree dependent upon the signal level, so that the treble signal is boosted still further before recording and and then cut by exactly the same amount upon replay. Since the noise added during recording is nearly all above 5 kHz, the cut in response upon replay will not only balance the boost in the recorded signal, but will cut down the added noise by the same amount — usually around 10 dB. The difference is dramatic, and sufficient to take the cassette medium to an acceptable noise performance.

A recent development is the Dolby C System which is claimed to not only improve noise performance still further, but to also increase the dynamic range (the difference between the loudest and the softest signal replayable) of the recording machine.

Of late, the dbx company have been pushing their 'compressor' method of reducing noise on tape quite hard and have succeeded in having it adopted by some professional machine manufacturers. The system operates differently to the Dolby variations, in that it compresses, or squashes down, the entire signal before recording, considerably reducing the variations in signal level. Upon replay the original differences are restored to the signal (expansion) once more pushing tape noise down to irrelevant levels. Much greater reduction in noise is possible with dbx, but it continues to have problems producing a playback as smooth as that which went into the record head!

There have been variations upon these themes; Philips and JVC have both produced their own noise reductions sytems neither of which are compatible with Dolby B. Interestingly, the JVC machine carried the Dolby system alongside their own 'ANRS' system.

Performance Parameters

There are a fair number of specifications connected with tape machines and very few are irrelevant. Some are accorded an importance they do not actually possess — much in the same manner that a particular feature of an amplifier, operating class for example, can be made into an advertising lead story for no other reason than that of convenience. We will be taking a brief look at the specs concerned with performance and working through

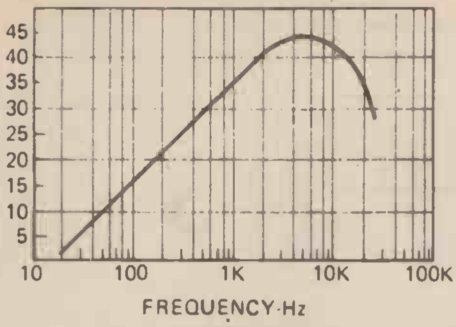


Figure 1. The frequency response generated by a tape head. This is the curve produced by recording a set of frequencies which have identical levels. As you can see, they don't stay that way!

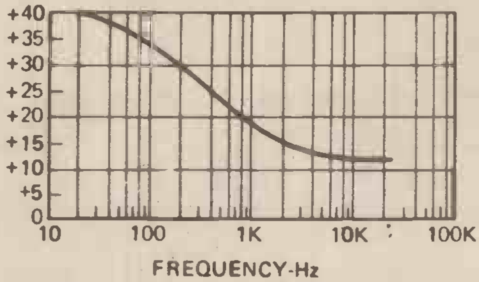


Figure 2. This is the equalising response required by the tape pre-amp circuitry to compensate for the curve of Figure 1. This will also help reduce the noise generated by the machine.

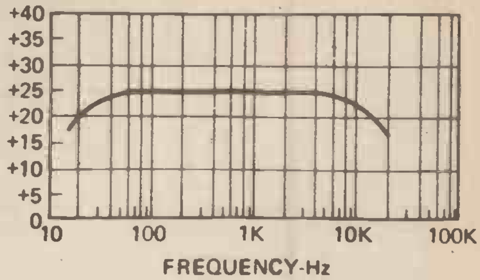


Figure 3. The result of combining the responses of Figures 1 and 2. A much more linear signal is recorded onto the tape.

the pros and cons of the different tape types on the market.

Ratios of noise: With whatever noise-reducer it has operating, a cassette machine should be able to better 65 dB (weighted) signal-to-noise ratio. What happens with the noise reduction out is really irrelevant, unless you happen to enjoy hiss!

Responding to frequencies: As the limits of human hearing are approximately 20 Hz-20 kHz, it is the aim of all hi-fi equipment to reproduce this range as faithfully as possible. Early cassette machines and tapes could hardly better 10 kHz as an upper limit of performance. Nakamichi took the art to 20 kHz before anyone else, but have since been followed beyond 15 kHz by the majority of manufacturers with metal and/or C_rO_2 tapes. A good tape deck, these days, should achieve 15 kHz without too much strain. When choosing a tape deck, pay particular attention to the manner in which it replays the extremes of the frequency specturm; all too often, an incorrectly adjusted machine will produce an uneven bass end.

Speedy Variations: Speed control of the tape itself is obviously of prime importance. Wow and flutter will be as noticeable on cassette machines as it is on record decks. On all but the most budget of budget models there should be no audible speed variations. As long as the peak W + F lies below 0.2%, all will be well. (Wow is the term applied to long-term speed charges and flutter refers to short-term, rapid oscillations in speed). Some of the better (ie higher priced) decks produce figures in the order of 0.05%, some four times better than the acceptable threshold.

Distorting the Truth: There are two types of distortion produced by a cassette deck; that generated by the electronics, and the odd harmonic distortions produced by the act of recording onto the tape itself — some intermodulation distortion (one frequency interfering with another) is also added to an signal by the process of recording. The electronics will add something of its own but, if the specified input levels are kept to, then the additions will be minimal. If they are exceeded, then, just like the free-standing amplifier, the deck will 'clip' the tops off the incoming waveform, distorting it badly. Acceptable *total* distortion figures — bearing in mind that results will vary with different types of tape — are anything less than 1%. Considerably more than for amplifiers, is it not? With the correct tape, and if the machine is set up *perfectly*, it is possible to better 0.2%, but it's a struggle!

Non-Facile Facilities

Of all the many, many facilities you will be offered on decks these days, which are worth having? Not many, but these are worth consideration.

Variable bias: The most useful add-on you can have. It must be backed-up with test oscillators, which allow you to set up the correct level of bias for good results at both low and high frequencies. Setting up the correct bias will optimise noise, frequency response and distortion; simple switching for different tape types is not really sufficient, any longer.

Peak metering: Or as near to peak as you can get, anyway. It is imperative for best quality results that the meters read as close to signal peaks as they can. Those parts of the signal which exceed the recommended maximum recording level will be grossly distorted and heavily compressed. Not good for the aurals. Good metering is expensive so if you are serious about making your own tapes, look closely at what each machine in your price range offers. Don't assume that just because the display is electronic ,ie LCD, or LED, that the meters are brilliant. The circuitry behind the displays might not be set up to peak-read.

Three heads: Are not necessarily better

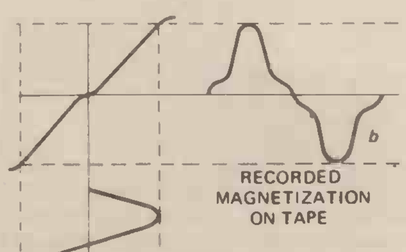
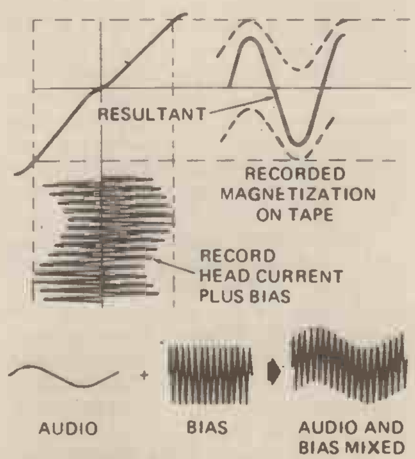


Figure 4. Without bias, distorion will ocurr when signals are recorded (above). Using high-frequency bias shifts the signal into a more linear region of the magnetisation curve. Result: less distortion.



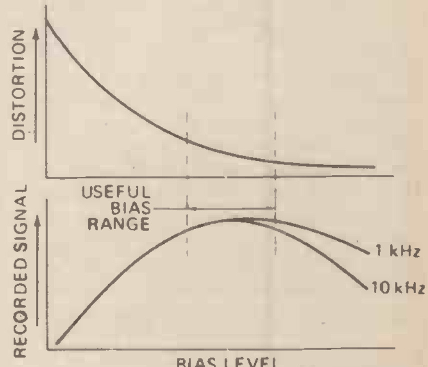


Figure 5. Bias level has a critical point, beyond which, high frequencies are attenuated. Reduction of distortion has to be balanced against loss of treble.

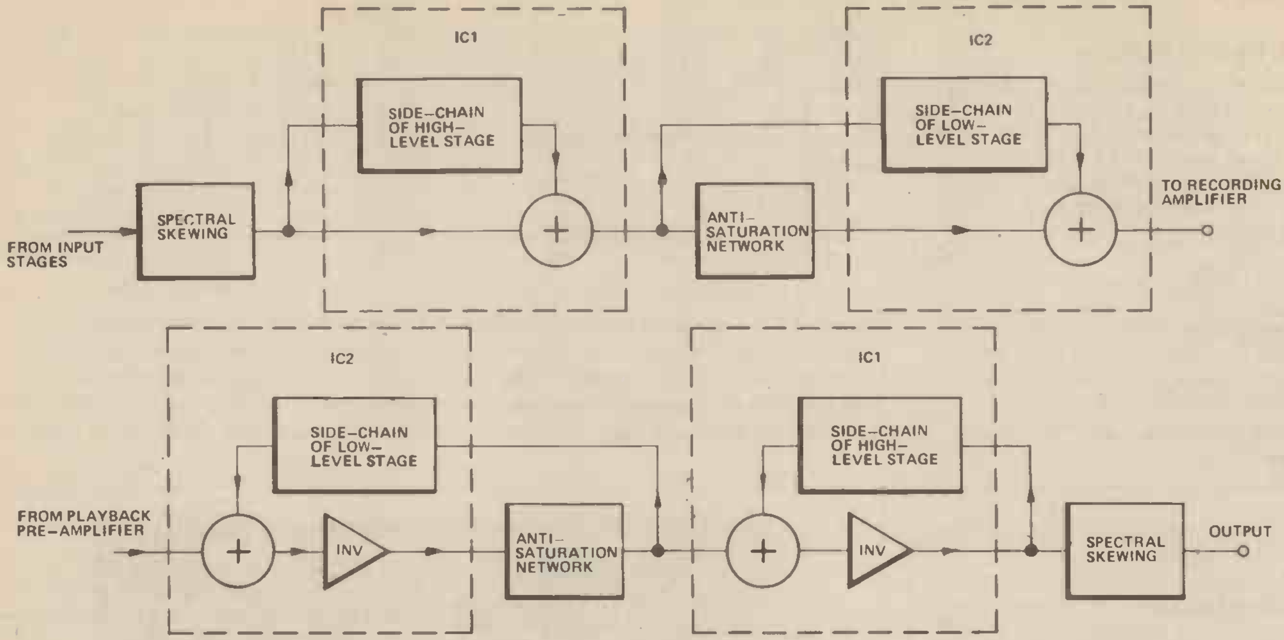


Figure 6. Block diagram of the Dolby C noise reduction system. The top circuit is the encoder, the lower is the decoder.

than two. Without the third head monitoring what is actually being recorded on to the tape is impossible. The importance of this, however, depends upon your personal taste; it's nice to have, but unless you're making your own music, not essential. Don't spend on the extra peice of metal unless the rest of the package is right for you.

Two Speeds: Some decks are now offer ing another speed in addition to the universal 1⅞ ips. Not all manufacturers offer the same alternative, however. The excellent, but now deceased, Elcaset ran at 3¾ ips and obtained higher performance as a result. There are now machines to be bought which offer 15/16 ips — but with reduced performance, naturally. Their main usage is for background music

MPX Filters: FM radios employ a tone at 19 kHz and another at 38 kHz as part of their method of operation. These *should* be filtered out at the tuner itself, but might not be completely removed from the signal presented to the tape deck. As the bias signal is also a high frequency tone, if the two are in any way connected ,ie one a whole number multiple of the other, they will interact and 'beat' like two tuning forks. An MPX filter is there to remove these multiplex (MPX) tones, ensuring clean recording. With the advanced state of tuner technology today, the MPX filter is probably a bit redundant, although it is good insurance to have one somewhere on the front panel, should you wish to make tapes off-air.

Tape Types

There are four catagories of tapes available for cassette machines, nowadays and even manufacturers are beginning to refer to them as "groups I-IV". Bias controls can thus be labelled 1-4 to avoid any possible confusion. Tape packaging should carry either a bias/equalisation setting or a simple "Group X" indication. The four types are: —

(i) Ferric (or normal)
(ii) Chromium dioxide

(iii) Ferri-Chrome (or F_eC_r)
(iv) Metal (or iron)

Taking the four in order, lets have a look at the pros and cons of the different formulations.

Group 1: Ferric Oxide. These were the first tapes to be released and were set up by the Philips specification for equalisation, etc. A fairly severe bass roll-off was employed; the equalisation time constant associated with this was 120 uS. Setting the equalisation switch to '1' or 'Normal' achieves this figure.

Advantages: the tapes are cheap, widely available and compatible with cheap portable recorders.

Disadvantages: limited output levels, high noise (comparitively) and high frequency compression.

Generally *not* recommended for hi-fi usage.

Group 2: Chromium Dioxide. Introduced to overcome the drawbacks of ferric formulations, C_rO_2 allowed a reduction in replay boost, thus cutting down perceived hiss considerably. The main drawback to chrome tapes is their low 'headroom' at mid-range frequencies — they will not take a high recording level at all; the particles 'saturate' and refuse to accept further magnetisation. Around 5 dB more bias must be used with C_rO_2 tapes, applied by switching to position '2'. For several other reasons, their manufacture is being discontinued by some manufacturers; chrome tapes may soon be seen as a short term answer, since superseded.

Some manufacturers have produced tapes which are basically ferric oxide, in chemical make-up, but are designed for use at the higher bias and different equalisation settings of Group 2 tapes.

Group 3: Ferrichrome. Since ferric oxide had problems and chrome tapes had failed to solve them, some bright spark had the idea of producing a tape using layers of both ferric and chrome — Ferrichrome! The idea was to overcome the need for excessive bias levels and provide a better noise performance. Ferric bias and Chrome equalisation settings were recommended, but quite a few machines have no position '3' — use half of '1' and half of '2'! Improved noise performance over ferric *was* achieved and some newer decks work well with these formulations.

Disadvantages: Increased mid-range distortions and higher cost.

Group 4: Metal. Iron is the most easily magnetised material of all and it follows, therefore, that if you could coat a tape with iron filings, it would hold a music signal beautifully! Group 4 tapes are an attempt to gain the maximum possible performance by using this best of all materials. Very high bias currents are required to imprint the signal on to the iron coating of the material — some 9 dB more than for normal tapes, in fact. This has led to improvements in recording head technology, simply to accept all this extra bias signal. The early metal decks gave little, if any, improvement in replay quality over Ferrichrome, but this has changed dramatically recently and the latest models offer superlative performance with Group 4 formulations. Immediate advantages are an improved high frequency response, less noise and cleaner mid-range with lower distortion.

Disadvantages: Cost, cost and more cost. Very expensive approximation to perfection, this. Try a couple on your machine before buying in any numbers.

Some Model Models

Once more, we round off by offering a shopping list of units with which we have had some experience. All the decks listed herein have been tested by us at some stage and found to offer good value for money and high performance. All are worth a look.

Under £100

Pioneer CT-320
Aiwa AD3100

£100 – £200

Technics RSM250
Pioneer CT-200
Trio KX-800

£200 – £300

Sony TCK81
Nakamichi N480

Expensive

Alpage AL300
Nakamichi N1000XL
Nakamichi N681Z

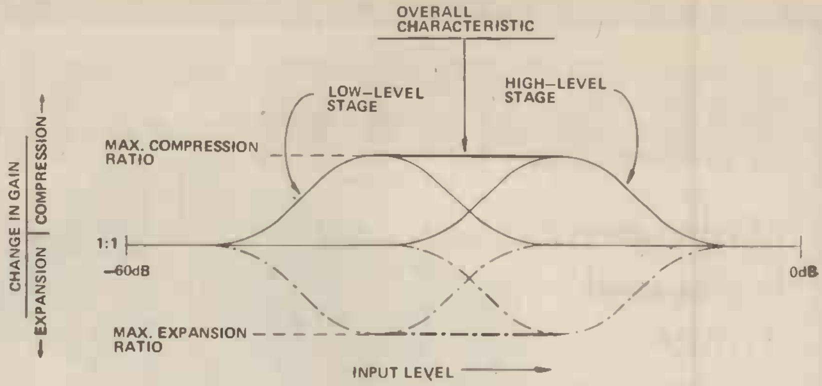
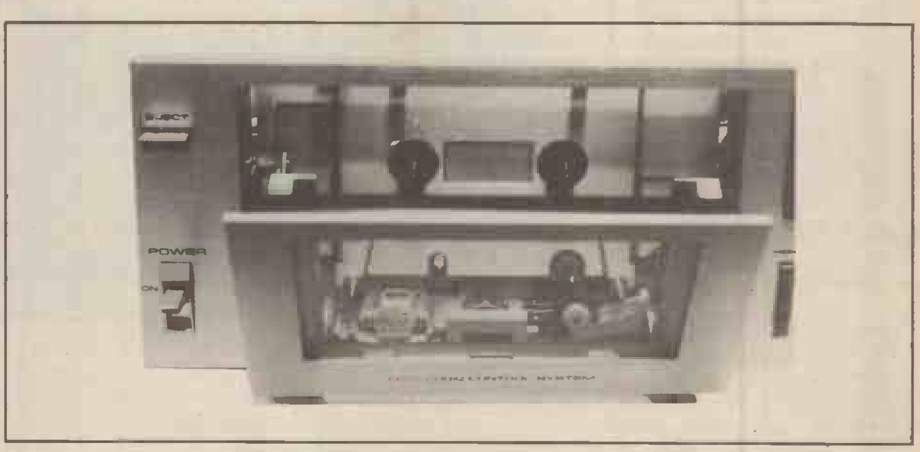


Figure 7. Dolby C actually operates in two stages. At no time is the signal processed by more than a single stage. Combined, the two stages produce 20 dB noise reduction.



