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Hobby Electronics

SEPTEMBER '81

ISSN. 0142-6192

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CMOS 4000

4000	0.13
4001	0.20
4002	0.14
4007	0.19
4008	0.70
4008AE	0.80
4009	0.30
4010	0.30
4011AE	0.24
4011	0.15
4013	0.35
4015	0.70
4016	0.30
4017	0.65
4019	0.68
4021	0.75
4022	0.68
4023	0.19
4024	0.45
4025	0.18
4026	1.05
4028	0.60
4029	0.75
4030	0.35
4035	0.75
4040	0.68
4042	0.65
4043	0.68
4043AE	0.93
4044	0.68
4046	0.69
4047	0.69
4049	0.30
4050	0.30
4051	0.65
4052	0.69
4053	0.69
4054	1.30
4055	1.30
4056	1.35
4059	5.75
4060	0.95
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4070	0.25
4071	0.22
4072	0.22
4073	0.22
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4076	0.60
4077	0.23
4078	0.25
4081	0.15
4082	0.25
4093	0.45
4099	0.99
4175	1.15
4502	0.90
4503	0.55
4506	0.75
4507	0.45
4508	1.99
4510	0.70
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4514	2.20
4515	2.50
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4520	0.80
4521	2.36
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4527	0.95
4528	0.95
4529	1.40
4539	1.10
4543	1.00
4549	3.50
4553	3.10
4554	1.73
4555	0.72
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4558	1.00
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4585	1.00
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4705	4.24
4706	4.50
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4723	0.95
4724	0.95
4725	2.24
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40085	0.99
40098	0.54
40106	0.54
40160	0.69
40161	0.69
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40193	0.75
40194	0.69
40195	0.69

TTL 'N'

7400N	0.10
7401N	0.10
7402N	0.10
7403N	0.11
7404N	0.12
7405N	0.12
7406N	0.22
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7417N	0.27
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7421N	0.28
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7426N	0.22
7427N	0.22
7428N	0.35
7430N	0.13
7432N	0.23
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7438N	0.22
7440N	0.14
7441N	0.54
7442N	0.42
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7444N	0.62
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7448N	0.56
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7453N	0.14
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7460N	0.14
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7472N	0.27
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7474N	0.28
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7481N	0.20
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7485N	0.75
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7489N	1.05
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7492N	0.35
7493N	0.35
7494N	0.70
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7497N	1.40
74100	1.10
74104	0.62
74105	0.62
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74109N	0.35
74110N	0.54
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74112N	1.70
74116N	1.98
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74120N	0.95
74121N	0.34
74122N	0.34
74123N	0.40
74125N	0.40
74126N	0.40
74128N	0.65
74132N	0.50
74136N	0.65
74141N	0.45
74142N	1.85
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74145N	0.75
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74185N	1.20
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74192N	0.55
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74279N	0.89
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74285N	3.50
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74293N	1.05
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74365N	0.85
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74367N	0.85
74368N	0.85
74390N	1.85
74393N	1.85
74490N	1.85

74LSN series

74LS00N	0.11
74LS01N	0.11
74LS02N	0.12
74LS03N	0.12
74LS04N	0.14
74LS05N	0.14
74LS08N	0.14
74LS09N	0.14
74LS10N	0.13
74LS11N	0.14
74LS12N	0.15
74LS13N	0.28
74LS14N	0.49
74LS15N	0.14
74LS20N	0.13
74LS21N	0.15
74LS22N	0.15
74LS26N	0.18
74LS27N	0.14
74LS28N	0.35
74LS30N	0.13
74LS32N	0.14
74LS33N	0.16
74LS37N	0.17
74LS38N	0.16
74LS40N	0.13
74LS42N	0.40
74LS47N	0.42
74LS48N	0.65
74LS49N	0.61
74LS51N	0.14
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74LS55N	0.15
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74LS74N	0.18
74LS75N	0.28
74LS76N	0.22
74LS78N	0.24
74LS83N	0.50
74LS85N	0.70
74LS86N	0.18
74LS90N	0.32
74LS91N	1.25
74LS92N	0.39
74LS93N	0.38
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74LS96N	1.20
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74LS109N	0.25
74LS112N	0.25
74SL113N	0.25
74LS114N	0.25
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74LS193N	0.68
74LS194N	0.42
74LS195N	0.42
74LS196N	0.65
74LS197N	0.65
74LS200N	3.45
74LS202N	3.45
74LS221N	0.60
74LS240N	0.99
74LS241N	0.99
74LS242N	1.65
74LS243N	1.65
74LS244N	0.83
74LS245N	1.50
74LS247N	1.35
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74LS249N	1.35
74LS251N	0.46
74LS253N	0.46
74LS257N	0.55
74LS258N	0.39
74LS259N	0.39
74LS260N	0.70
74LS266N	0.24
74LS273N	0.90
74LS275N	3.20
74LS279N	0.35
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74LS283N	0.44
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74LS293N	1.30
74LS295N	1.50
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74LS365N	0.35
74LS366N	0.35
74LS367N	0.35
74LS368N	0.35
74LS373N	0.78
74LS374N	0.78
74LS375N	1.15
74LS377N	1.99
74LS378N	1.40
74LS379N	2.15
74LS384N	2.50
74LS385N	4.20
74LS386N	0.29
74LS390N	0.68
74LS393N	0.61
74LS395N	2.10
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

74CXX series

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	0.80
74C161	0.80
74C162	0.80
74C163	0.80
74C164	0.80
74C165	0.84
74C173	0.72
74C174	0.72
74C175	0.72
74C192	0.80
74C193	0.80
74C195	0.80
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

Processors 8080

8080 series

8080AFC/2	7.50
8212	2.30
8214	3.50
8216	1.95
8224	3.50
8251	6.25
8255	5.40

6800/6809

6800P	3.75
68A00	4.25
68B00	4.75
6802	5.55
6809	15.00
6810	1.75
68A10	1.85
68B10	2.04
6820	1.95
6821	1.75
68A21	2.10
68B21	2.34
6840	4.25
68A40	4.55
68B40	4.75
6850	1.75
68B50	2.17
6852	2.47
68A52	2.75
68B52	2.95
68488	5.25

Z80 series

Z80A	4.99
Z80ADRT	7.50
Z80APIO	4.10
Z80ASIO/1	14.00
Z80ASIO/2	14.00
Z80ASIO/9	14.00
Z80CTC	4.00
Z80ACTC	4.50
Z8001	65.00

PROM

2708	2.00
2716	3.55
2532	8.50
2732	8.50

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	12.50
6116P-4	11.25
8264	12.50

XTALS

1MHz	3.00
3.2768MHz	2.00
4MHz	1.70
4.194MHz	1.70
4.43MHz	1.25
5MHNz	2.00
6.5536MHz	2.00
7MHz	2.00
8MHz	2.00
9MHz	2.00
10MHz	2.00
11MHz	2.00

Voltage Regulators

78XX 1A TO-220	0.58
78XX 1A TO-3	0.99
79XX 1A TO-220	0.60
79XX 1A TO-3	1.35
78G 1A TO-220	1.10
78G 1A TO-3	3.95
78H 5A TO-3 5v	4.25
78H 5A TO-3 12v	5.45
78HG 5A TO-3	7.45
79HG 5A TO-3	7.45
LM317 .5A TO-202	1.30
LM337 .5A TO-202	1.75
78S40 1.5A	1.20

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Hobby Electronics

SEPTEMBER 1981
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PROJECTS

FEATURES

NEWS & INFORMATION

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This month's cover shows Carole Anne with a look of determination on her face as she searches for hidden treasure with the HE 'Diana' Metal Detector. Why did we call this project Diana? *See page 10 for the answer*

The HE Short Wave Radio is easy to build and covers 1.5 to 33 MHz in three ranges — *see page 52*

HE Tool Set Offer — five high-quality tools for the electronics hobbyist — *details on page 29*

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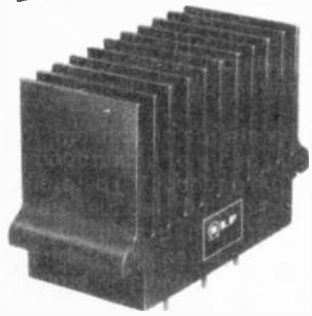
20 POWER AMPS 19 FUNCTIONAL MODULES DAWN

POWER UP TO 480 WATTS RMS SINGLE CHANNEL

Which amplifier?

I.L.P. Amplifiers now come in three basic types, each of which is available with or without heatsink. Having decided the system you want – home hi-fi (models HY30, 60 or 120 for example), super quality hi-fi with extra versatility (MOS120, MOS200) or Disco/PA/Guitar (HD120, HD200 or HD400) you will then decide whether amplifiers housed within their own heatsinks or plate amplifiers for bolting to a metal chassis will suit. With choice such as this and a brilliant new range of I.L.P. functional modules to choose from you now have the chance to build the finest audio system ever offered to the constructor.



AMPLIFIER WITH HEAT SINK

BIPOLAR Standard, with heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	DISTORTION T.H.D. Typ at 1kHz	DISTORTION I.M.D. 60HZ/7kHz 4:1	SUPPLY VOLTAGE TYP/MAX	SIZE mm	WT gms	PRICE	VAT	Without heatsinks: MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
HY30	15w/4-8Ω	0.015%	<0.006%	±18±20	76x68x40	240	£7.29	£1.09					
HY60	30w/4-8Ω	0.015%	<0.006%	±25±30	76x68x40	240	£8.33	£1.25					
HY120	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x40	410	£17.48	£2.62	HY120P	120x26x40	215	£15.50	£2.33
HY200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x50	515	£21.21	£3.18	HY200P	120x26x40	215	£18.46	£2.77
HY400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£31.83	£4.77	HY400P	120x26x70	375	£28.33	£4.25

Protection: Load line, momentary short circuit (typically 10 sec) *Slew rate:* 15V/μs *Rise time:* 5μs
S/N ratio: 100db *Frequency response (– 3dB):* 15Hz – 50kHz
Input sensitivity: 500mV rms *Input impedance:* 100kΩ *Damping factor.* (8Ω/100Hz)>400

HEAVY DUTY with heatsinks

MODEL NUMBER	OUTPUT POWER	T.H.D.	I.M.D.	SUPPLY VOLTAGE	SIZE	WT	PRICE	VAT	Without heatsinks: MODEL NUMBER	SIZE	WT	PRICE	VAT
HD120	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x50	515	£22.48	£3.37	HD120P	120x26x50	265	£19.84	£2.98
HD200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x60	620	£27.38	£4.11	HD200P	120x26x50	265	£23.63	£3.54
HD400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£38.63	£5.79	HD400P	120x26x70	375	£34.28	£5.14

Protection: load line, PERMANENT SHORT CIRCUIT (ideal for disco/group use should evidence of short circuit not be immediately apparent).
The Heavy Duty range can claim additional output power devices and complementary protection circuitry with performance specs. as for standard types.

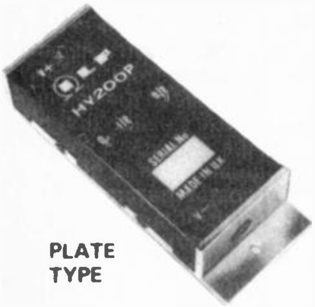


PLATE TYPE

MOSFET Ultra-Fi, with heatsinks

MODEL NUMBER	OUTPUT POWER	T.H.D.	I.M.D.	SUPPLY VOLTAGE	SIZE	WT	PRICE	VAT	Without heatsinks: MODEL NUMBER	SIZE	WT	PRICE	VAT
MOS120	60w/4-8Ω	<0.005%	<0.006%	±45±50	120x78x40	420	£25.88	£3.88	MOS120P	120x26x40	215	£23.32	£3.50
MOS200	120w/4-8Ω	<0.005%	<0.006%	±55±60	120x78x80	850	£33.46	£5.02	MOS200P	120x26x80	420	£28.53	£4.28
MOS400	240w/4Ω	<0.005%	<0.006%	±55±60	120x78x100	1025	£45.39	£6.81	MOS400P	120x26x100	525	£38.91	£5.84

Protection: Able to cope with complex loads, without the need for very special protection circuitry (fuses will suffice).
Ultra-fi specifications:
Slew rate: 20V/μs *Rise time:* 3μs *S/N ratio:* 100db *Frequency response (– 3dB):* 15Hz – 100kHz
Input sensitivity: 500mV rms *Input impedance:* 100kΩ *Damping factor:* (8Ω/100Hz)>400

PSU

POWER SUPPLY UNITS

MODEL NO.	FOR USE WITH	PRICE	VAT
PSU30	± 15V combinations of HY6/66 series to a maximum of 100mA	£4.50	£0.68
	The following will also drive the HY6/66 series except HY67 which requires the PSU30.		
PSU36	1 or 2 HY30	£8.10	£1.22
PSU50	1 or 2 HY60	£10.94	£1.64
PSU60	1 x HY120/HY120P/HD120/HD120P	£13.04	£1.96
PSU65	1 x MOS120/1 x MOS120P	£13.32	£2.00
PSU70	1 or 2 HY120/HY120P/HD120/HD120P	£15.92	£2.39
PSU75	1 or 2 MOS120/MOS120P	£16.20	£2.43
PSU90	1 x HY200/HY200P/HD200/HD200P	£16.20	£2.43
PSU95	1 x MOS200/MOS200P	£16.32	£2.45
PSU180	2 x HY200/HY200P/HD200/HD200P or 1 x HY400/1 x HY400P/HD400/HD400P	£21.34	£3.20
PSU185	1 or 2 MOS200/MOS200P/1 x MOS400/ 1 x MOS400P	£21.46	£3.22

All models except PSU30 and PSU36 incorporate our own toroidal transformers

FP480

BRIDGING UNIT FOR DOUBLING POWER

Designed specially by I.L.P. for use with any two power amplifiers of the same type to double the power output obtained and will function with any I.L.P. power supply. In totally sealed case, size 45 x 50 x 20mm, with edge connector. It thus becomes possible to obtain 480 watts rms (single channel) into 8Ω. Contributory distortion less than 0.005%.
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Which modules?

In launching eighteen different units all within amazingly compact cases to help make complete audio systems using I.L.P. power amplifiers, we bring the most exciting, the most versatile modular assembly scheme ever for constructors of all ages and experience. Study the list – see how these modules will combine to almost any audio project you fancy – and remember *all I.L.P. modules are compatible with each other*, they connect easily. Modules HY6 to HY13 measure 45 x 20 x 40mm. HY66 to HY77 measure 90 x 20 x 40mm. They are so reliable that all I.L.P. modules carry a 5 year no quibble guarantee.

MODEL NO.	MODULE	DESCRIPTION/FACILITIES	CURRENT REQUIRED	PRICE	VAT
HY6	MONO PRE AMP	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Volume/Bass/Treble	10mA	£6.44	£0.97
HY7	MONO MIXER	To mix eight signals into one	10mA	£5.15	£0.77
HY8	STEREO MIXER	Two channels, each mixing five signals into one	10mA	£6.25	£0.94
HY9	STEREO PRE AMP	Two channels mag. Cartridge/ Mic + Volume	10mA	£6.70	£1.01
HY11	MONO MIXER	To mix five signals into one + Bass/Treble controls	10mA	£7.05	£1.06
*HY12	MONO PRE AMP	To mix two signals into one + Bass/Mid-range/Treble	10mA	£6.70	£1.01
*HY13	MONO VU METER	Programmable gain/LED overload driver	10mA	£5.95	£0.89
HY66	STEREO PRE AMP	Mic/Mag. Cartridge/Tape/Tuner/Aux + Volume/Bass/Treble/Balance	20mA	£12.19	£1.83
HY67	STEREO HEADPHONE	Will drive headphones in the range of 4Ω – 2KΩ	80mA	£12.35	£1.85
HY68	STEREO MIXER	Two channels, each mixing ten signals into one	20mA	£7.95	£1.19
HY69	MONO PRE AMP	Two input channels of mag. Cartridge/ Mic + Mixing/Volume/Treble/Bass	20mA	£10.45	£1.57
HY71	DUAL STEREO PRE AMP	Four channels of mag. Cartridge/Mic + Volume	20mA	£10.75	£1.61
*HY72	VOICE OPERATED STEREO FADER	Depth/Delay	20mA	£13.10	£1.97
*HY73	GUITAR PRE AMP	Two Guitar (Bass/Lead) and Mic + separate Volume/Bass/Treble + Mix	20mA	£12.25	£1.84
†HY74	STEREO MIXER	Two channels, each mixing five signals into one + Treble/Bass	20mA	£11.45	£1.72
†HY75	STEREO PRE AMP	Two channels, each mixing two signals into one + Bass/Mid-range/Treble	20mA	£10.75	£1.61
†HY76	STEREO SWITCH MATRIX	Two channels, each switching one of four signals into one	20mA	£13.10	£1.97
†HY77	STEREO VU METER DRIVER	Programmable gain/LED overload driver	20mA	£9.25	£1.39

* Ready August – may be ordered now
† Ready September – may be ordered now

All the above modules operate from ±15V minimum to ±30V maximum – higher voltages being accommodated by use of dropper resistors. HY67 can only be used with the PSU 30 power supply unit

The modules are encapsulated and include latest design high quality clip-on edge connectors.

For easy mounting we recommend
B6 Mounting board for modules HY6 – HY13 78p + 12p. V.A.T.
B66 Mounting board for HY66 – HY77 99p + 13p. V.A.T.

All I.L.P. modules include full connection data.

I.L.P. Products are of British Design and Manufacture.

See our advertisement on page 65

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MONITOR

Help The Handicapped

WE ARE PLEASED to report that the response to the HE Project Design Competition for the International Year of Disabled Persons 1981 has taken an encouraging upturn during the last month (see comment under Your Letters, page 55). As a reminder, the closing date for the competition is *1st September 1981* — contact the Editor before this date if you have any questions about project designs.

While on the subject of IYDP it is worth noting the following:

First is a series of informal workshop sessions where those attending make aids for the disabled. Paul Tippell, lecturer in electronics, has been running these sessions during term time at Richmond-upon-Thames College, Egerton Road, Twickenham TW2 7SJ (tel 01 892 6656) during the last three years. The next sessions will begin on Tuesday 22nd September 1981 between 7.00 and 9.30 PM each week. Just contact Paul at the College or call in on any Tuesday evening at 7.00 PM and ask for Workshop H3.

Fee for each term (usually 12 weeks) is £9.

Examples of items that could be made at the sessions include electronic remote controls for operating radio, TV and other electrical appliances, devices for opening garage doors automatically when a car is driven up to them, remotely-controlled door locks and low-cost communications aids.

Paul told HE that one project completed recently by the workshop was an 'extended computer keyboard' which enabled a disabled person to program a computer — with his or her toes!

Second item for your diary is a low-cost course 'Disabled People — Living and Learning', organised by ACTIVE. It is to take place on the Isle of Wight on 25th September — full details are given in the first letter under Your Letters this month.

Third is 'IYDP And Then . . . ?' — the Autumn Conference of ACTIVE. It will take place on Saturday 17th October 1981 in the Great Hall, Imperial College, London SW7. This conference will look at the increasing importance of self-help and one-off solutions to the needs of severely disabled people, methods of approaching problems and some practical examples of equipment to make.

The conference will include a small exhibition of play, leisure and communication aids.

Fees, including refreshments and buffet lunch, are £6 for TLA/ACTIVE members, £6.95 for non-members and £15 for families (not more than four people).

Contact: Judy Denziloe, ACTIVE, Seabrook House, Darkes Lane, Potters Bar, Herts EN6 2HL (tel 0707 44571) for further details.

Handy Microcassette

JUST DELIVERED to the HE office is one of the latest devices from AIWA — the CS-M1.

You would be forgiven for thinking that the CS-M1 is just another ordinary radio/cassette recorder if it were not for the machine's size (rather, lack of it). AIWA calls the CS-M1 a micro stereo radio cassette recorder — and micro is definitely the operative word. Case dimensions are only *230 mm wide, by 80 mm high, by 36 mm deep*. It weighs in at only 720 g, too.

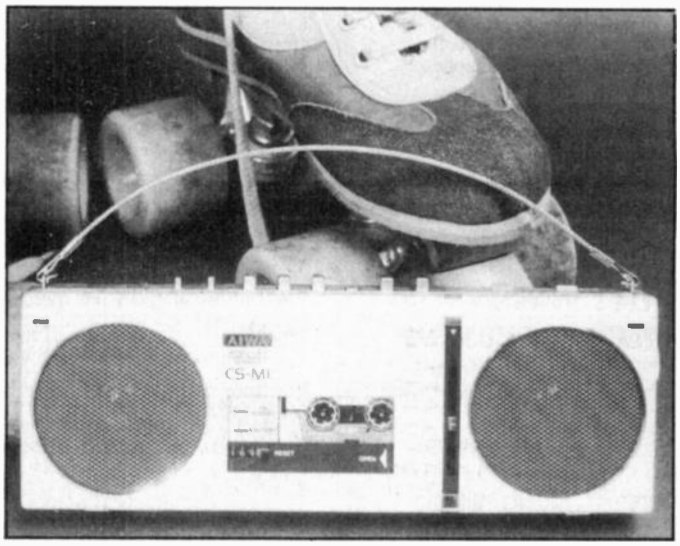
Apart from:

- recording and playing back using a microcassette (not a standard cassette)
- its small size
- a metal tape facility

the CS-M1 is similar to larger more conventional machines. The radio section features FM stereo and AM medium wavebands, while the tape section has cue/review controls, a tape position counter, built-in electret condenser microphones for stereo live recordings, and auxiliary inputs to record from an external source (such as your hi-fi system).

Many other features are also included, which we hope to tell you all about in a future Gadgets, Games & Kits supplement.

The AIWA CS-M1 retails at £109.95 or under.



Trap Those Signals!

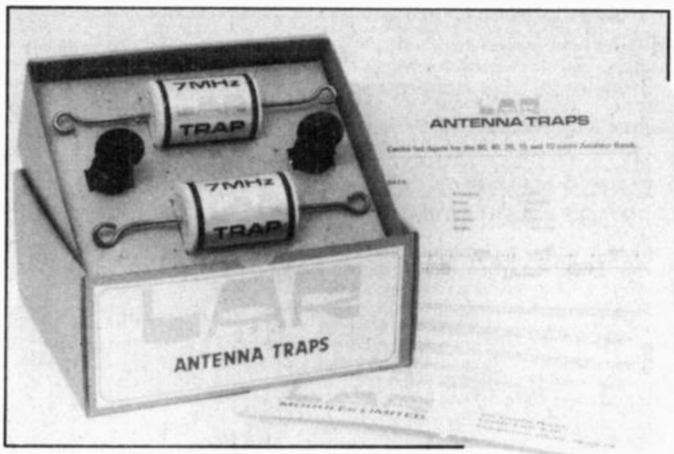
IF YOU PLAN to build the HE Short Wave Receiver, or have one already, then you need a good aerial to get the best results from it. Ler Modules Ltd claims that: 'About the easiest and least expensive way to be able to transmit/receive on five bands is to use a trap dipole'.

The company is offering a pair of LAR 7 MHz weatherproof traps, 500 W rating, a pair of lightweight end-insulators and instructions for making a five-band trap dipole for £12.50, including VAT (postage and packing £1.75 extra).

This dipole will cover the 80, 40, 20, 15 and 10 metre amateur bands.

Of course, you won't need the 500 W rating until you start transmitting, and you need an Amateur Radio Licence for that . . .

LAR Modules Limited, 60 Green Road, Leeds LS6 4JP (tel 0532 782224).



TV Games From Activision

EIGHT GAMES CARTRIDGES are planned for release in the UK in the autumn, from Californian-based Activision.

Under Monitor in the January '81 issue of HE we commented on the formation of Activision by some of the engineers who had been working for Atari and who had produced games cartridges which were compatible with Atari's Video Computer Game. We also mentioned the legal wrangle that had ensued between the two companies.

Now that the air has cleared, the cartridges are to be marketed in the UK by Computer Games Limited, with the following titles:

Tennis	Skiing
Boxing	Fishing Derby
Dragster	Kaboom
Laser Blaster	Freeway

According to Computer Games Limited, Tennis and Boxing will be the first to appear, in September, followed by Dragster and Laser Blaster in October, Fishing Derby and Skiing in November and Freeway and Kaboom (whatever *that* is) in December. Each game will cost £16.95, and we hope to review them in our Gadgets, Games & Kits supplement.

The games will be available from Circolec, 1 Franciscan Road, Tooting, London SW17 8BR (tel 01 767 1233).

Sharpen-up Your Hi-fi Pencils

A SMALL SNIPPET from the June 1981 issue of the Antique Wireless Newsheet, Number 71: 'Did you know that the name of "Sharp", that well known Japanese manufacturer of hi-fi and car radios, came from the 1920's when they produced an "everlasting pencil" — always sharp?'

Electronics News

Leader Test Gear From Sinclair

LOOKING FOR SOME test equipment? You might find what you want in the Leader range from Sinclair Electronics.

Although Sinclair Electronics has been stocking Leader products since the middle of last year, according to Tony Starling, SE's Sales and Marketing Manager, a recent decision was made to select 'items of potential interest' for the electronics hobby market.

Examples are the LSG-16 signal generator (£63.25 including VAT) and the LAG-26 audio generator (£73.60 including VAT).

The LSG-16 covers 100 kHz to 100 MHz (up to 300 MHz in harmonics) in six ranges. It has a 1 kHz modulator and provision for external modulation. A crystal oscillator facility is also provided.

The LAG-26 covers 20 Hz to 200 kHz in four ranges and has a rated harmonic distortion of within 0.5%.

We hope to test the above instruments and report on our findings in a furture Gadgets, Games & Kits supplement.

Further details from Sinclair Electronics Limited, London Road, St. Ives, Huntingdon, Cambs PE17 4HJ (tel 0480 64646).

Latest In Microcassette Recorders

PEARLCORDER S801 has been introduced by Olympus Optical Company, and is the smallest microcassette recorder that we've seen yet.

You may remember Move Towards Microcassettes, the special feature on pages 10 and 11 of the March '81 issue of HE. There we featured the D6710 microcassette recorder from Philips and the M5850FG microcassette recorder/radio from Sanyo. The S801, intended primarily for use as a dictating machine, is smaller than these two and offers some interesting features.

Instead of the conventional mechanical tape log counter, the S801 has an LCD display. This works in conjunction with a built-in memory, which enables you to stop the tape automatically at pre-programmed points indicated by the counter.

We tested a sample machine and found it comfortable to handle, although the slide controls took some getting used to after years of button-pushing. We also found that loading and unloading a cassette was not as fast or as easy as it was for the D6710 or M5850FG.

However, the S801 is a rugged looking machine built in a metal case and finished in matt black. It comes complete with a blank microcassette cartridge, pouch, wrist strap, personal earpiece and a set of batteries (two AA-size cells).

Olympus offers 12 different accessories to go with the machine, including a telephone pick-up, remote control switch, car cigarette lighter socket adaptor and an AC mains adaptor.

The cost is £106.42 (including VAT) from Offmech Services Limited, 13/19 Curtain Road, London EC2A 3LT (tel 01-247 8986).

Offmech offers full service back-up on microcassette recorders and dictating machines.

DXTV Reception Group

THE NATIONAL DXTV (long-distance television reception) group has been meeting regularly in London since February 1981.

This group, formed by George Grzebieniak (RS 41733), has acquired and made use of a large variety of TV equipment ranging from a 5" multi-band black-and-white TV to a 27" colour model which has provision for reception of satellite transmissions.

Details can be obtained from George Grzebieniak, c/o 185 Fleet Street, London EC4A 2HS, enclosing a self-addressed stamped envelope.

Rack Those Tools With Rawlplug

TWO RACKS have been introduced by the Rawlplug Company to help cope with the ever-increasing number of tools that do-it-yourself enthusiasts seem to accumulate.

First is the Rawlplug Handy Tool Rack which, it is claimed, will hold over 50 hand tools ranging in size from a medium-length saw to a 1/16" drill bit. The rack is made from stove-enamelled steel, measures 36" by 4" by 4" and can be fitted in a garage, shed, above a workbench or in a cupboard. It costs £4.99 including VAT and comes complete with fixing screws and — naturally enough — Rawlplugs.

The second rack is for the do-it-yourself gardener and will hold a mixture of long- and short-handled tools (we're sure that many HE readers fit in a spot of gardening between project building). This rack is about 36" long by 4", costs £4.99 including VAT and comes complete with fittings.

The Rawlplug Company Limited, Rawlplug House, London Road, Kingston-upon-Thames, Surrey KT2 6NR (tel 01 546 2191).

Amateur Radio Courses Taken By Fear

FRANK FEAR (G8CVR) will be running two courses in Amateur Radio from September this year.

The first will run for three 10-week terms and will cover the syllabus of the Amateur Radio Course Examination Number 765. Applicants need not have previous knowledge of the subject. The couse will be held at the Broadway North Adult Centre, Queen Mary's Grammar School, Sutton Road, Walsall, on Monday and Wednesday from 7.00 to 9.00 PM, starting from 21st September 1981. Enrolment days are Monday 14th and Tuesday 15th September, between 6.30 and 8.30 PM at the Adult Centre. Cost of the course is £5 per term, or £12.50 in advance for the three terms.

The second course will run for 10 weeks and is intended for those who have some previous knowledge of amateur radio or who have failed the May '81 examination. It will be held at Barr Beacon Comprehensive School, Old Hall Lane, Aldridge on Thursday evenings, from 24th September. Enrolment day is Thursday 17th September, between 6.30 and 8.30 PM at Barr Beacon, and the cost is £5.

Frank Fear has been running these courses for two years and, because of the unexpected response last year, was forced to run an extra evening course. The same arrangement could be made this year.

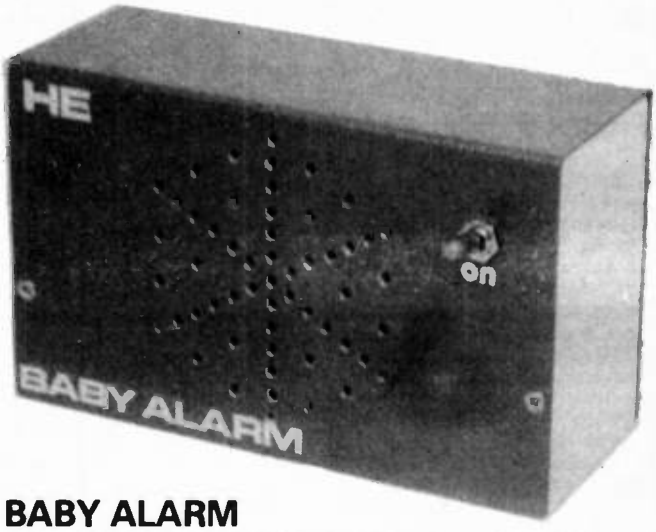
If you want details of these courses, contact Frank Fear on 0922 52706.