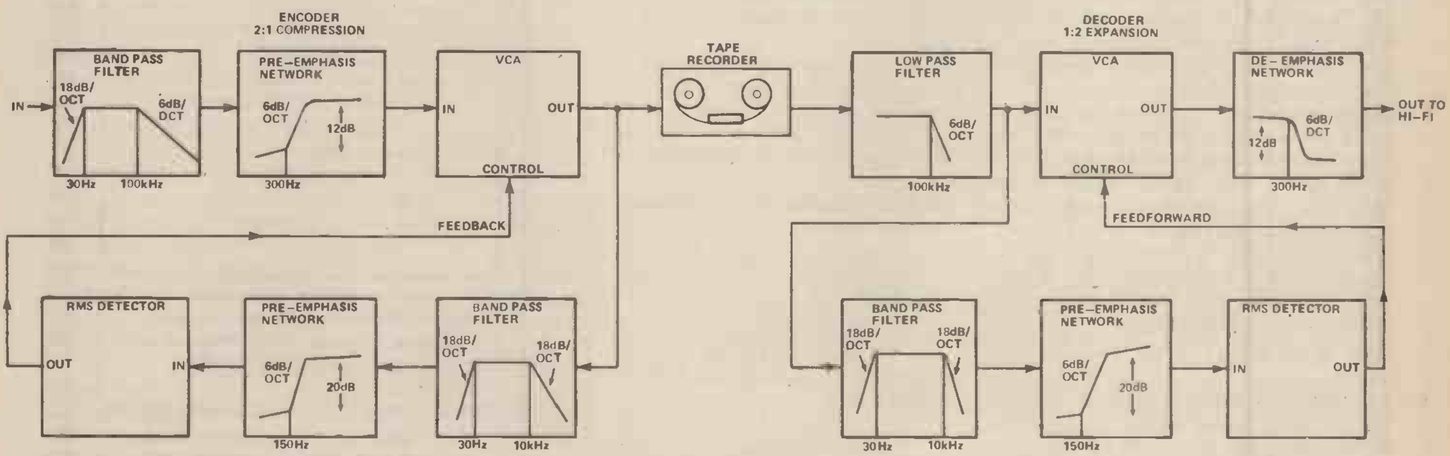
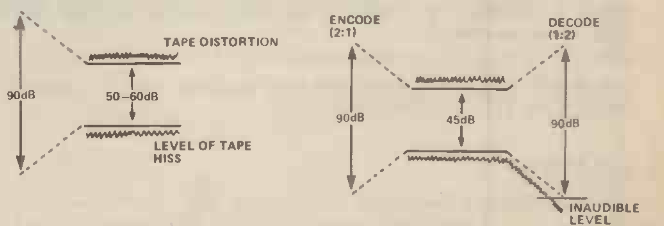


Figure 8. The dbx Type II noise reduction system in block diagram form. Although shown being used for a tape recorder, the system is equally applicable to disc.

Figure 9. By introducing 2:1 compression when recording – and accurately reversing the process on playback, the dbx system can reproduce almost the original dynamic range of the signal. Tape noise is also reduced, as a by-product!



HE

ELECTRONIC KITS

Micro-processor universal Timer

This incredibly versatile programmable timer can control up to 20 functions at accurately timed intervals over a period of a week. Originally developed for industrial and laboratory use it offers many interesting and exciting possibilities for the amateur constructor.
Based on a pre-programmed TMS 1000 Microprocessor, the unit provides a 24 hour clock with four independent relay controlled outputs with a programmable period of one week. Up to 20 daily or weekly programmable functions can be set via a keyboard. Any of the timer functions can be assigned to control any one of the four relay outputs thus providing almost unlimited programming possibilities.
No previous experience of microprocessor programming is necessary since the manual explains all the possible operations, clearly and simply, enabling the inexperienced user to be fully conversant within one hour. Completed programme steps are indicated by LED's
The kit comes complete with printed panel and may be installed either as a 'built-in' or a 'free-standing' unit. A stabilised power supply mounted on a separate printed circuit board is supplied with the unit. It requires the addition of a 12V, 1A transformer. There is space on the board for up to four output control relays. One is supplied with the kit. Further relays maybe ordered separately as required. Price: *(excluding wooden housing as illustrated)* **£48.37** inclusive of VAT and **DELIVERED FREE** on U.K. mainland.

APPLICATIONS

The programmable timer can provide central control of domestic electrical cooking, heating and entertainment equipment.
The possibilities are limited only by the imagination of the user.
Control of house lighting to discourage intruders; control of TV or audio equipment; sound or video recording control; automatic plant watering; automatic pet doors or feeding—are a few simple examples.
For the professional or industrial user many uses in this area of process control will be found.

TECHNICAL DATA:
Power supply:
Mounted on separate pcb with space for up to four output control relays. Requires 12V/1A transformer.

CONTROL SWITCHING:
Standard relays (one supplied with kit) will switch 2A.
Additional relays may be ordered separately.
National relay, order no. HT 12V.
Siemans relay, order no. R1 (NV12.

MICROPROCESSOR:
TMS 1000

DISPLAYS:
12mm 7 segment LED numerical display. LED programme function indicators.

DIFFICULTY GRADE: 3

KIT NUMBER: K1682

THE VELLEMAN KIT RANGE

2.2 Watt mini amplifier
Mono VU using LED's
7 Watt amplifier
Dimmer 1000 Watt
Dimmer 1000 Watt(deparasite)
High precision stopwatch
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FM oscillator
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60 Watt power amplifier
Power supply 1 Amp
Power supply for stereo 60 Watt amplifier
Running light
Digital panel meter
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Transistor ignition
Complex sound generator
50 Hz crystal base
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Central alarm unit
FM stereo decoder
High quality FM tuner
Digital frequency counter for receivers
CB power supply 3.5 Amp 12V
Digital thermometer
FM stereo receiver (19 in. rack-mounting)
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Infra-red receiver for tuner K2558
Infra-red transmitter for tuner K2558
Tape/slide synchronizer
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20 cm display (common cathode)
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Microprocessor-controlled EPROM programmer (built and tested)
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Audio Signal Generator

R.A. Penfold

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IF you are interested in building, servicing, or perhaps even designing audio frequency (AF) equipment of any kind, you are unlikely to get very far without the aid of a few basic items of test equipment. One of the most essential is a signal generator. For most audio tests and measurements, what is required is a good quality sinewave signal at any frequency within the audio spectrum. It should provide an output level that can be adjusted from zero to at least 1 volt RMS and that does not change significantly with alterations of the output frequency.

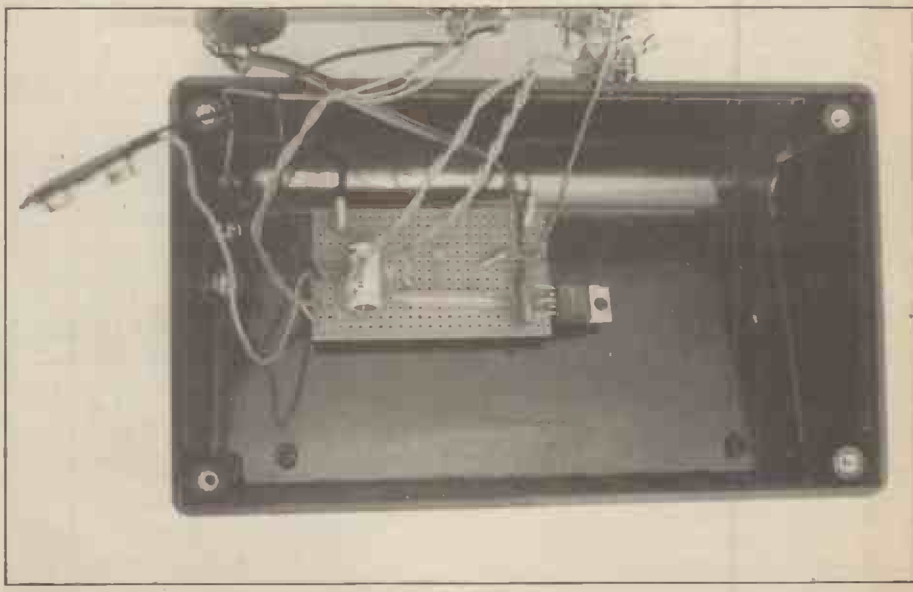
Our design fulfills these requirements, as it covers a frequency range of approximately 20 Hertz to 30 kHz in three ranges (20 Hz to 300 Hz, 200 Hz to 3 kHz, and 2 kHz to 30 kHz) and has a built-in stabilisation circuit that allows no significant change in the output level over this range. It is important that the output should be reasonably pure sinewave since any distortion of the waveshape may produce unwanted frequencies at the output. These could result in misleading readings when making frequency response tests and similar measurements. The total noise and distortion on the output of our design is less than 0.05%, which is good enough for any normal audio testing.

The unit has a maximum output level of about 1.6 volts RMS and this is continuously variable down to zero by means of a potentiometer and a three position switched attenuator. The low output impedance of the unit helps to maintain the output level under high load conditions.

The Circuit

The full circuit diagram of the unit is shown in **Figure 1**. It is built around an audio power amplifier IC and, although this may seem an unusual choice, it is actually ideal for this for this application since it gives low levels of noise and distortion plus a low output impedance, so that loading of the output is unlikely to cause a significant reduction in the output level or an increase in distortion.

The IC employed in the circuit is the TDA2006 which is similar to an ordinary operational amplifier IC, but has a high power output stage. This enables it to be readily used in a Wien Bridge oscillator, the configuration normally used in high quality sinewave generators. Like many operational amplifier circuits this one has dual balanced supplies, provided by two 9 volt batteries.



The internal view — not much of it, is there?

A Wien bridge oscillator uses two capacitors and two resistors to provide zero phase shift at the operating frequency of the circuit, but appreciable phase shift at all other frequencies. The Wien network, therefore, gives maximum positive feedback at its operating frequency and, provided the amplifier has sufficient voltage gain, oscillation occurs at this frequency. The loss through Wien network, at its operating frequency, is about 10 dB (three times), so the amplifier needs to have some voltage gain to sustain oscillation.

In this circuit the two capacitors in the Wien network are whichever two are switched into circuit by SW1; the use of three switched sets of capacitors gives the unit three ranges. One resistance of the Wien network is formed by R1 and RV1a in series, while the other is formed by R3 and RV1b. By making the two resistances adjustable, the unit can be tuned over each of the three frequency ranges. The operating frequency of a Wien network, incidentally, is $f_0 = 1/2\ RC$.

The voltage gain provided by IC1 is controlled by TH1 and R2, which form a simple negative feedback network; the voltage gain of the circuit is equal to the resistance of TH1 plus R2, divided by the resistance of R2. TH1 is a self heating, negative temperature coefficient thermistor. This simply means that it is enclosed in a glass envelope (in a vacuum) so that it is isolated from the surrounding temperature. It is intended to respond to the heating effect of a current passed through it, with a rise in temperature giving a reduction in resistance.

At switch-on TH1 will be 'cold' and will have a high resistance, giving IC1 a high voltage gain. This results in the circuit oscillating very strongly and a fairly high current fed through TH1 and R2 from the output. This current has a strong heating effect, so that the resistance of TH1 drops sharply; IC1's voltage gain is reduced and the circuit oscillates gently, but reliably, giving a good output waveform. If loading on the output, or some other factor, should cause a reduction in the amplitude of the signal at the output, the current through TH1 will be reduced slightly, its resistance increases and the output signal level will be restored to its original level. If the output level should increase for some reason, the opposite effect occurs; the current through TH1 rises, the voltage gain of IC1 is reduced and the output signal level falls back down again. Thus the thermistor AGC circuit ensures a pure output signal of constant amplitude. The output of IC1 is coupled by C8 to variable attenuator (RV2) and then to a conventional three step switched attenuator attenuation factors of 0, 20, and 40 dB. Although this attenuator might seem to be excessive, with VR2 in the circuit, it is in fact useful for reducing the output level when a very low amplitude signal is required — adjustments using RV2 alone would otherwise become very critical and difficult!

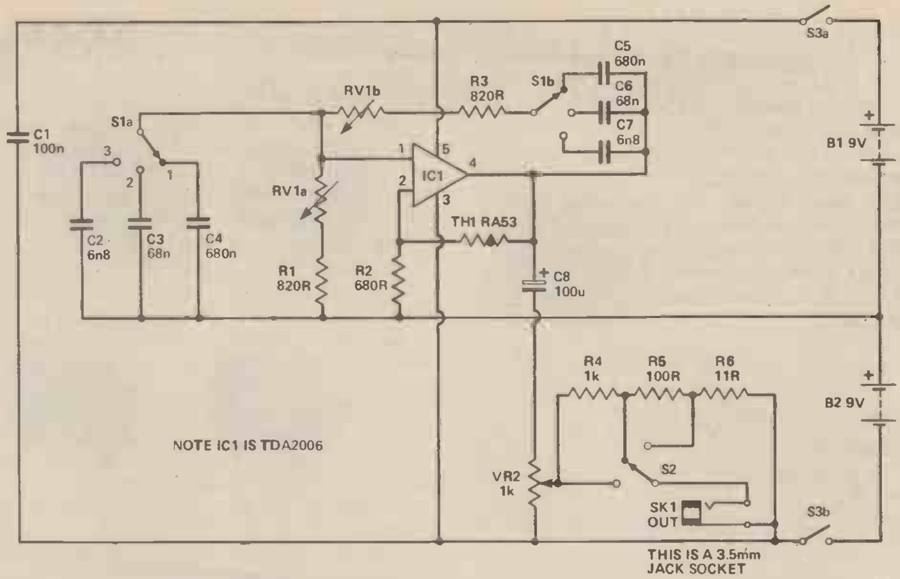


Figure 1. The circuit diagram.

Construction

Start by cutting the stripboard to size (13 strips by 24 holes) using a hacksaw, and drill the two mounting holes to take 6BA or M3 fixings (about 3.2 mm in diameter in either case). Next, solder the components into place (there are no breaks in the copper strips) following the component layout shown in **Figure 2**. TH1 is mounted horizontally on the board and should be treated reasonably carefully as it has a glass encapsulation. Splay the leadout wires of IC1 slightly to compensate for a different pitch to that of the board. Make sure C8 is connected the right way round.

Now drill the front panel of the case to take the five controls and output socket. We used a sloping front case but you can of course, use an ordinary

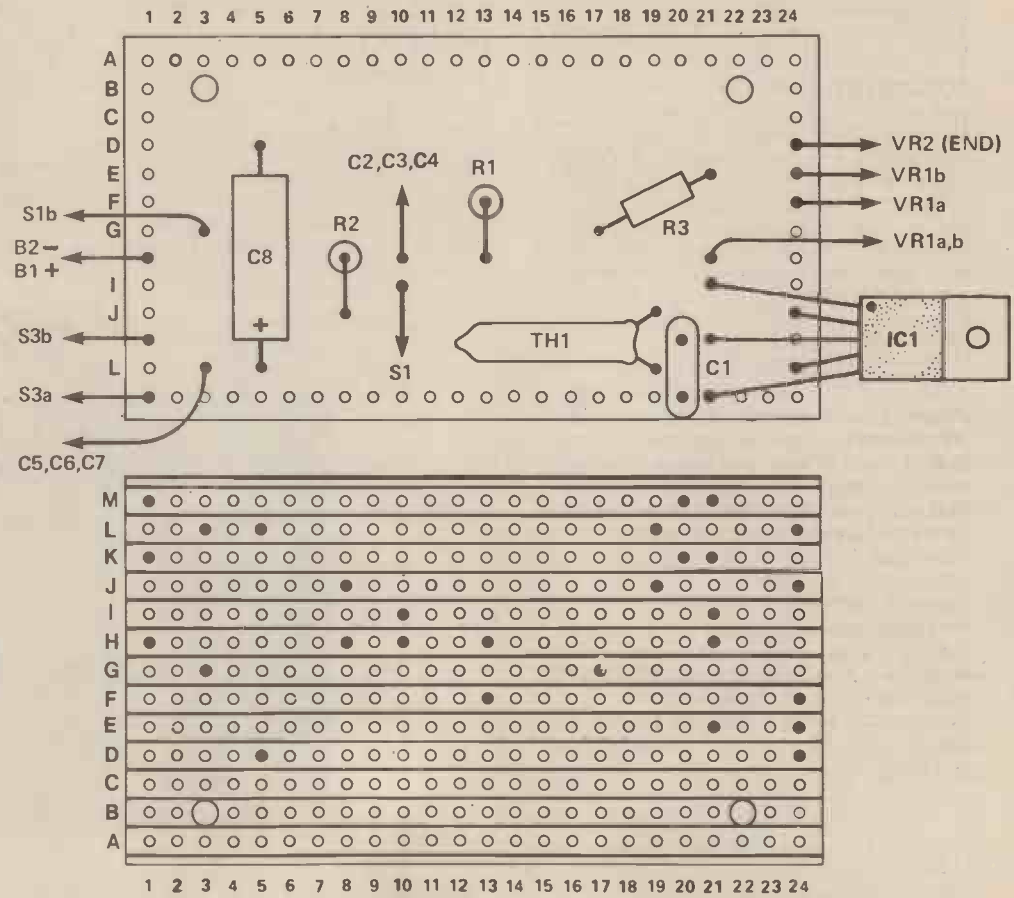


Figure 2. The component layout (top) and the solder 'dot pattern' (bottom). Note that there are no cuts in the Veroboard tracks.

type is you prefer. Mount C2, C3, C4, C5, C6 and C7 and R4, R5 and R6 on SW2, as shown in **Figure 3**. Then complete the rest of the wiring — this is also illustrated in **Figure 3**.