NEXT MONTH IN HE — NEXT MONTH IN HE — NEXT MONTH IN HE

Don't miss the October issue — out September 11

Hobby Electronics

Five low-cost projects for the home

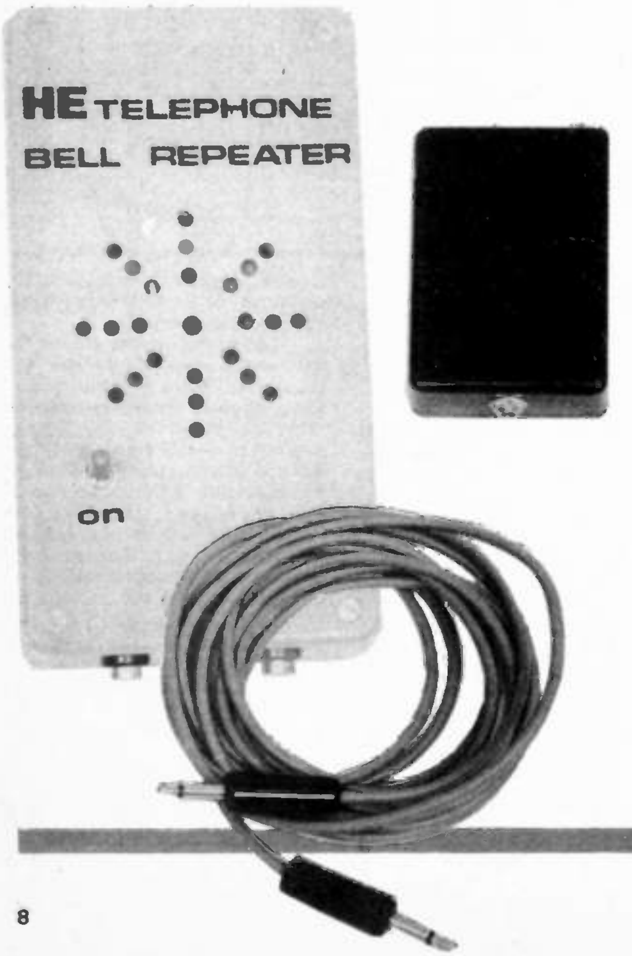


TOUCH LAMP
The HE Touch Lamp can be turned on and off with the lightest of touches. It's easy to build and handy to have at the bedside

COMBINATION LOCK
No keys to worry about with this project: you just need a good memory to remember the right push-button combination. A simple-to-build project with home security in mind

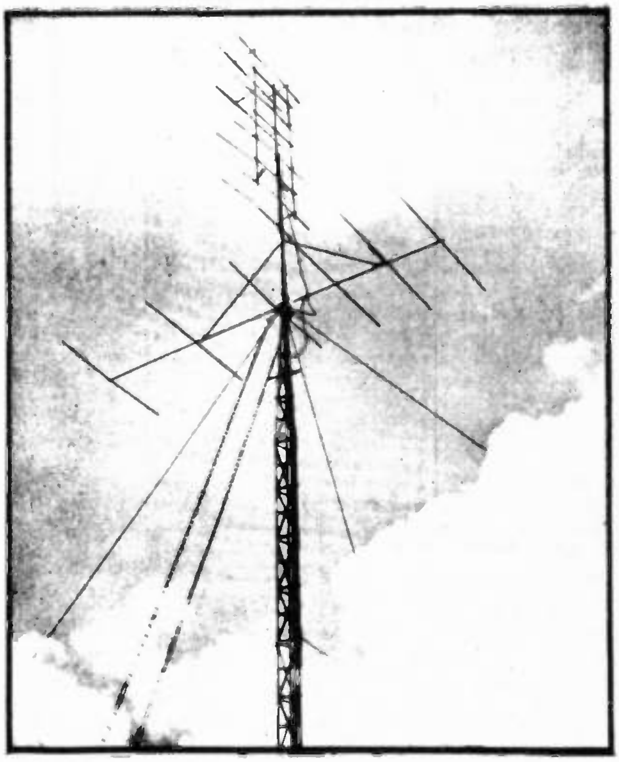
ENTRY PHONE
Imagine: a dark evening, it's pouring with rain and a stranger knocks at your front door. Now, instead of having to speak through the letter box you can address callers in comfort — with the HE Entry Phone

TELEPHONE BELL REPEATER
No, not an ingenious method of mass-producing telephone bells at home but a project that will relay the sound of a ringing 'phone to any other room in the house



BABY ALARM
This one is bound to be a hit with baby, so we've used a rugged box for the design. The HE Baby Alarm keeps an electronic ear open for you at the cotside

Main Feature

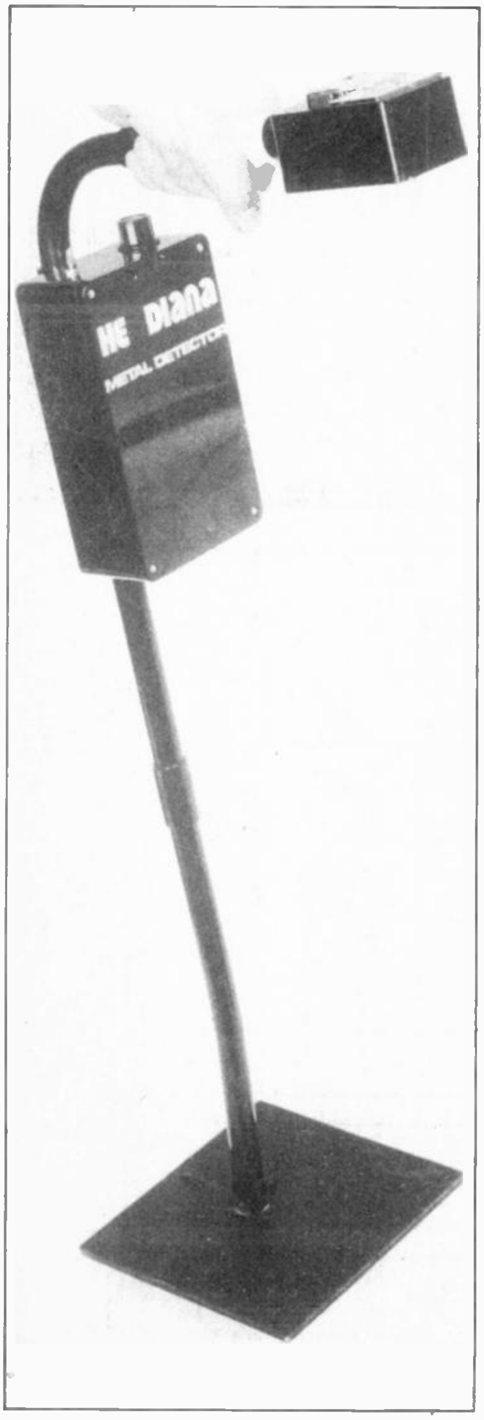


AERIALS
In the early days of radio, 'aerial' referred to a length of wire strung between a couple of convenient trees. Nowadays, aerials (antennae or antennas if you prefer) come in all shapes and sizes. This article looks at how aerials work and how they are constructed. If you are thinking of getting started on Citizen's Band when it becomes legal then this article will help you understand simple aerial design

Items mentioned here are those planned, but unforeseen circumstances may effect the actual contents

HE 'Diana' Metal Detector

Build yourself this pulse induction metal detector and perhaps you'll find yourself a fortune! It's ideal for beginners and novices to electronics *and* treasure hunting, because it is simple to construct and needs no special test equipment to set it up for use



The Roman goddess Diana (pictured on the right) was, according to myth, a huntress usually depicted in Roman art with bow and quiver, and accompanied by a hound. Because this project is the ideal metal detector for would-be treasure hunters we have adopted the name 'Diana' to evoke a hunting atmosphere.

The HE 'Diana' Metal Detector is easy to build and equally easy to use. You can make it out of readily available components and hardware well below the costs of equivalent commercial detectors.

Pulse induction (see How It Works) is used in the detector to create a very sensitive circuit — our prototype is capable of detecting the presence of small metal coins at a fair depth. It cannot, however, distinguish between ferrous metals (such as iron) and non-ferrous metals (eg, gold, silver, aluminium).

Construction

Build up the printed circuit board (PCB) as shown in **Fig.2**: start by inserting and soldering all low-profile components first (eg, resistors, diodes, IC sockets and preset resistors), making sure the diodes are the right way round. Also insert and solder the wire links.

Next insert the remaining components — carefully checking that both the transistor and the electrolytic capacitor are the correct way round. Solder in terminal pins where connections to the PCB are to be made.

Push fit the ICs into their sockets, aligning the dot or notch on the top of each IC with the notch shown in the overlay in **Fig.2**.

Now, mark and drill the larger of the two cases for the PCB pillars, potentiometer, switch, mounting clips, and the coil and meter wires. Mount the PCB, switch, potentiometer, and wire as shown in **Fig.3**.

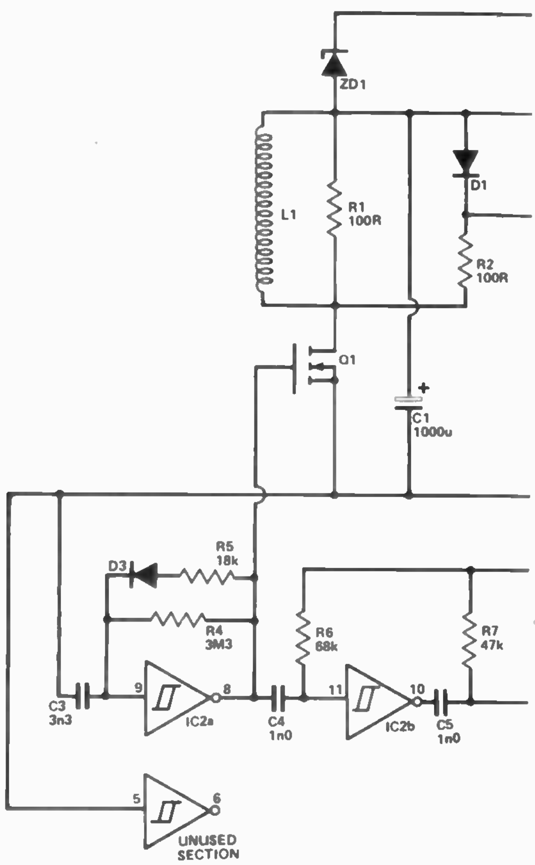
Next, cut out a round hole in the bottom of the smaller case for the panel meter. A suitable tool for this job is an Abraframe hacksaw. Another way to make the hole is to drill a circle of small holes and then file out the large hole.

Drill the four holes to fit the meter bolts (see **Fig.4**) then mount the panel meter in position.

Solder resistor R19 into position on the rear of the panel meter.

Using the hardboard rough side down, construct the search head of the metal detector as shown in **Figs.5** and **6**. Drill the hole for the handle connector. The four pieces of prepared beading are glued using a rapid-bond

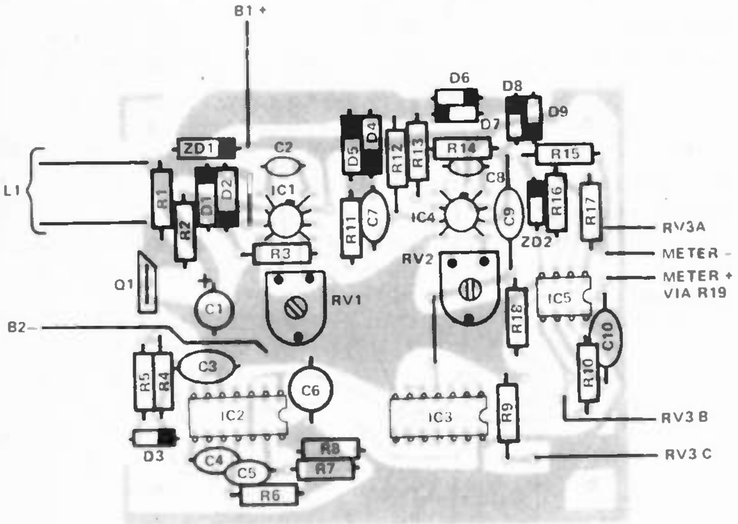
Figure 1. Circuit of the HE 'Diana' Metal Detector ▼



adhesive to the rough side of the hardboard, with the beading groove towards the board and facing outwards. Apply the glue to both the hardboard and the beading — also apply glue on the corners of the beading.

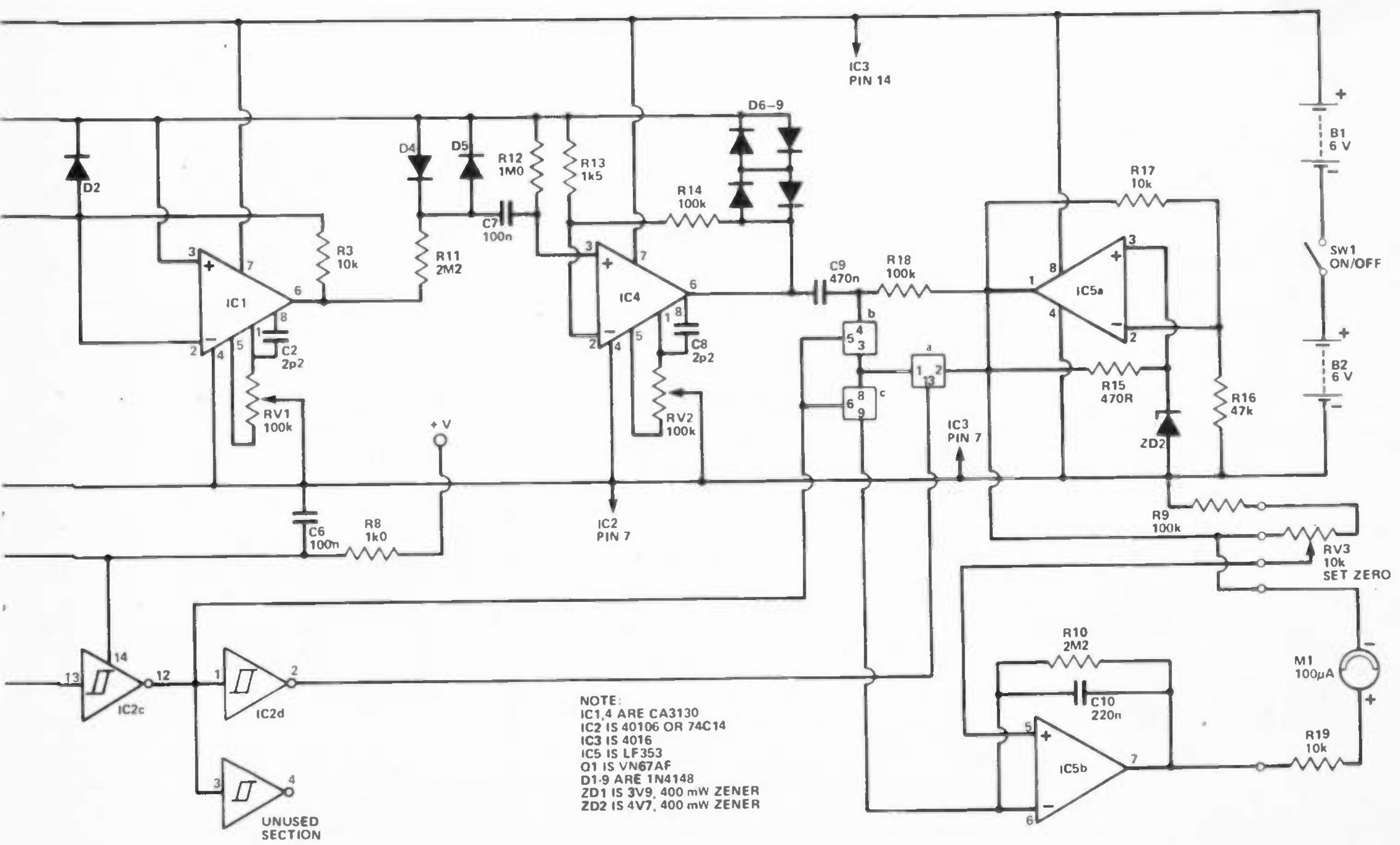
Hold the assembly for about five minutes till firm, then leave for at least two hours until the glue is fully cured.

Next wind the coil. Thread about one metre (1 m) of insulated copper wire through the hole from the 'beaded' side to the handle connector side, then carefully wind 22 turns of wire around the groove. Leave approximately 1½ metres over, for threading through the hole. The two wire ends of the coil need to be long



▲
Figure 2. PCB overlay showing component locations


Diana, mascot of our metal detector project, on her mettle as she goes to hunt



▶

enough to reach the electronics at the top of the handle with 200 mm to spare.

Now, assemble the handle parts as in **Fig.7**. Remember to drill a hole in the handle section for the wires into, and out of, the cases.

Cut the end off the hand grip before pushing it into position — a drop of washing up liquid as a lubricant will make positioning easier.

Now, connect 1 m of two core wire to the panel meter. as shown in **Fig.4**. Thread the wire through the handle and down the stem to the other case position.

Fasten the panel meter case to the handle.

Fix the larger case to the handle using two saddle clips. Thread the two ends of the search coil wire through the handle to join the PCB. Protect and cover this wire from the coil to the PCB using 2 mm sleeving. If you find it a difficult job to thread the coil wires through the sleeving, first insert a length of stiff wire and use it to pull through the coil leads.

Before connecting the panel meter into the circuit, make the following checks, using the panel meter as a makeshift voltmeter. If you connect a 100k resistor in series with the meter it will read 10 VDC full scale deflection (100 uA on the meter scale). Connect the lead from the negative terminal of the meter to the negative side of B2 and:

- Check that the voltage on ZD1 anode is about 9 V
- Measure the voltage at pin 6 of IC1 and adjust RV1 until this voltage equals the voltage at ZD1 anode
- Measure the voltage at pin 6 of IC4 and adjust RV2 until *this* voltage also equals the voltage at ZD1 anode

Once set no further adjustment is necessary.

Disconnect the batteries and then solder the panel meter wires to the PCB as shown on the overlay.

Move the search coil away from any metal — we suggest you hold it in mid-air to keep the search head clear of floor board nails or other metallic objects — and adjust RV3 until the meter reads zero.

The metal detector is now ready for use but you may wish to give the search head a few coats of varnish to help preserve it. All that remains is for us to wish you 'Happy Hunting'.

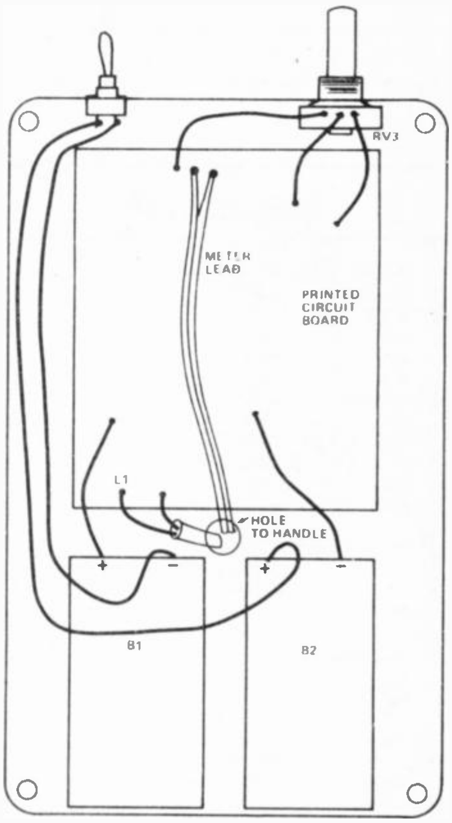


Figure 3. Layout and wiring of the main case, which holds the PCB and two batteries. Each battery consists of four AA-size cells

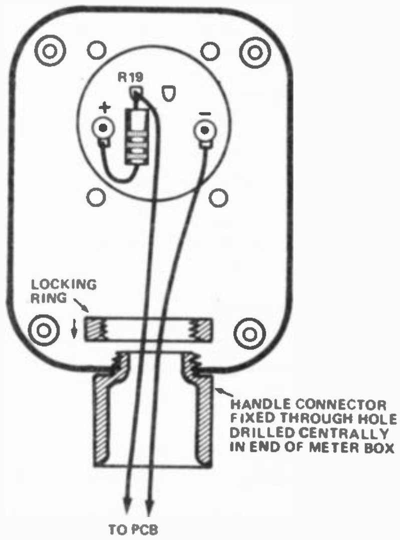
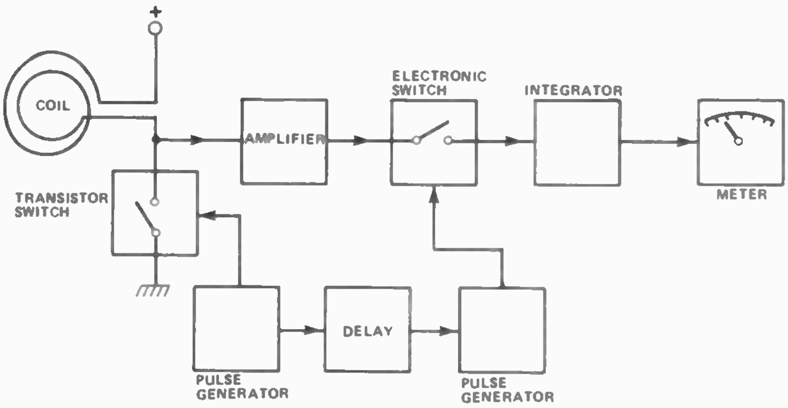


Figure 4. Inside of meter box, showing wiring and mounting of meter and handle connector

How It Works

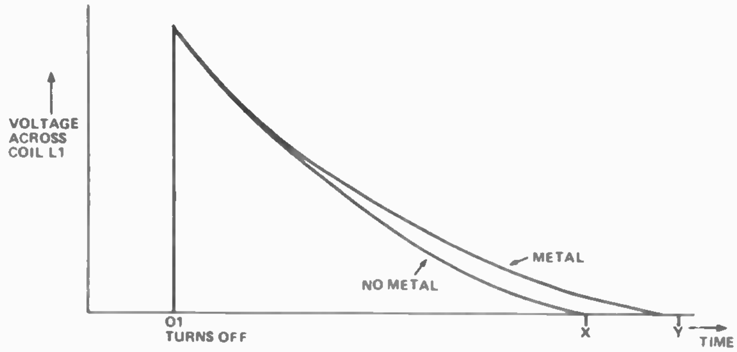
- **A magnetic field is built up around the search coil by passing a current through it. The current is then switched off and the magnetic field slowly decays to zero.**
- **The rate of decay of the field is altered by the presence of metal.**
- **The resulting voltage change across the coil is amplified and fed to the panel meter.**
- **Movement on the panel meter indicates the presence of metal.**



Oscillator IC2a generates a positive pulse which turns on Q1, with the result that a current builds up in search coil L1. At the end of this pulse, Q1 is turned off and the voltage waveform shown below appears across the coil, and falls to zero in time X. If metal is near the coil the voltage falls more slowly to zero (ie, time Y). Operational amplifiers IC1 and IC4 amplify the coil voltage 10 000 times. Monostable multivibrators IC2b and c generate a second pulse, accurately timed after the first pulse, which is used to turn on an electronic switch (formed by IC3a, b and c) just as the coil voltage is reaching zero.

As metal approaches the coil the voltage across it decays more slowly. Therefore the pulses passed by the electronic switch get bigger.

Integrator IC5b amplifies and smooths the pulses from the electronic switch and drives meter ME1. The output voltage from the integrator thus increases as the coil approaches metal, and this is registered on the meter.



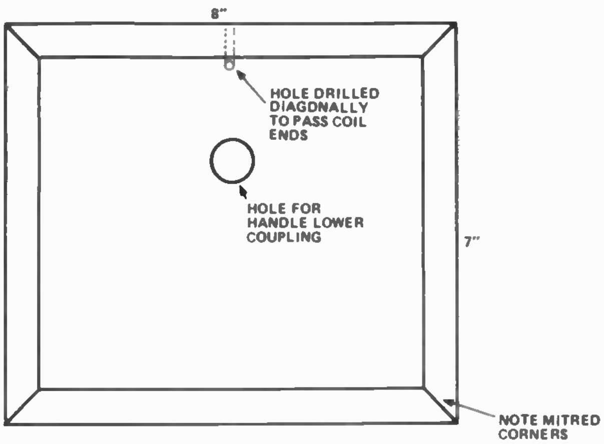
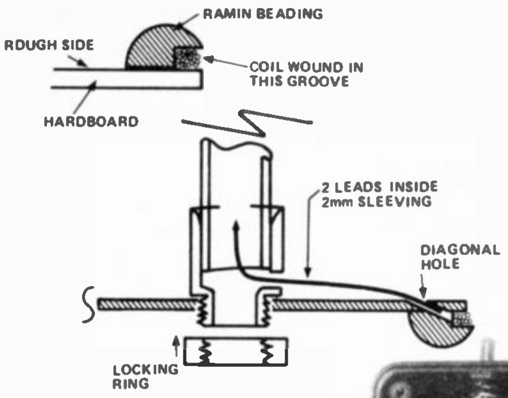
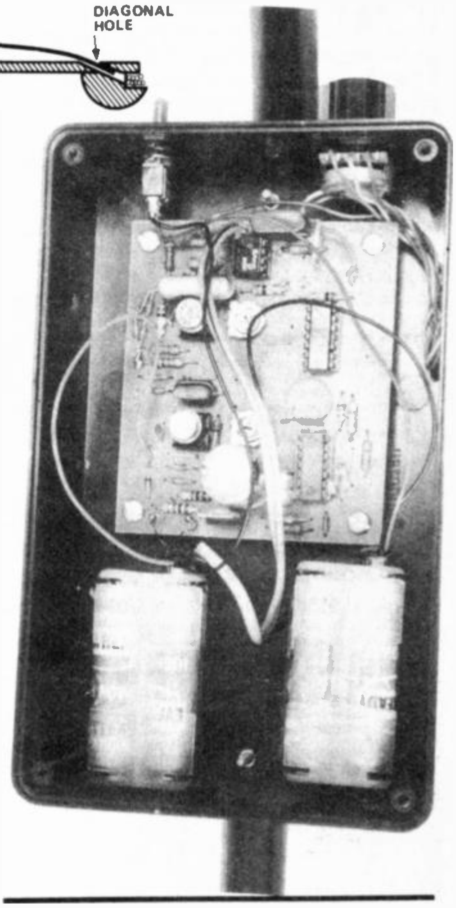


Figure 5. Underside of the search coil head



◀ Figure 6. Sections of the search coil head showing coil leadout and route up into the handle



Parts List

RESISTORS (All ¼ W, 5%)

R1,2	100R
R3,17,19	10k
R4	3M3
R5	18k
R6	68k
R7,16	47k
R8	1k0
R9,14,18	100k
R10,11	2M2
R13	1k5
R15	470R

POTENTIOMETERS

RV1,2	100k miniature horizontal preset
RV3	10k linear potentiometer

CAPACITORS

C1	1000u, 16 V electrolytic
C2,8	2p2 polystyrene
C3	3n3 polystyrene
C4,5	1n0 polystyrene or ceramic
C6	100n ceramic
C7	100n polyester
C9	470n polyester
C10	220n polyester

SEMICONDUCTORS

IC1,4	CA3130 operational amplifier
IC2	40106 or 74C14 hex Schmitt trigger
IC3	4016 quad bilateral switch
IC5	LF353 operational amplifier
Q1	VN67AF VFET transistor
D1-9	1N4148 diode
ZD1	3V9, 400 mW zener diode
ZD2	4V7, 400 mW zener diode

MISCELLANEOUS

SW1	single-pole, single-throw toggle switch

2 x battery holders + clips
100 uA panel meter
Cases to suit
Control knob
Wood for coil former
Handle assembly clips, bends and hand-grip
28 SWG insulated copper wire
2 mm sleeving
IC sockets and PCB pins

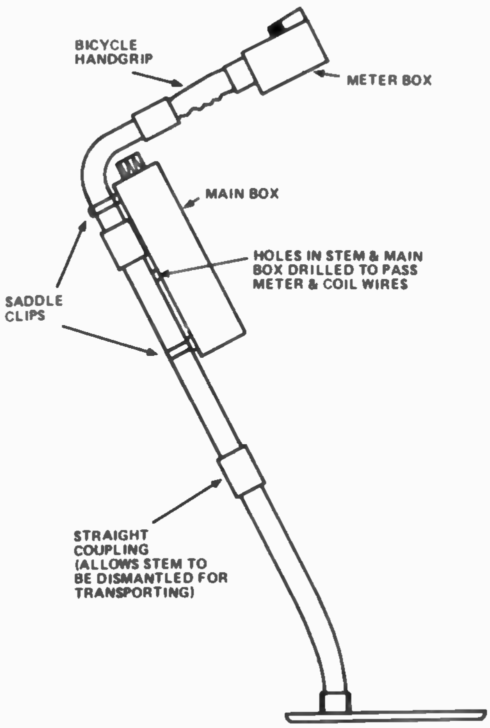
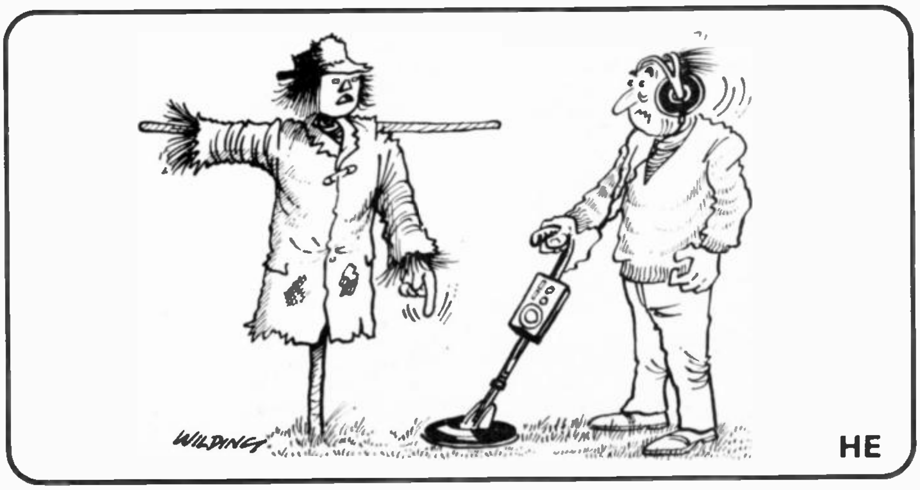


Figure 7. Details of handle and stem construction showing mounting positions of the two cases

Buylines

A full kit of parts is available from:
Magenta Electronics Ltd,
135 Hunter Street,
Burton-on-Trent,
Staffs
DE14 2ST
for £33.85. This price includes VAT, PCB, cases and all hardware, but please add 40p to cover postage and packing.



HE

Electronics In Diagnostic Medicine

Would you trust a computer to diagnose your illness? Graham Thirsk shows that although increased use is being made of electronic diagnostic techniques and data analysis, there will still be a need for the doctor and nurse

THE WORD ELECTRONICS in the title may be clear enough, but what is meant by diagnostic medicine? Put simply, it is the detective work that the doctor has to do to discover why your body is not functioning correctly when you are ill. This 'fault-finding' may be approached in many different ways, and some simple examples are: asking questions about the symptoms, using simple techniques such as taking your temperature, or looking and feeling for abnormal signs. More sophisticated techniques will often require the use of electronic equipment. The doctor collects all the facts together, derived from one or more of these techniques, and makes a logical deduction about the cause of the illness. This deduction will, of course, be guided by the doctor's experience. I used the expression 'fault-finding' because an electronics service engineer uses similar fault-finding procedures for electronic circuits.

Diagnosis From ECG

Electronic instruments have aided the detective work required in diagnosis since early amplifiers were first used to detect and display the electrical activity of muscle. Of particular interest is the electrical waveform produced by the heart muscle, and this waveform is called the electrocardiogram, or ECG. Early ECG machines were large and required a special electrically-screened room for their operation. It was also necessary for the patients to sit with their feet in water to ensure a good ground (earth return) connection. Modern ECG machines, however, can be small enough to fit into the doctor's black bag and require no screening. With the modern machines only simple electrode connections are required to the patient.

Advances in diagnostic techniques have often taken place as a direct result of advances in electronic technology and their application to medicine. Interestingly, these advances have often produced a demand for more sophisticated equipment to yield more information and hence stimulate further developments in electronics. An example of this interaction is shown by the development of ECG monitoring.

Studies of the ECG have shown that changes in the normal functioning of the heart are nearly always accompanied by changes in the ECG waveform. Consequently, the ECG is used widely to assist in diagnosis of malfunction of the heart. Such is the importance of the ECG that methods were devised for continuously displaying the ECG of certain high risk patients, such as those who had recently had a heart attack, on a cathode ray tube. As a result, much information was acquired about abnormal heart rhythms or arrhythmias and soon doctors felt that a record of the ECG during 24 hours in the normal life of these high risk patients would yield much valuable information about the condition of the heart. This could be done easily using a special portable cassette recorder, but to play back the recording would obviously require 24 hours in real time, which is impractical. The development of digital techniques, particularly in microprocessors and solid-state memories, has enabled instruments to be constructed which can replay the tape at high speed, memorise that patient's normal heart rhythm, detect any abnormal rhythms, store them and classify them according to a pre-programmed order of priority and the number of times each occurred. This processing can be completed within minutes for a 24-hour recording, and also the sections of ECG containing the abnormal rhythm can be displayed on an oscilloscope, following a simple machine instruction.

Doppler Analysis

The interaction between the development of electronic and medical sciences continues even now. A recent innovation has been the measurement of the flow of blood within the blood vessels. This technique uses the doppler shift of a burst of high frequency sound waves, ultrasound, by the movement of blood cells within the vessels. The doppler effect is simply a change in the sound pitch that results when there is a relative motion between the sound source and the observer. If a sound wave is reflected off the moving object then movement towards the sound source produces an increase in the pitch of reflected sound and movement away from the source produces a decrease in the pitch. If a continuous beam of ultrasound is passed into the body, any movement in the same axis will produce a change in frequency of the reflected beam. This is similar to frequency modulation as used in radio transmitters.

The returning beam is demodulated to remove the original carrier frequency and this leaves just the signal produced by the movement, the doppler information.

The information obtained in this way used to be analysed by amplifying the shift frequencies (typically 1 to 3 kHz) to drive loudspeakers. The analysis was based on listening to the result. Although apparently a crude method, much information about flow could be derived in this way. However, a more quantitative method of dealing with the data was required. Initially, a zero crossing technique (that is, counting the number of times a doppler waveform crossed the zero voltage point) was used to obtain information about the frequency content of the doppler signal. Subsequent research showed this method to be hopelessly inaccurate when used on complex signals such as those produced when studying blood flow. Recently, the availability of fast and inexpensive microprocessors made it possible to analyse the doppler signal mathematically to provide true real time spectrum analysis, together with a statistical treatment of the data. Such is the impact of this latest development and the diagnostic information it provides, that doctors are currently researching methods to best apply this powerful technique to diagnostic medicine. Improvements to the technique that might be incorporated into subsequent designs of instruments have already been suggested.

These two examples, ECG and doppler analysis, serve to illustrate the interaction between electronics and medicine, where advances in one discipline may stimulate developments in the other and vice versa.

Analysing Waveforms

Observations and recordings of electrical signals produced by various parts of the human body have long been important diagnostic tools. Several types of waveform can be obtained, some of the more important ones being electromyogram (EMG), produced by ordinary muscle, electroencephalogram (EEG), produced by brain cells and electrocardiogram (ECG), produced by heart muscle. All are detected by amplifying signals obtained from electrodes placed at different points on the skin surface and recorded on paper.

The ECG is the most commonly used and is probably the most useful. A typical ECG waveform is shown in Fig.1. The segments, P Q R S T represent electrical events occurring within the heart. Each occurs at a specific point in the cardiac cycle (one heart beat). The number of cardiac cycles occurring each minute is the heart rate, usually 70 beats/minute in a healthy person at rest, but as high as 160 beats/minute under stress or during exercise. The shape of the waveform and the time relationship of the segments yields important information about the state of the heart.

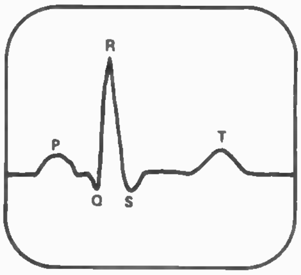


Figure 1. Typical ECG (electrocardiogram) waveform. It is divided into segments P Q R S T for analysis of electrical events in the cardiac cycle

Although this is an apparently simple technique, there is first the difficulty of detecting and selectively amplifying an electrical signal of approximately 1 millivolt (1 mV) peak-to-peak in the presence of induced AC noise such as 50 Hz mains hum of several volts peak-to-peak. Second, since the human body may be considered as being filled with a conductive fluid, an electrical signal from areas other than the ones being studied may also be present at the skin surface. For example, electrical signals produced by the movement of muscles is a common source of interference on ECG recordings. Third, it is generally recognised that a current flow of greater than 10 microamps (10 uA) across the heart can be fatal and since good electrical contact with the skin is essential, precautions must be taken to avoid leakage of current to the skin electrodes, especially when mains-powered equipment is used.

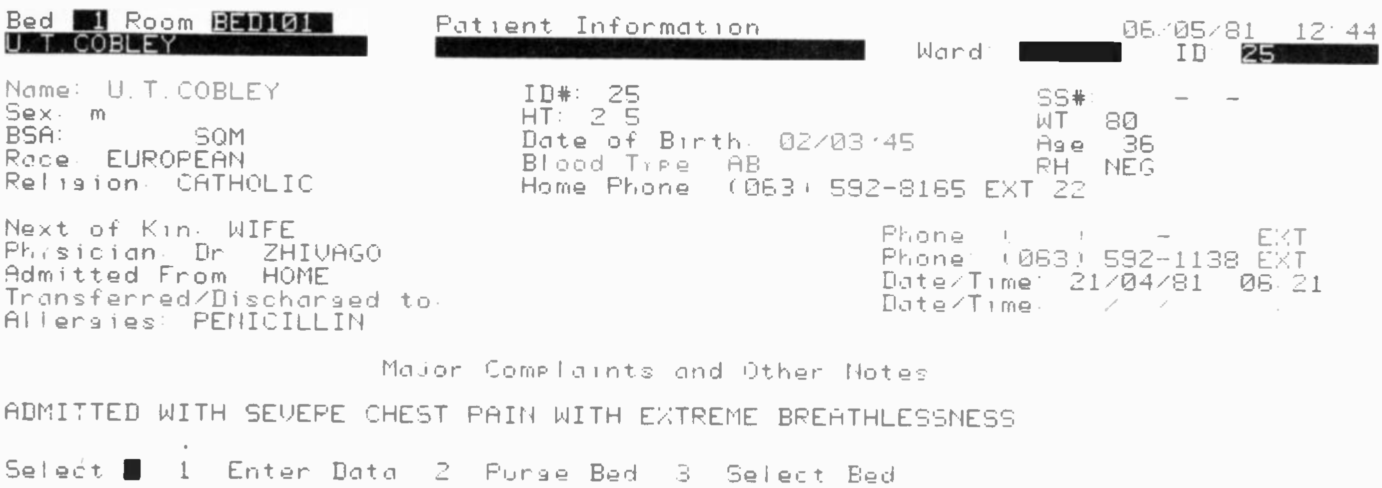
Use of modern circuit design has minimised most of these difficulties. Front-end circuitry is of the differential type offering a very high common mode rejection ratio (the noise, common to two amplified signals, tends to be cancelled out). Amplifiers with specific passband together with deep-notch filters (to limit amplification to an extremely narrow band of frequencies) further improve the selectivity and noise immunity of the instruments. Isolation of the patient from the instrument and power supplies is achieved by transformers or more recently by opto isolators (devices incorporating a light source and a light detector).

The ECG has become such an important index of heart function that all high risk patients, such as those undergoing surgery in the operating theatre or those in intensive care units, have their ECG waveform monitored continuously and displayed on a 'scope of some type. Early bedside monitors comprised a high persistence low sweep speed oscilloscope and an analogue meter giving an indication of heart rate. Modern monitors, however, can display several seconds of ECG waveform at one time, while continuously updating this display by using analogue-to-digital conversion and a digital memory. Digital display of heart rate is provided either by means of LED displays or as alphanumerics on the 'scope itself. An audible and visible alarm is also usually provided to alert the nurse immediately in the event of the heart rate exceeding preset limits.

Various other body functions may be monitored in a similar manner: temperature using thermistor probes, respiration by measuring impedance changes related to chest movements and blood pressure by means of strain gauge type pressure transducers.

Patient monitoring techniques have gradually been improved to provide further detailed information about the patient's condition. Patients recovering from a heart attack may now be allowed out of bed to walk around in the hospital and still have their ECG monitored by means of telemetry. In this, the ECG is modulated onto a radio frequency (RF) carrier wave and is transmitted by a short range transmitter to a base station where it is demodulated and displayed on a 'scope in the usual way. This provides a valuable half-way stage between intensive care monitoring in bed and the patient being allowed home.

Detection of abnormal heart rhythms or arrhythmias by observation of the ECG is an essential part of the monitoring of patients with heart disease. Some arrhythmias may be just an indication of impaired heart function, while other abnormal rhythms may be a threat to life. Arrhythmia detection initially depended upon constant observation of the ECG by the nurse and the recognition of abnormal patterns. However, it is not possible to concentrate on a display of this kind for more than 60% of the time and abnormal rhythms often went undetected. Automated detection systems are able to observe the ECG for 100% of the time, classify any arrythmias and store them in memory for later review. Normal and abnormal ECG waveforms are differentiated by a template matching process. In this, the monitor initially stores the normal waveform for a particular patient in its memory and compares all the subsequent waveforms



Bed 1 Room BED101
U.T.COBLEY
Patient Information 06/05/81 12:44
Ward ID 25

Name: U.T.COBLEY
Sex: m
BSA: SQM
Race: EUROPEAN
Religion: CATHOLIC

ID#: 25
HT: 2 5
Date of Birth: 02/03/45
Blood Type: AB
Home Phone: (063) 592-8165 EXT 22

SS#: - -
WT: 80
Age: 36
RH: NEG

Next of Kin: WIFE
Physician: Dr ZHIVAGO
Admitted From: HOME
Transferred/Discharged to:
Allergies: PENICILLIN

Phone: ( ) - EXT
Phone: (063) 592-1138 EXT
Date/Time: 21/04/81 06:21
Date/Time: / /

Major Complaints and Other Notes

ADMITTED WITH SEVERE CHEST PAIN WITH EXTREME BREATHLESSNESS

Select ■ 1 Enter Data 2 Purge Bed 3 Select Bed

Figure 2. Example of how information on individual patients can be printed out in hard copy form. The advantages of data handling equipment include immediate (automatic if required) updating of information, analysis of data and saving of time for nurses

with this template. Deviations from the template are then classified and stored for later review together with data on the number and types of abnormal rhythms detected.

Handling The Data

The volume of patient data now being produced by modern nursing methods has prompted the development of data handling equipment for medical purposes based on microprocessor technology. Features include:

- on-line assimilation of data from monitoring equipment and production of trend graphs for periods of up to 24 hours from this data
- analysis of data from arrhythmia monitors
- recording of drugs given to the patient, when they were given and in what doses
- storage of the patient's personal data such as age, weight, height, names of relatives and the name of the family doctor.

Hard copy of this information is also often provided for inclusion in the patient's medical notes, an example of which is shown in **Fig.2**. Data handling of this type has become sophisticated to the point where data obtained from blood pressure measurements made in the operating theatre can be analysed and interpreted on-line, providing the doctor with a complete diagnosis in a very short time.

The monitoring techniques described are all attempts to provide continuous information about the patient's condition, to collect and provide easy access to all this data while relieving the nurses of tedious routine observations and in this way enabling them to spend more time caring for the patient.

Diagnosis From Images

An area of medical diagnosis which is currently undergoing the fastest development, as a direct result of the advances in electronics, is diagnostic imaging. Diagnostic imaging is the science of producing pictures of the internal structures of the body without damage to them. The best known imaging technique is that which uses X-rays to produce a photograph of internal structures such as bone but which does not allow X-rays to pass through these structures. The technique is limited, since only structures that are opaque to X-rays can be seen with clarity. To see other structures, such as the stomach and intestines, these must first be outlined with a contrast medium which absorbs the X-rays. The patient must swallow a contrast medium (for example, barium sulphate) and then undergo a series of X-ray photographs as the contrast medium passes through the intestines. A further disadvantage of X-ray photographs is that they are static and cannot show motion of any kind. In fact, motion during exposure of the X-ray film results in blurred images. However, the most serious disadvantage of X-ray techniques is that X-radiation is known to be harmful to healthy body tissue and therefore excessive exposure should be avoided.

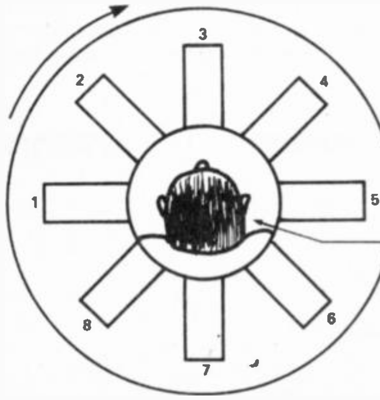


Figure 3. Scanning elements of a greatly simplified computerised tomography scanner. As shown, the patient's head is placed in the centre of the assembly. X-rays are emitted from elements 1 to 4 and are received by elements 5 to 8. The whole assembly then rotates a few degrees and the sequence is repeated

Advances in microcomputing techniques have enabled some of the shortcomings of X-ray imaging to be overcome. For example, X-ray scans of brain tissue can now be made using a computerised tomography scanner (CT Scanner). Initially developed by EMI this instrument produces pictures of successive sections (1 mm thick) through the head using X-rays (see **Fig.3**). Each element 1 to 4 in **Fig.3** sequentially emits a burst of X-rays which are received by the elements 5 to 8 and converted to an electrical signal which is stored by the computer. The scanhead revolves a few degrees after all the elements are fired and the sequence is then repeated. In this way, the computer memory stores information about the absorption of the X-rays as they pass through each tissue type and an image can then be reconstructed on a video monitor by reading the information out of the memory in the correct sequence. A complete brain scan requires 50 to 100 sections to be constructed, which is a lengthy process taking 20 minutes or more. The sections are often stored on floppy discs for later review and analysis.

Ultrasound Imaging

A technique for examining the interior of the body painlessly, without the use of X-rays, has been developed in the last 10 years. It uses high frequency sound waves, typically 1 to 10 MHz in frequency, to probe the organs of the body. From the echoes produced, pictorial images of the organs can be constructed by means of techniques first used for radar and sonar.

When pulses of ultrasound travel through a medium they are reflected and scattered in much the same way as audible sound. The diagnostic application of ultrasound depends mostly on the fact that the pulses are partially reflected at boundaries between tissues that differ in their ability to transfer the ultrasound energy (acoustic impedance). Acoustic impedance is dependent upon the density of the medium and the velocity of sound passing through it. The density of soft tissue is close to that of water and the velocity of sound through it is close to the velocity of sound through water. The velocity ranges from 1 450 metres per second in fat to 1 600 metres per second in muscle. Therefore, the difference in impedance between tissues is not very great and consequently the echoes are small.

Typically only 0.5% of the incident energy is reflected at a boundary in a manner that can be detected, and this requires a sensitive receiver. However, since much of the ultrasonic energy crosses the boundary it penetrates deeper into the body and thus is an effective probe of deeper organs. These strong reflections may limit the usefulness of ultrasonic diagnosis in some analyses.

The resolution of the system depends upon the wavelength used to form the image. Generally, resolution increases as the wavelength decreases. Since wavelength is inversely proportional to frequency, a better resolution requires high frequencies. In practice, the ultrasound is attenuated as it passes through the body by absorption and scattering, and the rate of attenuation is directly proportional to the frequency. Therefore, a compromise between resolution and depth of penetration is necessary. Frequencies of 3 to 5 MHz are the most useful for general ultrasound imaging.

The ultrasonic pulses are generated by a piezoelectric transducer, and usually the same transducer serves for detecting the pulse echoes. The piezoelectric crystal is excited by a voltage pulse at the resonant frequency of the crystal, causing it to emit a brief burst of high frequency sound. The length of the pulse is restricted to one wavelength by electrical and acoustic damping, to maximise the resolution of the system. The crystal then waits for returning echoes which cause it to vibrate and produce an electrical signal proportional to the amplitude of the echo. The distance of the reflecting boundary from the transducer can be determined by measuring the interval between the moment the pulse is transmitted and the moment the echo is received. Pulse echo information obtained in this way can be displayed on the CRT.

Image Display

A single sweep of the CRT is difficult to observe and so the process of transmit/receive is repeated at 1000 times/second to provide a flicker-free display. **Figure 4** shows a typical display obtained in this way and is known as an A mode (amplitude versus distance) display.

This type of display provides limited information about structures in the sound beam, so the echoes are usually presented in the form of a brightness modulated display (B scan). In the B scan each echo is represented by a spot of light, the brightness of which is proportional to the amplitude of the echo received. However, to form a pictorial image of a cross-section of the body, much more information is required.

In static scanners, which provide non-moving pictures, the transducer is mounted on a mechanical arm which is able to move in two directions. Data is then obtained not only on the strength of the echo and the position of the boundary, but also on the position of the probe and the direction of the ultrasound beam. Each position of the probe, together with the position and brightness of the echo, is stored by the scanner. If the probe is moved, different structures will be in the beam and different echoes will be returned. Thus by integrating all the lines of information at each probe position, a composite picture of the underlying structures can be built up. This picture has several different brightness levels equivalent to what is called a grey scale.

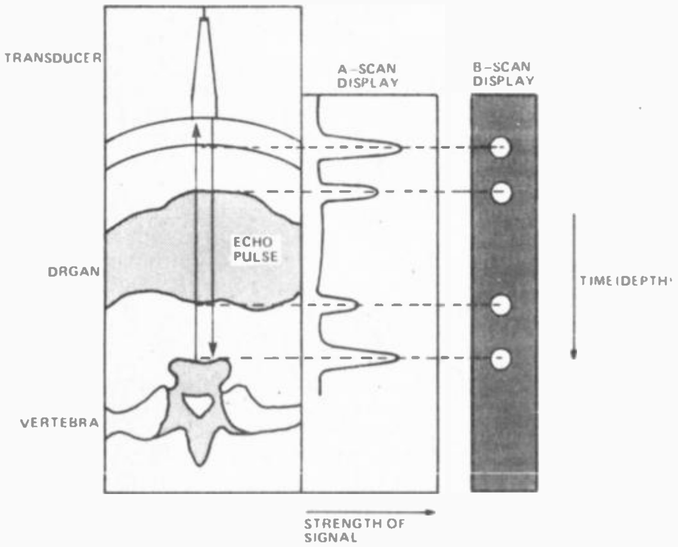


Figure 4. Example of display obtained from an ultrasonic scanner. The piezoelectric transducer transmits a pulse of sound and then 'listens' for the echo, in this example from the organs and bones in the abdomen

Intermediate lines of the image are stored by a scan converter. Early scan converters were analogue devices, but more recently digital scan converters have been developed. The analogue scan converter is a vacuum device resembling a CRT but the phosphorescent screen is replaced by a silicon target. The surface of the target consists of a mosaic of tiny silicon oxide elements, each of which stores a charge corresponding to the brightness of the image at that position. Once the image is formed, it is scanned by sweeping an electron beam of low intensity over the target in rapid horizontal motion, like the raster scan on a TV screen. The raster scan is repeated in the CRT and the current from the scan converter controls the current in the electron gun of the CRT. The result is a display of the image stored in the scan converter target. Satisfactory operation of the analogue scan converter requires careful adjustment.

To avoid some of these problems, digital scan converters were developed. In the digital scan converter the image information is split up into a regular, two-dimensional matrix of picture elements. A typical picture consists of 512 x 512 elements, and the position of each element corresponds to the location of a word in random access memory. The brightness of each picture element corresponds to the value of the word, and the composite picture stored in the memory can be read out and displayed on the CRT in the usual way.

The ultrasound pulse is attenuated as it travels through tissue and consequently for a given interface between tissues, the echoes become weaker as the distance from the transducer increases. To produce a display with uniform brightness, for similar echoes, compensation for attenuation is required. This is known as time gain compensation or TGC and it increases the gain of the receiving amplifier logarithmically, as the time from the transmission of the pulse increases. **Figure 5** shows a typical static B scanner in block form.

Real Time Scanning

Static B scans of this type take up to 15 seconds to build up an image of one full cross-section through the body and so cannot depict fast-moving objects such as the heart. So, a real time scanning system was needed that could rapidly produce a

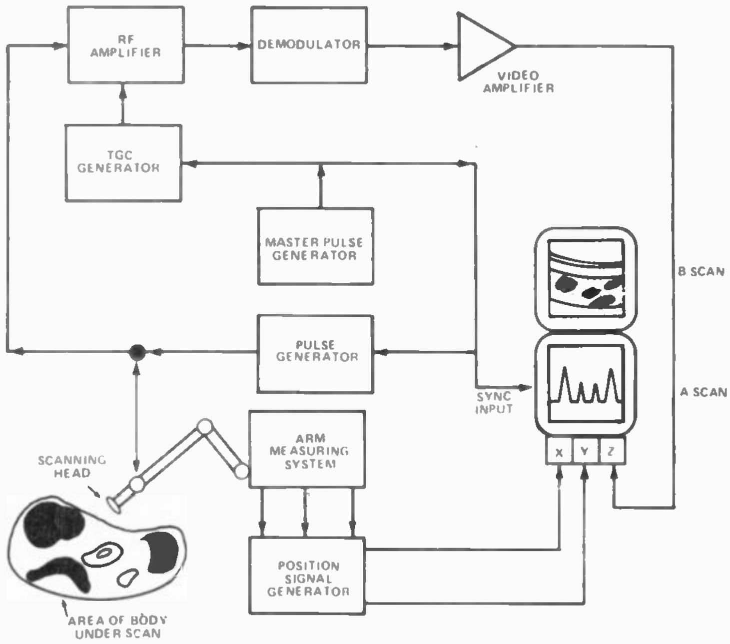
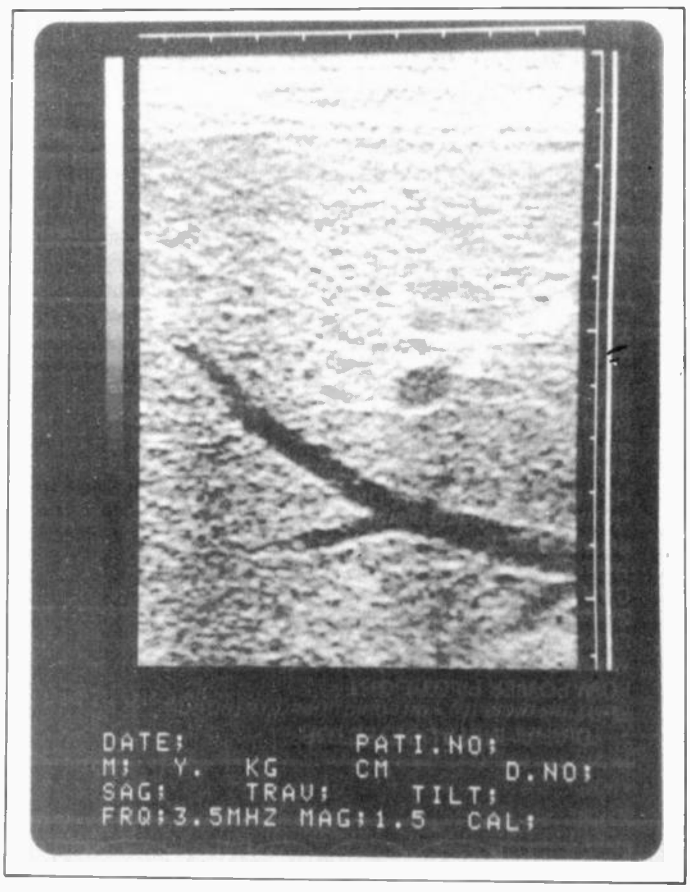


Figure 5. Main parts of a typical static B scanner

series of stop-frame images. Two advantages of such a system are the ability to freeze motion and to greatly reduce the time needed for an examination. Real time moving images are also easier to interpret than static ones. There are two main types of real time scanner: sector or linear array. In the first type of scanner the sound beam from the transducer is either mechanically or electronically swept across the patient at high speed. It produces a series of stop-frame images, like cine film. Linear array scanners have a probe consisting of up to 400 transducer crystals in line which are fired in rapid sequence to produce repeated scans. These transducers are very small so that several elements are usually fired together to increase the sound intensity. By introducing a delay in the signal path of each element, it is possible to focus the sound beam at selected distances, thus improving the resolution of the system. An image produced by a sector scanner is shown in **Fig.6**.

Figure 6. Ultrasound image of human liver, showing one of the blood vessels within it



Real time imaging is developing rapidly as a result of the application of new electronic technology. Memories with faster access times coupled with microprocessor control have enabled faster image formation with subsequently higher frame rates. This effectively allows even the fast motion of the heart valves to be frozen easily. Early instruments used 3-bit digital memories and could only differentiate light levels of echo intensity or grey scale. Now instruments may have 6-bit memories providing 64 levels of grey scale. As a result it is possible to distinguish different types of tissue boundary more easily since different boundaries return different intensities of echo and hence are depicted as a different shade of grey. Electronic miniaturisation has also allowed the scanners to be made small and portable, increasing their usefulness. An example of the most recently introduced sector scanner is shown in **Fig.7**.

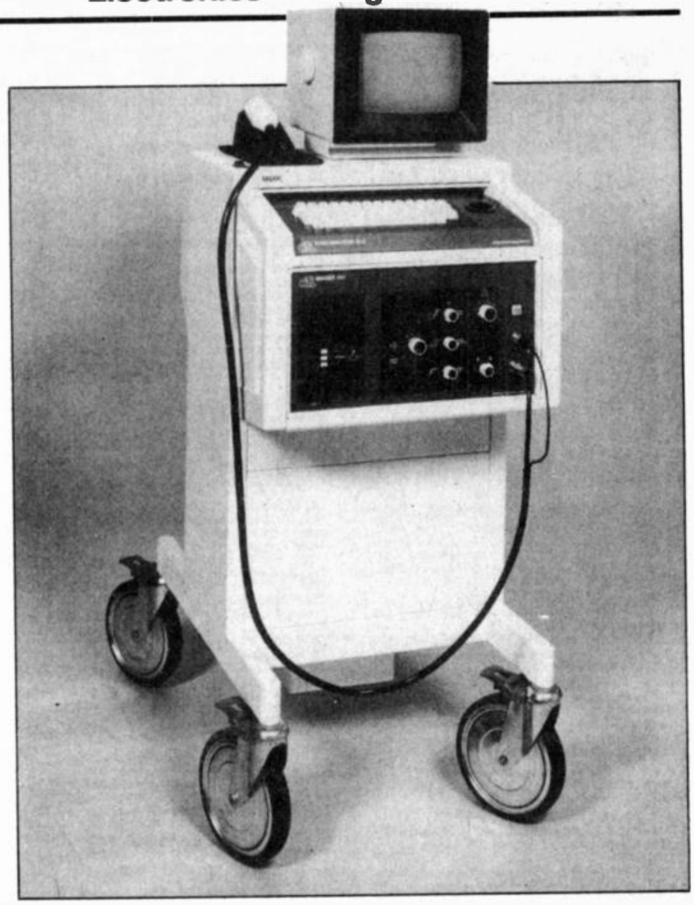


Figure 7. Example of sector scanner from Advanced Technology Labs Inc. The instrument, using microelectronics, provides a real time scan of body tissue derived from different intensities of reflected ultrasound. Tissue boundaries and composition are depicted by variations in shades of grey

Combining Pulse-echo And Doppler

Echo-ranging is not the only information that can be obtained from the use of ultrasound. Information about the velocity of a moving object may also be obtained from the doppler effect, described earlier in this article. Instruments using the basic doppler technique are used routinely to listen to the heart beat of the foetus during labour and to detect the flow of blood in its arteries.

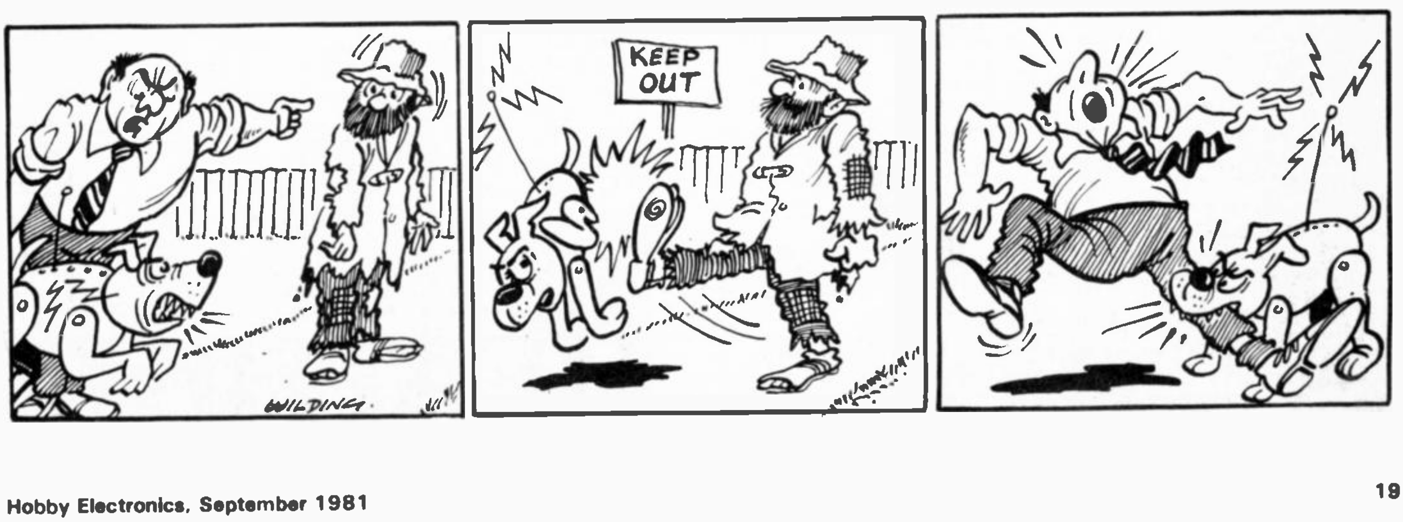
Combining the pulse-echo technique with doppler provides even more information and is known as pulsed doppler. Instead of emitting a continuous beam of ultrasound, only a short pulse is emitted. Measuring the time taken for the echo to return gives the position of the object, and the doppler shift gives the velocity of the object. The pulsed doppler technique offers the advantage of the ability to select one moving object when many are in the path of the sound beam. Instruments that combine two-dimensional images and pulsed doppler are now available, which allow the doctor to see a moving object such as blood in the artery and to measure the velocity or flow of the blood and the direction in which it is flowing. Analysis of the doppler shift frequencies can provide valuable information about the flow of blood in the arteries; whether it is laminar or turbulent flow and whether the flow is the same all the way across the blood vessel. From this data the doctor can tell if the artery is occluded (blocked) or stenosed (narrowed) — all without any discomfort to the patient.

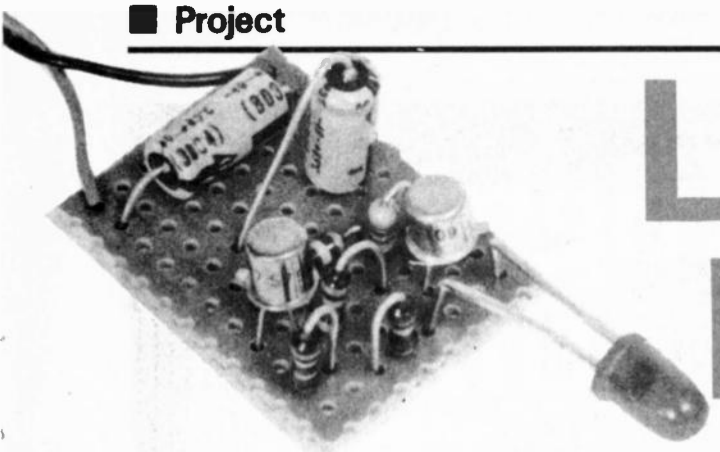
Looking Ahead

What of future developments in medical diagnosis? The ultimate end point must surely be fully automatic diagnosis by a small diagnostic computer. However, automatic diagnosis is not yet possible since the doctor often uses the data from diagnostic tests in an intuitive way which the best computers currently available are still not able to do.

Realistic advances in medical electronics will almost certainly be aimed at reducing the workload of the doctors and the nurses. On-line data acquisition and analysis together with a complete listing of the patient's medical history and personal data will provide the doctor with the information he or she needs to make a correct assessment of the patient's condition. Written record-keeping will be minimised, as will routine observations of the patient, so that the nurse will have more time to care for the patient. Current developments in electronic technology will almost certainly improve the quality of imaging techniques. Recent advances in analogue delay lines, such as surface acoustic wave devices, have enabled sector scanners to be constructed which are non-mechanical, where the ultrasound beam is steered by delaying the pulses used to excite the transducers. An instrument recently introduced changes the black-and-white image produced by ultrasound scanners into a colour picture and this shows up the small differences between tissues much better. Development of the pulsed doppler technique is aimed at providing a coloured overlay of the flow in the blood vessel or heart on the black-and-white two-dimensional image produced at the same time.

The use of electronics in diagnostic medicine is widespread, and ranges from digital thermometers to complex imaging instruments: only the more interesting techniques have been included in this article. Perhaps next time you visit a hospital you might like to look for some of the sophisticated electronic instruments that are being used there. **HE**





Low Power Pilot Light

Build yourself this simple circuit to fit inside battery-powered equipment — it will warn you that you have left the equipment on and that you are wasting valuable battery power

HOW MANY TIMES have you gone to your tranny to listen to your favourite programme, only to find that the battery is dead because the last time you tuned in you forgot to turn off the radio? This sort of thing can happen quite often to battery-powered equipment and the chances are you won't have any fresh batteries.