A couple of PP3 batteries are used to power the unit, and have a resonably long operating life. However, the current drain from each battery is about 15 mA, and it would be advisable to use larger batteries (say a couple of PP6s or PP7s) if the unit is likely to receive a great deal of use.

Parts List

RESISTORS
(All ¼ W 5%)

R1,3	82OR
R2	68OR
R4	1k
R5	100R
R6	11R

POTENTIOMETERS

RV1	10k linear dual gang carbon
RV2	1k linear carbon

CAPACITORS

C1	100n polyester (C280)
C2,7	6n8 polycarbonate
C3,6	68n polycarbonate
C4,5	680n polycarbonate
C8	100u 10V electrolytic

SEMICONDUCTOR

IC1	TDA2006 Audio Amplifier

MISCELLANEOUS

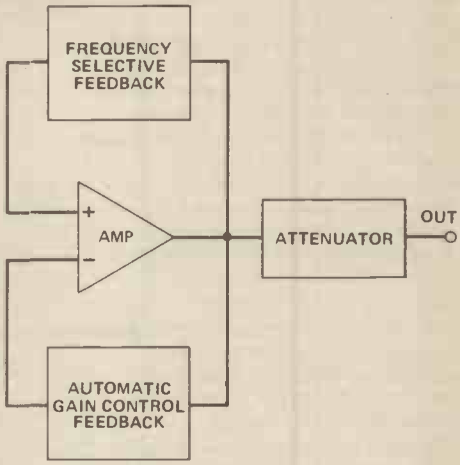
S1,2	3 way 4 pole rotary switches
S3	Rotary DPST switch
B1,2	PP3 size batteries
SK1	3.5 mm jack socket
TH1	RA 53 Thermistor

Case, veroboard, control knobs, two PP3 type battery connectors, test leads, wire, solder, etc.

BUYLINES page 68

How It Works

The circuit is built around an audio power amplifer IC which, as usual, has two inputs — an inverting (–) input and a non-inverting (+) input. Positive feedback is applied from the output to the non-inverting input and it is made frequency selective so that the frequency of oscillation can be set. However, the circuit will oscillate only if the amplifier has sufficient gain. Excessive gain will result in the output waveform becoming distorted and producing unwanted frequencies, so the gain is maintained at just the right level by an AGC circuit in the negative feedback loop from the output to the inverting input. A switched attenuator at the output enables the amplitude of the signal to be reduced by a factor of 10 or 100; there is also a 'volume control' attenuator which enables the signal to be continuously varied from zero up to the maximum level permitted by the switched attenuator.



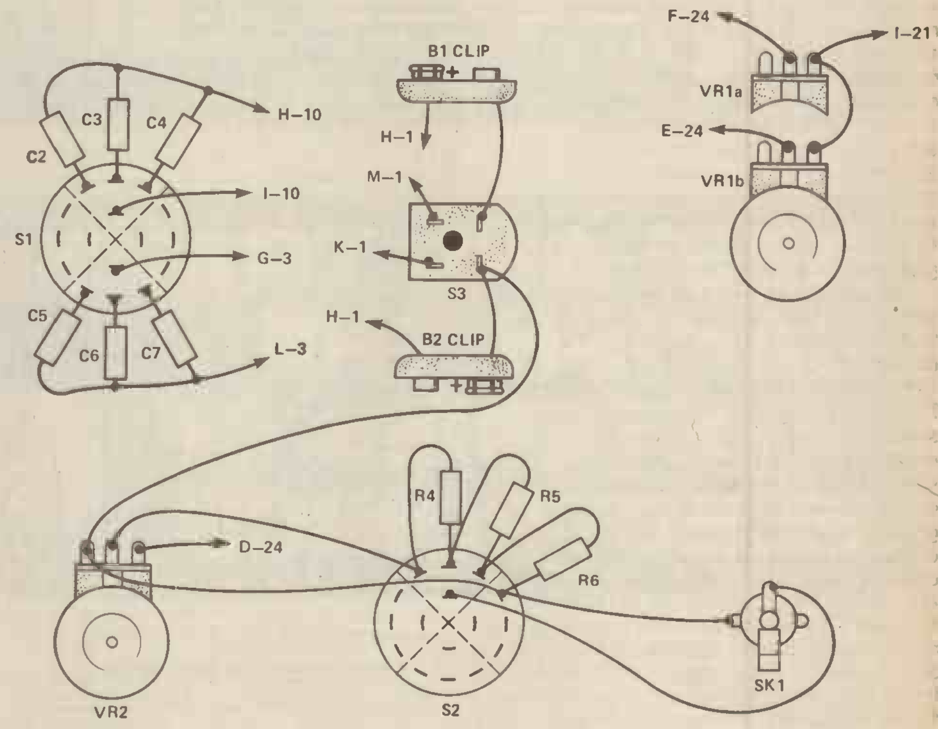
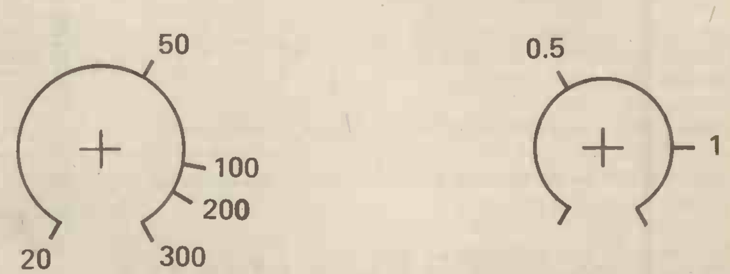


Figure 3 (top). One of the reasons the Veroboard layout is so straightforward is that most of the components are wired to the panel controls! Follow the diagram carefully, making sure that the wires go to the connection points indicated.

Figure 4 (bottom). Templates for the frequency scale (left) and the fine level control (right). They are not intended to be accurate, only to give an indication of the frequency or output level. The frequency scale is multiplied by one on Range 1, by 10 on Range 2 and by 100 on Range 3.



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KITS & COMPONENTS

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[Shaped Leds]

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Rectangular	5x2.5mm	17p	20p	20p
Square	5x5mm	17p	20p	20p
Triangular	5mm	17p	20p	
Arrowhead	2.5x5mm	17p	20p	

[Flashing Leds]
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[Tri Colour Leds]
5mm round... 30p 5mm Rectangular 32p

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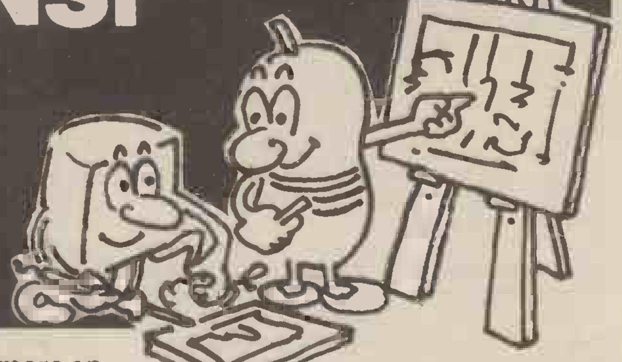

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CHARLES BABBAGE

Charles Babbage was born in Teignmouth, South Devon, to wealthy parents who gave him that most precious gift — a good education, with considerable encouragement to his mathematical talents. These were evident, as is often the case, at a very early age. By the age of 20 he had founded the Analytical Society, which was intended to encourage the teaching of mathematics in this country and, in particular, to make better known in Britain the developments in mathematics which were taking place across the Channel. His work earned him a place as a Fellow of the Royal Society in 1816, making him one of the youngest men ever to have been elected as FRS.

By that time, he had started the work which was to win him a place in history. In 1812, he had been captivated by the thought that mathematical tables, such as logarithms, could be calculated mechanically instead of being laboriously computed by hand, as it were. During 1813, he constructed a small mechanical calculator, similar in principle to the kind of thing that is nowadays sold as a toy, but able to calculate values to eight decimal places. His work revealed several mistakes in earlier sets of tables, and led to a considerable improvement in the accuracy of engineering calculations.

The Industrial Revolution was accompanied by a demand for some method of coping with more complicated calculations, particularly for solving those problems in mechanical engineering which would be very laborious to carry out by traditional pen-and-paper methods. In 1823 Babbage was commissioned by the Government of the day to construct a mechanical calculator which would work to 20 decimal places, a task which he completed despite the formidable difficulties involved. The problem of backlash in gear trains, for example, was one that plagued any attempt to use mechanical methods for precision equipment. Remember that in 1823 the idea of using electricity for performing calculations was a century too early. It was, after all, in the same decade that Michael Faraday, demonstrating the first dynamo, was asked what use could possibly be made of it! Don't laugh — the opponents of electricity, then, used exactly the same arguments as the opponents of nuclear power do now.

By 1828, Babbage's career was sufficiently distinguished to ensure his appointment as Lucasian Professor of Mathematics at Cambridge, a post which he held with distinction until 1839. It was in 1834 that he embarked on a scheme which, though doomed to failure by the inadequate technology of the time, was to prove his masterpiece. This was the 'analytical engine' — to us, us, a computer. His design owed a debt

a computer. His design owed a debt to an earlier engineer, Jacquard. Jacquard was a designer of looms for weaving complicated patterns and he had devised a system of loom control that can only be described as programming. A set of punched cards was fed into a controller and holes in the cards were detected by a set of rods which were then used to select the threads for the weaving. The Jacquard system was fast and accurate, once the program was correctly punched, and gave its users an enormous advantage over their competitors, putting thousands *into* work. Another demonstration of the fact that success comes by chasing new ideas, not by propping up old ones.

Babbage reasoned that Jacquard's loom system could also be used to control a calculating machine and he started work on a specification, for which he received another Government grant. His specification shows that he thoroughly understood all the ideas that we now deem essential in computing. He realised, for example, that there could be several types of inputs to the machine, which he called number codes (data, as we now call it), direction codes to control the movement of numbers (addressing), and operation codes to determine what would be done with a number (opcodes).

His anticipation of modern computing methods was complete. He made it clear, for example, that an essential operation of his analytical engine would be the conditional transfer — what we now call a branch or jump. The idea, then as now, was that when the result of an operation was well defined, like being zero, negative, or positive, it could be used to decide what the next operation should be, choosing betwen two or more options. This, undoubtedly, is the feature that distinguishes the programmable calculator and the computer from the ordinary calculator and there is plenty of evidence to show that Babbage was well aware of its importance.

He also seems to have followed up the possibility that the results of a calculation could be used to change some of the operating codes, so that the program could modify itself — even nowadays, this is considered as pretty advanced programming. Babbage's ideas were never very well circulated, and few among his contemporaries had any idea of what he was aiming at and how important his work would be. One notable exception was Ada, Countess Lovelace, daughter of the poet, Lord Byron. She goes down in history as the first computer programmer, because she seems to have grasped Babbage's designs well enough to write several programs for the machine — even though it was never completed.

All they needed was technology. There was simply no way that mechanical methods using gears, with all the problems of backlash, could cope with such advanced designs and electricity was still a curiosity. By 1842, the Government, which had been remarkably patient, withdrew its support and the Babbage computer was never completed.

Another attempt to make a Babbage machine was made by a Swedish mathematician in Stockholm in 1855, but this too had to be abandoned. Babbage, disheartened, made no attempts to follow up his own work and died in 1871, in London, without having seen his dream fulfilled.

His working life was one of continual problem-solving and invention but few people realise, to this day, the extent of his work. It was Babbage who compiled the first actuarial tables (expectance of life), on which all life insurance is based and these tables still give a better picture of our health than any other evidence. They show, for example, the remarkable rise in life expectancy over the past 100 years. (If you think that the simple life is a healthy one, look up the actuarial tables for the 1860s — they make chilling reading; the simple reason for the Victorian families of 10 to 20 children was the hope that one or two of them might actually survive to adulthood.) Babbage should be remembered as the man who brought these awful statistics to our attention. He also invented the cowcatcher, used on US railway locomotives in the pioneer days, and the speedometer; but his pioneering effort on computers, rediscovered in 1937, are the greatest monument to his genius. **HE**

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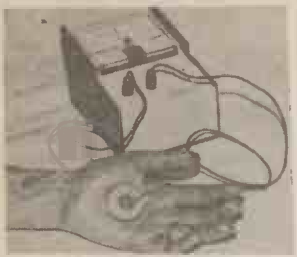

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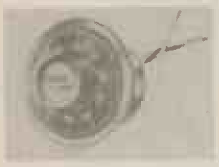

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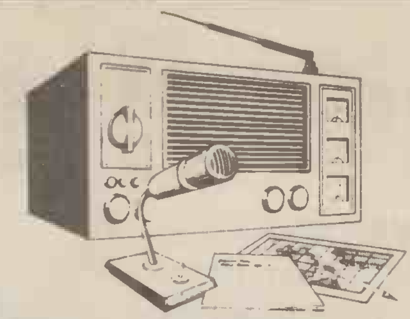

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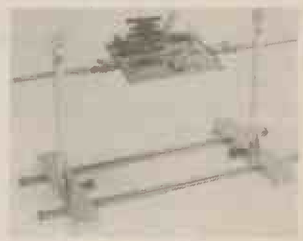

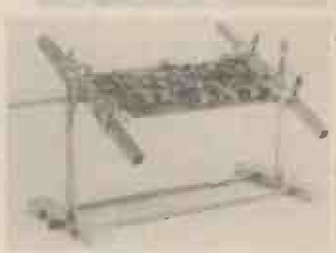

CNC 9

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QUICK PROJECT:

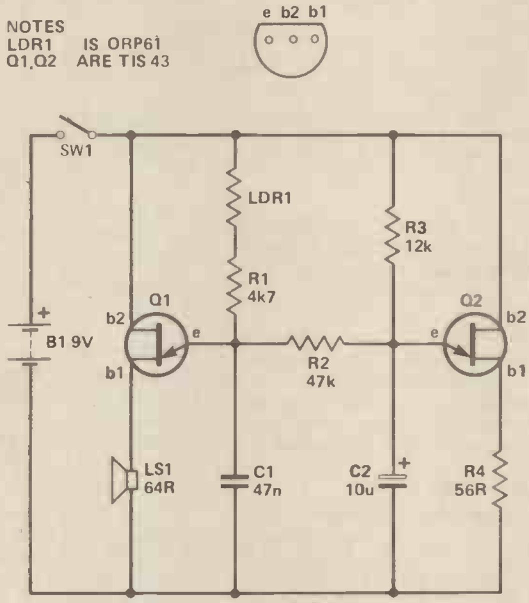
LIGHT SEEKER

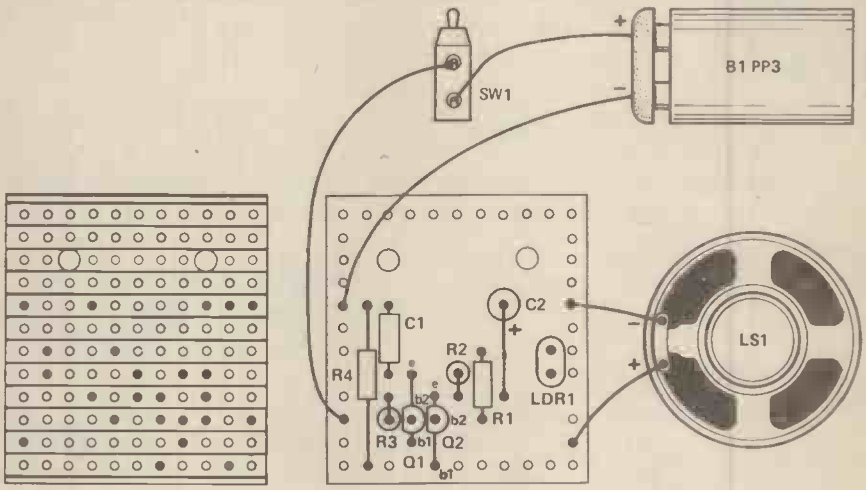
The warning tone means 'Shut the door, quickly'!

IF you've ever worked with photographic materials, you'll know how important it is to ensure that there is no light present when handling sensitised materials (ie light sensitive paper). This is not a problem if you can be there all the time. However, if you need to leave the room, it would be handly to have some means of protecting those valuable films.

One way of doing this is to use a device which provides an audible tone upon exposure to light — the Light Seeker circuit does this admirably. In fact it will produce a pulsed warbling tone that increases in frequency depending on the intensity of light present.

The circuit is a simple combination of two unijunction relaxation oscillators, one modulating the other. Relaxation oscillators are the most common application of unijunction transistors because very few external components are needed to get the thing oscillating (a single resistor and capacitor will do). In our design there are two oscillators; one produces around five pulses per second and this modulates the second one, which is oscillating at a frequency of about 300 Hz rising to 4000 Hz when bright light is shone on the LDR (light dependent resistor). The frequency of oscillation is determined by the resistor and capacitor networks connected across the supply lines and to the emitter of each transistor. For instance, the circuit around Q2 is composed of R3,R4 and C2. The resistor from b1 (base one of Q2) connects to ground via the current limiting resistor R4. The other two components effectively control the frequency of oscillations. Each time C2 charges up via R3, there is a point where the emitter of Q2 no longer acts as a high impedance and the capacitor discharges through R4. After discharging, b1 is zero volts and so the emitter again appears as a high impedance. This exponential charge/discharge cycle repeats at a rate determined by the values of R3 and C2 and produces a rounded sawtooth output. With two such oscillators, the seeker provides an audible pulsed tone, whose frequency is dependent on the resistance of LDR1, which in turn depends on the amount of light present. Resistor R2 acts to couple both oscillators to a degree which allows C1 and C2 to fully complete their respective charge/discharge cycles. Current consumption is about six milliamps, and so a PP3 should last quite some time.





Parts List

RESISTORS
(All ¼ W 5% carbon)
R1 . . . . 4k7
R2 . . . . 47k
R3 . . . . 12k
R4 . . . . 56R

CAPACITORS
C1 . . . . 47 n polyester C280
C2 . . . . . 10 u 10 V radial electrolytic

SEMICONDUCTORS
Q1, Q2 . . . . TIS 43
unijunction transistor

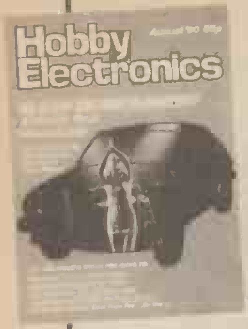
LDR1 . . . . ORP 61
light dependent resistor

MISCELLANEOUS
SW1 . . . . . SPST on/off toggle switch
LS1 . . . . speaker (64R or greater)
B1 . . . . PP3 9V Battery

PP3 clips, veroboard (11 strips, 11 holes), case, wire etc.

See Buylines (page 68) for availability of these components.

HE



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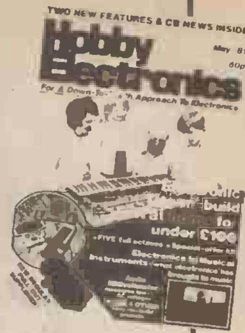

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July 1981
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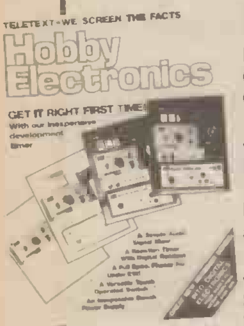
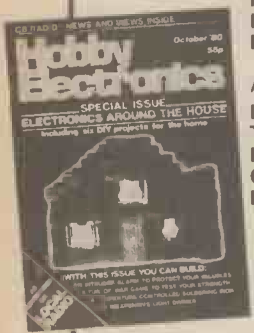
August 1981
Electronic Ignition, Thermometer, Electronic Organ (final part), RPM Meter, Bench Power Supply, Radio Control Survey, Into Electronic Components Part 1.





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RADIO RULES SINES OF THE TIMES

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Ian Sinclair

IF YOU'VE DABBLED a bit in electronics construction, you've probably found out, by now, how easy it is to make oscillator circuits such as multivibrators, which generate square, or nearly square, waves. Generating sinewaves seems much more difficult, at low frequencies at least. It all seems a bit odd, when everyone tells you how important sinewaves are, that they should be so difficult!

In the early days, no-one had any difficulty generating sinewaves. All you had to do was to rotate a coil of wire between the poles of a magnet and, behold, you had a sinewave at the ends of the wire! Add a pair of slip-rings to make the connections to the rotating coil (Figure 1) and you had an alternator. That's one of the reasons why the sinewave is important — you can generate it mechanically. In the early days of radio, alternators like this were used, spinning at high speeds, to generate the carrier waves for Morse signals.

The use of alternators is fine so long as we don't need really high frequency signals, but is causes a bit of difficulty when we want frequencies around 1 MHz. A large coil revolving one million times per second is a device no-one would want to be close to, so other methods are needed. The 'other methods' all end up with that useful circuit, an inductor in parallel with a capacitor — otherwise called a parallel resonant circuit. Now let's be clear about one thing right away. The parallel resonant circuit doesn't, by itself, generate sinewaves. What it does is to grow sinewaves. Grow them? It's as good a description as any, for what happens. If, somehow, you start a current flowing in the inductor of a parallel resonant circuit then that current can't just keep on flowing, because it charges up the plates of the capacitor until the voltage builds up enough to make the current first fall to zero, then reverse direction. Then, the current builds up in the in the *opposite* direction until, once again, it has charged the capacitor to a voltage (the other way round now) which will make the current reverse. This cycle creates, (as naturally as the rotation of a coil between the poles of a magnet), a sinewave. It can't keep going, though, any more than the alternator coil can keep spinning, without some outside help. That help, as far as the parallel resonant circuit is concerned, is provided by a transistor, a valve or whatever else we can use to keep the current flowing.

There's the snag of course. We can make a transistor pass current between its collector and its emitter by bringing the voltage between the base and the emitter above about 0V55. (that's the magic figure for a silicon transistor). Now this current is in one direction, from collector to emitter if the transistor we use is an NPN type, but the current won't flow the other way. If we connect our parallel resonant circuit to the collector circuit of an NPN transistor, then, we can't just start the transistor conducting at any old time. The sinewave which is shaped by the parallel resonant circuit will have a definite frequency, whose value depends on the values of inductance and capacitance in the circuit. If we briefly made the transistor conduct by applying a short positive voltage to the base (a positive pulse), the parallel resonant circuit would oscillate — but only for a short time. Certainly, it oscillates for a lot longer than the time of the pulse at the base of the transistor (just as a bell rings for some time after it has been struck), but the oscillations die out — just as the sound of the bell does. Because of the similar behaviour, in fact, a circuit used in this way is called a 'ringing' circuit (Figure 3).

The Positive Answer

To keep the oscillation going, we have to make the transistor conduct each time the current through the coil is flowing in the *right* direction — that is, from supply to earth. When the current reverses, the transistor has to shut off otherwise it will simply take all the current which should be going into charging the capacitor. The

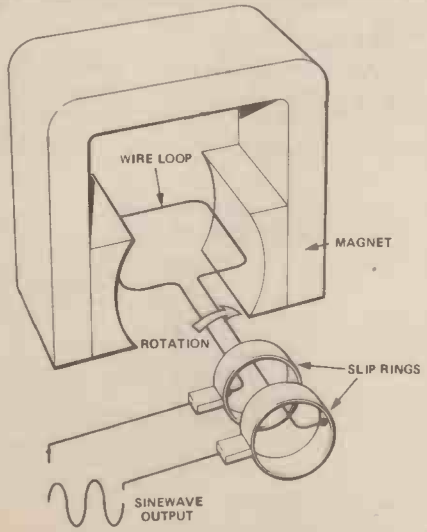


Figure 1. The alternator principle. As the wire loop rotates between the poles of the magnet, a sinewave signal is generated. The frequency of the sinewave is equal to the number of complete revolutions per second of the coil.

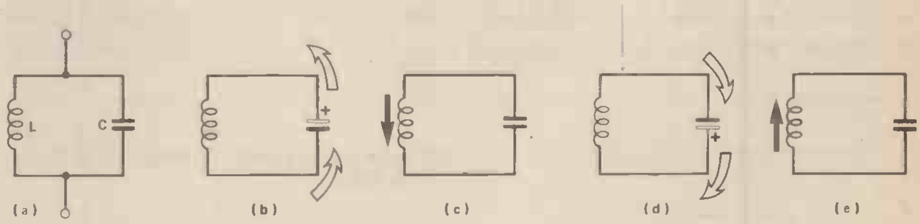
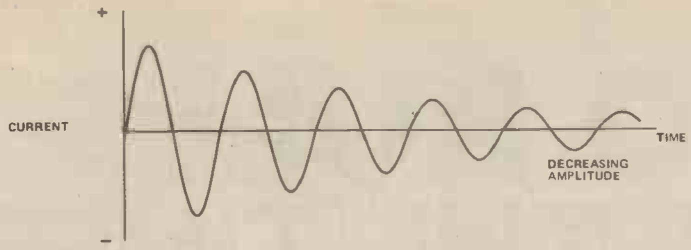
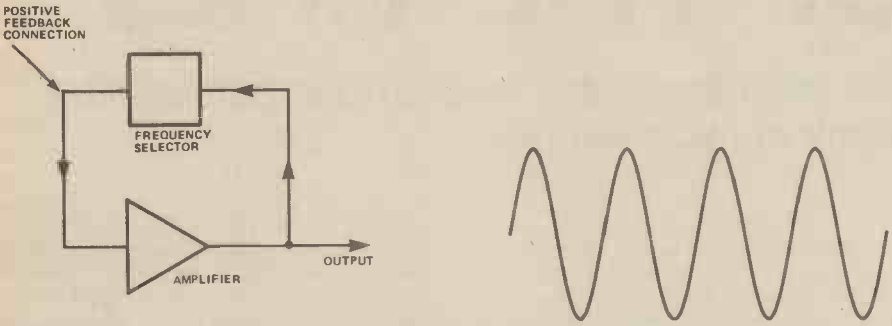


Figure 2. Charge and discharge in a parallel resonant circuit; (a) the circuit; (b) the capacitor discharge (c) causes current to flow through the coil and then the recharging of the capacitor (d); the process then reverses, reversing the direction of current through the coil (e).



◄ Figure 3. The waveform produced by a 'ringing circuit'. A current pulse applied to a parralel resonant circuit causes the charge/discharge cycle of Figure 2, but eventually the current dies away.



◄ Figure 4. To produce continuous oscillation, the ringing circuit needs to be 'stuck' by a succession of current pulses, at exactly the right moments. This is achieved by a positive feedback connection, via the parallel resonant circuit, arranged so that the amplifier conducts only when its output voltage is in phase with the voltage across the tuned circuit.

way we can ensure the base voltage of the transistor causes it to conduct at the right time is by feeding it with a bit of the sinewave generated by the parallel resonant circuit (**Figure 4**). This is a positive feedback connection; just as the current in the inductor starts to flow earthwards, the transistor starts to conduct, helping the current on its way and so generating a voltage which turns the transistor harder on, helping the action a bit more. When the current reverses, the voltage at the base of the transistor drops, cutting off the current and allowing the inductor to get on with the job. The result is a sinewave oscillator. Any sinewave oscillator which uses a parallel resonant circuit must include a circuit which feeds signal to the base of the transistor to provide the current drive for the oscillations. Seems simple enough but in fact there are a remarkable variety of sinewave oscillators, many of which carry names that date back to the very early days of radio.

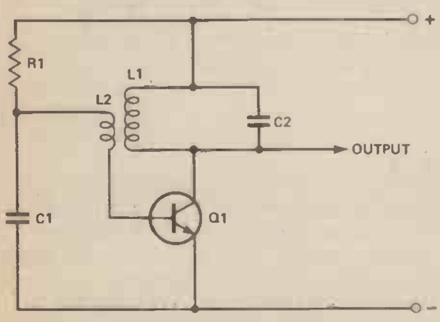
A circuit for a sinewave oscillator — an old reliable favourite — is shown in **Figure 5**. Two windings are needed; one (L1) is part of the resonant circuit, while the other (L2) is a feedback winding which switches the base voltages of the transistor up and down as needed. To make the circuit self-starting, a little bit of bias is needed to start the transistor conducting and this is provided by R1, decoupled by C1. If the oscillator is to operate at a high frequency, L1 may consist of a few turns of wire on a ferrite rod or a hollow former. L2 should have about 1/4 to 1/5 the number of turns of L1, as a rough rule-of-thumb. Lower frequency sinewaves can be generated if L1 and L2 are windings of a transformer with a ratio of around 1 : 5, using the larger winding for L1. Sinewaves of 20 kHz or less can be generated when a capacitor of about 0u1 is used to tune L1, but the windings must not have a high resistance, otherwise oscillation may not start.

Bright Idea

When you make or use a pair of coils in this circuit, there's a 50:50 chance that the oscillator won't work — this is because you can seldom be sure about which way the currents flow in the windings. The easiest cure is the practical one — if it doesn't oscillate, reverse the connections to L2. But how do you know if it's oscillating, without using a 'scope? One old-fashioned way to find out if a high frequency oscillator is working is to use a low-wattage torch bulb, something using less than 60 mA at around 2V5, connecting it to a few turns of a coil, as shown in **Figure 6**. Hold this lot near L1 and the bulb will light as the coil picks up the frequency generated by the oscillator. Don't go too close, though, otherwise the load on the oscillator may be enough to stop it working.

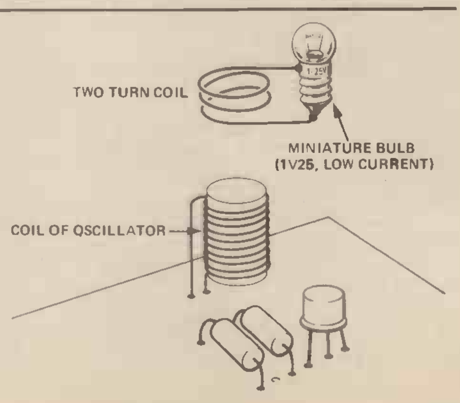
Another type of oscillator, called a Hartley after its inventor, is shown in **Figure 7**. There are several varieties of this design, all recognisable by the use of a tapped coil, and Figure 7 shows two of them. The one shown in **Figure 7 (a)** uses the tap on the coil to connect the supply line, and feedback is taken from the end of the coil opposite the collector connection. Because the collector and the base of the transistor cannot be allowed to be at the same DC voltage, a capacitor is used to couple the feedback to the base. The value of this coupling capacitor, C1, must be considerably greater than the value of capacitor C2, which is used to tune the coil. Another variety of the Hartley circuit is shown in **Figure 7(b)**, with the feedback, this time, taken to the emitter of the transistor. A resistor must be connected between the emitter and the earthline, to avoid shorting out the signal or, as an alternative, an inductor called a radio frequency choke (RFC) can be used. Resistor R1 and R2 are used to bias the transistor, so ensuring that the circuit will start oscillating when it is switched on. The capacitor, C1, is also important; it ensures that no signal reaches the base of the transistor from the collector circuit. Any signal reaching the base will kill the oscillation, so that C1 is essential — it 'decouples' the base.

One version of a circuit called a Colpitts oscillator is shown in **Figure 8**. The coil, this time, is a single winding with no



◄ Figure 5. An oscillator using a feedback coil, L2.

► Figure 6. Detecting oscillation. Unless the oscillator is a powerful one, the bulb will have to be a miniature low-voltage, low current type. These are not easily obtainable, but an LED can be substituted if more turns of the coil are used.



tapping — a convenient arrangement! The tapping is still there, though, in the form of capacitors C2 and C3. The tuning of the parallel resonant circuit is carried out by the combination of C2 and C3 in series while the signal to feed to emitter is tapped by C2 and C3 acting as a potential divider. Once again, capacitor C1 has the essential job of decoupling the base.

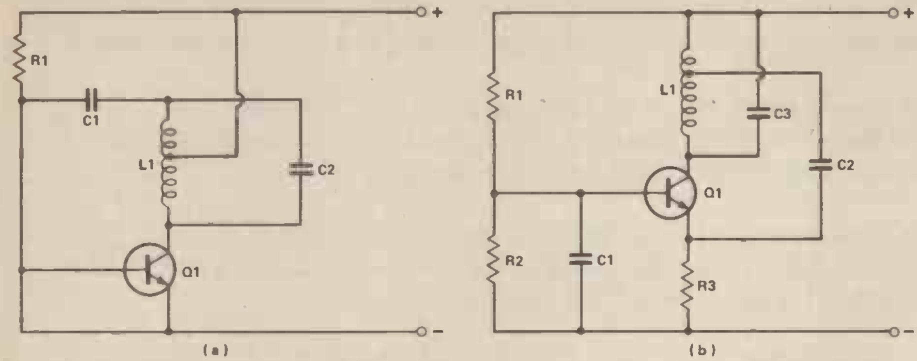


Figure 7. Two versions of the Hartley oscillator; (a) feedback to base; (b) feedback to emitter.

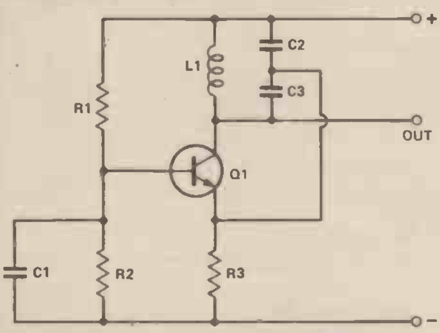


Figure 8. One version of the Colpitts oscillator.

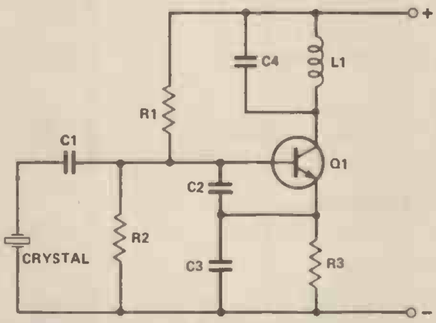


Figure 9. A crystal oscillator, one of a large number of circuits using the method of obtaining a precise and stable frequency.

Crystal Gazing

The best sinewaves, though, are shaped not be a conventional parallel resonant circuit but by a quartz crystal, connected as if it were an inductor. An example of a crystal oscillator which can generate a very precise and perfectly shaped sinewave, is shown in **Figure 9**.