Now, wouldn't it be nice if you could fit a LED pilot light to the equipment, to give a visual warning when it has been left on? The problem with such a method is that the current drawn by the LED (about 20 mA) could result in the pilot light using more power than it saves.

A more practical alternative is to use a low power pilot light such as this one. The HE Low Power Pilot Light flashes a LED for only very short periods, at intervals of about 1 s. Because the LED is on for only a small fraction of the total time, the *average* current consumption is very low. Thus battery life will not be significantly reduced with the use of this project, even if the battery is a small, low capacity type.

A flashing LED pilot light also has the advantage of being more noticeable than a non-flashing type.

Construction

Insert and solder the five resistors into the Veroboard, according to Fig.2, followed by the two capacitors. Make

Parts List

RESISTORS (All ¼ W, 5%)

R1	1M2
R2	100k
R3	18k
R4	10k
R5	1k8

CAPACITORS

C1	1u0, 16 V electrolytic
C2	10u, 16 V electrolytic

SEMICONDUCTORS

Q1	BC109 NPN transistor
Q2	BC179 PNP transistor
LED1	0.2" red LED + panel clip

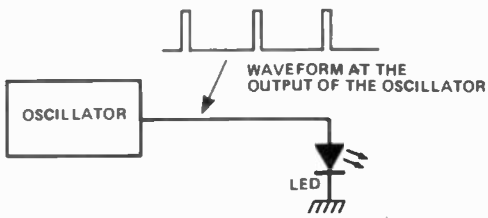
MISCELLANEOUS

Veroboard, 8 strip x 11 hole, 0.1" matrix.

How It Works

This project consists of a simple oscillator, producing pulses which light the LED at about one-second intervals.

The LED is on for only about 5% of the total time. Thus the *average* current consumed by the circuit is very small, so it won't waste battery energy while doing its job.



Initially transistor Q1 is biased into conduction by resistor R1, and it in turn biases Q2 into conduction via current limiting resistor R2. Transistor Q2 therefore supplies a current to LED1 through R5. Capacitor C1 then charges from the supply lines through Q2, R4, and the base circuit of Q1, causing a substantial base current to flow into Q1. This results in Q1, Q2 and LED1 all being switched on.

Capacitor C1 soon becomes fully charged, and the large base current to Q1 ceases. Transistors Q1 and Q2 then start to switch off, and the voltage at Q2's collector falls, forcing a reduction in the potential at Q1's base since the voltage across C1 remains unaltered. This results in Q1, Q2 and LED1 all switching off. Capacitor C1 now discharges through R4, R5, LED1, and the base circuit of Q1, reverse biasing Q1 and holding it in the off state. The discharge path has a higher resistance than the charge path, giving the required relatively long off time of the LED. When C1 has discharged, R1 again biases Q1 into conduction, and the cycle commences from the beginning once again.

Resistor R3 is needed to ensure that leakage currents do not cause Q2 to be partially switched on when it should be turned off, which would reduce the efficiency of the unit. Capacitor C2 is a supply decoupling component and it prevents the pilot light circuit transmitting noise spikes to the main equipment via the supply lines.

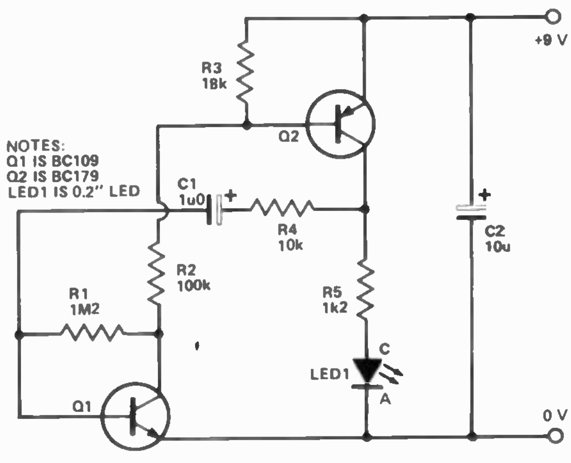


Figure 1. Circuit of the HE Low Power Pilot Light. The suggested Veroboard layout for the project is overleaf in Fig.2

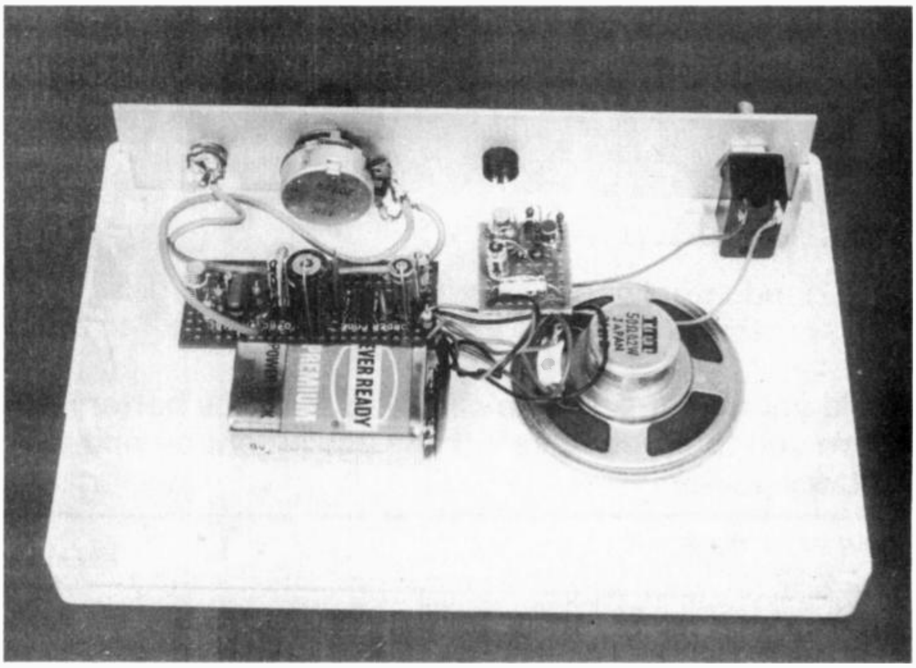
sure you polarise the capacitors correctly.

Now, mount transistors Q1 and 2, checking before you solder each one in that it is the right way round.

Solder in LED1, the same way round as shown in Fig.2. Now, bend it down so that it lies in a horizontal line with the Veroboard.

Finally, solder a couple of coloured leads from the corresponding points (red to +9 V; black to 0 V) long enough to go to the supply points of the equipment into which the project fits.

The circuit board does not need to be fastened down because it is adequately mounted when LED1 is fitted into its panel clip. So, all you need to do now is drill a hole in the panel of your battery-powered equipment to fit the LED panel clip, push in the LED (complete with circuit board) and connect the board to the supply points of the equipment.



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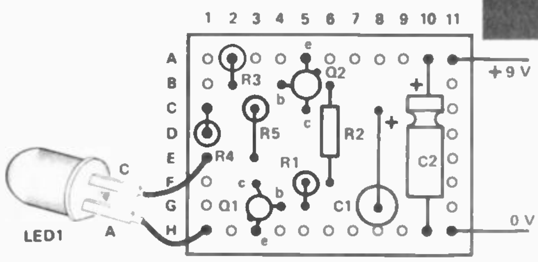


Figure 2. Veroboard layout. Note no track breaks are required

Buylines

You should find no difficulty in obtaining components for this project.

Approximate price for all parts (including Veroboard) is £1.50.

TECHNICAL ? TERMS

Understanding The Hall Effect

Semiconductors behave very strangely in the field — magnetic, that is. Ian Graham gives a brief explanation of the Hall effect

OF ALL THE EFFECTS depending on the influence of a magnetic field on semiconductor charge carriers, the best known is probably the Hall effect. Edwin Herbert Hall (1855-1938), an American physicist, observed the result of applying a magnetic field to a semiconductor, through which he passed a current at right angles to the field. The arrangement is shown in **Fig. 1**.

In **Fig. 1**, a magnetic field of B Wm^{-2} (webers per square metre) in the Y-axis acting on a current (I) along the X-axis deflects 'holes' along the Z-axis to the bottom of the P-type semiconductor. Holes (vacant atomic positions in the crystal lattice) are the majority charge carriers in a P-type semiconductor. In N-type, the majority charge carriers, electrons, would be deflected to the bottom of the semiconductor.

Facial Motion

This movement of charges to one face of the semiconductor produces a potential difference at right angles to both the current (Ix) and the magnetic field (By). This potential difference is called the Hall voltage (V_H) and is given by:

$$V_H = \frac{3\pi By.Ix}{8p.e.d} \times 10^4,$$

where e is the charge on an electron,
d is the thickness of the semiconductor (cm)
p is the hole density (cm^{-3}).

This strange behaviour of charges follows a well-known rule in physics — Fleming's Left Hand Rule — used to predict the behaviour of a current-carrying conductor in a magnetic field.

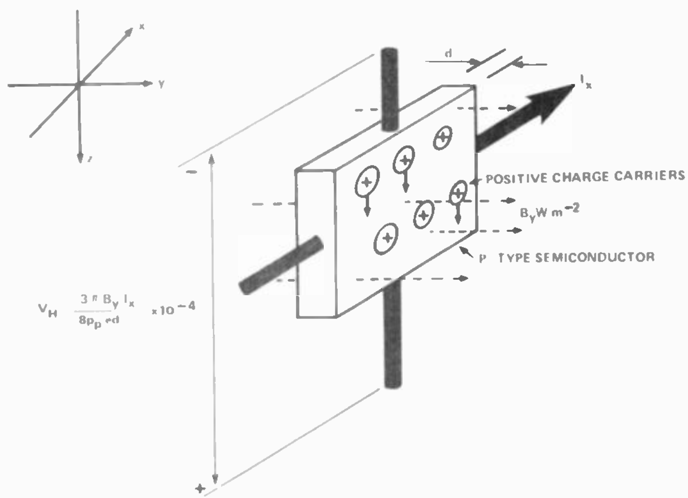


Figure 1. Result of applying a magnetic field to a current-carrying semiconductor — the Hall effect

Applications

Hall discovered an interesting effect, but how can it be used? By fixing any two of the three variables the third can be measured. For example, an unknown magnetic field can be measured by finding how big a Hall voltage it produces compared with a reference field. Many of the devices available use indium antimonide or indium arsenide, because they exhibit a large Hall effect and are not greatly affected by temperature.

The TL170C uses the Hall effect to sense steady-state magnetic fields. It has a built-in output transistor for use on voltages up to 30 V and requires a supply of 5 V at 4 mA (output high) to 6 mA (output low).

Max output current	
(output low)	20 mA
(output high)	20 uA (max)
Output voltage	
(at 16 mA, output low)	0.4 V

Table 1. Output characteristics of TL170C Hall effect switch. The TL172C is a normally-off switch. A positive-going magnetic field switches the output low

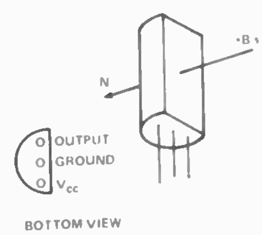


Figure 3. Outlines of TL170C and TL172C Hall effect devices

TYPE	SBV566	EA218	FA22E
Imax control (mA)	50	150	200
Hall emf (mV at mT at mA)	130 at 75 at 10	85 at 1000 at 100	120 at 1000 at 100
Control R (ohms)	30	3	2
Hall R (ohms)	30	1.5	1.5
Offset max (V/A)	1.0	0.005	0.002

Table 2. Characteristics of three readily-available Hall effect devices

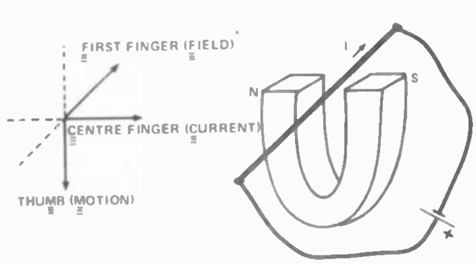


Figure 2. In this example the direction of the force on the wire can be determined from Fleming's Left Hand Rule. Point your first finger in the direction of the magnetic field and your centre finger in the direction of the current. Your thumb should now be pointing downwards. The wire will be deflected downwards. If your thumb is pointing upwards, you've discovered Fleming's Right Hand Rule — change hands

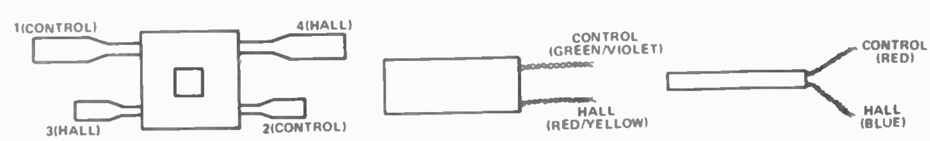
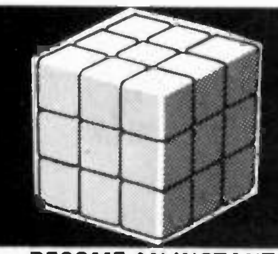


Figure 4. Outlines of the three devices described in Table 2 : SBV566 (left), EA218 (centre) and FA22E (right)

HE



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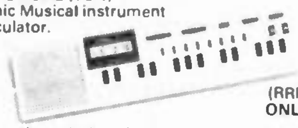

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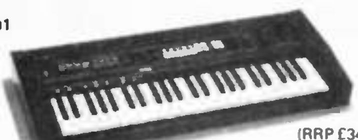

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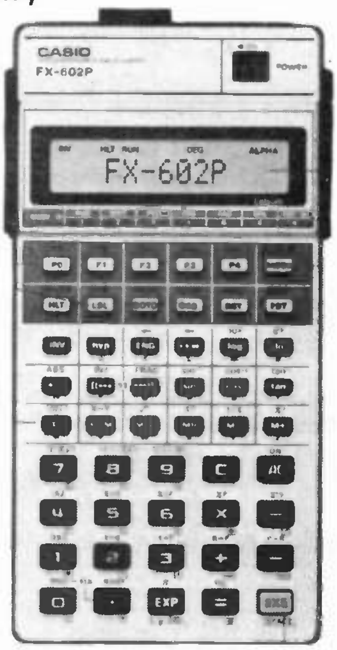

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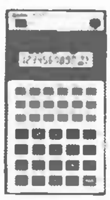

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Famous Names

This fifth part of our Famous Names series looks at the life of Oliver Heaviside. Like Isaac Newton before him, Heaviside showed original genius in his work and discovery

ONE OF THE most tantalising aspects of writing biographical notes is that our knowledge of a person seldom matches up to our interest in what he has achieved. We may find, for example, that the life of some obscure worthy who did very little for electrical or electronic science is completely documented simply because he served on every committee that he could get to. On the other hand, there is the problem of the towering genius about whom practically nothing is known. Oliver Heaviside definitely falls into the second category. Gradually and painfully, researchers are discovering details of the life of this quite extraordinary man who, had he sought publicity for his theories, might easily have outshone Einstein in popular mythology.

Heaviside was born in 1850, and seems to have had only an ordinary school education. By the age of 20 he was working as a telegrapher — one of the 'glamour' occupations of these mid-Victorian days. He might well have continued this work, which gave him the opportunity for reading electrical theory, but for the sudden occurrence of deafness which forced him to retire in 1874. From what little we know of these early years we discover that his nature was retiring and introspective, and his deafness was a further burden which made him even more reluctant to communicate with others.

From the time of his retiral at the age of 24 he decided to devote the rest of his life to electrical research, work which was inspired by the problems of telegraphy which he had encountered at first hand.

We are still sorting out some of the work which he did in these years — and what we have found so far points to the conclusion that Heaviside was of that extremely rare species — an original genius, comparable to Isaac Newton. Like Newton, he was prone to write down his results in obscure phrases and notes, and also like Newton, to invent new mathematical methods to cope with the problems on which he was working.

One of the main problems which he solved, and which appeared in his 'Electrical Papers', published in 1892, was that of long-distance telegraphy. It's one thing to transmit sine waves on wires over long distances, but the square waves which are generated by a Morse key are something quite different. A long telegraph line has stray capacitance to earth, and it also has some inductance: these components combine to integrate waveforms, converting the square waves from the key into a rounded shape which was incapable of operating the paper-tape punch at the other end of the line.

Theory Of Transients

We feel now that we know quite a bit about what are called transients — the currents which flow for brief periods when stray capacitances are being charged or discharged. But *do* we? A startling number of examples of malfunction of microprocessor equipment turn out to be the result of the effects of transient currents caused by the very fast rising and falling pulses used in the circuits. Consultants complain that not enough is known or taught about transients, and the most popular bus structure (S100) for small computers positively invites transient troubles. We just don't seem to learn — despite the fact that Heaviside solved all these problems.

In classical legends, the story of Cassandra tells how she was cursed with the ability to prophesy the future with complete accuracy. Cursed? Yes, because no-one would ever believe her. Heaviside must have felt this way after the publication of his papers. Although what he had done was the foundation of modern pulse theory, only a handful of people were able to see what he had done and understand its significance. Two factors contributed to this neglect. One was the fact that Heaviside had invented his own form of algebra to deal with transients. It's now known as the Heaviside Calculus, though it's not used much nowadays. Engineers generally couldn't grasp Heaviside calculus, and were suspicious of such a new approach. Mathematicians were obsessed by the need for rigorous proofs of Heaviside's theorems — and were unable to find any. Heaviside himself was totally uninterested in proving his theorems, which to him seemed so obvious as to need no proof. He also took the traditional engineers' view that the important thing was to get on with making use of his discoveries, rather than deal with the 'nit-picking' business of academic discussion. He had little patience with anyone who wanted to discuss his work, and this intolerant attitude offended many who might have been of great assistance to him. If we think what it must have been like to be such a shy, deaf genius, we surely cannot pass harsh judgement on either Heaviside or those whom he offended. The results of his work spoke more eloquently than anything that could be said, however, and thanks to a few dedicated engineers who were prepared to try out Heaviside's remarkable conclusions, long-distance telegraphy became possible.

Practical Proof

What was the solution? Heaviside recognised the problem as one which we could now call line matching. He reasoned that a line with the correct ratio of series inductance to stray capacitance would behave like a pure resistance, the quantity we now call the characteristic impedance of the line. Every time we use coaxial cable or turn-line, we're making use of Heaviside's theories — they permeate the whole of electronics. The conclusion which Heaviside reached, which so many of his contemporaries found quite unbelievable, was that a long telegraph line needed extra inductance added, in series, at intervals, so that the characteristic impedance of the line matched the resistance of the receiving equipment. At the time it must have seemed like telling a driver that a road could be covered faster by adding a few Z-bends! Nevertheless, a brief trial confirmed that Heaviside was absolutely right, and long-distance telegraphy arrived. Within a decade, it seemed that the bed of the Atlantic would be covered in telegraph cables!

Meanwhile, Heaviside, embittered by the reception of his 'Electrical Papers', turned back to further research on fundamental electromagnetic theory, building on the firm foundations laid by James Clerk Maxwell, who had died in 1879. Recent studies of Heaviside's work during this period reveal that he had already concluded that the 'mass' of an electron must increase as the speed of the electron approaches the speed of light. This was to be one of the most easily tested conclusions of Einstein's Theory of Special Relativity some 20 years later, and it is only one of an astonishingly well thought out set of conclusions which Heaviside published in his 'Electromagnetic Theory' between 1893 and 1912. One of these conclusions has caused Heaviside's name to be immortalised in the way which is familiar in Science — by having something named after him.

On 12 December 1901, Marconi succeeded in establishing that radio waves could be transmitted over really long distances, by his transmissions from Newfoundland to Poldhu in Cornwall. He attempted this in the face of a chorus from engineers and scientists that it 'couldn't be done' — three words which have stimulated engineers more than anything else. There was one voice missing. Heaviside knew exactly how it was possible — he had already worked out the theory, and in 1902, secure in the knowledge that no-one could challenge the truth of long-distance radio, he published his theory.

Briefly it was that the radiation from the sun must ionise (split into charged particles) atoms of the gases in the atmosphere, and that these charged ions would then act to reflect radio waves whose wavelength fell between defined limits, encompassing in particular the bands which were to be known as the 'short waves'. For once, Heaviside was not out on a limb of his own because Kennely, of Harvard, was also working along the same lines.

It was impossible to prove Heaviside's ideas at the time, but two years before his death radar methods showed reflecting regions in the atmosphere between 50 km and 400 km above the surface of the earth. One set of these layers was called the Heaviside, another the Kennely: each consists of several strata, the distance of which from the earth varies according to the time of day or night. Heaviside died in 1925, with the knowledge that his name would be remembered in at least one sphere of activity.

That was 56 years ago. To this day, we are still finding evidence of his genius. His mathematical system, the Heaviside Calculus, has now been shown to be perfectly sound although it has been superseded by the use of Laplace Transforms. Only time will tell what other remarkable inventions and discoveries are tucked away in the volumes of Heaviside's notes.

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Quick Project: Light/Water Alarm

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The circuit is little more than a standard 555 oscillator driving a loudspeaker so that the required audio tone is generated. Pin 4 of integrated circuit IC1 would normally be connected to the positive supply rail, but in this circuit it is taken to the negative supply rail via resistor R1. This prevents the oscillator from operating unless the photocell PCC1 is subjected to a reasonably high light level (daylight is more than adequate). The voltage at pin 4 of IC1 then goes positive, and the tone is generated by the unit.

The same basic action occurs if PCC1 is replaced by a water sensor. Normally R1 takes pin 4 to the negative rail, but the low resistance across the sensor when it is bridged by rain or tap water is sufficient to activate the unit. (*Pure* water has a high resistance and will not trigger the unit.)

The CMOS version of the 555 (the ICM7555) is used in the project to give a low standby supply current of only 80 uA.

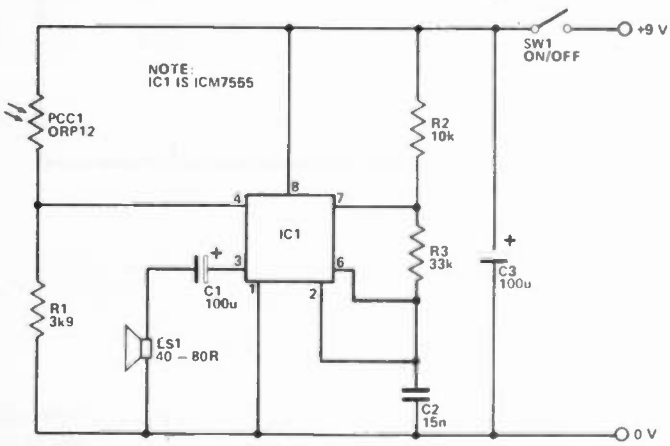

Figure 1. Circuit of the Light/Water Alarm

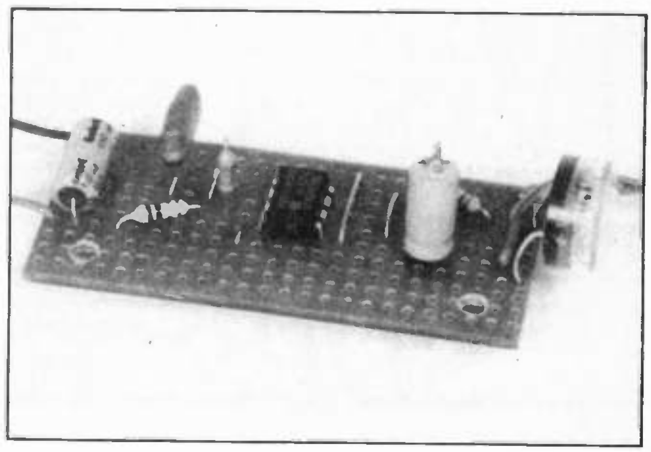

Figure 2. View of the project

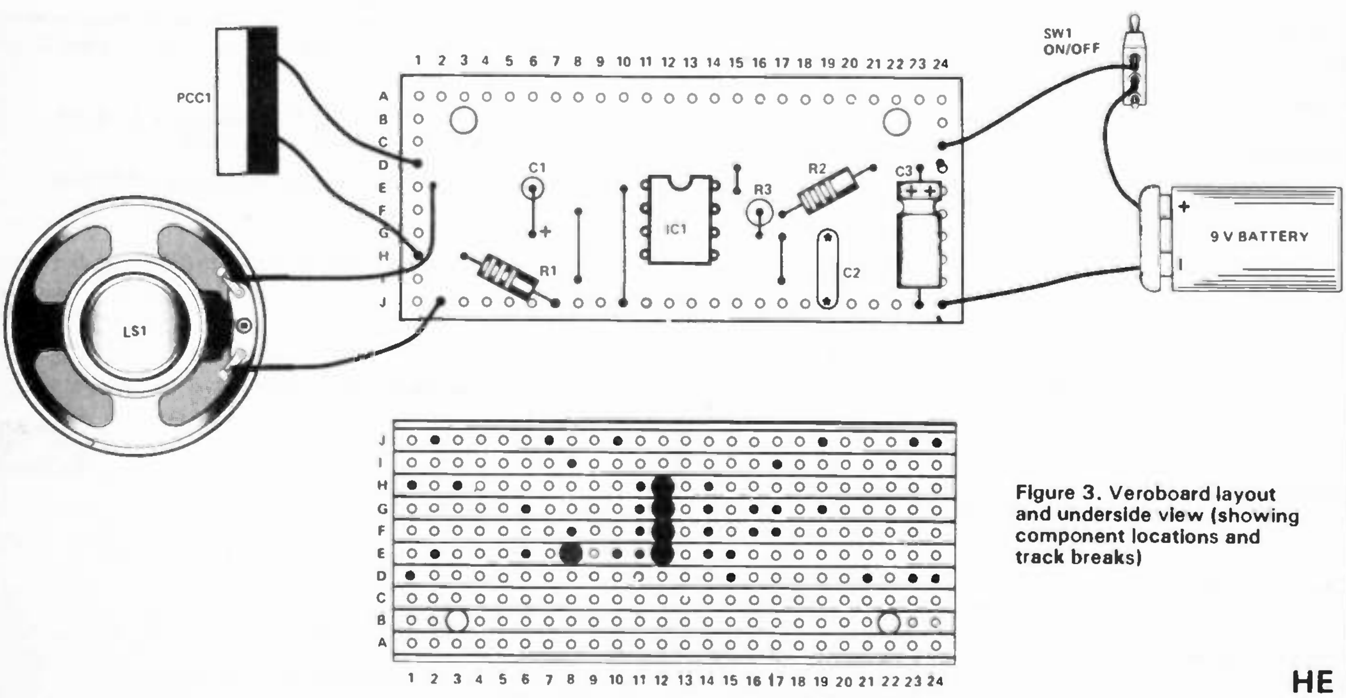

Figure 3. Veroboard layout and underside view (showing component locations and track breaks)

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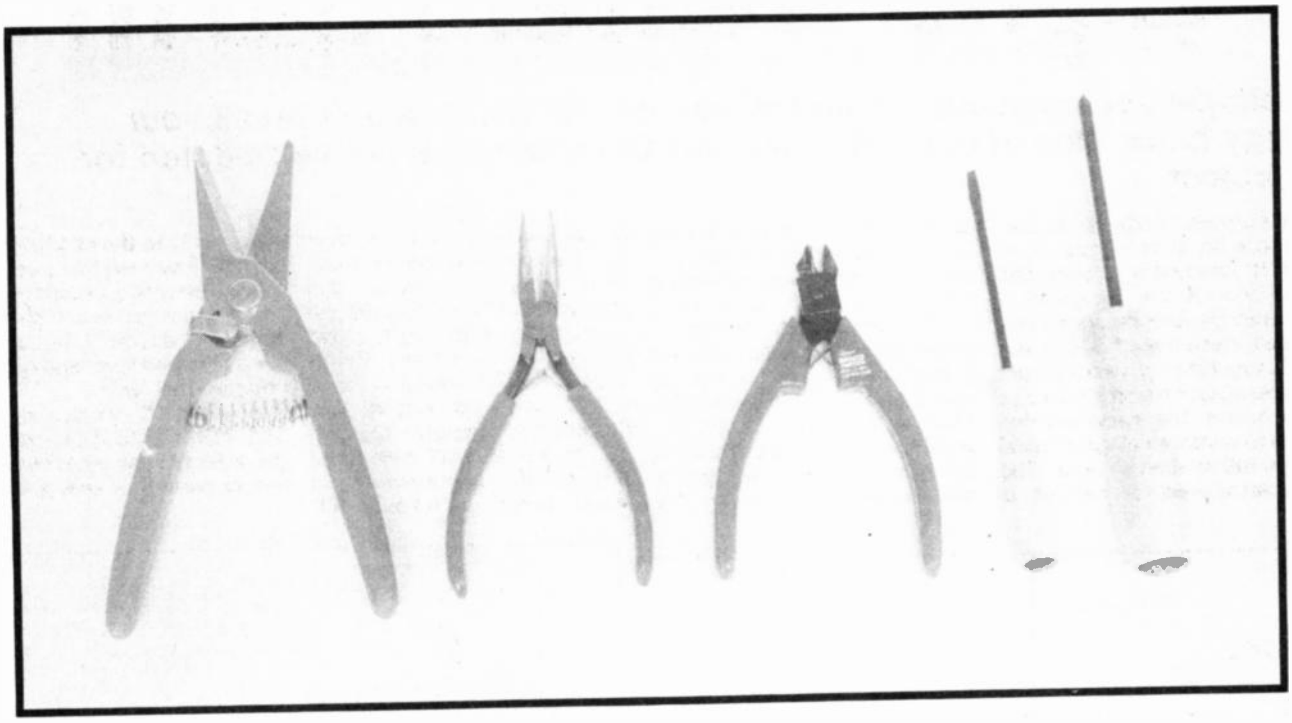
HE Tool Set Offer



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7410	15p
7411	20p
7412	20p
7413	25p
7414	35p
74C14	90p
7416	27p
7417	27p
7420	17p
7421	30p
7422	22p
7423	25p
7425	30p
7426	30p
7427	25p
7428	30p
7430	17p
7432	30p
7433	30p
7437	30p
7438	30p
7440	17p
7441	70p
7442A	50p
7443	112p
7444	112p
7445	80p
7446A	93p
7447A	60p
7448	60p
7450	17p
7451	17p
7453	17p
7454	17p
7460	17p
7470	36p
7472	30p
7473	30p
7474	25p
7475	38p
7476	32p
7480	50p
7481	100p
7482	84p
7483A	50p
7484	100p
7485	90p
7486	25p
7489	210p
7490A	30p
7491	60p
7492A	40p
7493A	30p
7494	75p
7495A	50p
7496	50p
7497	140p
74100	85p
74107	34p
74109	40p
74116	90p
74118	75p
74119	90p
74120	70p
74121	30p
74122	48p
74123	50p
74125	40p
74126	40p
74128	40p
74132	45p
74136	32p
74141	75p
74142	200p
74145	70p
74147	100p
74148	75p
74150	100p
74151A	45p
74153	50p
74154	80p
74155	60p
74156	60p
74157	50p
74159	100p
74160	60p
74161	60p
74162	65p
74163	60p
74164	90p
74165	90p
74166	90p
74167	200p
74170	160p
74172	300p
74173	75p
74174	75p
74175	75p
74176	70p
74177	70p
74178	100p
74180	60p
74181	160p
74182	90p
74184A	120p
74185	120p
74186	500p
74188	325p
74190	75p
74191	75p
74192	75p
74193	75p
74194	75p
74195	60p
74196	70p
74197	70p
74198	120p
74199	120p
74221	75p
74251	70p
74259	120p
74278	150p
74279	80p
74283	75p
74284	250p
74285	250p
74290	100p
74293	100p
74298	100p
74365	55p
74366	55p
74367	55p
74368	55p
74390	100p
74393	100p
74490	120p