It's not so difficult, then, is it? Well, no — not as long as you want high frequency oscillations, anyway. But what happens if you want low frequency oscillations — a few kHz or less? Then, inductors get large and expensive because of the large values you would need for operating these frequencies. Worse still, all that wire makes for high resistance, which causes the shape of the sinewave to distort. In fact we have to abandon parallel resonant circuits at low frequencies — but that's another story!

In radio circuits, however, the parallel resonant circuit is vital. It crops up,in one form or another, in almost every 'block' of every radio. This month, we have had a broad look at parallel tuned circuits and how they work — soon, we will get to grips with the theory, showing how to work out the resonant frequency and other important factors. Later we will go onto look at oscillator circuits in more detail, together with the other basic blocks of radio circuitry.

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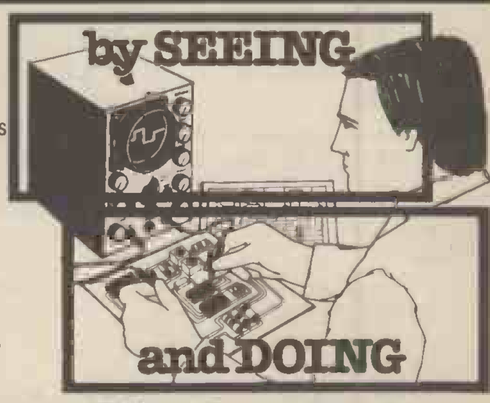

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INTO ELECTRONIC COMPONENTS

THE FIRST ICs ever made were (mainly) digital types, and by far the majority of ICs manufactured today are digital ICs. The reason is that digital signals are peculiarly suited for ICs, and it is much easier to design complex digital ICs than equally complicated linear ICs.

A digital signal is an OFF or ON signal, without any state between. A square wave is a type of digital signal, because the voltage is either at a positive or negative peak; it spends only a negligible time getting from one to the other. Now why should this be important? Imagine for a moment a transistor with a load resistor of 500R, operated from a 5V supply. Suppose that the transistor is passing no current. The power dissipated in the transistor is then zero — no current means no watts. If we now suppose that the transistor is passing about 10 mA, then its collector voltage will be low (saturated at 0V2) and the power dissipated by the transistor must also be low, only 0.2 x 10 mW or 2 mW. If we had biased the transistor to half the supply voltage, as we do when we want linear amplification, then it would pass 5 mA at 2V5 and the power dissipation would then be 5 x 2.5 mW (12.5 mW), a lot more than it dissipates at full current. In a digital IC, no transistors are biased 'half-way'; they are either fully off or fully on. In this way, each transistor dissipates only a small amount of power, so large numbers of transistors can be packed together in an IC without causing the chip to run excessively hot.

Over the years of IC development there have been many digital types produced. By types, we mean the types of *circuits* that were used, rather than the jobs that the chips performed. For example, in old books you will find references to DTL, RTL and other long-forgotten types of ICs — some of these are now so completely forgotten that it is impossible to even get pinout diagrams for them. The only types worth considering today are TTL and CMOS chips; these are the ones we shall look at this month.

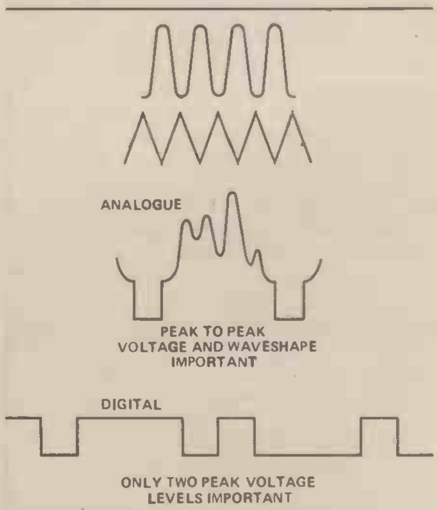


Figure 10.1 Digital and analogue signals. The difference is that the digital signals have only two important voltage levels and the voltage switches very rapidly between the two.

The most important differences between these two types of digital ICs are that TTL ICs are based on bipolar transistors (PNP and NPN types) and CMOS are based on MOSFETs, TTL has low input resistance and can pass currents of several milliamps, while CMOS has very high input resistances and can pass only small amouts of current, often less than a milliamp.

TTL Tale

TTL digital ICs are intended to operate from a 5 V stabilised supply, whose voltage must be held close to 5V at all times. Though the ICs will generally work in supply voltages as low as 4V5, correct operation cannot be guaranteed unless the supply voltage is maintained within the limits of 4V75 to 5V25. Voltages above 5V5 are risky because some TTL circuits will overheat at such levels, and most of them will be damaged if they are operated for any length of time at 6 V.

The reason for this fussiness about voltage is that the input stage of a TTL digital IC is a common-base transistor (Figure 10.2), whose base is connected to the supply voltage through a resistor of a few thousand ohms. This results in a feature of TTL circuits which many beginners find most confusing; the input of any TTL circuit is the emitter lead of a transistor. When this input is at logic level 1 (+5V for TTL), the input transistor is cut off because both base and emitter are at the same +5V level and the collector voltage is also high, around +5V. When the input emitter is connected to logic level zero, which is earth, current will flow from base to emitter. The value of the resistor which connects the base to the +5V supply ensures that the transistor is thoroughly saturated and passing enough base current to make the collector-to-emitter path a very low-resistance one. In this condition, the collector voltage is low, and a current passes from the emitter to earth. The 'standard' TTL circuit will then pass 1.6 mA from its input terminal to earth.

Unlike most transistor circuits, then, in which a current has to pass into the input when it is taken positive, the TTL input passes current *out* from its input when the input is taken to zero volts. Any circuit which is connected to the input of a TTL IC must therefore be able to pass this current — to *sink* this current, in the jargon of the TTL designers — when it forces the TTL input low. Because of this, an emitter-follower is not a good circuit for passing signals to (*driving*) a TTL IC. When the emitter-follower is cut-off, the IC current will have to pass through the emitter resistor of the emitter-follower (Figure 10.4), and the voltage across this resistor may be too high to guarantee that the IC will be at logic 0.

For example, if the IC can pass 1.6 mA, and is guaranteed to behave correctly if the logic 0 voltage is below 0V8, then an emitter-follower with a 1k emitter resistor is completely unacceptable as a driver. With 1.6 mA flowing through 1k, the voltage drop would be 1V6, which is

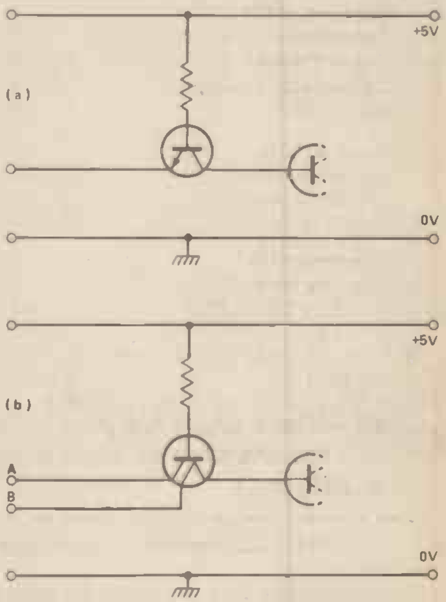


Figure 10.2 The usual TTL input stage; (a) a common-base stage; multiple emitter contacts can be formed; (b) if more than one input is needed.

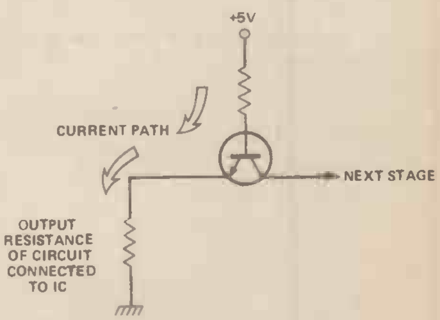


Figure 10.3 Why current passes out from Input of a TTL IC at logic 0 input.

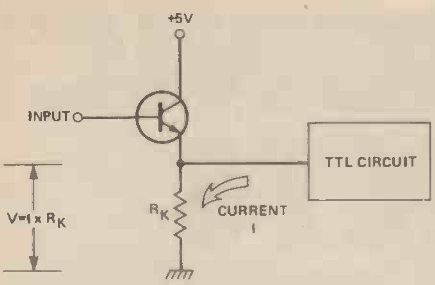


Figure 10.4 Using an emitter-follower to drive TTL is unsatisfactory.

much too high. It might work with a few ICs, but what counts is that it must work with *all* ICs.

A common-emitter circuit (**Figure 10.5**), by contrast, is very much better. With the transistor cut-off, the load resistor connected to +5V will ensure that the input of the IC goes to +5V. When the transistor is switched on, the collector-to-emitter circuit will easily pass 1.6 mA to earth, with a voltage drop of only about 0V2 if the transistor is saturated.

Digital circuits make use of TTL ICs connected together, so that we can expect to find the output of one IC connected to an input of another. This is possible only if the output of one IC can sink the input current of the next and, because the output of one IC may have to

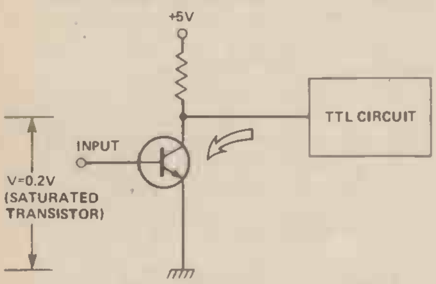


Figure 10.5 Using a common-emitter amplifier circuit to drive TTL is much better.

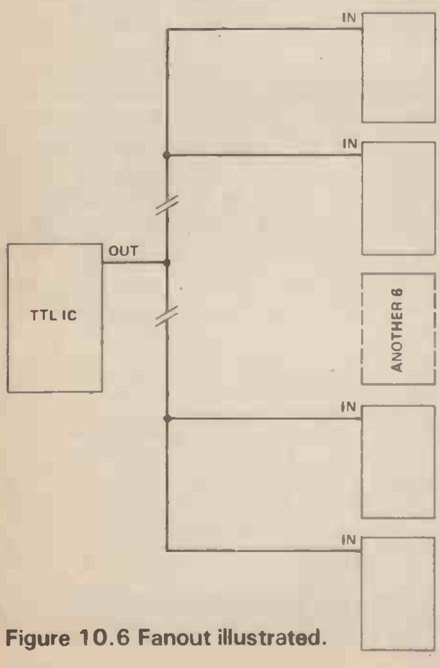


Figure 10.6 Fanout illustrated.

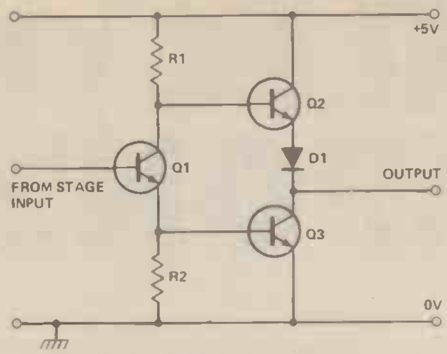


Figure 10.7 A typical TTL output stage

drive several inputs, the manufacturers usually arrange the output circuit so that it can sink the current of ten intputs. If an input needs to pass 1.6 mA, for example, the output must be able to sink a current (pass current to earth) of 16 mA if it is to drive ten inputs. This requirement is called a 'fanout of ten'.

The usual output circuit uses two transistors in series with a diode (**Figure 10.7**), directly coupled to the collector and emitter leads of a driver transistor. First, imagine that the base of the driver transistor Q1 is cut-off. This will make the emitter voltage zero and the collector voltage high, so that current will pass through R1 into the base of Q2, which passes current. This makes the output voltage high, though, because of the 0V6 difference between base voltage and emitter voltage of Q2, The emitter voltage of Q2 cannot rise above 4V4 which is 0V6 below 5V; the output voltage cannot rise above about 3V8 because of the 0V6 drop across diode D1.

Now, say the base voltage of Q1 is raised, so it is saturated. The collector voltage will be low, and the emitter voltage will rise, until Q3 is switched on. Because the base of Q3 is connected directly to the emitter of Q1, the emitter voltage will not be able to rise higher than 0V6, and the collector voltage only will be about 0V2 higher, at about 0V8. This would, normally, be enough to switch Q2 on, but the diode D1 prevents this (a silicon diode needs about 0V6 to conduct) so that the base voltage of Q2 would have to be at least 1V2 above zero to make Q2 conduct. Therefore, Q3 conducts and this will make the voltage at the output about 0V2, well within the guranteed voltage for a zero logic level.

The low voltage is really important, because it is only the low voltage which allows the input to pass current, which the output will have to sink. Because all of the transistors in the chip are made at the same time, and are therefore similar, the circuit can also pass current out from the output when the output voltage is high, around 3V8. This voltage cannot be guaranteed by the manufacturers, however, because if a lot of current is passed, the high voltage can fall quite noticeably, to less than 3V. For experimental purposes, though, there is no objection to using an output to drive an LED like the circuit of **Figure 10.8** (the recommended method is to use an additional IC, an inverter, in the circuit of **Figure 10.9**).

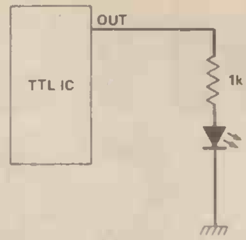


Figure 10.8 Using a TTL output to operate an LED — simple method.

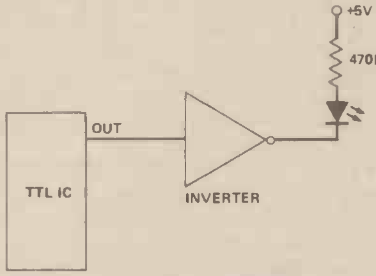


Figure 10.9 The recommended circuit for driving LEDs.

This business of guaranteed voltage levels is important, because it affects trouble-shooting measurements. You cannot expect to read +5 V as the high voltage at an output unless there is a resistor, called a 'pull-up' resistor, connected between the output and the +5V supply line. Neither can you expect to find a true zero reading at an output which is driving several inputs because there may be enough current flowing to raise the voltage to more than 0V2. What you can expect, though, is that the voltage in the high state, logic 1, will be above the manufacturer's guaranteed level (usually 2V4) and that the voltage in the low state will be below the manufacturer's guaranteed level (0V4 typically).

Identity Crisis

There are several variations of TTL circuits which are still with us. The original range of TTL circuits, pioneered by Texas Instruments and also manufactured by many other suppliers, used code numbers starting with 74. These ICs employed the techniques described in this article, with input currents of 1.6 mA and output sinking capability of 16 mA, so that a fanout of ten could be achieved. For some computer applications, the speed of switching of standard TTL circuits, which is around 30 nanoseconds, is too slow, so a (smaller) range of high-speed TTL circuits, the 'S' series was manufactured. These used higher currents flowing inside the chips to achieve higher switching speeds. The chips carried numbers starting with 74S, so that a 7408 was a stan-

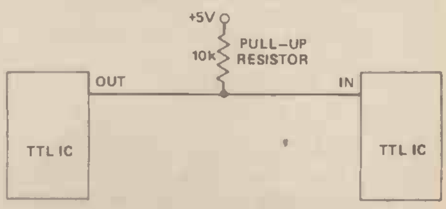


Figure 10.10 Using a pull-up resistor to ensure the logic 1 voltage.

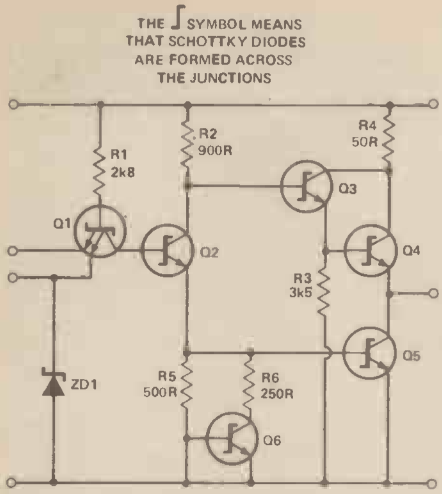


Figure 10.11 The equivalent circuit of an LS type of TTL gate, using Schottky diodes, which have a very low forward voltage drop.

dard AND gate and the 74S08 would be a high-speed AND gate.

Later on, a new principle, the low-power Schottky circuit, was used to make a range of TTL-type circuits which combined lower currents with high-speed operation. These were distinguished by the 74LS type numbers, and are now the main type of TTL ICs. The 74L S series use input currents of 0.4 mA and output currents of only 4 mA for the same fanout of ten, but are as fast or faster than the standard range. The standard 74 range is now, in fact, no longer produced for new equipment, though stocks should last for some time to come.

Gather No MOS?

CMOS ICs use MOSFETs, with entirely different circuitry. The circuits contain both N-channel and P-channel MOSFETs, arranged so that only one of the pair is ever turned on at a particular time. The range of power supply voltages that can be used is much more flexible than the TTL +5V — in general CMOS circuits can operate with supplies in the range 3V to 15V. Practically no current is needed to hold the inputs at either voltage level, high or low, and only very small currents can be passed either out from, or into, the outputs. Most CMOS circuits which we see here are from the RCA series, bearing serial numbers from 4000 upwards, but National Semiconductor manufacture a range with type numbers starting with 74C and which, very usefully, follow the same numbering system as TTL, so that a 74C08 is a CMOS version of the 74LS08.

Early CMOS chips suffered from a reputation for being easily damaged by static and users were recommended to take remarkable precautions such as being chained to a metal bench, with wrist straps, to ensure discharging of static. Nowadays, CMOS ICs can be handled with few special precautions (unless you work in a room where static is a problem). One of these is that CMOS chips should never be plugged into or removed from a circuit which is switched on. Another is that an earthed soldering iron should always be used — never use an iron which is not earthed, in any case!

By keeping any CMOS chip in its packing until ready for use, using holders and plugging in the chip only when the circuit is nearly complete — and with the +ve and −ve leads of the board shorted — you should have no problems. The most important thing is that CMOS chips should be the last items put on the board and that each input should have a resistor connected either to earth or to the +ve supply line.

When you take a quick look at CMOS and TTL, you might find it difficult to see why CMOS has not completely superseded TTL. CMOS can, after all, use a much greater range of power supply voltages and pass much lower currents so that battery-operated circuits can be designed. What makes the difference is that a lot of circuits still require very fast operating times, so CMOS circuits do not generally find much application in computing or in digital control equipment where speed is important. For most home-constructed circuits, however, CMOS ICs or similar (PMOS, NMOS) are more likely to be sed.

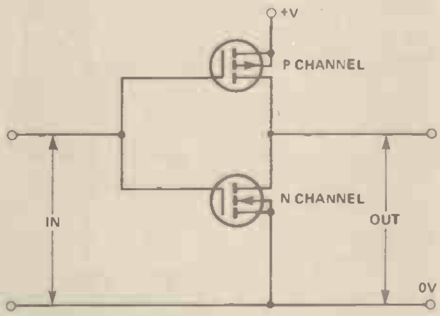


Figure 10.12 Circuit of a CMOS inverter, which uses both P− and N−channel MOSFETs.

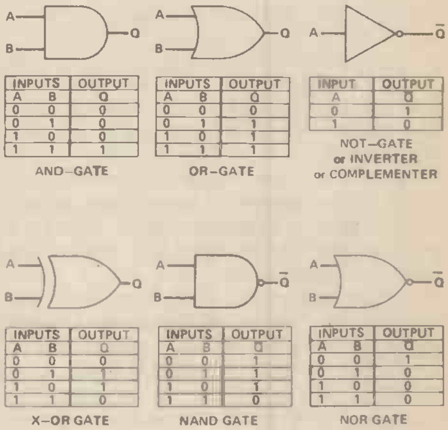
Open And Shut Case?

We've called this series Into Electronic Components and we've tried to stick to components, and what they do, rather than become involved in circuit theory. Digital ICs, however, can't easily be separated from circuitry because each digital IC is itself a complete circuit. So, we now have to spend some time on the types of circuits built in to digital ICs, whether TTL or CMOS.

All digital ICs can be grouped into two types: combinational or sequential. The difference between the types is important. Combinational circuits have several inputs and one output, and each combination of inputs will give pre-determined output. For example, a chip which has two inputs can have four possible sets of input voltages; these are 0,0 ; 0,1 ; 1,0 ; and 1,1 (where 1 means high voltage and 0 means low voltage). For each set of inputs there will be a definite output voltage (0 or 1) and that chip can never produce any other result. The simplest combinational circuits are 'gates' and the easiest way of summarising their action is by using what are called 'truth tables'. A truth table is just a list of all the possible inputs to the gate, along with the output voltage (0 or 1) that is produced by each set of inputs. Different types of gates have different truth tables, and the types that are avialable in IC form are the AND, OR, NOT, X-OR (Exclusive-OR) NAND (NOT-AND) and NOR (NOT-OR). Their symbols and truth tables, for two-input gates, are shown in Figure 10.14.

GENERAL COMPARISONS	TTL	CMOS
Supply Voltage	4V75–5V25	4V-12V
Fanout	10 max.	50 or more
Operating Temperature	0 to 70 deg.C	-40 to 80 deg.C
COMPARING 4–INPUT NAND GATES		
Input Current	40 uA (1),1.6 mA (0)	10 pA
Output Current (max)	30 mA	0.25 mA
Switching Time	11 nS	300 nS

Figure 10.13 CMOS and TTL compared.



AND–GATE

INPUTS		OUTPUT
A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

OR–GATE

INPUTS		OUTPUT
A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

NOT–GATE or INVERTER or COMPLEMENTER

INPUT	OUTPUT
A	$\bar{Q}$
0	1
1	0

X–OR GATE

INPUTS		OUTPUT
A	B	Q
0	0	0
0	1	1
1	0	1
1	1	0

NAND GATE

INPUTS		OUTPUT
A	B	$\bar{Q}$
0	0	1
0	1	1
1	0	1
1	1	0

NOR GATE

INPUTS		OUTPUT
A	B	$\bar{Q}$
0	0	1
0	1	0
1	0	0
1	1	0

Figure 10.14 Symbols and truth tables for gates.

It would be possible to build any type of gate circuit using only NAND or only NOR gates, but simpler circuits can usually be achieved by using the full range of gates though designers often prefer to make use of one type of gate as much as possible, just to simplify the parts list for a circuit.

A circuit for checking the action of logic gates is shown in Figure 10.15. The gate is placed on the Eurobreadboard and LEDs, along with current-limiting 1k resistors are used to monitor the output (or outputs). The inputs are provided by DIL changeover switches, obtainable from Electrovalue and other suppliers. The switches must be wired so that the inputs of the gate are always connected either to 1 or 0; inputs should never be left 'floating', ie unconnected.

When several gates are connected, the truth table can be worked out trying all the combinations of inputs and observing the outputs (taking a lit LED as logic 1), as outlined above. The alternative is to draw

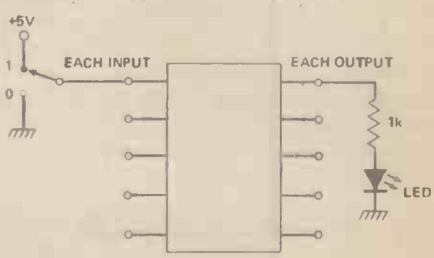


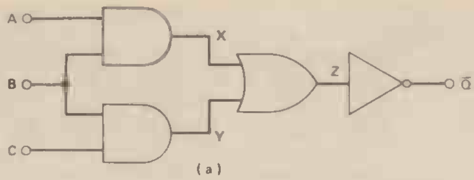
Figure 10.15 Checking the action of a gate or gate circuit by finding its truth table experimentally

an extended truth table (Figure 10.16). Each connecting line from an output to another input is labelled with a letter and the outputs of the first set of gates are then entered into the truth table. The next set of gates can then be treated, using the outputs of the first lot as inputs to the second, and so on until all the columns of the truth table have been filled in.

The other type of digital circuit is the sequential circuit, in which the *sequence* of inputs determines the output, rather than the combination of inputs. A counting flip-flop is a typical sequential circuit, and a sequence table for such a flip-flop is shown in **Figure 10.17**. The input consists of pulses which, in this example, are at regular intervals, qualifying for the name 'clock' pulses. The output of the circuit switches over for each clock pulse, so that one pulse will switch the output from 0 to 1, the next will switch it from 1 to 0. The action is rather like a 'push-on-push-off' light switch.

There is another type of flip-flop, the latching flip-flop, which uses the clock pulse to 'transfer' an input to the output terminals. Looking at a typical example of this type, **Figure 10.18**, the voltage at the output is made equal to the voltage at the input on each clock pulse and is kept at the value until the next clock pulse arrives. All sequential circuits are based on flip-flops, just as all combinational circuits are based on gates.

Next month we move on from active components and take a look at transducers — devices for transforming other forms of energy into electrical signals.



(a)

A	B	C	X	Y	Z	Q
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

(b)

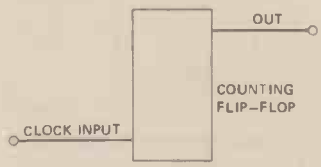
A	B	C	X	Y	Z	Q
0	0	0	0	0		
0	0	1	0	0		
0	1	0	0	0		
0	1	1	0	1		
1	0	0	0	0		
1	0	1	0	0		
1	1	0	1	0		
1	1	1	1	1		

(c)

A	B	C	X	Y	Z	Q
0	0	0	0	0	0	1
0	0	1	0	0	0	1
0	1	0	0	0	0	1
0	1	1	0	1	1	0
1	0	0	0	0	0	1
1	0	1	0	0	0	1
1	1	0	1	0	1	0
1	1	1	1	1	1	0

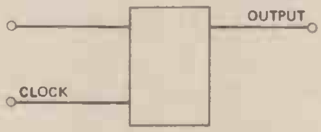
(d)

Figure 10.16 Finding the truth table of a gate circuit by paperwork; (a) circuit; (b-d) stages in filling in truth table.

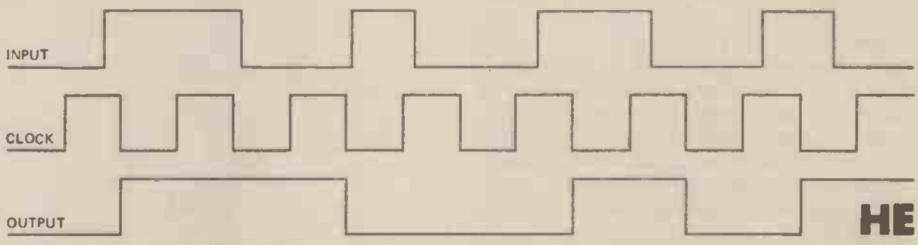


IN	OUT
0	0
1	0
0	1
1	1
0	0
1	0
0	1

Figure 10.17 A sequence table for ▶ counting flip-flop.



◀ Figure 10.18 The action of the edge triggered latching flip-flop. The output changes only when the trailing edge of the clock pulse arrives, in this example.



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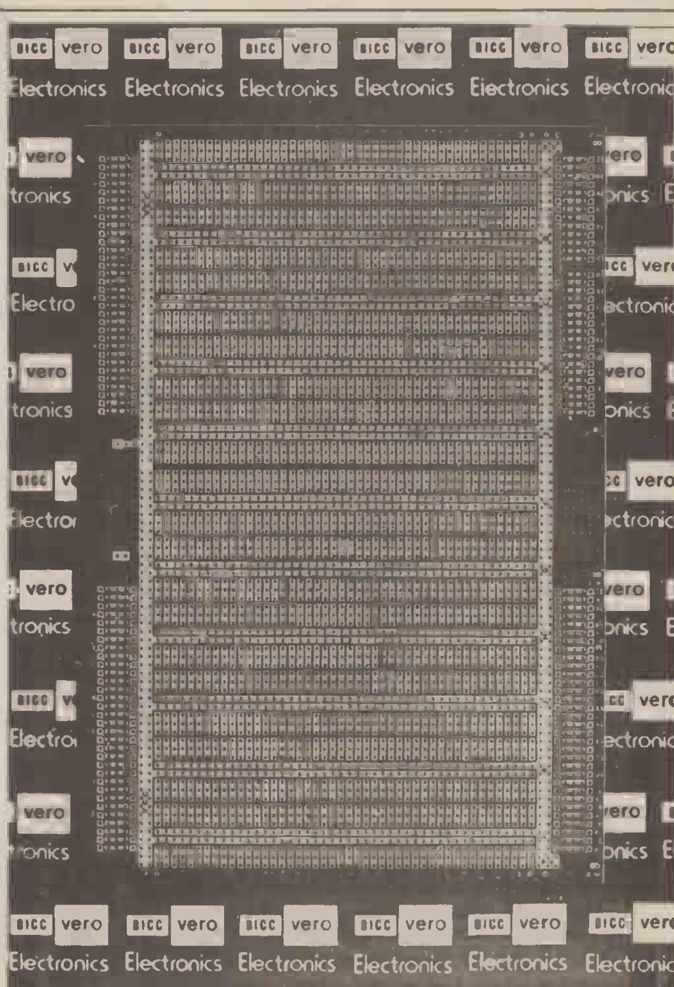


Cable Tracker

A D-I-Y Useful

THIS nifty little project is a must for the handyman — even if your Do-It-Yourself experience is limited to the occasional shelf! Our Cable Tracker will detect not only cables, but also pipes and nails buried in wood, thus saving the extra work — and expense — that would result if you should accidentally drill into a central heating or water pipe. Safety is another important aspect of this project, as it will allow you to avoid live cables and gas pipes. Have you ever cut into a piece of wood with a saw and struck a hidden nail? Not much good for the blade, is it! Well, the HE Cable Tracker will also detect nails in wood, to a depth of at least 1 cm.

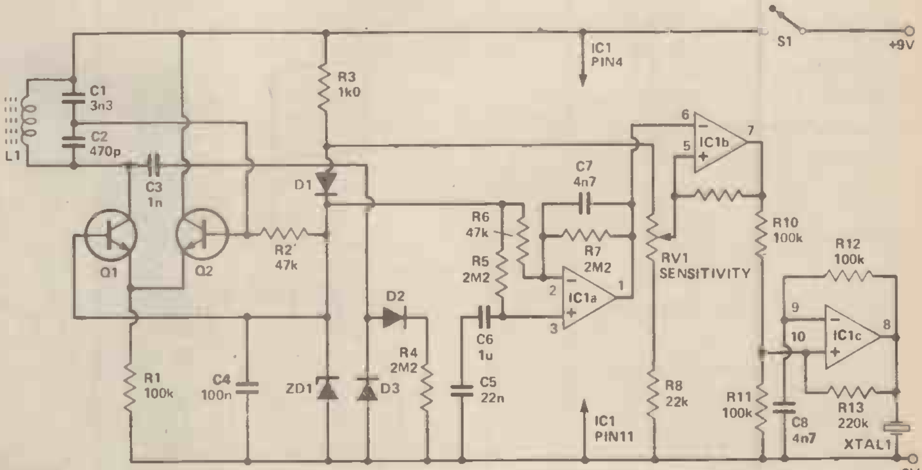
The Cable Tracker is very simple to use — just run it over the wall, about 1 cm from the surface, where you suspect there may be a hidden pipe or cable. We have used an audible output to indicate the presence of metal, which allows you to watch where you're going, rather than having to look at the Tracker.

The Circuit

Transistors Q1 and Q2 are connected in an oscillator circuit using L1, C1 and C2 as a high 'Q' tuned circuit resonant at 100 kHz. A high 'Q' circuit is very efficient, producing a generous output at one specific frequency. If even a small piece of metal is brought close to the search coil (L1), however, the inductance of the coil will be altered, reducing the 'Q' of the circuit and hence its output voltage. This change in voltage is detected by the remainder of the circuit.

The oscillator output is full-wave rectified by D2, 3, producing a steady DC voltage across C5. This voltage is AC coupled (so only sudden changes in the DC level will be passed) via C6 to the non-inverting (+) input of IC1a. The inverting input is held at a fixed level by ZD1, R5 and R6 and, provided the voltage across C5 remains constant, the output of IC1a is held at 3V9.

If the oscillator output falls, though, the change is amplified by IC1a and passed to the inverting input of IC1b, which is wired as a comparator. It compares the voltage at the inverting input with a reference voltage, from the sensitivity preset PR1. When the output from IC1a drops below this preset level, IC1b output goes high and switches on the audio oscillator, IC1c. This drives the piezo transducer with a frequency of a few kHz, giving an audible warning that metal is present near the detector head.



NOTES
Q1,Q2 ARE BC183
D1,D2,D3 ARE 1N4148
ZD1 IS BZY88C3V9
L1 SEE PARTS LIST
XTAL1 IS PIEZO TRANSDUCER
IC1 IS TL064

Figure 1. The Cable Tracker circuit diagram.

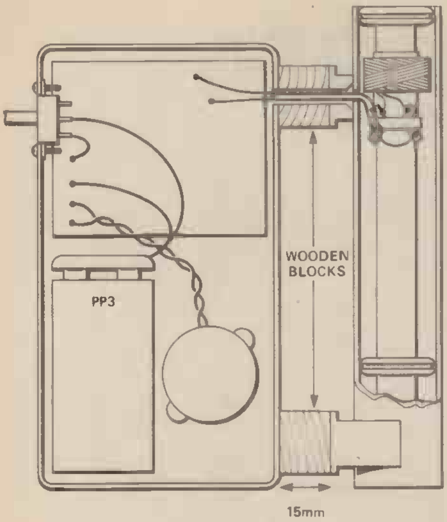
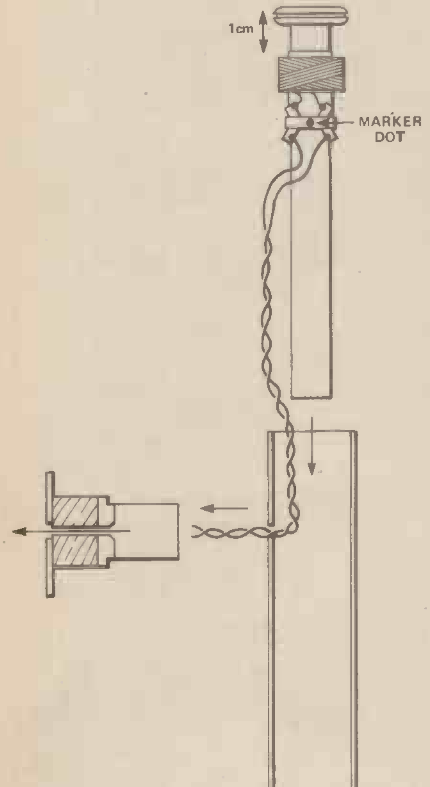


Figure 2 (above). Fitting the pipe in to the clips.

Figure 3 (below). Assembling the detector head. Don't forget to thread the wires through the hole in the pipe, then into the case. Grommets are used to seal both ends of the pipe, as shown.