74LS SERIES

74LS00	14p
74LS02	14p
74LS03	16p
74LS04	16p
74LS05	18p
74LS08	18p
74LS09	20p
74LS10	17p
74LS11	20p
74LS13	25p
74LS14	45p
74LS20	17p
74LS21	20p
74LS27	20p
74LS30	17p
74LS32	27p
74LS37	20p
74LS38	20p
74LS42	50p
74LS47	50p
74LS51	24p
74LS55	30p
74LS73	25p
74LS74	24p
74LS75	28p
74LS76	20p
74LS83	50p
74LS85	70p
74LS86	36p
74LS90	35p
74LS92	40p
74LS93	35p
74LS96	110p
74LS107	45p
74LS109	60p
74LS112	40p
74LS113	45p
74LS114	45p
74LS122	42p
74LS123	55p
74LS124	120p
74LS125	30p
74LS126	30p
74LS132	45p
74LS133	30p
74LS136	30p
74LS138	40p
74LS139	40p
74LS145	75p
74LS147	160p
74LS148	90p
74LS151	70p
74LS153	60p
74LS154	200p
74LS155	50p
74LS156	50p
74LS157	50p
74LS158	60p
74LS160	45p
74LS161	45p
74LS162	45p
74LS163	45p
74LS164	60p
74LS165	100p
74LS166	120p
74LS170	120p
74LS173	70p
74LS174	70p
74LS175	55p
74LS181	140p
74LS190	55p
74LS191	55p
74LS192	60p
74LS193	60p
74LS195	50p
74LS196	60p
74LS197	65p
74LS221	60p
74LS240	90p
74LS241	90p
74LS242	80p
74LS243	80p
74LS244	80p
74LS245	90p
74LS247	140p
74LS251	50p
74LS253	40p
74LS257	45p
74LS258	45p
74LS259	90p
74LS266	25p
74LS273	90p
74LS279	45p
74LS283	60p
74LS298	160p
74LS323	250p
74LS324	150p
74LS348	200p
74LS365	36p
74LS367	36p
74LS368	50p
74LS373	100p
74LS374	100p
74LS375	50p
74LS377	90p
74LS378	70p
74LS390	60p
74LS393	60p
74LS399	200p
74LS445	140p
74LS670	170p

4000 SERIES

4000	15p
4001	18p
4002	20p
4006	65p
4007	20p
4008	60p
4009	40p
4010	40p
4011	16p
4012	20p
4013	35p
4014	60p
4015	60p
4016	30p
4017	50p
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	60p
4041	70p
4042	55p
4043	60p
4044	70p
4046	80p
4047	75p
4048	55p
4049	30p
4050	30p
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	20p
4070	20p
4071	20p
4072	20p
4073	20p
4075	20p
4076	60p
4081	20p
4082	20p
4086	72p
4089	150p
4093	40p
4094	150p
4095	95p
4096	95p
4097	340p
4098	90p
4099	120p
40100	220p
40101	132p
40102	180p
40103	180p
40104	99p
40105	120p
40106	50p
40107	60p
40108	470p
40109	100p
40110	300p
40114	250p
4502	75p
4503	50p
4507	40p
4508	200p
4510	65p
4511	50p
4512	65p
4514	150p
4515	150p
4516	75p
4518	50p
4520	70p
4521	150p
4526	75p
4527	90
4528	75p
4532	90p
4534	500p
4536	300p
4538	120p
4543	100p
4553	290p
4556	60p
4560	180p
4569	180p
4572	30p
4583	100p
4584	50p
4585	100p
4724	150p
40097	90p
14411	700p
14412	900p
14433	1100p
14500	700p
14599	290p

INTERFACE ICs

AD536A	£13
AD561J	1400p
AD7524	600p
DM8131	375p
DP8304	450p
DS8835	250p
DS8836	150p
DS8838	225p
MC1488	65p
MC1489	65p
MC3446	300p
MC3480	850p
25S10	350p
58174	£12
75107	160p
75110	160p
75114	160p
75150	140p
75154	150p
75182	230p
75324	375p
75361	150p
75363	150p
75365	150p
75451/2	72p
75491/2	70p
8T26	120p
8T28	140p
8T95	160p
8T97	160p
81LS95	120p
81LS96	140p
81LS97	140p
81LS98	140p
9602	220p

93 SERIES

9301	160p
9302	175p
9308	316p
9310	275p
9311	275p
9312	160p
9314	165p
9316	225p
9321	225p
9322	150p
9334	360p
9368	250p
9370	300p
9374	200p

74S SERIES

74S00	60p
74S04	60p
74S05	75p
74S08	75p
74S10	60p
74S20	60p
74S30	60p
74S32	90p
74S37	90p
74S64	60p
74S74	90p
74S85	300p
74S86	180p
74S112	120p
74S114	120p
74S124	300p
74S132	160p
74S133	75p
74S138	225p
74S139	225p
74S157	250p
74S163	300p
74S174	250p
74S175	320p
74S194	350p
74S241	450p
74S260	70p
74S373	400p
74S374	400p

LINEAR ICs

Type	Price
AY1-0212	600p
AY1-1313	668p
AY1-1320	320p
AY1-5050	140p
AY3-1270	840p
AY3-8910	750p
AY3-8912	650p
AY5-4007D	520p
CA3046	70p
CA3048	225p
CA3080E	60p
CA3086	48p
CA3089E	225p
CA3090AO	375p
CA3130E	90p
CA3140E	50p
CA3160E	100p
CA3161E	140p
CA3162E	450p
CA3189E	300p
CA3280	160p
DAC1408-8	200p
HA1388	260p
ICL7106	850p
ICL8038	300p
ICM7555	80p
LF351	48p
LF356P	90p
LM10C	425p
LM301A	27p
LM311	70p
LM318	200p
LM319	225p
LM324	45p
LM339	65p
LM348	75p
LM358P	50p
LM377	175p
LM380	75p
LM381AN	180p
LM386	95p
LM393	100p
LM709	36p
LM710	50p
LM725	350p
LM733	100p
LM741	18p
LM747	70p
LM748	35p
LM2917	200p
LM3302	100p
LM3900	70p
LM3909	70p
LM3911	130p
LM3914	225p
LM3915	225p
LM3916	225p
LM13600	125p
MB3712	200p
MC1310P	150p
MC1458	40p
MC1495L	350p
MC1496	70p
MC3340P	120p
MC3403	90p
MM57160	620p
NE531	150p
NE555	20p
NE556	70p
NE564	420p
NE565	120p
NE566	155p
NE567	140p
NE571	425p
NE5534A	250p
PLL02A	500p
RC4136	70p
S566B	270p
SAD1024A	1250p
SFF96364	800p
SL490C	400p
SN76013N	170p
SN76477	175p
SP8515	750p
TA7120	200p
TA7204	250p
TA7205	250p
TA7222	200p
TA7310	200p
TBA641B11	300p
TBA651	200p
TBA800	90p
TBA810	100p
TBA820	90p
TBA950	300p
TCA220	350p
TCA940	175p
TDA1004	300p
TDA1008	320p
TDA1010	225p
TDA1022	570p
TDA1024	100p
TDA1034B	250p
TDA1170	300p
TDA2002V	325p
TDA2020	320p
TL071/81	45p
TL072/82	75p
TL074	130p
TL084	110p
TL170	50p
UAA170	175p
ULN2003	100p
UPC1156H	300p
XR2206	300p
ZN414	90p
ZN419C	225p
ZN424E	135p
ZN425E	350p
ZN427E	625p
ZN1034	200p

VOLTAGE REGULATORS

Fixed Plastic TO-220

	+ve		-ve	
1A			7905	55p
5V	7805	50p	7912	55p
12V	7812	50p	7915	55p
15V	7815	55p	7918	70p
18V	7818	55p	7924	70p
24V	7824	55p	79L05	60p
100mA	TO-92		79L12	60p
5V	78L05	30p	79L15	60p
12V	78L12	30p		
15V	78L15	30p		

OTHER REGULATORS

Type	Price
LM309K	135p
LM317T	200p
LM323K	500p
LM723	37p
78HGKC	600p
78HO5KC	550p
78MGT2C	135p
79HGKC	600p
TL497	300p

OPTO-ELECTRONICS

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

OPTO-ISOLATORS

Type	Price
ILD74	130p
MCT26	100p
MCS2400	190p
TIL111	90p
TIL112	90p
TIL116	90p

LEDS

Type	Price
0.125"	
TIL32	55p
TIL209 Red	13p
TIL211 Gr	20p
TIL212 Ye	25p
TIL216 Red	18p
0.2"	
TIL220 Red	16p
TIL222 Gr	18p
TIL228 Red	22p
Rectangular LEDs (R, G, Y)	30p
NSB5881	570p
TIL311	600p
TIL312/3	110p
TIL321/2	130p
TIL330	140p
7750/60	200p

DISPLAYS

Type	Price
3015F	200p
DL704	140p
DL707 Red	140p
FND357	120p
FND500	110p
FND507	110p
MAN3640	175p
MAN4640	200p

DRIVERS

Type	Price
9368	250p
9370	300p
UDN6118	320p
UDN6184	320p

TRANSISTORS

Type	Price
AC126	25p
AC127/8	20p
AC176	25p
AC187/8	25p
AF116	50p
AD149	70p
AD161/2	45p
AU107	200p
BC107/8	11p
BC109	11p
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	36p
BC477/8	30p
BC516/7	40p
BC547B	16p
BC548C	9p
BC549C	18p
BC557B	16p
BC559C	18p
BCY70	18p
BCY71/2	22p
BD131/2	50p
BD135/6	54p
BD139	56p
BD140	60p
BD189	60p
BD232	95p
BD233	75p
BD235	85p
BD241	70p
BD242	70p
BDY56	200p
BF200	32p
BF244B	35p
BF256B	70p
BF257/8	32p
BF259	36p
BFR39	25p
BFR40	25p
BFR41	25p
BFR79	25p
BFR80	25p
BFR81	25p
BFX29	40p
BFX30	34p
BFX84/5	40p
BFX86/7	30p
BFX88	30p
BFW10	90p
BFY50	30p
BFY51/2	30p
BFY56	33p
BFY90	90p
BRY39	45p
BSX19/20	24p
BU104	225p
BU105	190p
BU108	250p
BU109	225p
BU126	150p
BU180A	120p
BU205	200p
BU208	200p
BU406	145p
E300	50p
E308	50p
E310	50p
MJ2501	225p
MJ2955	90p
MJ3001	225p
MJE340	60p
MJE2955	100p
MJE3055	70p
MPF102	45p
MPF103/4	40p
MPF105/6	40p
MPS6531	50p
MPS6534	50p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	32p
MPSA70	50p
MPSU06	63p
MPSU07	60p
MPSU45	90p
MPSU65	78p
OC28	130p
OC35	130p
TIP29A	40p
TIP29C	55p
TIP30A	48p
TIP30C	60p
TIP31A	58p
TIP31C	62p
TIP32A	68p
TIP32C	82p
TIP33A	90p
TIP33C	114p
TIP34A	115p
TIP34C	160p
TIP35A	225p
TIP35C	290p
TIP36A	270p
TIP36C	340p
TIP41A	65p
TIP41C	78p
TIP42A	70p
TIP42C	82p
TIP54	160p
TIP120	120p
TIP122	130p
TIP142	130p
TIP147	130p
TIP2955	78p
TIP4055	70p
TIS43	48p
TIS93	30p
ZTX108	12p
ZTX300	13p
ZTX500	15p
ZTX502	18p
ZTX504	30p
2N457A	250p
2N696	35p
2N697	25p
2N698	45p
2N706A	30p
2N708	30p
2N918	45p
2N930	18p
2N1131/2	36p
2N1613	25p
2N1711	25p
2N2102	70p
2N2160	350p
2N2219A	30p
2N2222A	30p
2N2369A	25p
2N2484	30p
2N2646	45p
2N2904/5	30p
2N2906A	30p
2N2907A	30p
2N2926	9p
2N3053	30p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
2N3565	30p
2N3584	250p
2N3643/4	48p
2N3702/3	12p
2N3704/5	12p
2N3706/7	14p
2N3708/9	12p
2N3773	300p
2N3819	25p
2N3820	50p
2N3823	70p
2N3866	90p
2N3902	700p
2N3903/4	18p
2N3905/6	20p
2N4037	65p
2N4061/2	18p
2N4123/4	27p
2N4125/6	27p
2N4401/3	27p
2N4427	90p
2N4871	60p
2N5087	27p
2N5089	27p
2N5172	27p
2N5179	90p
2N5191	90p
2N5194	90p
2N5245	40p
2N5296	55p
2N5401	50p
2N5457/8	40p
2N5459	40p
2N5460	60p
2N5485	44p
2N5875	250p
2N6027	48p
2N6041	160p
2N6044	160p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2N6292	65p
2SC1172	150p
2SC1306	150p
2SC1969	200p
2SC2028	120p
2SC2029	250p
2SC2078	200p
3N128	120p
3N140	120p
3N141	110p
3N201	110p
3N204	120p
40290	250p
40361/2	75p
40408	90p
40409	100p
40410	100p
40411	300p
40594	120p
40595	120p
40673	95p
40871/2	100p

DIODES

Type	Price
BY127	12p
BYX36-300	20p
OA47	9p
OA81	15p
OA85	15p
OA90	9p
OA91	9p
OA95	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5401/3	14p
1N5404/7	19p
IS920	9p

HEATSINKS

For TO220 Voltage Regs and transistors 22p
For TO5 12p

BRIDGE RECTIFIERS

Type	Price
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

Type	Price
400mW	9p
1W	15p

TRIACS PLASTIC

Type	Price
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

Type	Price
1A 50V	70p
1A 400V	90p
3A 400V	100p
8A 600V	140p
12A 400V	160p
16A 100V	160p
16A 400V	180p
BT106	110p
C106D	45p
MCR101	36p
TIC44	27p
2N3525	130p
2N4444	140p
2N5060	34p
2N5064	40p

LOUDSPEAKERS

Size		
2½	64R	80p
2½	8R	80p
2	8R	90p
1½	8R	100p

MODULATORS

Type	Price
6MHz UHF	375p
8MHz UHF	450p

MEMORIES

Type	Price
2101-4L	400p
2102-2L	120p
2107B	500p
2111-4	250p
2112-4	300p
2114L	160p
2114-2L	200p
4027-3	300p
4044	700p
4116	200p
4118 (200ns)	500p
5101	300p
6116 (150ns)	£11
6514 45	£5
6810	200p

ROM/PROMs

Type	Price
71301	700p
74S188	225p
74S287	350p
74S471	650p
74S571	650p

CPUs

Type	Price
1600	1200p
1802CE	750p
2650A	£16
6502	500p
6800	370p
6802	550p
6809	£16
8080A	450p
8085A	550p
INS8060	1000p
TMS9980A	£20
Z80	425p
Z80A	550p

EPROMs

Type	Price
1702A	500p
2708	300p
2716 (+5V)	400p
2532	700p
2732	700p

SUPPORT DEVICES

Type	Price
3242	800p
3245	450p
6522	500p
6532	775p
6821	180p
6845	£10
6850	180p
6852	370p
6875	600p
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3.5795MHz	175p
4.00MHz	290p
4.194MHz	250p
4.43MHz	125p
5.0MHz	250p
6.0MHz	250p
6.144MHz	250p
7.0MHz	250p
7.168MHz	250p
8.00MHz	250p
8.867MHz	250p
10.00MHz	250p
10.7MHz	250p
12.0MHz	350p
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18.432	250p
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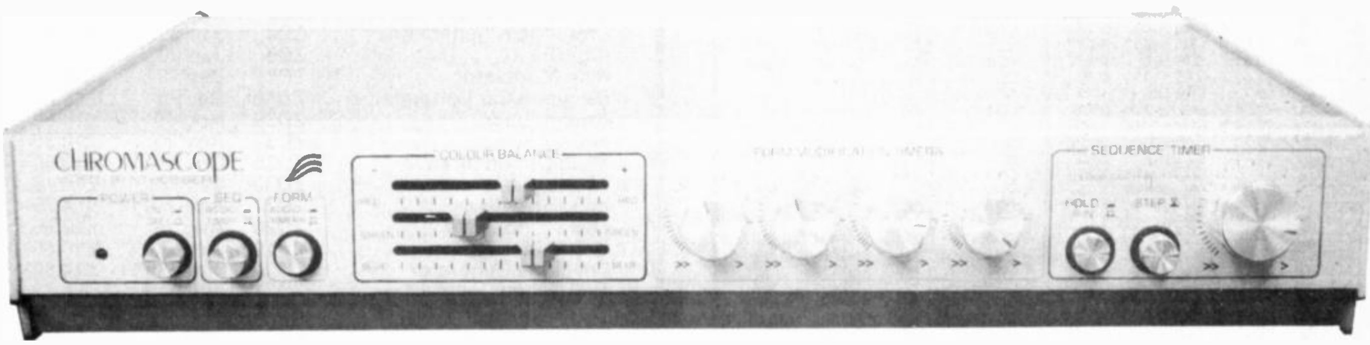
Gadgets Games & Kits

Featured this month by Ian Graham — the latest thing in video synthesisers from CEL Electronics, three new games cartridges from Atari, Bib Hi-Fi's video recorder head cleaning kit and two handy pieces of test gear from Lawtronics — pocket-sized continuity and transistor testers



Chromascope — TV Light Show

We first described the two video synthesisers from CEL Electronics, the C-101 (domestic model) and the P-135 (professional model) under Monitor in the August '81 issue. (Note the 'a' in Chromascope, not 'Chromoscope' as printed last month.)

When the C-101 is coupled to the aerial socket of a colour TV receiver, it will produce an almost infinite variety of continuously changing multi-coloured abstract patterns and shapes. If an audio signal is applied to the C-101, the colour of individual patterns, or the sequence in which they change, can be influenced by the amplitude (volume) or frequency (bass, mid-range or treble) of the signal.

Model C-101

Retail price of the C-101 is £295 plus VAT (*but see special introductory offer to HE readers on page 37*). It has a smartly finished case with aluminium trim panels and simulated hide cover panels. Sockets are provided for connecting the synthesiser to a TV receiver and, for modulation effects, to an audio system.

The TV aerial is plugged into the C-101: when the synthesiser is switched off the aerial is automatically reconnected to the aerial socket of the TV for normal programme viewing. A separate 15 VDC power supply adaptor is supplied for use with the C-101.

Operation

When the C-101, adaptor, TV receiver and audio system (if you want sound-to-light effects) are all connected up, as described in the instruction manual, the TV is set to a spare channel and a button marked 'Step' is pressed on the synthesiser. When you tune the TV into the signal generated by the C-101 a colour bar pattern — thick vertical bars of white, yellow, cyan, green, mauve, red and blue — appears on the screen. You use this pattern to tune in the TV precisely and to set brightness, contrast and colour controls on the TV.

When you release the Step button the light show begins: coloured patterns and shapes appear and merge in random fashion, at rates determined by the settings of the controls.

Control Functions

Front panel controls are divided into six groups:

Power	On/off button and LED indicator. As soon as this button is pressed the synthesiser is connected to the DC supply from the adaptor, and the aerial is disconnected from the TV
Seq	This button selects two modes of control for the sequence of patterns: timer, where the sequence is determined by a built-in timer, or audio, where it is determined by the content of the incoming audio signal (for example, by the beat of a piece of music)
Form	This button selects two modes of control for the movement of form within a pattern: form modification timer (four independent timer controls are provided for this mode) and audio modulated (determined by the content of the incoming audio signal)
Colour Balance	Three slider controls enable you to set up the overall hue of the picture, using the primary colour combinations of red, green and blue
Form Modification Timers	Four controls allow the setting of the rates of change for colours and shapes within a particular pattern
Sequence Timer	Three controls are provided in this group: Hold, Step and Sequence Timer adjustment. The Hold button stops timer- or audio-controlled pattern sequencing. The display does not freeze, however, because the pattern modification timers continue to change the patterns to a limited extent and the display still responds to audio stimulation. If you like a particular design then you can retain it indefinitely by pressing the Hold button. The main function of the Step button is to select a colour bar display. Operation of Step will also make the pattern sequencing random, so that the machine will never repeat the display

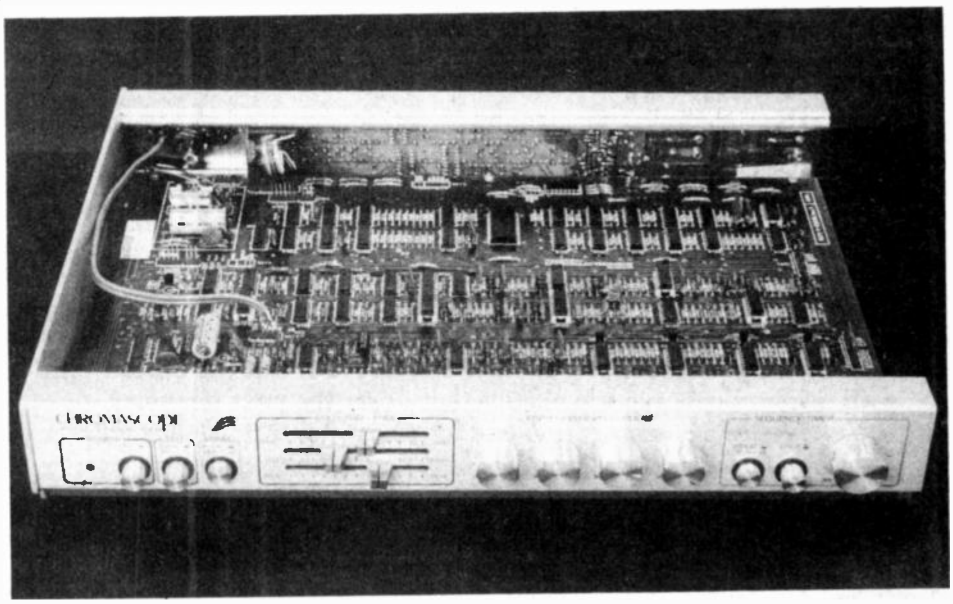
On Test

We demonstrated the C-101 to two different audiences, of widely differing age groups. Two different makes of TV were used in the demonstrations.

The younger group was enthralled by the patterns displayed, particularly when the picture was modulated with some music by Jean Michel Jarre. The general view seemed to be: 'We like the effects produced by the C-101, but it's too expensive'.

Response from the older group was less demonstrative but nonetheless positive. One of our audience commented on how this compact machine, with the great variety of effects that it produced, was a good example of how modern 'chips' had brought such machines down in size. Comments about the cost echoed those made by the younger group.

The only technical niggle *we* had was with the power supply adaptor unit. This seemed to get very hot during use. A plus point for the C-101 was its ability to display a colour bar pattern. This is used by TV service engineers to set up TV displays and gives an instant check of the overall colour balance.



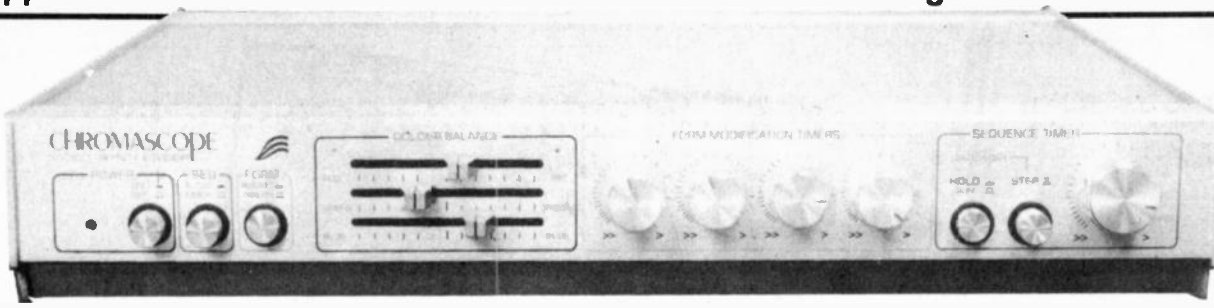
Feedback

We spoke to Robin Palmer, director of CEL and designer of Chromascope, after we had tested and evaluated the C-101. The first question we put to him was about the price. He told HE that Chromascopes use analogue and digital electronics, much of it working in a random fashion, so it was difficult to shrink the design down to a handful of ICs. The enormous PCB, which takes up most of the case was, he said, 'a pig to develop' over a two-year period. He added that he would have loved to have made something cheaper but users would have become bored with it very quickly.

When asked to comment on the heat produced by the adaptor, he said that PSUs from an early batch do run hot — by design. But these were 'perfectly reliable' and he claimed to have had some running for months without problems. However, his supplier has assured him that adaptors in future batches will run cooler.

Palmer also commented on the professional interest in Chromascope. Professional users are now asking for a version of the P-135 which will give a still picture (static patterns, that is) and plain colours that can be adjusted separately for use as background displays.

He has already designed a version for France (SECAM TV system)



and aims to penetrate Japanese and American markets. The existing machines are suitable for PAL users in Europe. (The PAL system is used in the UK.)

CEL Electronics Limited, River Way, Harlow, Essex CM20 2DP (tel 0279 418611).

Bib Compact Video Recorder Maintenance Kit

Until recently, video recorders were the preserve of the BBC and pools winners. Now, as prices plummet, almost 20 manufacturers are producing about 50 standard and portable systems. They're available for sale and hire and there's a growing second-hand market. If your family has invested in a second-hand machine or your service agreement has lapsed, you may be interested in doing the routine maintenance work yourself.

Bib Hi-Fi now have a 'Videophile' range of accessories to serve the growing video market. This month I've been looking at their Compact Video Recorder Maintenance Kit. For a recommended retail price of £5.47 including VAT you get a set of five head cleaning tools, a bottle of tape head cleaning fluid and an aerosol can of Dust-Away air blast. The kit has thoughtfully been packed in a clear container the same size as a VHS cassette so you can store it in your video cassette rack.

The kit contains comprehensive instructions to clean VHS and Betamax heads. The innards of a video cassette recorder are delicate at the best of times, but Bib's instructions feature the necessary do's and don'ts. It does involve taking the cover off your machine, so tread very carefully. All the parts of the kit are available as separate items. The 'Videophile' range also includes title labels, head cleaning cassettes (VHS and Betamax), tape eraser, tape splicer, tape head demagnetiser, TV screen anti-static treatment kit, etc. You should be able to get the Bib Compact Video Recorder Maintenance Kit from any good video/hi-fi store.

Game, Set And Match: Atari Games Cartridges

Game — Football; Set — Television; Match — You versus the Atari Videocomputer System (or a human opponent). Atari has added three new games cartridges to its extensive range. Pele launched Atari's 'Championship Soccer' cartridge during a recent visit to London. The familiar black plastic box gives you a choice of 54 different games — 1-27, two-player; 28-54, single-player. The game variations are achieved by offering different combinations of team speed, penalties, goal size and game difficulty. There are three players and a goal-keeper on each side, manoeuvred about the pitch by your joystick controllers. You can dribble, kick, tackle and score your way around the screen in glorious colour. Who needs Match of the Day? Nice touch — when you score, the computer lays on your own personal fireworks display to celebrate.

Atari's Othello cartridge offers four variations: 1-3, you versus the computer at increasing difficulty levels; game 4, a two-player game. The object is to convert as many of your opponent's counters to your colour as possible. In **Fig. 1**, you are black and it's your turn to move. You can convert

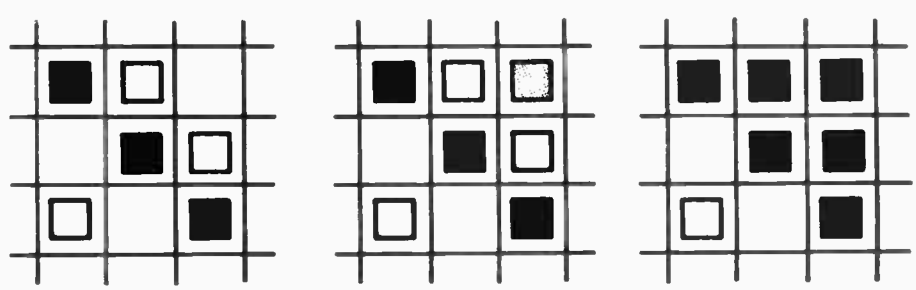
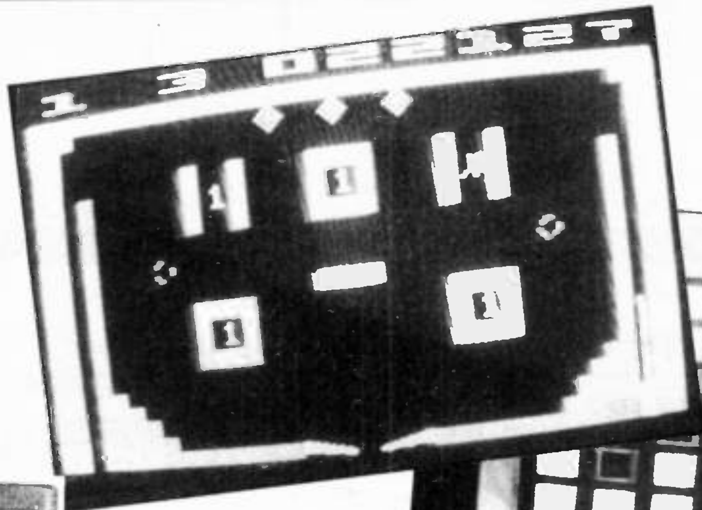
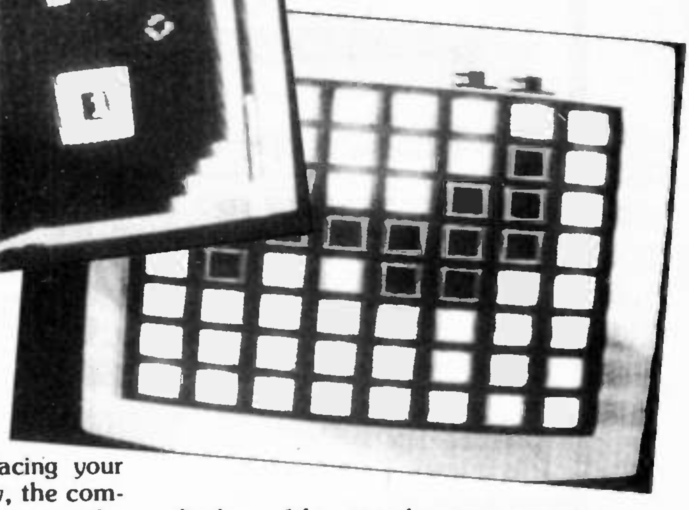


Fig. 1 Playing Othello on Atari





two white counters by placing your piece top right. Fortunately, the computer does make mistakes on the lowest play level, so it can be beaten.

Last, but by no means least, I plugged in Video Pinball to try the four variations — two single-player and two two-player. The screen was immediately filled with drop-targets, rollover indicators, spinners and bumpers. It all happens — as the ball bounces around, lights flash and the score mounts up. You can nudge the ball towards a target, but beware — nudge too much and you incur a tilt penalty.

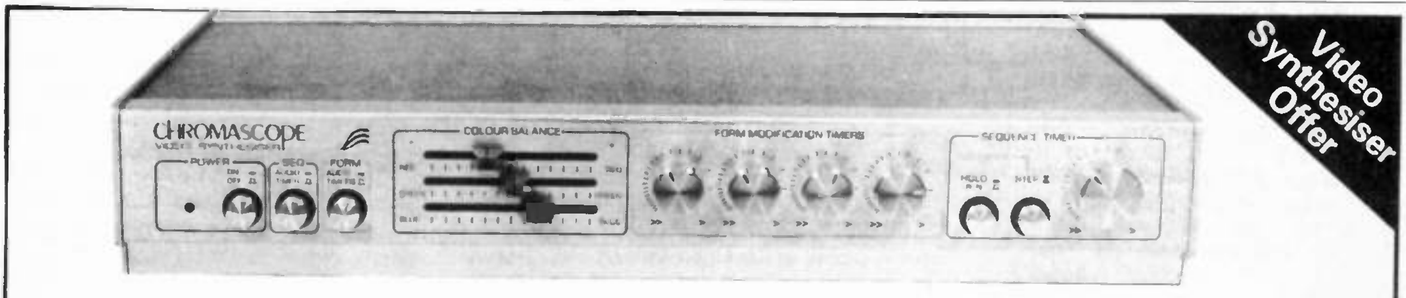
All three games are played with joystick controllers. Prices — Football £29.95, Othello £23.95, and Pinball £23.95. All prices are inclusive of VAT. You can get hold of an Atari Videocomputer System to plug them into for less than £100.

Testing, Testing, 1,2,3,: Lawtronics Test Gear

Lawtronics sent me two interesting pieces of test gear to look at. Its TT2 Transistor Tester is a 'go, no-go' tester for NPN and PNP transistors and diodes. It's simple to operate. Diagrams on the top of the tester's case show you how to connect the two probes and component operation is indicated by two LEDs. Power is supplied by a PP3 battery.

If you think you have a broken wire somewhere, check it out in no time with the CT2 Continuity Tester. Power this time is from two PP3s. The CT2 has two switched resistance ranges (R25 and 1R) and can easily be calibrated using a single potentiometer adjustment.

The CT2 and TT2 are, I feel, overpriced at £17.50 and £22.00 respectively. Lawtronics can supply an extensive range of test gear including oscilloscopes, counter timers, digital and analogue multimeters, signal sources, logic analysers and breadboards, probes, test leads, etc. Lawtronics Ltd, 139 High Street, Edenbridge, Kent TN8 5AX.



Video Synthesiser Offer

Chromascope Offer for HE Readers

WE REVIEW the Chromascope C-101 Video Synthesiser in this month's Gadgets, Games & Kits supplement.

When the C-101 is connected to your colour TV receiver it will produce a spectacular display of coloured patterns and shapes, which merge and blend in random fashion (see the cover of this month's issue). Connect it to your audio system as well and the display will respond to the audio signal, adding a visual dimension to music.

By special arrangement with CEL Electronics, we are offering the C-101 at an introductory price of £249 plus VAT (normal retail price £295 plus VAT). This offer closes on 30th November 1981.

Choose between three methods of payment: Cheque, Barclaycard, or Access.

To: HE Video Synth Offer, Modmags Limited, 145 Charing Cross Road, London WC2H 0EE

Please send me my C-101 Video Synthesiser at £286.35, including VAT and delivery.

I enclose a cheque made payable to Modmags Limited for £286.35

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I wish to pay by Barclaycard. Please charge to my account number

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Please note that the offer applies to UK mainland only. Allow 28 days for delivery

Quick Project:
Car Lights Delay

An easy-to-build project for your car, which operates your car lights to let you see your way around after you've parked in the dark. A couple of minutes later, when you're safe and sound in the house, the car's lights are automatically extinguished

When push-button PB1 is pressed this project turns a car's spotlight or headlights on for a fixed period of around two minutes. At the end of this time the lights are turned off automatically. When not in use the project's current consumption is zero.

Circuit operation is simple. Transistor Q1 is connected as an emitter follower (its emitter voltage is always the same as its base voltage) with emitter load R2, and base bias provided by C1. Transistor Q2 forms a common emitter amplifier, with the relay coil RLA as its collector load. Its base bias arises from R2 and Q1 emitter. Power is applied to the circuit via N/O (normally open) relay contacts RLA/1 which are shunted by the push-button PB1.

Initial operation of PB1 connects the circuit to its power supply. At this time C1 is fully discharged, so Q1's base is effectively shorted to the positive supply line. Transistor Q1's emitter 'follows' the base voltage (+12 V) so +12 V appears there. Transistor Q2 is driven on by the current through R2 and thus the relay is turned on. As this takes place, contacts RLA/1 close thus maintaining power after push-button PB1 has been released. Relay contacts RLA/2 also close and power is applied to the spot- or headlights. The above operation occurs almost instantaneously, as the push-button is pressed.

Capacitor C1 now starts to charge slowly, and the base voltage of Q2 (via emitter follower Q1) drops exponentially towards 0 V. After a delay of about two minutes the voltage decreases enough to turn transistor Q2 off. The relay contacts must now open, disconnecting power to the circuit and to the lights.

When construction of the board is complete, mount the project in a suitable case, and install it in your car.

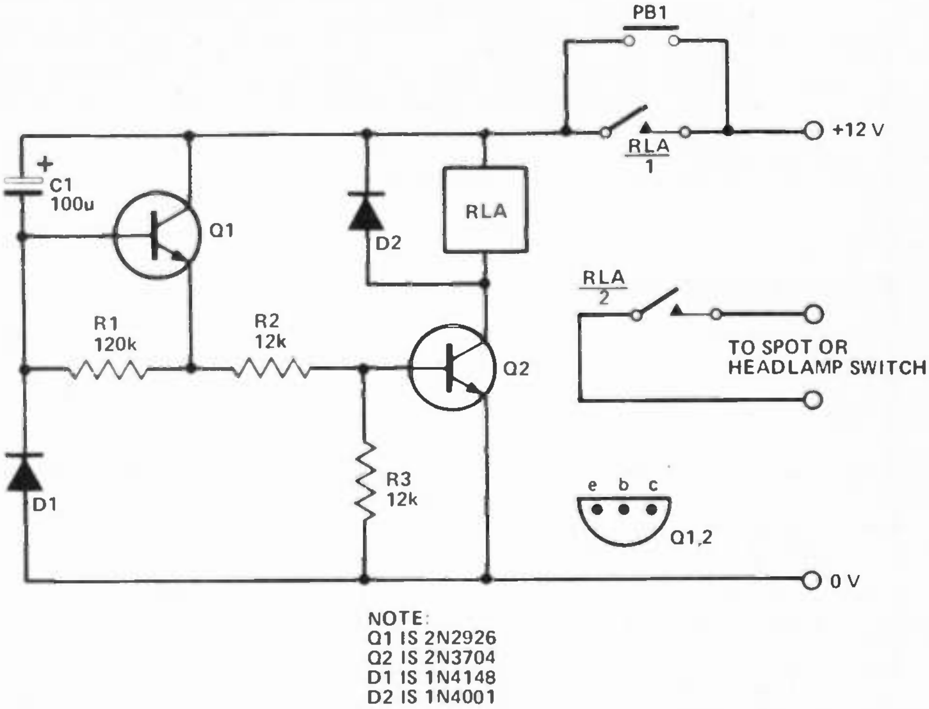


Figure 1. Circuit of Car Lights Delay

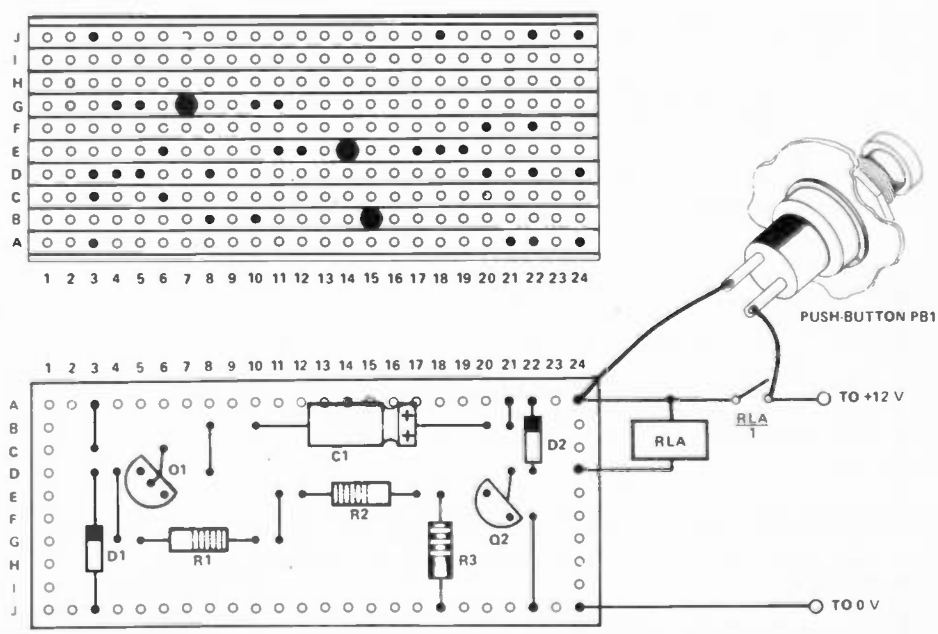


Figure 2. Veroboard layout, connection details and underside track breaks

HE

Building Site

This month, Keith Brindley tells you all about the most often used process in the whole area of electronics — soldering

THERE'S NO DOUBT, one of the first jobs to master in electronics is that of soldering. However you build a project, whether on printed circuit board (PCB) or Veroboard, you will have to solder the components in.

When done properly, a soldered joint (the connection between a component lead and the copper track of the circuit board) is the neatest and most permanent way of making any connection between the separate parts of a project. Of course, one joint which has been badly soldered can render the same project useless. It's very important, therefore, to do the job right.

Practice Makes . . .

There's nothing quite like repeatedly doing a job to improve performance, and soldering is no exception. The more often you build a circuit board the better you'll become at soldering, but even so there are a couple of tips you can follow to help get it right immediately: have the correct tools for the job, and keep everything as clean as possible.

The right tool for the job is a good quality soldering iron, for electronics use. We've come a long way from the time when a soldering iron was simply a wooden-handled rod of iron, the tip (or bit, as it is correctly known) of which was thrust into a hot fire, till glowing red hot. This sort of iron is not meant for electronics but for heavier jobs such as lead pipe plumbing. Nevertheless, the name of the modern tool 'soldering iron' comes from its red-hot predecessor.

A modern iron consists of an electrically heated element at the end of an insulating (usually a form of plastic) handle. A slide-on or screw-on bit fastens over the heated element and it is this bit which is used to heat the circuit board connections before solder is applied. **Figure 1** shows how a typical soldering iron is constructed. The element will be rated by its power in watts, eg, 15 W, 25 W, etc, and various bit thicknesses will be obtainable.

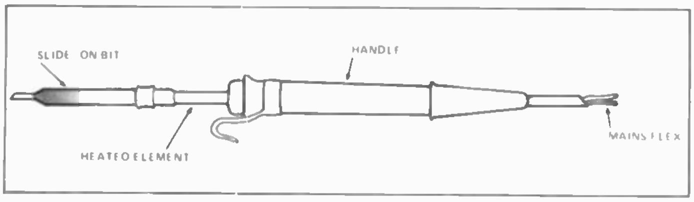


Figure 1. A typical modern mains-powered soldering iron

The power of an iron and its bit thickness are largely matters of the physical size of the connections to be soldered, although personal preference will play a part, too. The larger the area of the connection to be soldered, the more heat will be dissipated away from the bit. Thus, more power will be required to maintain the required temperature to melt the solder. For circuit board use, a 15 W soldering iron is adequate and certainly no greater than 25 W is necessary. If you use a more powerful soldering iron than this you might damage the components by overheating them.

A bit thickness of ⅛" to 3/16" is ideal for circuit board work.

What's Best?

Most irons are mains-operated but there are exceptions: some are designed to be operated on a lower AC voltage (eg, 50 VAC), and so a step-down transformer is used to provide this from the mains, and some types (see **Fig.2**) are battery-powered. The iron in **Fig.2** contains its battery inside the handle-type body and the battery is made up of nickel-cadmium cells — so it is rechargeable — hence the recharger you can also see. It features enormous advantages over mains-operated or low-voltage AC-operated irons, mainly because (being battery-powered) it is *cordless:* no more fiddly mains flex getting in the way while you try to solder. With the use of such an iron you are, at last, completely free of having to be within four feet of a mains outlet. For instance, soldering jobs on the car which are usually a nightmare with a mains-operated iron become a very simple job. A cordless soldering iron is also useful if you are soldering CMOS integrated circuits into a PCB, because it has no earth connection, and therefore you can't damage the ICs by static discharge.

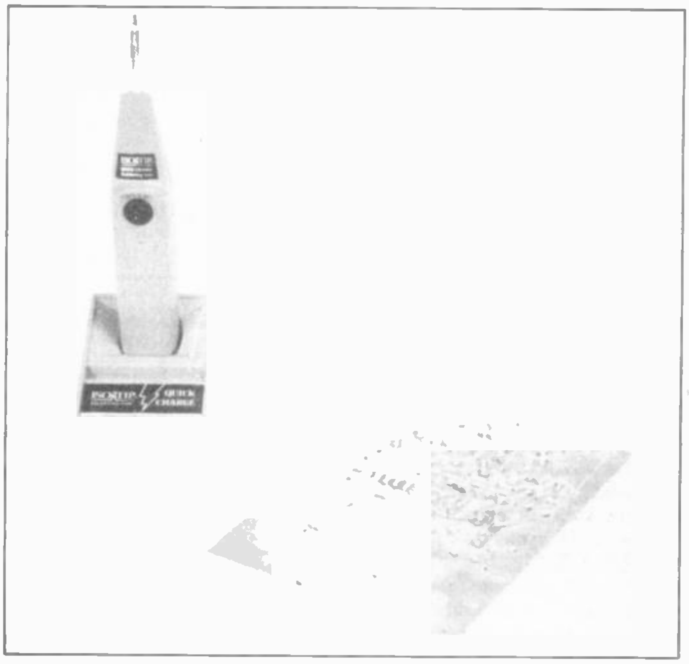


Figure 2. Cordless, rechargeable soldering iron plus recharger

The iron takes about four hours to reach its fully charged state, once the recharger is turned on and the iron put into it. The cells inside the iron cannot be overcharged or damaged by leaving the iron in the recharger, so you can leave it in this position till required. Operating the iron is easy — lift it from the charger, press the 'on' button, wait 3-5 s to allow the bit to heat up, then solder the joint as you would with any iron.

Once fully charged the iron can be used for a constant period of about 15 minutes without needing charging, but using the iron for about 20 s at a time every few minutes (an average amount when soldering — remember you're never actually using an iron constantly) will give a working time of well over an hour between charges.

A Clean Sweep

Everything you use when soldering; ie, iron bit, component leads and circuit board *must* be clean and grease-free. The smallest amount of grease or dirt could cause a faulty joint.

Keep the tip of the soldering iron bit clean by wiping it every few minutes, when hot, over a damp sponge or rag — the tip should have a shiny, silvery surface.

Clean the copper track of the circuit board with household ▶

scouring powder and a damp rag. **Figure 3** shows a PCB which has been half cleaned (ie, one half of the board has been cleaned with scouring powder then washed — the other half hasn't). The difference is obvious because the cleaned copper surface has a bright, shiny appearance rather than a dull one. Another way to clean the board is with methylated spirits and a rag, although this doesn't remove any oxide layer on the copper — it just removes grease.

If the component leads are dirty or greasy, rub them lightly with a piece of emery cloth before inserting them into the circuit board.

Insert and solder components one at a time, then cut off the excess component leads using a good pair of side-cutters, close to (but *not on*) the soldered joint.

When you actually apply the soldering iron to the joint to be soldered, remember to heat the copper track rather than the component lead. You see, copper is a good heat conductor and therefore the applied heat from the iron will be dissipated quickly away from the joint, and more heat will be needed. If too much heat is applied to the component lead then obviously the heat is conducted along it to the component body and heat damage might occur.

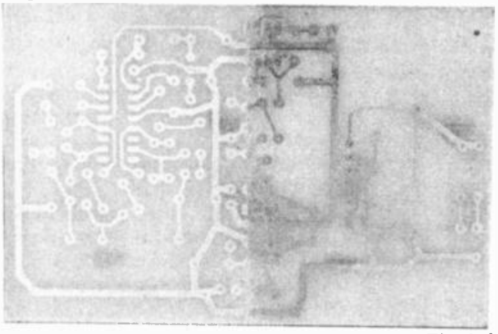


Figure 3. Here you can see how dirty a PCB can get. The left-hand half of this board has been cleaned with household scouring powder, the other half hasn't. Dry joints are easy to make on a dirty PCB

The order of steps in soldering a joint is as follows:

- Apply the hot soldering iron bit to the copper track of the board, about ⅛" away from the component lead and leave it there for a few seconds
- Touch the end of a length of solder to the other side of the hole which the component lead goes through, and wait for it to melt (see **Fig.4**)
- Move the bit of the iron up to touch the component lead, still keeping it on the copper and at the same time applying more solder until the solder flows all round the hole and up the lead in a concave arc shape
- Remove the iron bit and let the joint cool

Nothing to it, is there, when you know how! Keep practising — see you next month.

You can obtain a cordless rechargeable soldering iron similar to ours, from:

West Hyde Developments Ltd,
Aylesbury
(telephone 0296 20441)

for about £25.

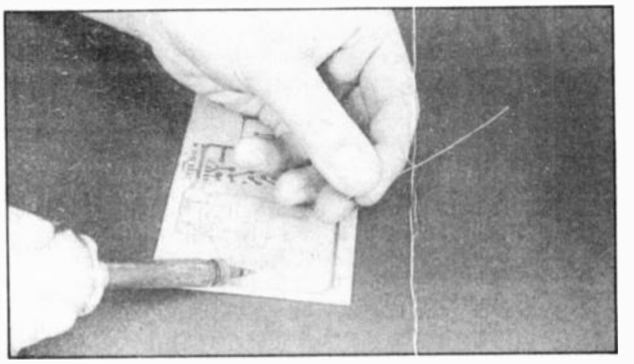


Figure 4. Solder just beginning to melt onto the copper track around the hole of a PCB. When this occurs you know that the joint is hot enough

HE

Clever Dick

Shock! Horror! Clever Dick shows rare generosity and gives away *two* binders this month

BACK IN THE June '81 issue of HE, Clever Dick came to a close with a letter from someone claiming to be Professor S. Unwin. It ended with 'Await deep joy at your reply', and I ended with 'Binder to the reader sending the best suggestion'. Well here it is.

Dear Clever Dick,
I think I can help your correspondent of last week, Prof. S. Unwin. I suspect that he is an alien of the Planet Arpeggio or has spent some time there.
My wife and I spent a two-decade holiday in the seventeenth century (their time) and I picked up the language, oh yes!

Prof. Unwin
Your problem Professor, is a question of impedilode. I assumi that you have a single outputilode on the recordi tape contraption and headphone socketer fittilode for an extoni speakibold. If your speakibolds are of equali impedilode and you connectiwire them in serilode, you add the impedilode which gives you approx halfmo outputilode and much reduced musipoo, oh yes.
If howeverlode, you connectiwire the speakibolds in the parallelimode, it then halfmos the impedilode of the combined speakibolds, therebymo giving, approx doublo the outputilode and much increasimo the musipoo with much greater joy, oh yes.
Yours sinceriwish,
Mr. Viv Reed

Right, for that you get a bindilode. If the 'Professor' sends me his address then I'll send him suggestions received from other readers.

Two letters were received from readers in response to Martin Portman's request for HEBOT spares in the July '81 issue. The first was from Richard Bradford in Canterbury, Kent and the second was from Ian Fosberry in Thurmaston, Leicester. Thanks for your letters — I'll send them to Martin.

Richard Bradford, incidentally, suggested a camera flash as an HE project: I'll see how it develops in the HE Long-term Ongoing Ideas Laboratory.

Next letter was sent with the aim of helping P. Smith, who wrote in the June '81 CD: 'I would like to know who sells the AY-3-8610 IC and how much it costs'.

Dear CD,
Having just read a letter from one P. Smith concerning the AY-3-8610 integrated circuit.

I am NOT a dealer, but I have a few of these circuits.
They are not new, but I can guarantee they will all work.
I would be happy to supply a fellow constructor with this IC for just the price of postage.
D. R. Jaynes
Harlow, Essex

Our thanks to Mr Jaynes for his wish to help a fellow constructor. If P. Smith drops me a line I'll pass on his address.

Off to sunny Finland now.

Dear Clever Dick,
I have the honour of being a reader of your excellent magazine, and I would like to ask about three tings.
1. You had an article in HE (May '81) about a microcomputer named ZX81. I would like to know more about it. What shall I do?
2. Is anybody who reads this magazine interested in corresponding with me? I am from Finland but my language is Swedish. I am a sixteen-year-old boy in desperate need of exercise in English.
3. What is this "Binder" that everyone nearly fights about?
I hope you forgive my bad English.
Peter Degerlund
01490 Vanda 49, Finland

First tings first. We covered the ZX81 — in kit form — in the Gadgets, Games & Kits supplement in the July '81 issue.
Second, if anyone would like to correspond with Peter, drop me a line.
Third, not only will I send you a copy of HE but I'll also send you a coveted Binder (I'm in a silly and generous mood — for this issue only).

I asked in the July issue if anyone could beat Ben Chaston's letter for brevity — and still make sense.

Dear CD,
No!
F.R.Maher
Formby, Liverpool

Any sensible replies?

Another short one, this time written on the noble headed paper of Eton College.

Dear Clever Namesake,
Please could you tell me where I could get 3.5 mm stereo jack male and female sockets for mini-portable-stereo-tape-players?
Dick Gibbons
Eton College, Windsor, Berks

I'd like to say 'yes, they're available from . . .' but I can't. After a quick phone round I soon came to the conclusion that these were specialist items. Plenty of *mono* 3.5 mm sockets and plugs around but no stereo versions. Sorry, but it looks like it's time for a redesign of whatever you're making. (What's wrong with highly-popular old-fashioned ¼-in diameter types?)

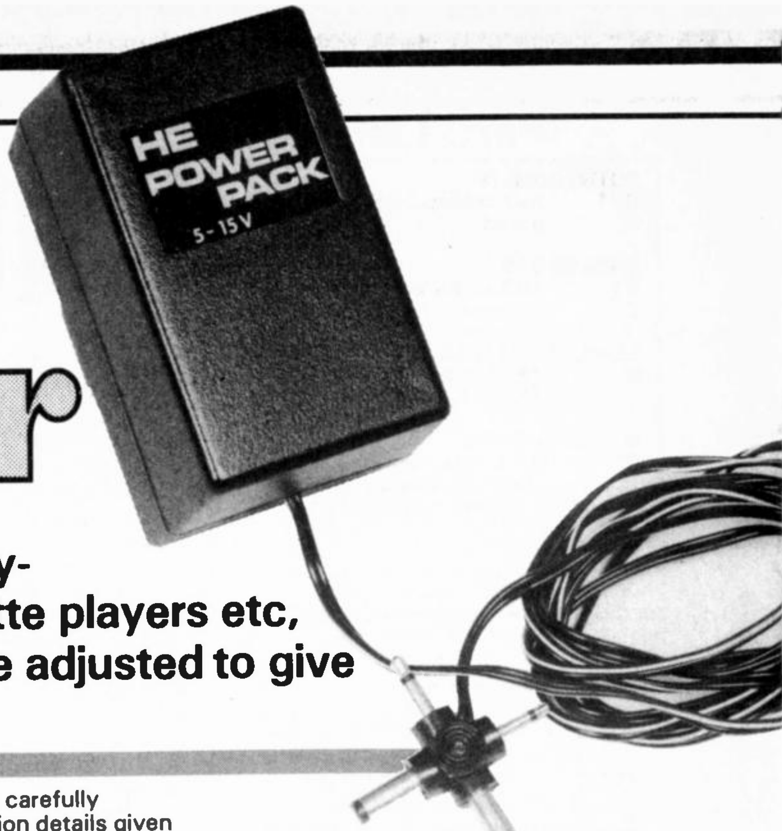
Now one from a desperate reader.

Dear CD,
I am writing in a state of extreme desperation and hope that you can offer a remedy.
Recently I purchased components for an LCD multimeter and now am trying to find close tolerance resistors for range setting. I require especially the following values: 9M, 900k, 90k, 9k, 1k. Whilst Lascar Electronics supply 0.25% tolerance values, they are not prepared to supply these independent of a kit.
P. M. Hitching
Croydon, Surrey

The MPR24 range of 0.25 W resistors from Mullard Limited covers a wide range of values, temperature coefficients and resistance tolerances extending down to 0.01%. Mullard distributes these through Intel Electronics, Henlow Trading Estate, Henlow, Beds (tel 0462 812505) but, because they are such specialist items, the resistors are very expensive. Minimum orders are 20 of any one type, at 0.05% tolerance, at a cost of *£1 each*. As suggested by Intel, it would be cheaper to buy 100-off (for example, 0.25% tolerance, 100-off would cost 14½p per resistor). But 100-off of a single value will not, in any configuration, give all the values that you mention.

And that's the end of the page. See you in the next issue. **HE**

Mains Adaptor



An ideal project for users of battery-powered calculators, radios, cassette players etc, because the HE Power Pack can be adjusted to give the voltage you require

PROJECTS ARE OFTEN designed with a particular case or enclosure in mind. The HE Power Pack is a good example — when we first saw the case, from West Hyde Developments, we knew exactly what to design into it. This case was specifically intended to house mains power supply units, and features three pins (in the shape of the pins of a standard 13 A plug top) which plug straight into a 13 A mains outlet socket.

Our circuit (**Fig.1**) gives a regulated output of between 5 V and 15 VDC, adjusted and set by a preset resistor. Current output is anything up to about 350 mA.

An integrated circuit is used in the project to regulate the output voltage and although this IC (the 7805) is normally used in a fixed-voltage (5 VDC) supply we have adapted the circuit so that it will give a variable output voltage.

Construction

Insert and solder the two diodes into the printed circuit board (PCB) making sure that they are the correct way round, as shown in the overlay in **Fig.2**. The bodies of the diodes must be mounted as close to the surface of the PCB as possible.

Solder in PCB pins wherever connections are to be made to the circuit board, then insert and solder all remaining components, following the overlay diagram. Clip the heatsink on to IC1.

Now open the plastic power supply case and take out the sub-chassis. Break or cut off the transformer mounting lugs so that the transformer will fit into the case.

Using good quality contact adhesive and following manufacturers' instructions as to use, stick the transformer to the sub-chassis.

Next, using the contact adhesive, stick the PCB to the sub-chassis to fit underneath the edge of the transformer. **Figure 3** shows a view of the project in which you can see the details at this stage.

Wire up the project carefully following the connection details given in **Fig.2**.

Solder leads to the live and neutral terminals, inside the power supply case, and bend the leads up to the top of the case. Refit the sub-chassis and then solder the remaining ends of the live and neutral leads to the PCB and the transformer, where shown in **Fig.2**.

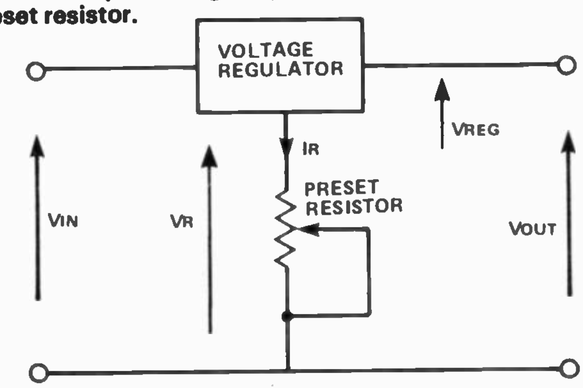
Tightly attach a cable tie to the output lead, so that no damage will occur if it is pulled. A view of the project at this stage is shown in **Fig.4**.

Stick a small piece (about 1" by ½") of foam sponge onto the inside lid of the case, positioned so that when the two halves of the case fit back together, the sponge pushes down onto the transformer, preventing movement.

Finally, plug the supply into a mains outlet, turn on, and measure the voltage at the supply output. By adjusting preset resistor RV1 you should obtain an output voltage variable between about 5 VDC and 15 VDC. Set the output voltage to what you require, switch off, remove the supply from the mains outlet and screw the two halves of the case together.

How It Works

The workhorse of this project is a voltage regulator integrated circuit which sets the output voltage (V_{OUT}) to a value determined by the setting of the preset resistor.



The input voltage (V_{IN}) comes from the rectified output of mains transformer T1. Diodes D1 and 2 give full-wave rectification of the 12 VAC transformer output.

Capacitor C1 provides smoothing of the rectified voltage and V_{IN} will be about 18 VDC.

Integrated circuit IC1 is a 5 V voltage regulator, and whatever the output voltage of the circuit, V_{REG} will always be 5 VDC.

The value of current I_R is 1.5 mA for IC1 (from manufacturers' data) so we can calculate the voltage across the preset resistor from Ohm's law. For example, if the value of the preset is 1k0 then:

$$V_R = 1.5\ mA \times 1000,$$

$$= 1.5\ V.$$

The output voltage is simply the sum of the two voltages, ie,

$$V_{OUT} = 1.5 + 5 = 6.5\ V.$$

Thus, by varying the value of the preset resistor the output voltage can be varied.

Parts List

POTENTIOMETER
RV1 4k7 miniature horizontal preset

CAPACITORS
C1 1000u, 25 V electrolytic
C2 220n polyester

SEMICONDUCTORS
IC1 7805, 1 A voltage regulator
D1,2 1N4001, 1 A diodes

MISCELLANEOUS
T1 0-12-0-12 V, 6 VA miniature transformer
Printed circuit board mounting fuse clips
FS1 500 mA, 20 mm fuse
Case (see Buylines)

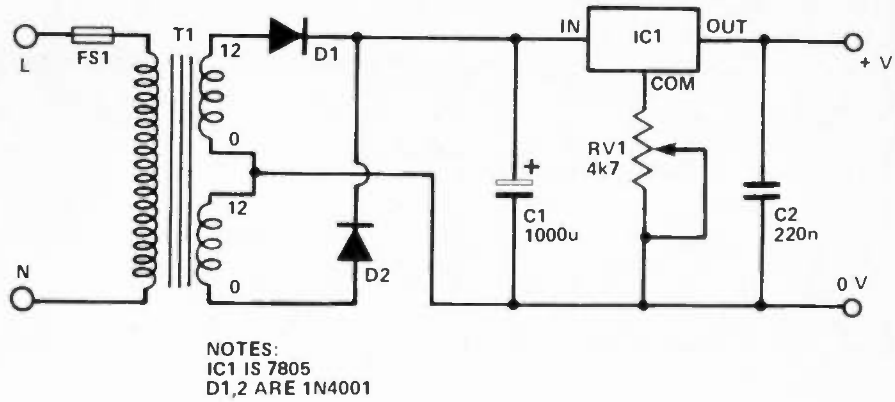
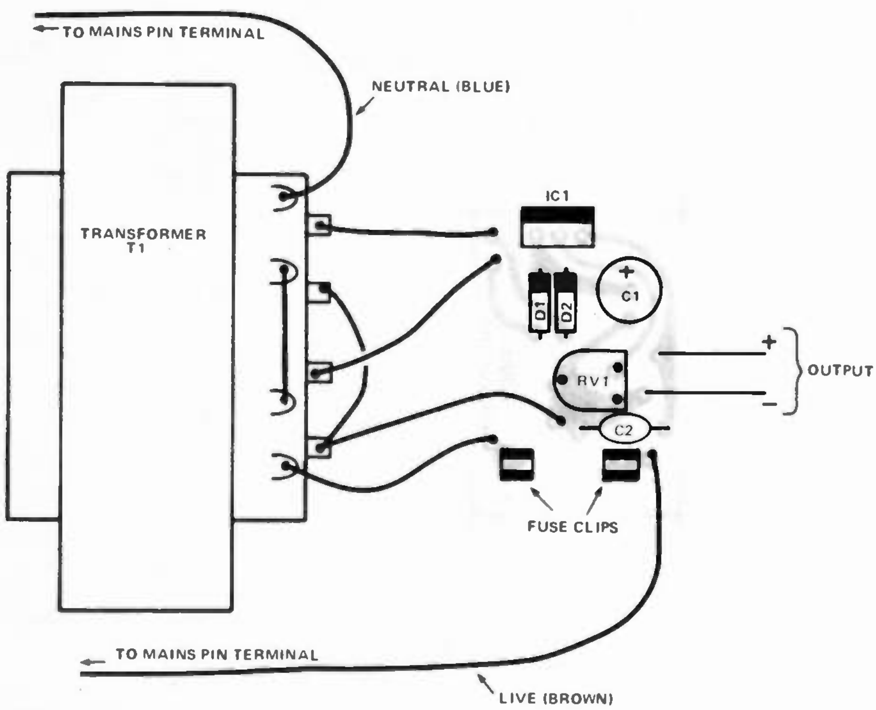


Figure 1. Circuit of the HE Power Pack



Buylines

You should have few problems obtaining component parts for this project and the approximate price (excluding case and PCB) will be £4.50.

If you have any trouble finding a source of supply for transformer T1, you can buy it direct from:

Verospeed,
Stansted Road,
Boyatt Wood, Eastleigh,
Hants SO5 4ZY

by sending them a cheque for £2.10.

The mains power supply case is obtainable from:

West Hyde Developments Ltd
Aylesbury
(telephone 0296 20441)

and its order code is PSC200K (for a black case) or PSC200W (if you want a white case).