Construction

Assembly of the Cable Tracker is simplified by the use of a printed circuit board and a ready-wound coil.

Start with the 'detector head'. Using a suitable adhesive, stick the clips to the wooden blocks and drill a hole (about 5 mm) through one of the clip/block assemblies. Position the pipe in the clips, as shown in **Figure 2**, and drill through the pipe, using the previously drilled hole as a guide. Now take the pipe out of the clips and glue the block/clip assemblies in position on the case — take care to put the one with the hole in it at the top, as shown. When the glue has set, drill through the case, again using the pre-drilled hole as a guide.

Other holes must be drilled near the resonator, to allow the sound out, and for the on/off switch. Remember to leave plenty of room below the switch for the assembled PCB.

Tape the coil in position on the ferrite rod, about 1 cm along from the end, with the coil tabs towards the centre of the rod. Solder two 150 mm lengths of wire to the coil and put a grommet on the 'coil end' of the ferrite rod to seal it into the pipe. Twist the coil wires together and push the ferrite rod down the pipe, at the same time threading the wires through the hole in the pipe as shown in **Figure 3**. Push the pipe into its mounting clips, remembering to thread the wires through the pipe clip into the case. Fitting the second grommet needs patience; lubricate it with washing-up liquid and gently push it into place using a screwdriver.

Next the PCB is assembled with the help of the PCB overlay, **Figure 4**. Start by soldering the terminal pins for the coil connections. Insert the resistors round and solder into place, then solder all the capacitors — all types in *this* circuit can go either way round. The preset may also be soldered in place. Take care to insert and solder the diodes (the broad band is the cathcode end) and transistors the correct way round. Solder the IC socket with pin number 1 in the correct place, but leave out the IC until later.

Now solder the following; the black lead (-ve) of the battery clip, the leads from the resonator and a length of wire ready to go to the switch. The PCB can now be fastened to the bottom of the case, using small pieces of double-sided adhesive tape. The ceramic resonator and battery can also be taped to the case — these are a snug fit, so position them carefully before fixing. The battery must also be fixed in position, to avoid interference with the detection circuit.

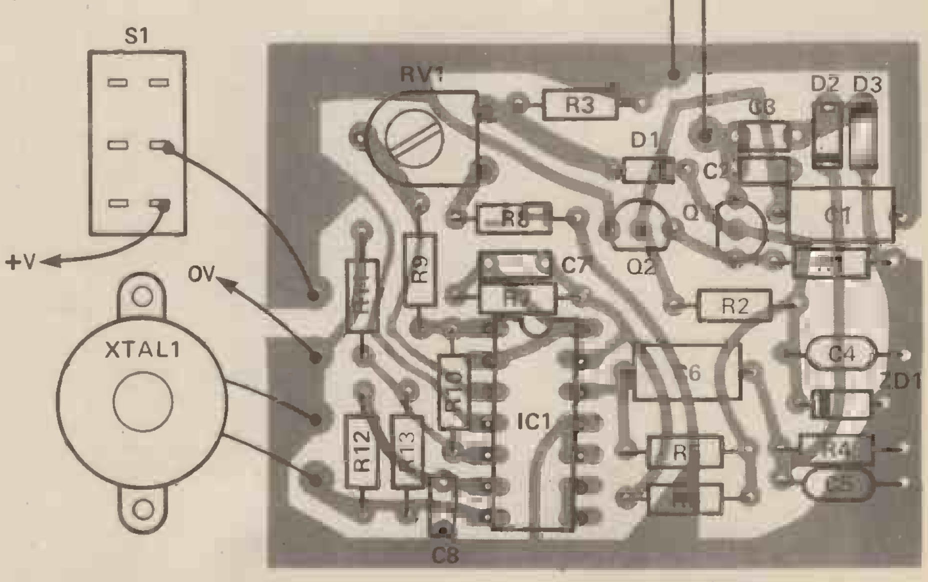
Fix the switch and solder the lead from the PCB, and the red lead from the battery clip, to it. Finally, solder the leads from the coil to the terminal pins on the PCB. The IC can now be inserted — take care, it must be the right way round.

Setting Up

Connect the battery and move to an area away from the metal — this includes your watch and rings! Switch on; the circuit adjusts its sensitivity after switch on, so wait for approximately 10 seconds. Using a non-metallic trim tool, turn the preset clockwise until a bleep sounds, then turn it back approximately 1/8th turn — this is the most sensitive position, but if you are using the tracker to find large objects you can lower the sensitivity. To use the tracker, hold the box and pass the detector tube over the wall. The optimum distance is about 1 cm away. Note that a very damp wall will interfere with the detection circuit.

Now you can put up your shelves or pictures — with the confidence that you will not need to rewire or replumb!

Figure 4. The PCB component overlay. The foil pattern is reproduced on page 72.



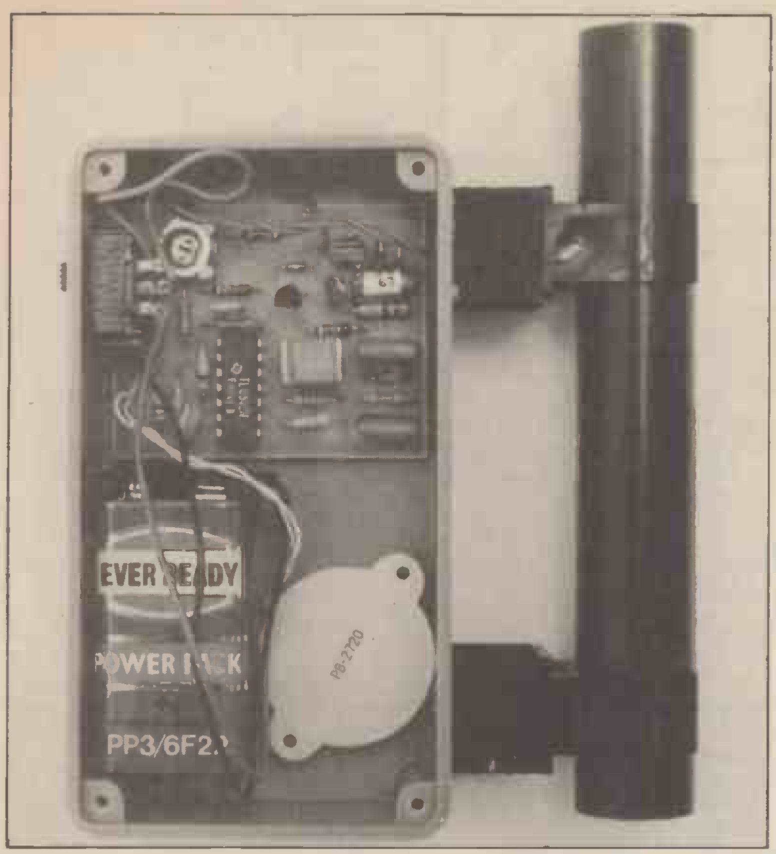
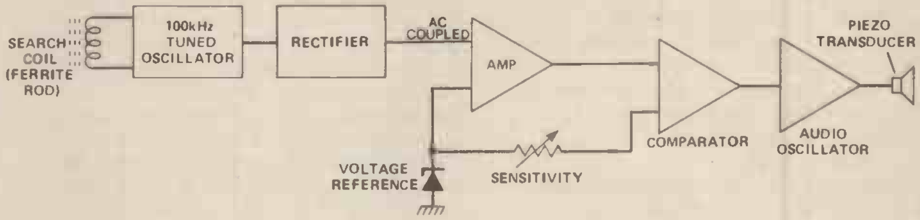


Figure 5 (above). End view of the pipe, with grommet in place.

Figure 6 (left). Internal view of the completed Cable Tracker.

How It Works

The circuit for the HE Cable Tracker can be divided into six basic blocks (see diagram). The detector part of the circuit consists of a tuned oscillator; when even a small piece of metal is brought near the search coil, the output from the oscillator falls significantly. This change is amplified and compared with a preset reference level, set by the sensitivity control. The comparator detects any sudden change in the output of the oscillator and will switch on the audio oscillator, which drives the transducer.



Parts List

RESISTORS
(All ¼ watt carbon film 5%)
R2 R6 . . . . 47k
R3 . . . . 1k
R4, 5, 7, 9 . . . . 2M2
R8 . . . . 22k
R1, 10, 11, 12 . . . . 100k
R13 . . . . 220k

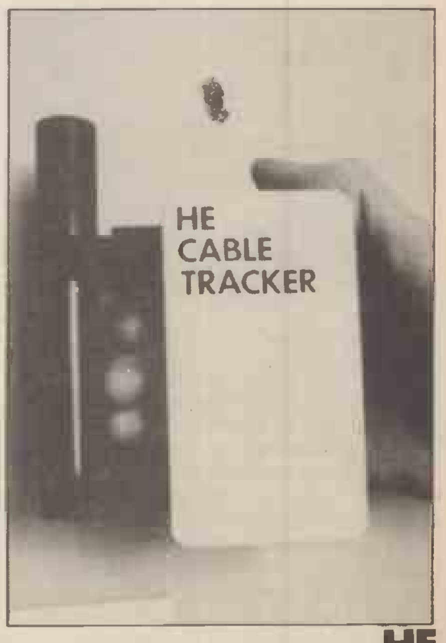
POTENTIOMETERS
RV1 . . . . . . 22k min horizontal preset

CAPACITORS
C1 . . . . 3n3 polystyrene 63 V
C2 . . . . 470p ceramic (low temperature coeff) or polystyrene
C3 . . . . 1n ceramic
C4 . . . . 100n C280 polyester
C5 . . . . 22n C280 polyester
C6 . . . . 1u multilayer min polyester (100 V)
C7, 8 . . . . 4n7 ceramic

SEMICONDUCTORS
Q1, Q2 . . . . . BC183 NPN transistors
D1, 2, 3 . . . . . 1N4148 signal diodes
ZD1 . . . . . BZY88C 3V9 zener diode
IC1 . . . . TL064CN quad BIFET op-amp
X1 . . . . Piezo sounder (ceramic transducer)
S1 . . . . min. slide switch SPST

MISCELLANEOUS
L1 . . . . 100 mm x 9.5 mm dia ferrite rod with long wave coil type CTL
Printed circuit board; plastic case; plastic pipe & clips; wood, grommets, and wire. 14 pin dil socket. PP3 battery clip.

BUYLINES . . . . page 68



HE

BUYLINES

A Digital Thermometer

THERE ARE two things to note about the thermometer project; first, it uses two separate boards and, second, if you buy our recommended case everything fits inside *exactly*. So, you will have to cut and shape the boards carefully and also make sure you mount them as shown in the diagrams.

The components are spaced on the main PCB to ensure that the temperature around the sensor (IC1) is not influenced by any of them — wiring it off the board is even better. This component will probably be the most difficult to obtain, but you can get it from **Crewe Allan & Co. Ltd.**, of 51, Scrutton St., London.

The CMOS ICs (including the 7555) can be bought from **Technomatic** along with the seven-segment displays. You will generally find that Technomatic can supply most of the semiconductors used in our projects. So, if you want to save on postage you know where to go!

Another source for semiconductors, and some hardware items, is **Watford Electronics**. They stock the ZTX300 transistors and the low voltage Zener diode; you will also find a range of suitable presets in their catalogue.

The only other parts that might be hard to buy are all available direct from **BICC-Vero**. They make and supply the case with battery compartment, the two-digit LED bezel and the Veropins. If you want further details of any of their products, just drop them a line (enclosing an SAE).

The cost of components (excluding case, PCBs and the optional bezel) should be under £13.

Light Seeker

THE Light Seeker is probably one of the simplest, yet most versatile quick projects, we've ever run. None of the component values are particularly critical, since oscillation occurs readily. Make sure you put the transistors in the right way round, though — they only work when base 1 is feeding the load. These unijunction transistors seem to be going out of fashion, sad to say, but they can still be bought from **Electrovalue** (T1S43) in their catalogue), who also sell the 64 ohm speaker — don't use a lower impedance, as the transistors will overheat.

The light-dependent resistor is available from **Maplin**. We used the ORP61 with a side-on sensitive element, though the ORP60 will work just as well.

Due to the large tolerance of electrolytic capacitors, it may be worth buying a pack of ten, say, and choosing the one which gives a nice even 'warble'. A good bargain on these commonly used capacitors can be obtained from **Delta Tech & Co. Ltd.**, of 82, Naylor Road, London N20 OHN.

The cost of this Quick Project is around £4.

Signal Generator

THIS DESIGN must be one of the easiest signal generator circuits around, for the quality. It uses only a single IC! Most of the cost is in the switches and controls and the only hard-to-obtain component is the thermistor (RA53), which is sold by **Maplin**, or **Watford's** R53 type is a suitable equivalent.

The heart of the project, IC1 (TDA2006), is available from **Technomatic**, where you can also get the rotary switches (they call them wafer switches).

The resistors and potentiometers can be purchased from **Watford** or **Electrovalue**, who will be able to supply all the capacitors between them.

The case used on our prototype was a plastic type with a single metal panel on the top. This was used because of its neat appearance, but any small case can be used. A glance through the **West Hyde** catalogue will give you some idea of the wide range available.

The cost of this project, complete, is about £7, depending on which case you choose.

Echo-Reverb

THE HE Echo-Reverb is a single PCB project, making construction straightforward if you follow the instructions in the article carefully. The only component requiring special handling is the 4046 CMOS IC. Luckily, they are quite easy to obtain should you have to replace one.

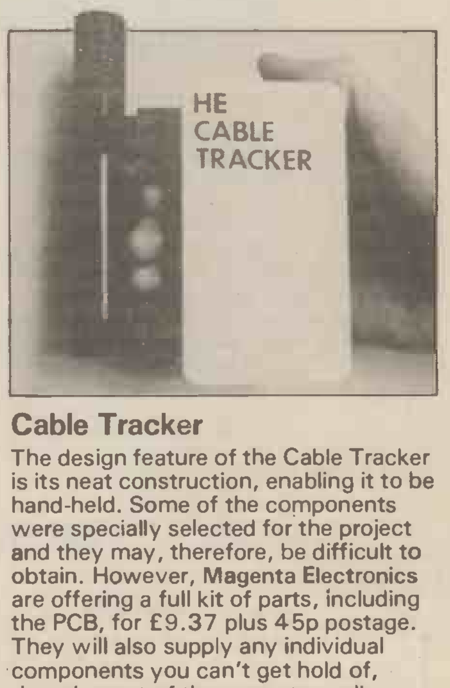
The remaining semiconductors are quite a mixed bunch, but not unusual. The voltage regulator, bridge rectifier and signal diodes are stocked by **Watford**, who are also one source for the PCB mounting transformer. If you happen to get a type that doesn't fit our board, it is sometimes possible to change the position of the tags — but be careful you don't break the thin wires from the primary windings.

The delay line ICs (TDA1022) are quite expensive and it's worth shopping around a bit for the cheapest. **Rapid Electronics** offer them at a reasonable price, with the added bonus of a quick turn around for mail order customers.

The 1000 microfarad capacitor, though not an unusual component, will have to be chosen to fit on the PCB. **Electrovalue** supply the correct size capacitor, as well as the others in the project.

Most of the hardware and switches,etc are to be found in the **Bi-Pak** catalogue, along with a good selection of knobs and the pots that go with them.

We used quite an expensive case for the prototype, to give it a professional finish. It also provided the necessary screening, being a totally enclosed metal box. A suitable alternative may be found in the range of instrument cases offered by **BICC-Vero**. If you leave out the case in estimating your total outlay, it should come to around £24.



Cable Tracker

The design feature of the Cable Tracker is its neat construction, enabling it to be hand-held. Some of the components were specially selected for the project and they may, therefore, be difficult to obtain. However, **Magenta Electronics** are offering a full kit of parts, including the PCB, for £9.37 plus 45p postage. They will also supply any individual components you can't get hold of, though most of them are generally available from mail order suppliers.

A good bet for the capacitors is always **Electrovalue**, but you must ensure that low temperature coefficient types are used where specified; an alternative to this is to use polystyrene types.

The semiconductors, including the transistors, diodes and IC, are available from **Watford**, **Rapid** or **Technomatic**.

This leaves the piezo transducer and the coil. Both these items were specially selected for the circuit, however, the transducer can be replaced with any device of high impedance (a few kilohms or so) and the coil can be any long wave type, though you may lose some sensitivity. **HE**

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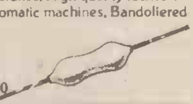

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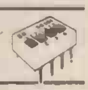

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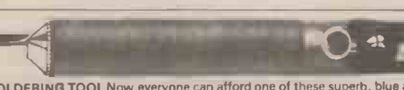

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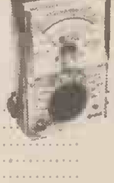

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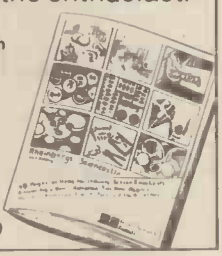

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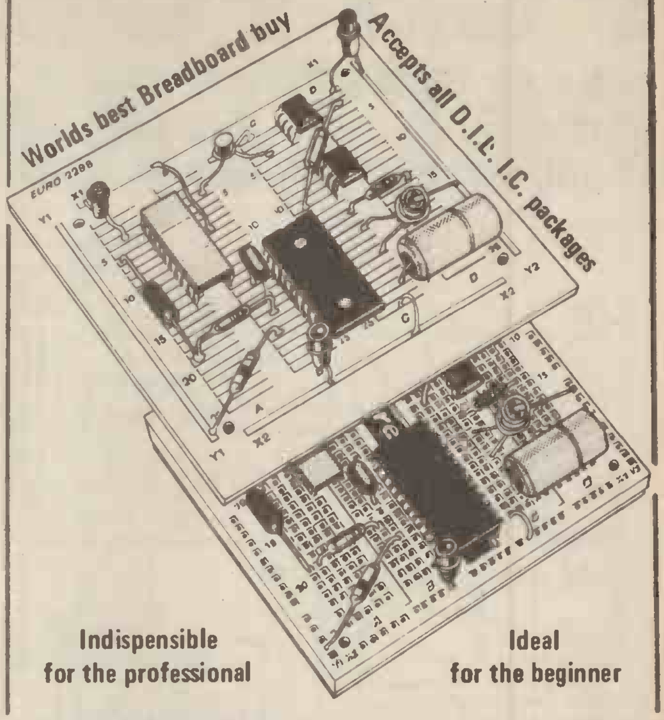

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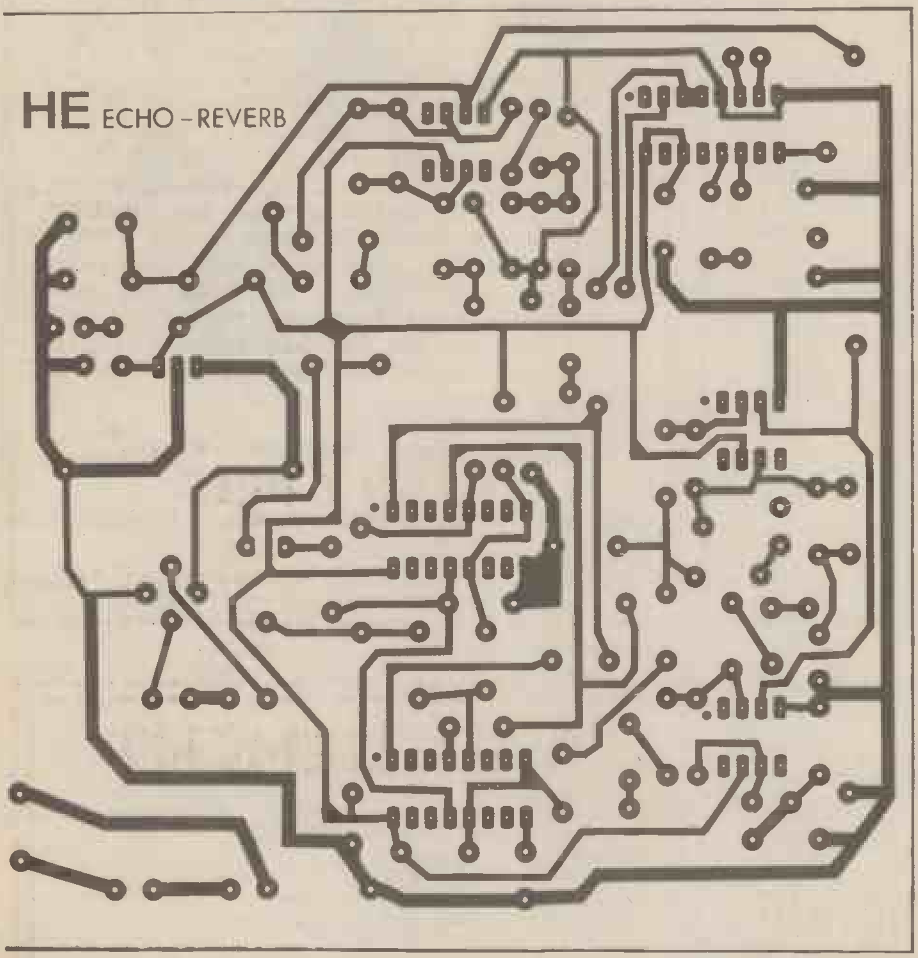
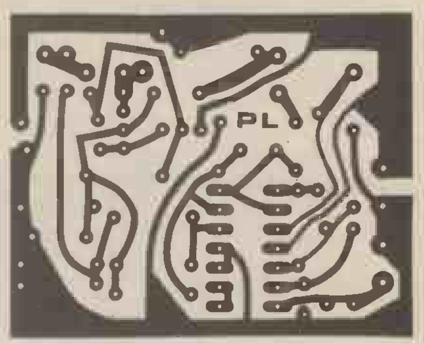
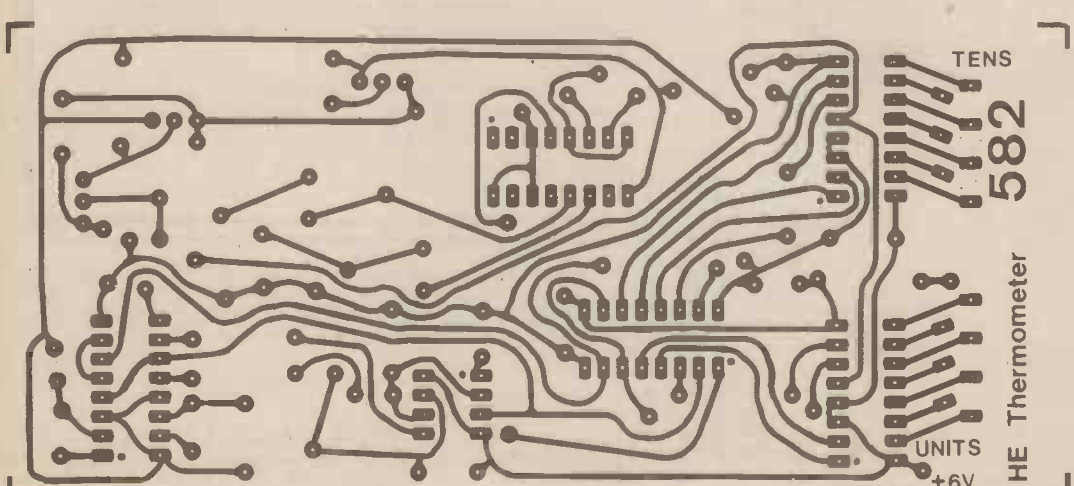


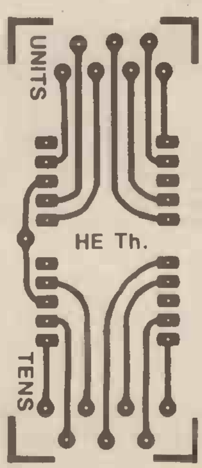


Above: PCB foil pattern for the HE Cable Tracker; don't forget to drill the three lead-out holes on the left.

Left: The HE Echo-Reverb PCB foil pattern. This board will take the mains voltage inputs at the bottom left, so make sure all the copper is etched away. The tracks contain sharp angles at some places — be careful to check these have not been dissolved by the ferric chloride.

Below: The two foil patterns for the Digital Thermometer. Some of the tracks on this board run quite close together, so make a thorough check of the underside before switching on! The main board fits snugly inside the case and must be made to fit — the small board's width must also be controlled, as there is a limited gap beneath the top of the case.





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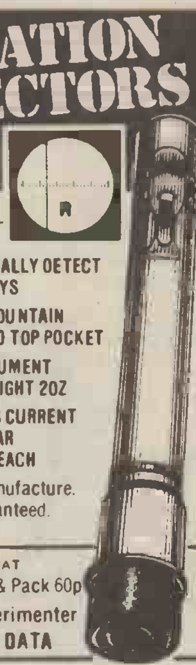

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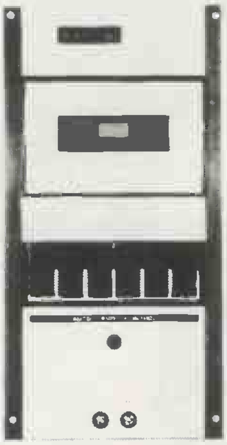

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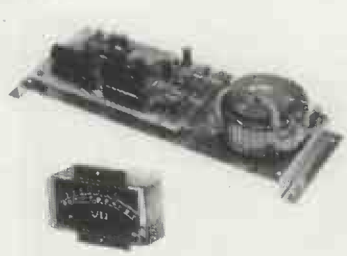
8" 50 watt R.M.S. Impedance 8 ohms, 20 oz. 1½" aluminium voice coil, Resonant Frequency 40Hz, Frequency Response to 6KHz, Sensitivity 92dB. Also available with black cone fitted with black metal protective grill. **Price: White cone £8.90 each. Black cone/grill £9.50 each. P & P £1.25 each.**

OMP POWER AMPLIFIER MODULES

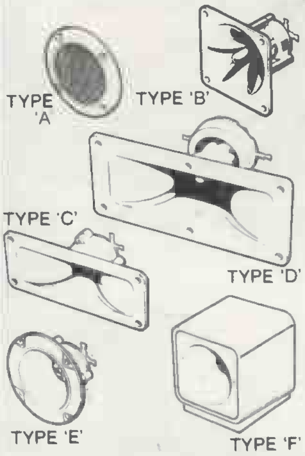


Vu Meter

100 WATT R.M.S.
Power Amplifier Modules with integral toroidal transformer power supply and heat sink. Supplied as one **complete** built and tested unit. Can be fitted in minutes. Auxilliary stabilised supply and drive circuit incorporated to power an L.E.D. V.u. meter, available as an optional extra.
SPECIFICATION:
Max. output power 100 watts R.M.S. (OMP100)
Loads: (Open and short circuit proof) 4-16 ohms
Frequency Response 20Hz-25KHz ± 3dB
Sensitivity for 100 watts 500mV at 10K
T.H.D. 00.1%
Size: 360 × 115 × 80mm
Prices: OMP 100W £29.99 £2.00 P&P
V.u. Meter £6.50

PIEZO ELECTRIC TWEETERS – MOTOROLA

Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). **FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER.**



TYPE 'A' (KSN2036A) 3" round with protective wire mesh, ideal for bookshelf and medium sized Hi-fi speakers. **Price £3.45 each.**

TYPE 'B' (KSN1005A) 3½" super horn. For general purpose speakers, disco and P.A. systems etc. **Price £4.35 each.**

TYPE 'C' (KSN6016A) 2" × 5" wide dispersion horn. For quality Hi-fi systems and quality discos etc. **Price £5.45 each.**

TYPE 'D' (KSN1025A) 2" × 6" wide dispersion horn. Upper frequency response retained extending down to mid range (2KHz). Suitable for high quality Hi-fi systems and quality discos. **Price £6.90 each.**

TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-fi monitor systems etc. **Price £4.35 each.**

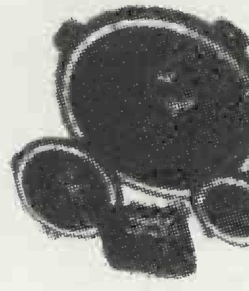
TYPE 'F' (KSN1057A) Cased version of type 'E'. Free standing satellite tweeter. Perfect add on tweeter for conventional loudspeaker systems. **Price £10.75 each.**
U.K. post free (or SAE for Piezo leaflets).

Matching 3-way loudspeakers and crossover

Build a quality 60watt RMS system 8ohms

Build a quality 60 watt R.M.S. system.

★ 10" Woofer
★ 3" Tweeter
★ 5" Mid Range
★ 3-way crossover



Fitted with attractive cast aluminium fixing escutcheons and mesh protective grills which are removable enabling a unique choice of cabinet styling. Can be mounted directly on to baffle with or without conventional speaker fabrics. All three units have aluminium centre domes and rolled foam surround. Crossover combines spring-loaded loudspeaker terminals and recessed mounting panel.
Price £22.00 per kit + £2.50 postage and packing. Available separately, prices on request.

12" 80 watt R.M.S. loudspeaker.
A superb general purpose twin cone loudspeaker. 50 oz. magnet, 2" aluminium voice coil. Rolled surround. Resonant frequency 25Hz. Frequency response to 13KHz. Sensitivity 95dB. Impedance 8ohm. **Attractive blue cone with aluminium centre dome.**
Price £17.99 each + £2.50 P&P.

B.K. ELECTRONICS

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★ SAE for current lists. ★ Official orders welcome. ★ All prices include VAT. ★ Mail order only. ★ All items packed (where applicable) in special energy absorbing PU foam. Callers welcome by prior appointment, please phone 0702-527572.

Step-by-step fully illustrated assembly and fitting instructions are included together with circuit descriptions. Highest quality components are used throughout.

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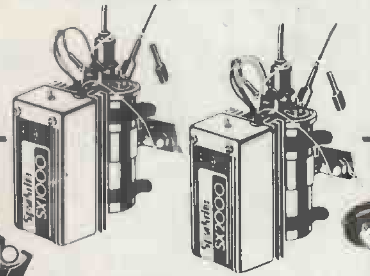
- Contact breaker driven
- Three position changeover switch
- Over 65 components to assemble
- Patented clip-to-coil fitting
- Fits all 12v neg. earth vehicles



MAGIDICE
Electronic Dice
- Not an auto item but great fun for the family
- Total random selection
- Triggered by waving of hand over dice
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- Hours of continuous use from PP7 battery
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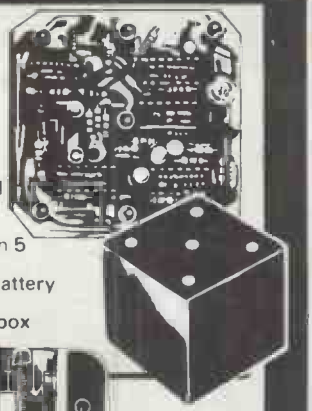
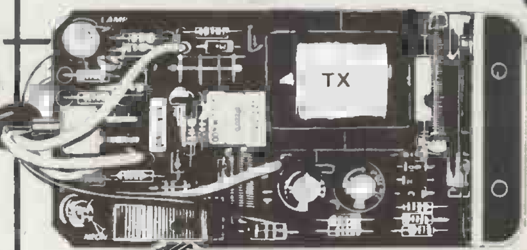
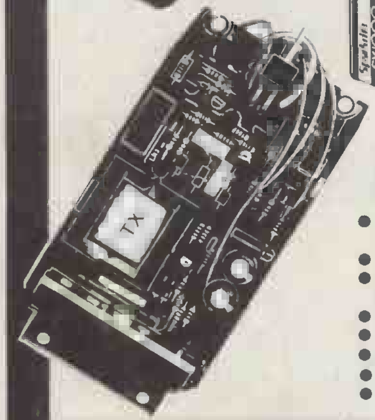
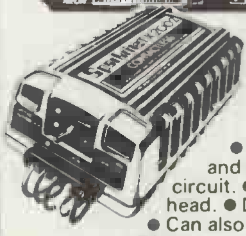
- Supplied in superb presentation gift box



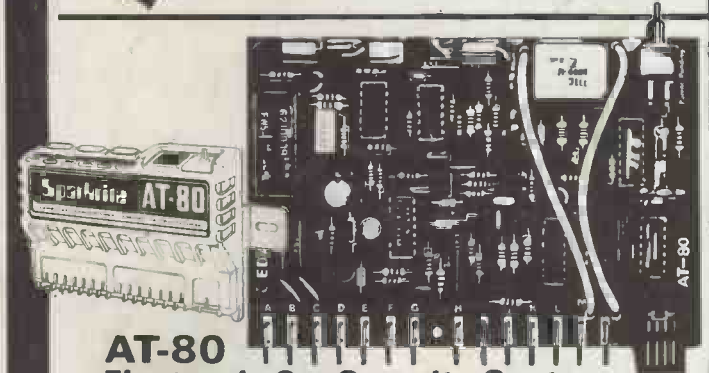


SX2000
Electronic Ignition
- The brandleading system on the market today
- Unique Reactive Discharge
- Combined Inductive and Capacitive Discharge
- Contact breaker driven
- Three position changeover switch
- Over 130 components to assemble
- Patented clip-to-coil fitting
- Fits all 12v neg. earth vehicles





TX2002
Electronic Ignition
- The ultimate system
- Switchable contactless.
- Three position switch with Auxiliary back-up inductive circuit.
- Reactive Discharge. Combined capacitive and inductive.
- Extended coil energy storage circuit.
- Magnetic contactless distributor trigger-head.
- Distributor triggerhead adaptors included.
- Can also be triggered by existing contact breakers.
- Die cast waterproof case with clip-to-coil fitting
- Fits majority of 4 and 6 cylinder 12v neg. earth vehicles.
- Over 150 components to assemble



AT-80
Electronic Car Security System
- Arms doors, boot, bonnet and has security loop to protect fog/spot lamps, radio/tape, CB equipment
- Programmable personal code entry system
- Armed and disarmed from outside vehicle using a special magnetic key fob against a windscreen sensor pad adhered to the inside of the screen
- Fits all 12V neg earth vehicles
- Over 250 components to assemble

VOYAGER Car Drive Computer
- A most sophisticated accessory.
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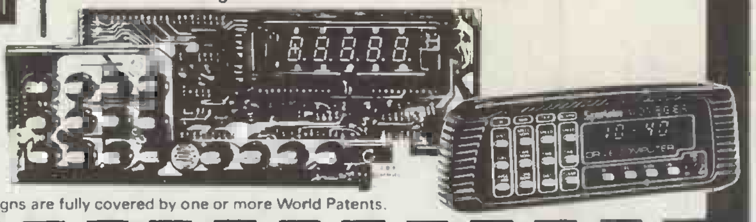
- Full Imperial and Metric calibrations.
- Over 300 components to assemble.

A real challenge for the electronics enthusiast!



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