◀Figure 2. Overlay of the PCB for the project and connection details

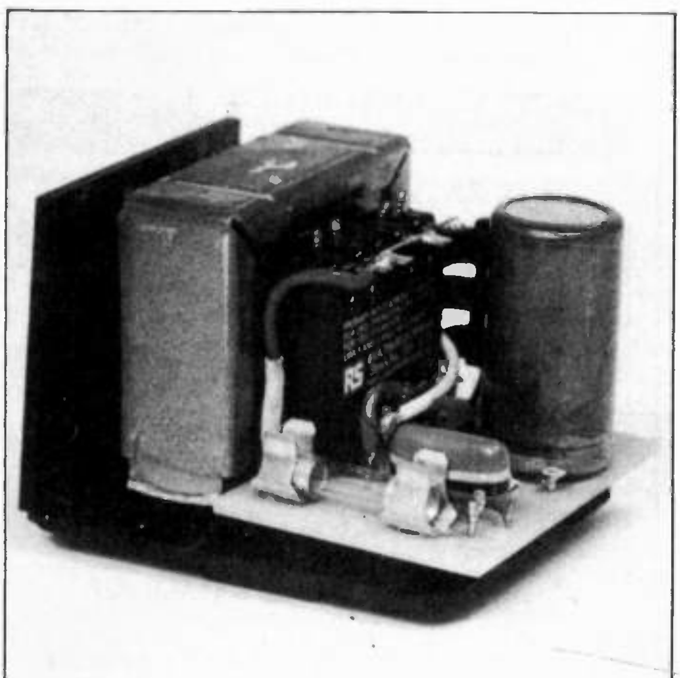


Figure 3. View of the project fitted to the sub-chassis, before insertion into the case

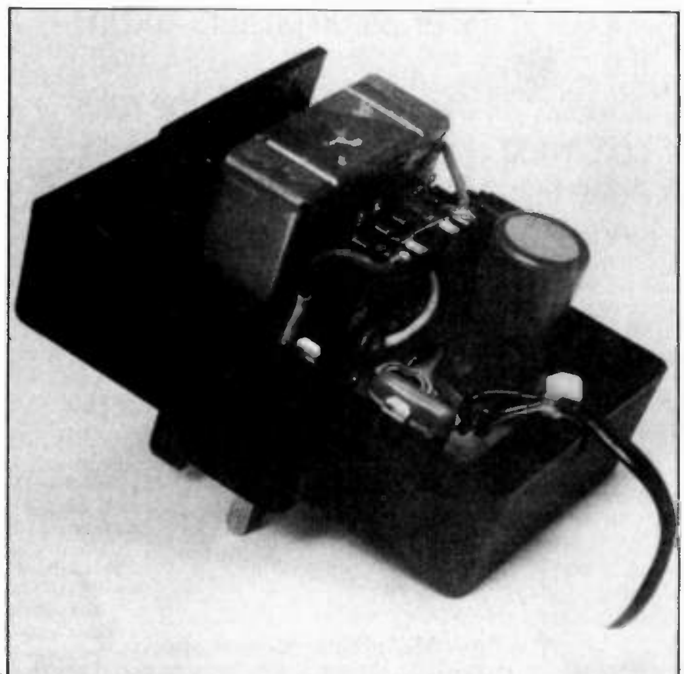


Figure 4. Internal details of the HE Power Pack

HE


"NO - I DON'T THINK AN HOUR A DAY OF 'COMPUTER JOGGING' COUNTS AS EXERCISE!"
FLETCH

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Into Electronic Components

The second part of this beginners' series on the components we use in electronics deals with the measurement of voltage, current and resistance. Ian Sinclair tells you how to make these measurements, using the HE Multitester (see special offer on page 50)

I MENTIONED Georg Simeon Ohm last month. His name has been given to a law (Ohm's law) which we use more than any other in electronics, and one which must be understood and used correctly if we are to make any real progress. Even today, more than a century after he lived, Ohm's law is often misunderstood, so this looks like a good time to set the record straight and look at the quantities his law deals with.

Quantities

We can start with the quantities voltage and current. Current is the flow of electricity and is measured in amperes (amps); voltage is the 'push' that drives the current along, and is measured in volts. In a circuit, the more volts you use the harder the 'push'; that is, the current increases.

Our idea of resistance to the flow of current is expressed as the ratio volts/current (ie, voltage divided by current). The unit of this quantity is the ohm, so we could just as easily call the ohm the volt/amp.

A lot of people get that far — and then stick. The trouble is that electric current is invisible, and it can be difficult to concentrate well on invisible quantities. To get around this, it's easy to compare electric current with something more tangible, like water in a pipe. The movement of water in a pipe is something like electric current, and the pressure of the pump that makes the water move through the pipe is something like electric voltage. Let's imagine now that one section of pipe (Fig.1) is narrower than the rest of the pipe in the 'circuit'. A narrow pipe is a high resistance for the flow of water, and the water will need to have quite a high pressure to keep up a good rate of flow through the narrow piece of pipe. We can measure this pressure difference between the ends of the narrow piece of pipe, using a pressure meter (called a manometer, if you want to know!).

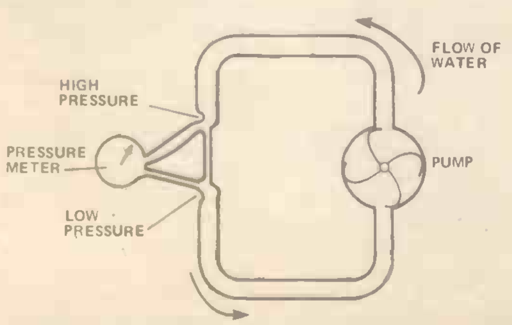

Figure 1. Pressure in water pipes. Most of the pressure caused by the action of the pump is needed just to keep water flowing through the narrow section of pipe

Now the pump provides all of this pressure, and thus we can measure a pressure difference across the pump also; but there's an important difference between these two measurements. Suppose we clamped the pipe closed at each side of the pump (Fig.2). There is still a pressure difference between the ends of the pump but there is no pressure difference across the narrow piece of pipe, because the pipe is no longer connected to the pump. The pressure across the piece of narrow pipe was *caused by the pressure of the pump*.

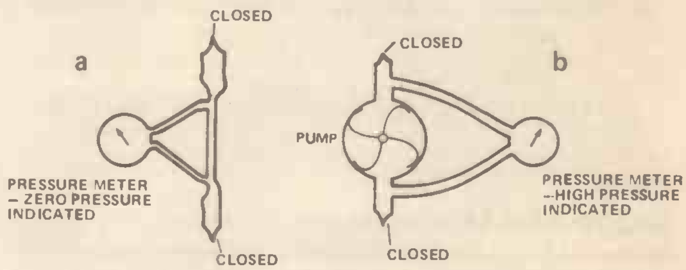

Figure 2. Comparing pressures: (a) the narrow piece of pipe does not *cause* pressure, it's the pump (b) which causes the pressure

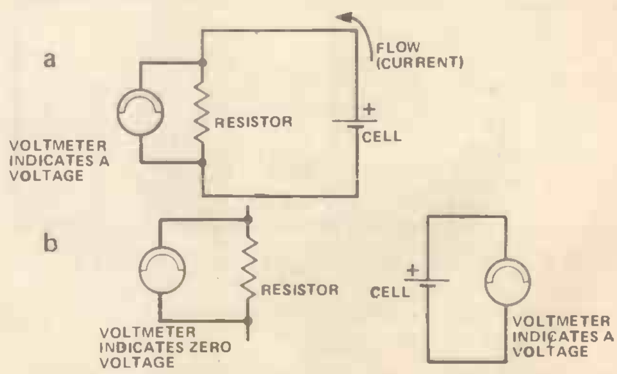

Figure 3. The electrical circuit: (a) there is a voltage across any resistance in the circuit — this is just the amount needed to make current flow. Just like the water circuit, there is no voltage across the resistance by itself (b), only across the 'pump', in this example a battery

Now let's go back to the electric circuit (**Fig.3**). The 'pump' for an electric circuit is the battery or generator which can push electrons round a circuit. If we have a resistor anywhere in the circuit, we will measure a voltage across it as long as there is a current flowing (when it's connected to the 'pump'), but not when the circuit is broken, because the resistor is not a generator.

Whenever a current flows through a resistor, then, it's possible to measure a voltage between the ends of the resistor. The amount of this voltage can be expressed by the equation:

$$V = IR,$$

so that if we have a current of 0.2 amps (abbreviated to 0.2 A) and a 20 ohm resistor (ie, a 20R resistor), then the voltage is calculated by

$$V = 0.2 \times 20,$$

which is 4 volts (ie, 4 V). We can also apply this equation to a complete circuit. Suppose the 20R resistor is part of a circuit whose total resistance is 50R. If we connect this to a battery whose voltage is 10 V, then the current (see **Table 1**) is given by

$$I = V/R,$$

which in this example is 10/50, equal to 0.2 A.

VOLTS, AMPS, OHMS	UNITS
$V = I \times R$	V IN VOLTS
$R = \frac{V}{I}$	R IN OHMS
$I = \frac{V}{R}$	I IN AMPS

Table 1. The three versions of the electrical circuit law which we know as Ohm's law

The common mistake that many of us make is to call the V = IR equation (along with derivatives I = V/R and R = V/I) 'Ohm's law'. It isn't, but it's a handy name, because the use that we make of the equation depends so much on Ohm's law. What Ohm's law actually states is simply that the quantity, resistance, is a constant for a sample of metal at a constant temperature. If this wasn't true, we could not use the equation V = I R so freely, because we would have to use a different value of resistance for each different value of voltage or current. You'll appreciate that point a lot more when we come to deal with diodes in Part 6 of this series.

More of that later, because we have to look now at how we are going to use the multimeter in practical measurements, and before we can do that, we need to know some more about the multimeter itself.

Inside The Multimeter

At the heart of the multimeter is a moving-coil movement. This consists of a shaped magnet (**Fig.4**), whose poles enclose a tiny coil of wire. The coil is supported by thin wires (which act as springs), and it carries on its shaft the pointer which swings over the dial to show the readings of the multimeter. Connections are made through the thin wire springs to the ends of the coil, so that *current* can be passed through the coil.

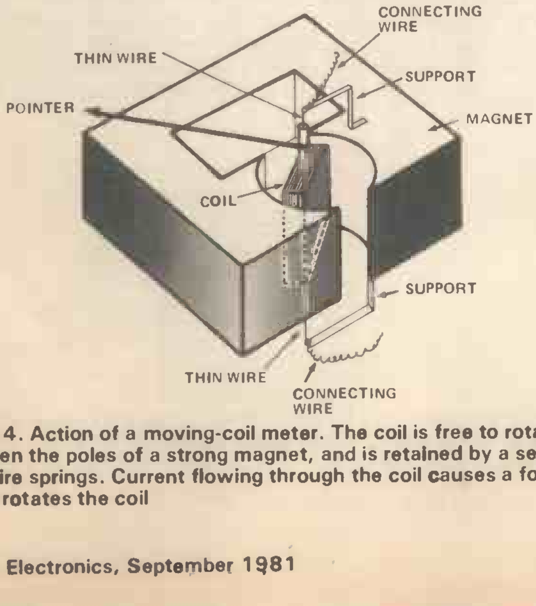

Figure 4. Action of a moving-coil meter. The coil is free to rotate between the poles of a strong magnet, and is retained by a set of thin wire springs. Current flowing through the coil causes a force which rotates the coil

Yes, that's right — current. That's the quantity that causes the needle to move over the scale, no matter what you think you are measuring. When a wire is close to a magnet, and there is a current flowing through the wire, a force exists between the wire and the magnet. How much force? It depends on how much current is flowing, and that's why we use this principle.

The coil of wire has, of course, a resistance, which is called the internal resistance of the movement. The movement will also deflect full-scale (as far as the pointer can travel) for some measurable amount of current, and this amount is called the FSD (full scale deflection) current. The size of this FSD current depends on how strong the magnet is, and on how many turns of wire are on the coil, and also on the size of the coil — but these are problems for the designer of the movement.

Multimeter Design

Knowing these values, internal resistance and FSD current, we can design a multimeter, using the moving-coil movement. Let's take, just for starters, the current ranges. Suppose we have a movement where FSD is 50 uA and the internal resistance is 500R: fairly typical values for modern movements (the HE meter is better than average, with its FSD of 18 uA). Now, as our imaginary movement comes, it can't measure any amount of current greater than 50 uA, which isn't much good if you want to measure milliamps.

No, you don't have to make a different movement to measure a higher current range! All you have to do is to split the current so that only a constant fraction of it goes through the movement — and design things so that the fraction is no more than 50 uA. It's like saying that only 100 cars per hour can go down the High Street, but cars can go through the town at a rate of 300 per hour. The solution just has to be to send 200 of them along another route, and that's the type of solution we use to measure currents which are larger than the FSD. The 'other route' is a resistor which is connected in parallel with the meter movement, as in **Fig.5**. Now this doesn't just send some current another way, it always sends the *same fraction* of the current the other way. For example, if we fix it so that 3/4 of the total current goes through the resistor and 1/4 through the meter, then these ratios apply to each value of current. Put in 40 uA, and 30 uA goes through the resistor and 10 uA through the meter. Put in 100 uA, and 75 uA goes through the resistor and 25 uA through the meter movement.

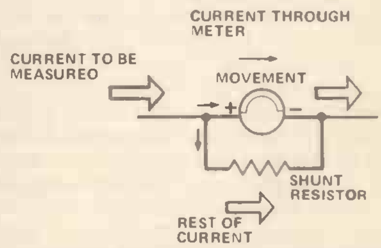

Figure 5. Using a shunt resistor to take a definite fraction of the total current past the coil. This lets us measure currents which are much too high to pass through the coil

By using these resistors, called shunts, we can adapt a moving-coil movement for larger values of current than the FSD current. There's no change in the movement, through. The FSD does not change, it's just that when the needle indicates full-scale, the total amount of current is greater, because there is current passing through the resistor as well.

We can also adapt the movement to read volts, by making use of Ohm's law. Suppose we have a movement with 1 mA FSD, internal resistance of 100R, and we want to be able to measure 10 V. By Ohm's law, if we use metal (or carbon) for the resistor, it will have a constant amount of resistance, so we can use V = IR. For 1 mA to flow with 10 V applied means that the total resistance in the circuit must be 10k. We could, of course, wind a coil for the movement which would have a resistance of 10k, but that's not needed. All we need to do is to connect a resistor in series with the movement, as in **Fig.6**, so that the *total* resistance is 10k. Since the meter movement has 100R of internal resistance, we need to add 9900R to make up the 10k, and that's the value we would need to connect in series with the movement.

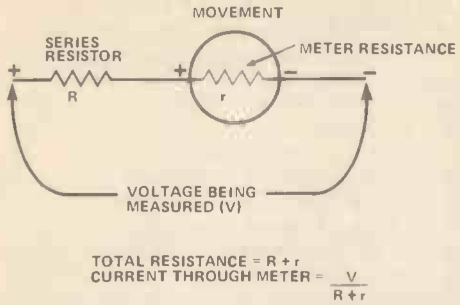

Figure 6. Using a series resistor for voltage ranges. The series resistor will pass an amount of current which depends on the voltage (Ohm's law), so that the meter reading is proportional to voltage

Going Ohm

Next problem — how do we get a multimeter to read in ohms? The answer is to use the meter to indicate the current which a small battery passes through the resistor — and that's why the multimeter contains a dry cell or a battery (both in the HE meter, accessible when you unscrew the two screws at the back and carefully take the two halves of the meter apart).

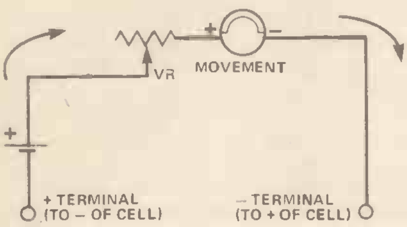

Figure 7. Meter arrangement for resistance measurements. A cell inside the meter is used to provide a voltage to pass current through the resistance, and the movement measures the current. Note the reversed voltages at the terminals

The circuit is shown in **Fig.7**. When you switch to the OHMS range, the positive terminal of the internal battery is connected to the '–' of the movement, and the negative terminal of the internal battery is connected to one end of a variable resistor — the OHMS SET resistor. The other end of the variable resistor is connected to the '+' terminal of the meter — which is now a negative terminal because it is connected to the negative terminal of the battery! The negative terminal of the movement is still connected to the negative terminal on the meter case.

Now when we connect the multimeter terminals together, shorting them out, the amount of current that flows depends on the amount of resistance in the circuit — and all of that resistance is in the OHMS SET variable resistor. We can set this so that the amount of current that flows is equal to the FSD current of the meter. Since the terminals of the multimeter are shorted together, this reading corresponds to having zero ohms connected to the terminals, and the FSD of the meter is marked as zero ohms on the ohms scale. When we now connect a resistor between these terminals, this will add to the total resistance in the circuit, so that the current is less, and the reading on the dial is less. The OHMS scale is not linear — equal distances along the scale do not correspond to equal amounts of resistance. For example, if the variable resistor has to be set to 60k (using a 3 V battery and with a meter of 50 uA FSD), so that this passes the FSD current, then connecting a 25k resistor across the terminals will make the total resistance equal to 85k, so that the current becomes 3/85 mA, which is 35 uA. Now if we use a 50k resistor across the terminals, the total resistance will now be 110k, and the current will be 27 uA, which is certainly not half of 35 uA. The first 25k of added resistance causes a drop in current of 50 — 35 uA, equal to 15 uA, and the next 25k we add (to give 50k) causes a drop in current from 35 uA to 27 uA, ie, only 8 uA.

This causes the OHMS scale to have its markings widely separated at the low-resistance end, but cramped very closely at the high-resistance end of the scale, so that the difference between, for example, 1k and 2k on the OHMS x 1 scale of the HE meter is almost impossible to measure. That's why we need more than one ohms range, and the correct one to use is one which gives a reading around the middle of the scale, definitely not at the cramped left-hand side.

The measurements of voltage, current and resistance are the three important ones for the work that we'll be doing — we won't be using the AC volts range in this series, because everything we need to do can be done using a battery supply. We're dealing with components and their actions, after all, not with large circuits.

Practice Makes Perfect

Now to more practical matters, and a closer look at Ohm's law. Start by placing a 1k0 resistor (see **Fig.8** for the colour identification) on the Eurobreadboard. The resistor has two leads, and they must never be put into holes on the same line, because if you do, the resistor is not in any kind of circuit. Give yourself some space, put one lead of the 1k0 resistor into line Y1 and the other in line 5A. Also in line 5A, plug in a short length (a couple of inches or so) of tinned copper wire, of around 18 SWG. Don't on any account use stranded wire, because it tangles with the Eurobreadboard spring clips and won't come out again without a struggle.

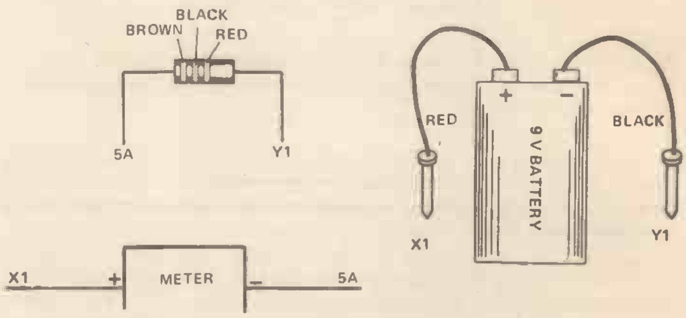

Figure 8. Reading current through a resistor. The markings at the ends of the leads in the drawings are the Eurobreadboard hole reference numbers/letters

Now connect the battery, which by this time you should have fitted with wire leads ending in single-strand wire or pins. The negative ('–', black) lead of the battery should be plugged now into line Y1, and the positive ('+', red) lead into line X1. These are the lines that we'll use throughout this series for the power supply leads.

We can now measure how much current a 9 V battery will send through a 1k0 resistor. Set the meter to its 50 mA range, and clip the negative lead of the meter to the piece of tinned copper wire which is in line 5A. Now clip the positive lead of the meter to the end of the battery lead which is in line X1 (see **Fig.8**). The circuit which you have made is shown in **Fig.9** — the battery is pushing current through the meter and also through the 1k0 resistor. All the current that flows through the 1k0 resistor has had to pass through the meter, so what we measure on the meter is the current through the resistor. If you're using the HE meter, switch to the more sensitive 25 mA range by putting the slider switch to its VA/2 position, and take another reading.

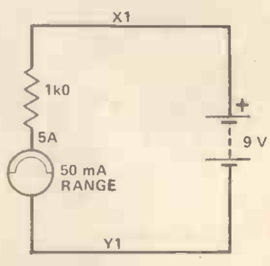

Figure 9. The circuit of the arrangement shown in Fig. 8

We could also calculate how much this current should be.

Using the Ohm's law equation for current I,

$$I = \frac{V}{R}$$

$$= \frac{9}{1000} = 0.009 \text{ A},$$

ie, 9 mA. The meter reading should be somewhere near this.

Why just 'somewhere near'? Well, as we'll see, nothing is ever exact in the world of electronic components. Generally, if you get to within 10% of a calculated value, you're close enough, because mass-produced components are never exactly the values that they claim to be. This is a matter of tolerances, which we'll look into next time.

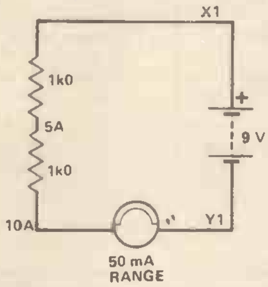

Figure 10. A pair of resistors (both 1k0) connected in series. The Eurobreadboard numbers show how the resistors can be positioned on the Eurobreadboard

Now have a look at the circuit in **Fig.10**. This is shown as a circuit diagram, with the Eurobreadboard line numbers written in so that you can place the components in the same locations as I am using for the circuit right here in front of me. The way these resistors are connected here is called a series connection, and the meter will measure the current through them. How much current is flowing? Note the value, because the Ohm's law equation can make use of this value to calculate the total resistance, using R = V/I. How does this calculated value of total resistance compare with the value you get by adding the values of the two resistors?

This type of connection is a series connection, and the result of a series connection of resistors is always more resistance — the sum of the resistor values. Now try the circuit in **Fig.11**. The resistors are in the same lines, so the current will split up, and some of it will flow through each resistor. Measure this total current. How much current do you think should flow through each resistor? Now calculate the total resistance, which is expressed as:

$$\frac{9 \text{ V}}{\text{Total current}},$$

and compare this value with the value for each resistor, 1k0.

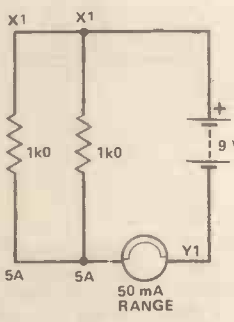

Figure 11. Two resistors in parallel

Connecting resistors in parallel like this always results in a lower total resistance value. Now try the circuit in **Fig.12**. The resistors are both 1k0, and this time we'll measure the voltage across just one of them. Switch the meter to its 10 V range (with the slider switch in its VOA position), and clip the – COM lead to the Y1 battery connection. Plug the red probe lead into the + input of the meter, and touch the end of the probe against the resistor wire in line 5A (either wire in this line). Theory tells us that the voltage should be 4.5 V.

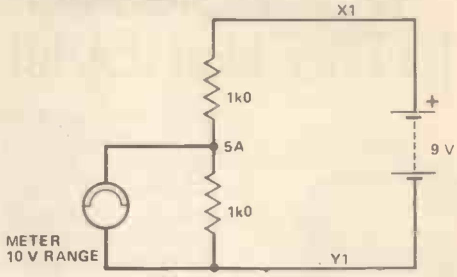

Figure 12. Potential divider circuit. The meter is set to measure the voltage across one of the 1k0 resistors. This value should be almost exactly half of the battery voltage (remember that the resistors can be 20% high or low)

Now repeat using two 1M0 resistors (**Fig.13**). Theory tells us that the voltage should still be 4.5 V — but see what you measure with the meter 'negative' (black) lead connected to line Y1, and the positive probe lead on line 5A. Less than 4.5 V?

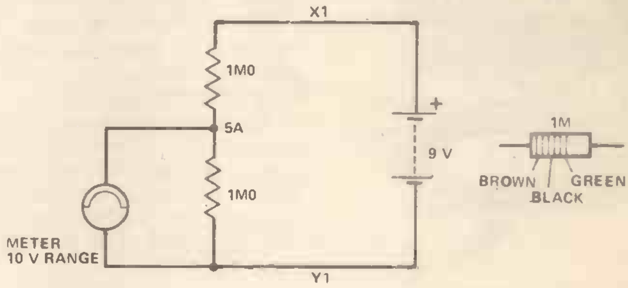

Figure 13. Potential divider circuit, this time using two 1M0 resistors. What voltage do you find this time? With no meter connected, the voltage is still equal to half the battery voltage

Nothing wrong with the theory — the problem is the way we're using the meter. As we said right at the start, the meter needs current. When it takes that current from a circuit, the voltage in the circuit changes — so the meter reading is of the voltage that has changed in a circuit. How do we know when we can rely on a voltage reading? As it happens, we do know when the readings of voltage should be reliable. For every meter, there's a 'goodness' factor, measured in thousands of ohms-per-volt, or k/volt. This figure, multiplied by the full-scale range of voltage that the meter is set to gives the total resistance of the meter when it is being used as a voltmeter. This resistance should be at the very least 10 times as much as the resistance between the supply + and the point where we are measuring voltage. For example, if we use the HE meter on its 10 V scale, then with a goodness factor of 25k/V, the total resistance of the meter is 250k. This is a lot more than 10 times 1k0, which is why we can rely on the measurements of voltage we read across the 1k0 resistor in **Fig.12**, but it's not high enough compared with 1M0, which is why the reading for the circuit in **Fig.13** is lower than it should be. There's nothing wrong with the meter — it measures the voltage which is present when it is connected. What it can't do is to measure the voltage that is present when it is not connected and so not affecting the current in the circuit.

Take care, then, with voltage readings in circuits where resistors with large values are present. If in doubt, repeat a reading using a higher range (25 V instead of 10 V, for example, using the slide switch of the HE meter to bring in a range which is of higher voltage and double the goodness factor, 50k/V instead of 25k/V). If the reading on the higher range is of a higher voltage value, then you have meter-resistance problems. The biggest giveaway is when every voltage range gives about the same amount of deflection of the needle — then you know you can't believe any of them!

Next month — we meet some resistance! **HE**

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THIS Multitester offers much more than a standard multimeter, as the specification shows. Apart from DC and AC voltage, DC current, resistance and decibel ranges, the HE Multitester has a range doubler for voltage and current measurements. Thus sensitivity on DC voltage ranges extends to 50k/V.

The meter dial is large (111 mm by 89 mm) and easy to read. It has a mirror strip to improve accuracy of readings.

The new series Into Electronic Components has been written around this Multitester. Although other instruments can be used in conjunction with the series, the HE Multitester is undoubtedly the best choice.

So take advantage of this special offer: the Multitester is supplied complete with test leads with probes attached, batteries and instructions for only £19 plus 95p post and packing.

Specification

- Overload protected by two silicon diodes
- Uses double-jewelled ± 2% meter with mirror and ± 1% temperature stabilised resistor

Measurement	Ranges	Accuracy	Remarks
DC Voltage	0-125-250 mV 0-1.25-2.5-5-10 -25-50-125-250 -500-1000 V	±4% 125 mV to 2.5 V 500 to 1000 V ±3% except as noted	Sensitivity 50k/V range doubled 25k/V normal
AC Voltage	0-5-10-25-50- -125-250-500 -1000 V	±4% of full scale	Sensitivity 10k/V range doubled 5k/V normal
DC Current	0-25-50 uA 0-2.5-5-25-50 -250-500 mA 0-5-10 A	Same as for DC voltage	
Resistance	0-2k -20k -200 k 0-2M-20M (centre scale 10)	±3% of scale length	Batteries: one penlight 1.5 V one rectangular 9 V
Decibels	– 20 to + 62 dB		8-ranges
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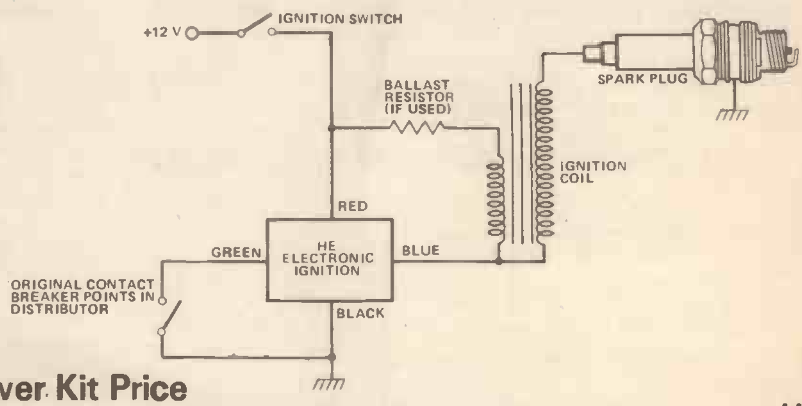
HE Electronic Ignition – Additional Information

DESMOND ARMSTRONG, designer of the HE Electronic Ignition project published in last month's issue, asked us to pass on some additional information to readers.

If you refer to the circuit in Fig.7 on page 13 of the August '81 issue, you will see a ballast resistor connected in series with the ignition switch. Although the circuit will function as shown, it is better to connect the red supply lead from the HE Electronic Ignition directly to the + 12 V supply from the ignition switch, but retain the ballast resistor in series with the ignition coil (see revised version of Fig.7 on this page).

Second point is about the mica washer for transistor Q2. To ensure reliability it is best to use a *thick* mica washer or, as Desmond suggested, two thin ones sandwiched together. Don't forget to smear a small amount of heat-sink compound on both sides of the washer (or washers) to improve heat conduction.

Desmond has just returned from a trip to Israel by Minivan — fitted with the HE Electronic Ignition, of course!



HE Electronic Ignition connected to the standard Kettering ignition circuit. This is a corrected version of Fig. 7 shown on page 13 of the August '81 issue, where the ballast resistor was shown in series with the ignition switch. The correct position of the ballast resistor (if your car ignition system has one) is in series with the ignition coil, as shown above

Lower Kit Price

Under Buylines on page 13 of the August '81 issue, we said that Technomatic was producing a kit for the HE Electronic Ignition project for £18.50 including VAT for callers (70p extra for postage and packing for mail order customers).

Technomatic has now reduced the price of its kit to £16 including VAT (add 70p for postage and packing).

Technomatic Limited, 17 Burnley Road, London NW10 (tel 01-452 1500 or 01-450 6597).

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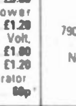

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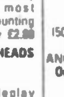

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Tune in to the airwaves with this easily-built project which offers worldwide reception of short wave transmissions at a low cost

Short Wave Receiver

A COMPLEX COMMUNICATIONS receiver is a difficult constructional project and is also likely to be quite costly. Fortunately, a sophisticated receiver is not essential if you just want to listen in on some of the transmissions on the short wave bands. A simple TRF (tuned radio frequency) receiver, such as this design, will do the job quite satisfactorily. It will provide many hours of enjoyment and can be built quite easily at a low cost.

Although a TRF receiver is not as selective as a superhet receiver (it cannot sort out closely-spaced stations as well as a superhet can) it is highly sensitive and should be capable, with a suitable aerial, of worldwide reception.

Our design (**Fig.1**) covers the entire short wave spectrum in three tuning ranges, with approximate coverage of each as follows:

Range 3 1.5 MHz to 5 MHz
Range 4 5 MHz to 17 MHz
Range 5 10 MHz to 33 MHz

The above range numbers are those used by Denco Limited, the manufacturer of the tuning coils for this project. Band changing is accomplished by simply changing the plug-in tuning coil in the receiver. Plugging in coils is obviously a little less convenient than band switching, but it does simplify construction and reduces cost. It is a method of band changing that is often used in simple short wave sets.

The receiver requires an external aerial, and quite good results can be obtained using only a short length of wire. The output of the receiver is primarily intended to drive low impedance headphones, but high impedance 'phones can also be used. For short wave reception, headphones are preferable to using a loudspeaker, but the receiver can even be used with a loudspeaker having an impedance in the range 8-80 R.

Construction

House the receiver in a metal case — we used an instrument case measuring 203 by 127 by 51 mm but any metal case of about this size will be suitable. Mount the four controls and phone socket on the front panel.

Drill or punch a 15 mm diameter mounting hole for VC1. Now, glue the variable capacitor in place behind the hole using a good quality adhesive. The capacitor has provision for mounting by way of three short 4BA screws, but it is much easier simply to glue it in place.

Mount sockets SK1 and SK2 onto the rear panel of the case on the left-hand side (as viewed from the rear).

Drill or punch a 15 mm diameter hole in the rear panel just to the right of the two sockets. This hole enables different tuning coils to be fitted and removed from the receiver without having to remove the lid, and makes changing ranges much quicker and easier.

Make an L-shaped bracket from 18 or 16 SWG aluminium to hold the coilholder about 30 to 35 mm behind the cutout in the case. The coilholder is actually a B9A valve holder.

Most of the components are fitted into one of our standard 10 strip by 24 hole 0.1" matrix Veroboards, and this is constructed using the normal techniques. **Figure 2** gives full details of the component board. Check that each semiconductor and electrolytic capacitor is in the board the correct way round before soldering them and insert Veroboard pins at each connection point.

When the circuit board is completed mount it in the case. Now, wire up the project as shown in **Fig.3**. Keep the leads as short as possible or the receiver will become less efficient over the higher frequency bands. Use a solder tag fastened to one of the mounting bolts of the coilholder as a chassis connection point.

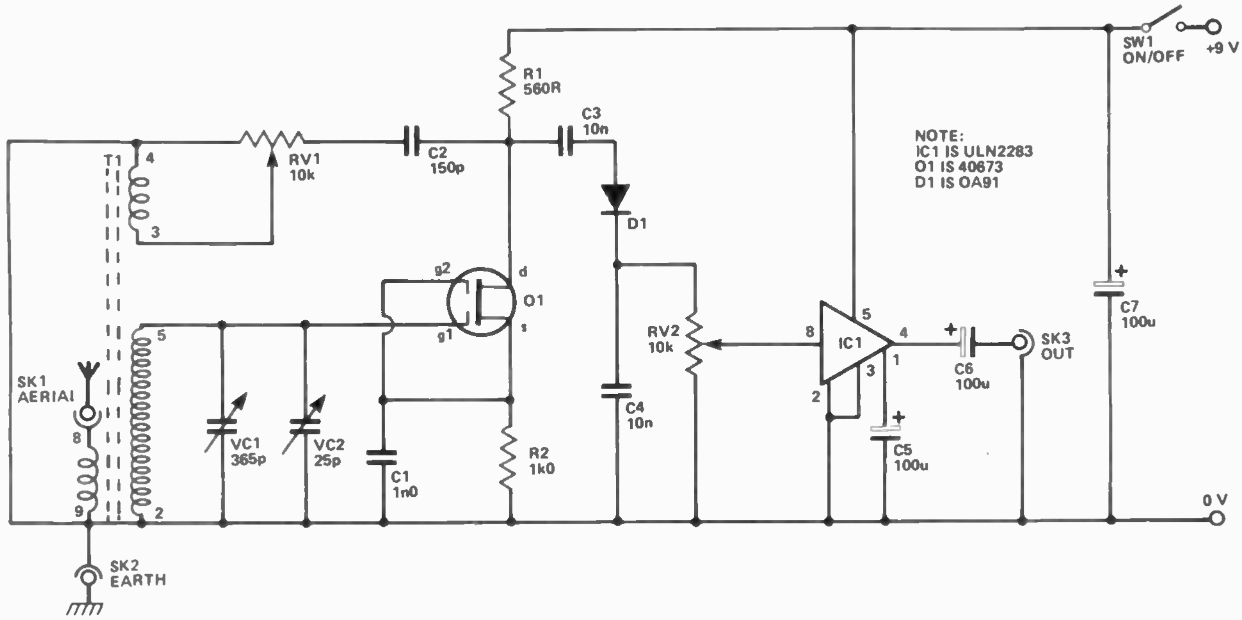


Figure 1. Circuit of the HE Short Wave Receiver

Using The Set

An aerial must be connected to the aerial input, SK1, if the receiver is to function properly, and a few metres of wire strung around the room will provide reasonable results. However, for good results on the low frequency bands (range 3) a long outdoor aerial is preferable, and this can simply consist of about 10 to 40 m of aerial wire strung between any two convenient points. For best results the wire should be positioned high up and clear of buildings or other large obstructions. (For more information about aerials keep your eyes glued to HE's pages — in a forthcoming issue we plan an aerial feature.)

On low frequency bands an earth connection can also boost signal strengths, and an earth can be made by attaching a lead to a piece of metal pipe, and then burying the pipe in the ground. The free end of the lead is connected to SK2.

Potentiometer RV2 is the volume and on/off control, variable capacitor VC1 is the coarse tuning control, and VC2 is used for fine tuning. Potentiometer RV1 is the regeneration control, and it is essential that this is adjusted correctly if good results are to be attained. With very little regeneration the radio's performance will be poor. As RV1 is advanced you will find that sensitivity increases and tuning becomes 'sharper'. However, at some point regeneration will become excessive and the RF amplifier will break into oscillation. This will be heard as an increase in the background noise level and an audible tone of varying pitch as the set is tuned over stations. Proper reception of ordinary AM radio transmissions is not possible with the circuit oscillating, and RV1 should be backed off just below the threshold of oscillation. Sensitivity and selectivity will then both be at maximum. It will be necessary to readjust RV1 each time the tuning is altered, to keep the set at optimum efficiency. With a little practice the set soon becomes easy to operate though, and using a receiver of this type is easier than it may at first seem.

CW (Morse) and SSB (single sideband) are the main types of transmission used on the short wave amateur bands, and can be received by adjusting the regeneration control just beyond the threshold of oscillation. For SSB signals the tuning must be adjusted very carefully or the audible signal will be shifted in pitch. If the tuning is well off the correct setting, the signal may even be completely scrambled.

When first trying out the receiver it is advisable to use the range 4 coil. The main broadcast bands are on this tuning range, and these normally provide a number of strong transmissions whatever the time of day or year.

Parts List

RESISTORS (All ¼W, 5%)	
R1	560R
R2	1k0
POTENTIOMETERS	
RV1	10k linear potentiometer
RV2	10k logarithmic potentiometer with switch (SW1)
CAPACITORS	
C1	1n0 ceramic
C2	150p ceramic
C3,4	10n polyester
C5,6,7	100u, 10 V electrolytic
VC1	365p air-spaced (Jackson type O)
VC2	25p air-spaced (Jackson type C804)
SEMICONDUCTORS	
Q1	40673 dual gate MOSFET
IC1	ULN2283 power amplifier
D1	OA91 diode
MISCELLANEOUS	
T1	Denco DP coil, green ranges 3,4 and 5
Sk1,2	4 mm sockets
Sk3	3.5 mm jack socket
Case to suit	
B9A valveholder	
Battery + connector	
Control knobs	
Veroboard, 24 hole x 10 strip, 0.1" metrix	

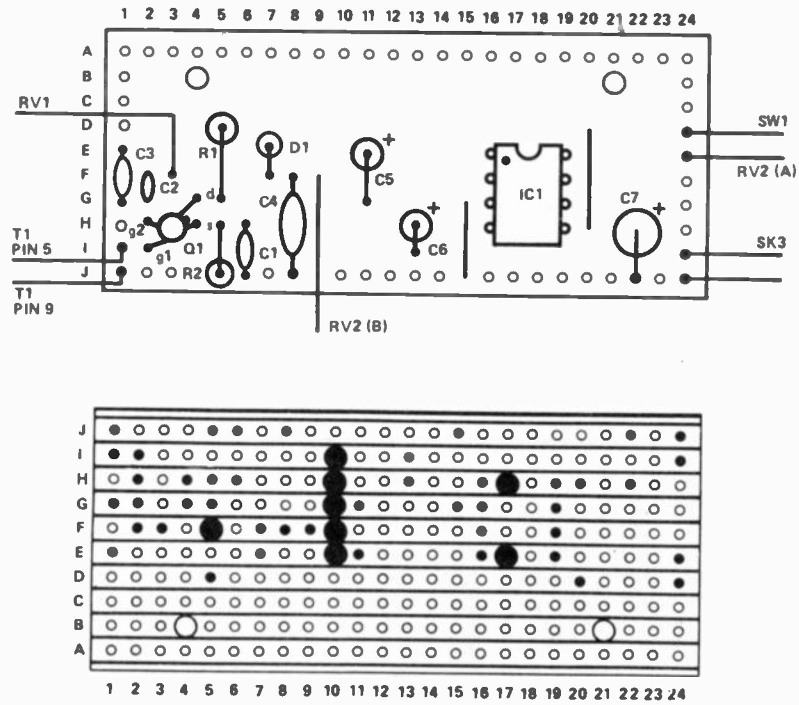
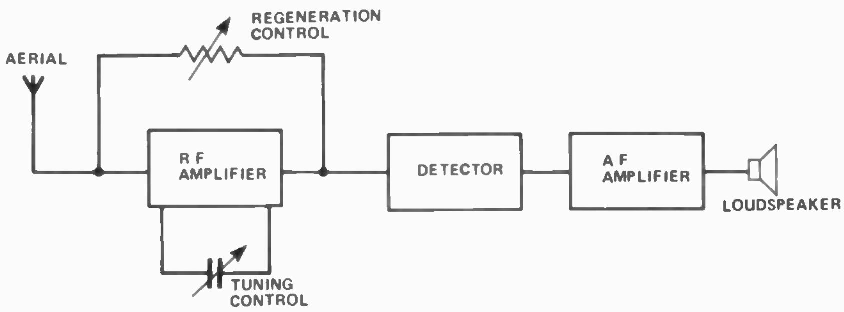


Figure 2. Veroboard layout, and underside view showing component locations and track breaks

How It Works

Signals received by the aerial are fed to a tuned amplifier which selects the desired signal and amplifies it. Some of the amplified signal is fed back to the amplifer input to improve sensitivity and selectivity.

The selected RF (radio frequency) signal is then fed to a detector which recovers the AF (audio frequency) signal from it. The AF signal is then amplified before being fed to a loudspeaker or headphones.



The tuned circuit, which resonates at the desired reception frequency, is formed by the main winding of T1 and the parallel capacitance of VC1 and VC2. Variable capacitor VC1 is the main tuning control, and VC2 is what is termed the 'bandspread' control. This has a much lower value than VC1, and therefore covers only a small part of each tuning range. This makes fine tuning much easier using VC2 rather than VC1. The aerial signal is coupled into the tuned circuit by a small coupling winding on T1.

Transistor Q1 is a dual gate MOSFET which is used in this application as a common source amplifier. The signal selected by the tuned circuit is fed direct to the gate 1 terminal of Q1. The main winding of T1 provides gate 1 biasing for Q1.

Some of the amplified output at the drain of Q1 is fed back to the tuned circuit via C2, RV1, and the third winding of T1. This positive feedback (known as 'regeneration') tends to boost the gain of the circuit and thus gives improved sensitivity. Selectivity (ie, the set's ability to 'separate' stations on the crowded SW bands) is also enhanced with this regeneration process.

Most of the output from Q1 is coupled by C3 to a simple diode demodulator which uses D1, C4, and RV1 in a conventional arrangement. Apart from acting as the load resistor for the detector circuit, RV1 is also the volume control and acts as the bias resistor for integrated circuit IC1. The latter is an audio power amplifier IC which has an internally preset voltage gain of 43 dB, which is just about the ideal figure for this application. The only discrete components required by the ULN2283, apart from the volume control/input bias resistor are: a decoupling capacitor for the internal bias circuit (C5), and an output DC blocking capacitor (C6). Capacitor C7 is the supply decoupling capacitor for the entire circuit.

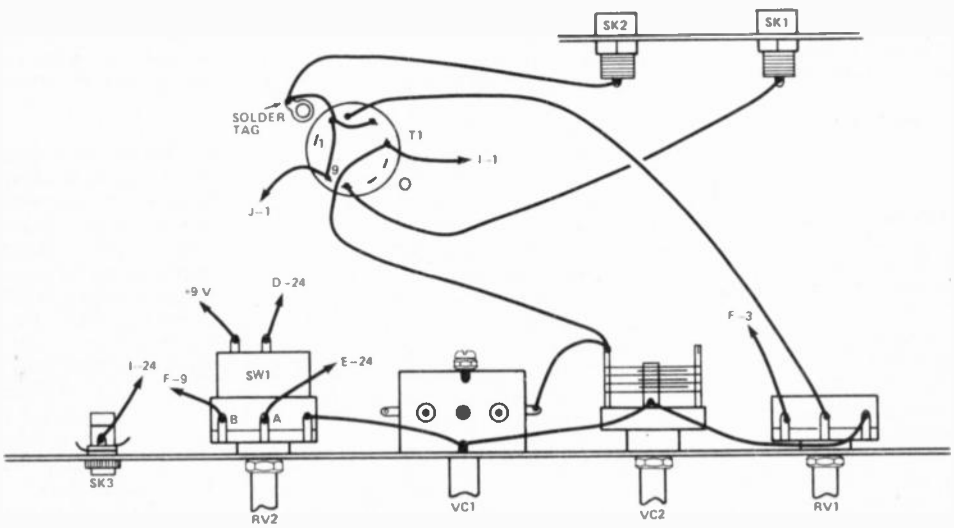
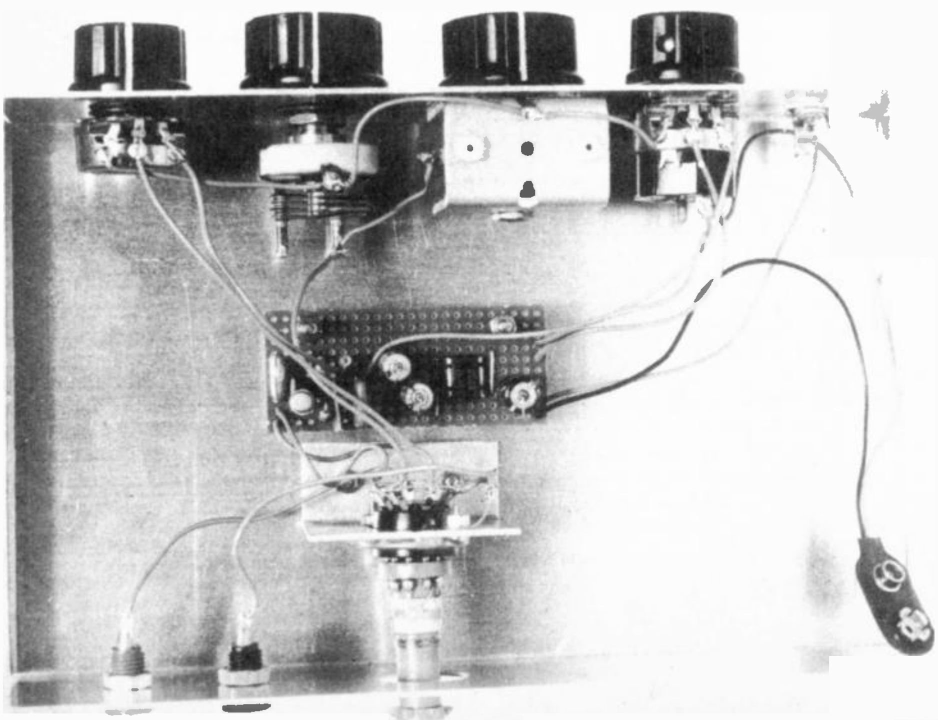


Figure 3. Connection details of the project



Buylines

The two variable capacitors, coils, and B9A holder are available from Watford Electronics.

The ULN2283 IC can be obtained from Ambit International.

There should be no problems in obtaining the other parts which are all standard types, and total cost of parts (excluding case) will be approximately £16.

HE

Your Letters

The Editor replies to a selection of your letters

I RECEIVED SEVERAL letters and enquiries following the publication of Electronic Aids For The Disabled in the July '81 issue of HE. As I had hoped, the article appeared to act as an inspiration to some readers to take part in our Project Design Competition for the International Year of Disabled Persons 1981. Unfortunately, we couldn't avoid printing the coupon for the competition on a page backing onto one of the PCB overlays for the HE Electronic Organ.

Judging from the encouraging response so far, we made the right decision to extend the closing date to 1st September 1981.

The first letter contains details of a course to be held by the Isle of Wight branch of ACTIVE.

Dear Mr Davies,
I was delighted to read your feature article 'Electronic Aids for the Disabled' in your July issue. As a member of ACTIVE I know Roger Jefcoate very well and his enthusiasm and knowledge is quite something when it comes to discussing helping disabled people.

Although we on the Island may appear to be 'out in the sticks' (or even all at sea!) to mainland hobbyists there is, nevertheless, a growing group of electronics enthusiasts who are becoming interested in the formation of an ACTIVE branch here.

This Committee is arranging a week of conferences on disability during the week September 21/26. Of particular interest to those who may feel that they would like to achieve something of real value, using the skills they have acquired through our hobby, is the Day Course, 'Disabled People — Living & Learning'. This will take place on September 25th at the I.O.W. College of Arts & Technology. This course is being organised in consultation with Roger Jefcoate; so, if as a result of your article, readers would like the opportunity of talking with Roger and hearing him talk about the ways people can help, a trip to this lovely Island of ours should prove a great experience in more ways than one. In conjunction with the Course, Southern Vectis Ltd are offering a package trip which will include two nights hotel accommodation, train and boat fares, conference fees and lunches — and for good measure a round the Island trip by coach. **All for about £35!**

The Course will provide much to interest those who would like to know about ACTIVE and will show the way forward to those who, as yet, are unsure as to how their skills might be utilised. ACTIVE will be well represented and Judy Denziloe, who is the group's development officer, will speak on the role of ACTIVE in the field of disability.

If you are able to print this letter I would be particularly pleased to hear from hobbyists on the Island who may be interested in the formation of an ACTIVE group and would be happy to arrange a meeting to discuss it. My own involvement with electronics came from my interest in the work of the group and I would welcome the opportunity of talking with people similarly attracted.

With all good wishes for the continuing success of your magazine.
Bill Stock,
73/75 High Street,
Ryde, Isle of Wight
PO33 2SU
(tel 0983 63437)

Dear Editor,
Please can you help me? I am looking for a circuit for a guitar practice amp.

I would prefer that it uses batteries, has one input and uses ordinary stereo headphones for the output.
Martin Paffet,
RAF Cosford,
Wolverhampton, West Midlands

PS Great mag, keep it up (creep, creep!)

It appears that you didn't receive an answer to your first letter. This is one suggestion that we will definitely consider for a future project. Perhaps we'll call it the HE Harmony — it will enable electronic guitar players to live in harmony with their neighbours.

If you can't wait until we publish a design, you could refer to the Bench Amplifier project in the January 1981 issue (pp 37-38). Provided you can ensure that the total impedance of your headphones lies within the range 40 to 80R, this amplifier should give reasonable results. I'll make sure you receive a copy of the article.

Dear Mr Davies,
Ref. Letters Page, July 81 & Chuffer Project

I was surprised to read your reply to P. Prodromov's letter regarding the Chuffer project on page 56 of the July 81 issue.

Twelve-year-old young Prodromov didn't stand much of a chance with the Chuffer project in the January 1981 issue. In **Fig.1** *on page 55 there should not be a connection between the top of RV2 (C2+) and battery +ve (IC1, pins 4 & 8). This error is also in* **Fig.3** *on page 56. With this connection the chuff rate will be fixed, since the voltage on C2 will be fixed at the battery voltage.*

Funny that you didn't know this, perhaps no-one else has attempted to make this project.
Dave Mills,
West Bridgford, Nottingham

PS Support the anti-post-script movement.

We rechecked the project file and yes, your comment about Fig.1 was correct. However, apart from the incorrect numbering of capacitor C9 that I mentioned in my earlier reply, the fault in Fig.1 did not find its way onto the Veroboard layout.

The Chuffer, by the way, appears to have been a popular project.

PS The postscripts are sometimes the most amusing parts of letters.

Sir,
I have recently purchased the Kikusui 538A oscilloscope but find, to my dismay, that the probes are not included.

I would be most grateful if you would recommend a type, and place of purchase.
Mr. D. F. O'Gara
Chellaston, Derbyshire

We did not include probes in the price of the HE Special Offer Oscilloscope — the illustration merely showed how the 'scope could be hooked up to a typical circuit layout. Super-deluxe probes are not required for a 'scope of this type (particularly because the bandwidth extends to only 5 MHz). A suitable pair of probes are available from the supplier of the Kikusui 538A, that is:

Telonic-Berkeley UK Limited,
2 Castle Hill Terrace,
Maidenhead, Berks
(tel 0628 28057)

for £3.45 including VAT, post and packing. These come complete with crocodile-clip probe-ends.

Dear Sir,
I am wondering whether you could publish another robot project such as you did in HE November and December '79 and January '80, as I am very interested in this aspect of electronics and cannot obtain a back number for November '79.
R.S. Andrew
Winslow, Bucks

We have no plans at present for a HEBOT 2. I would not advise you to tackle the first HEBOT design because some of the mechanical components are no longer available.

And that brings Your Letters to an end for this issue.

HE

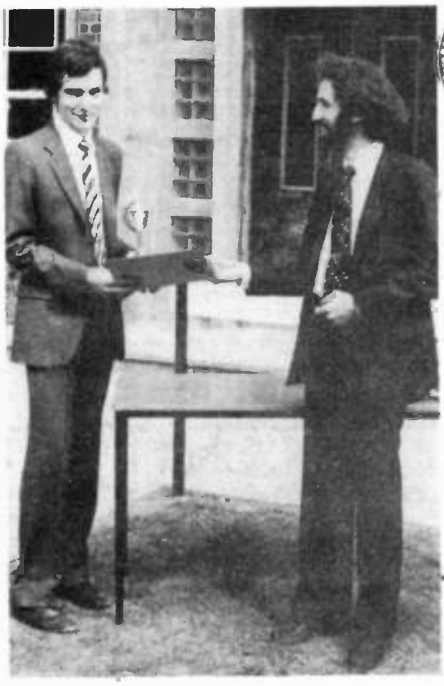
Prize Winners!

Hobby Electronics Wales & West Schools' Electronic Project Competition 1981

On Tuesday 7th July 1981, Nicholas Murphy, of Abingdon School, Oxford and Paul Varischetti of Ashmead School, Reading were presented with their prizes by HE's Editor

WE GAVE DETAILS of the HE Wales and West Schools' Competition on page 28 of the August '81 issue. Tuesday 7th July was selected as 'prize day' and Hugh Davies, accompanied by Peter Freebrey, Modmags' exhibitions manager, visited the schools of Nicholas Murphy, First Prize winner and Pierre Varischetti, Third Prize and Top Junior Prize winner.

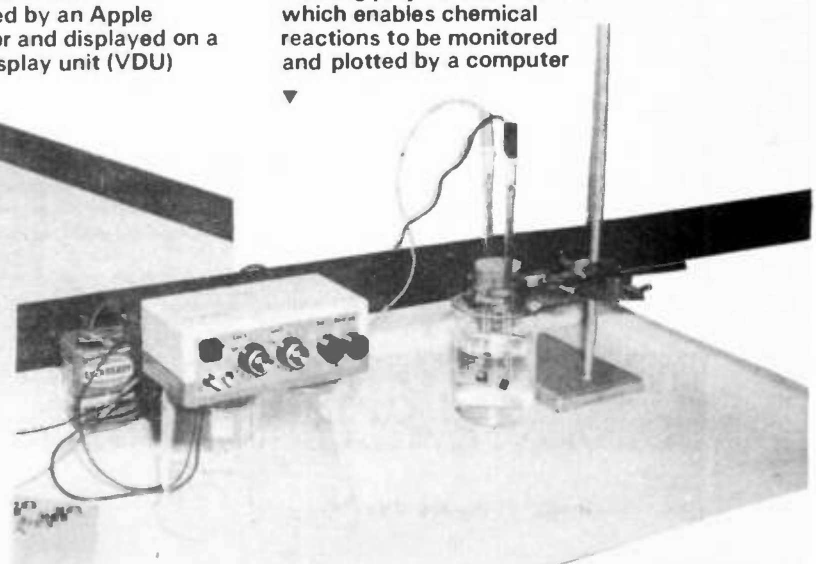
Second Prize winner Paul Miller, of Filton High School, Stoke Gifford, Bristol, received a £50 component voucher.



Nicholas receiving his £100 component voucher and the Hobby Electronics Award Trophy for Abingdon School from Hugh Davies. The school also received two Kikusui 538A oscilloscopes

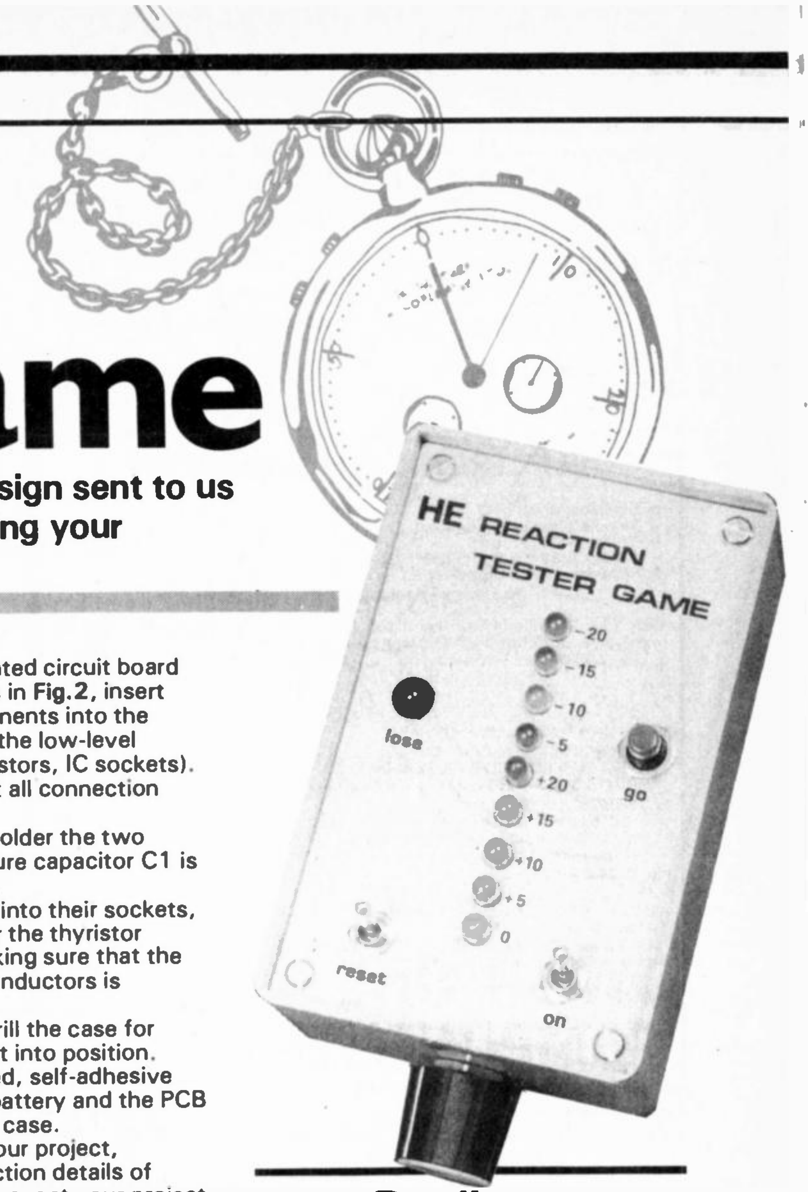
Pierre Varischetti receives his two prizes: a £25 component voucher (Third Prize) and a Galactic Invaders television game (Top Junior Prize)

Here our First Prize winner demonstrates the use of his project. The change in conductivity of the solution under test is converted to a voltage change by Datafeed 1 and this information is processed by an Apple computer and displayed on a visual display unit (VDU)



Nicholas Murphy's prize-winning project, Datafeed 1, which enables chemical reactions to be monitored and plotted by a computer

Reaction Tester Game



Here is a 'game' project, adapted from a design sent to us by a reader. It provides a novel way of testing your reactions — and it's fun, too!

THERE ARE ONLY a limited number of ways you can use a 4017 and a 555. Or so we thought.

We used to think that the stockpile of possible ways of combining the two ICs had been exhausted until we opened the mail one morning and saw this ingenious idea for an electronic game from A. Trafford (see **Fig.1**).

The game has, as its main feature, a row of coloured LEDs. When you switch on, the bottom LED lights up, ready for play. When the 'GO' button is pressed the light moves up the row. The idea is to get the light as far up the row as possible — the higher up the row, the higher your score — but not past LED5. You see, LED5 gives maximum score (+ 20 points) and if the light goes further up than this you *lose* points.

Finally, if the light goes further then LED9 (− 20 points) another LED (LED10 — LOSE) lights up, and stays on until you reset the game.

Now, as far as we're concerned, this game must definitely be the very last way that these two ICs can possibly be used together — or do you know different?

Construction

Following the printed circuit board (PCB) overlay details in **Fig.2**, insert and solder all components into the board, starting with the low-level components (ie, resistors, IC sockets). Solder in PCB pins at all connection points.

Next, insert and solder the two capacitors making sure capacitor C1 is the right way round.

Push the two ICs into their sockets, and insert and solder the thyristor SCR1 into place making sure that the polarity of all semiconductors is correct.

Now, mark and drill the case for switch SW2 and fit it into position.

Using double-sided, self-adhesive pads, stick the 9 V battery and the PCB to the bottom of the case.

Finally, wire up your project, following the connection details of **Fig.2**. A tip to help prevent your project becoming a 'bird's nest' is to wire each switch or push-button separately, twisting the leads before soldering. Similarly the 11 wires connecting the PCB to the LEDs should be twisted together.

Buylines

None of the component parts will be difficult to obtain. Approximate price of components (excluding, as usual, the PCB and case) is £7.

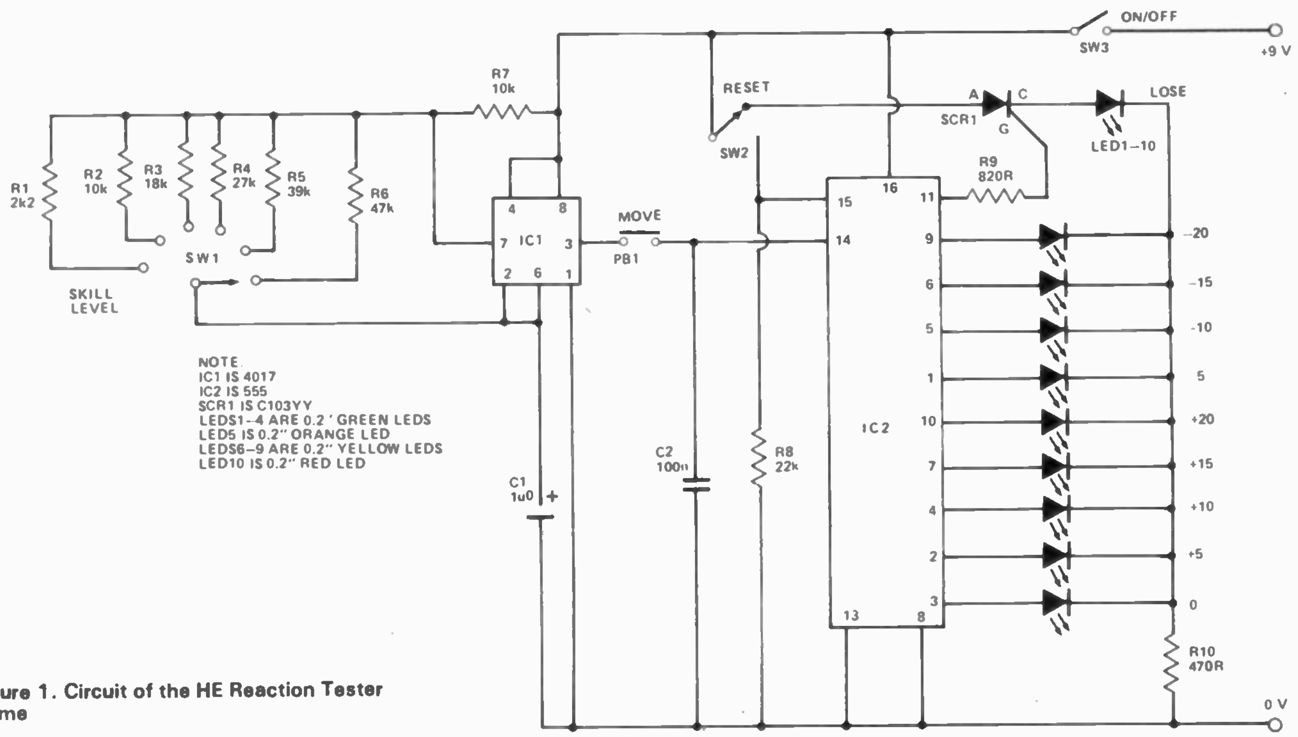
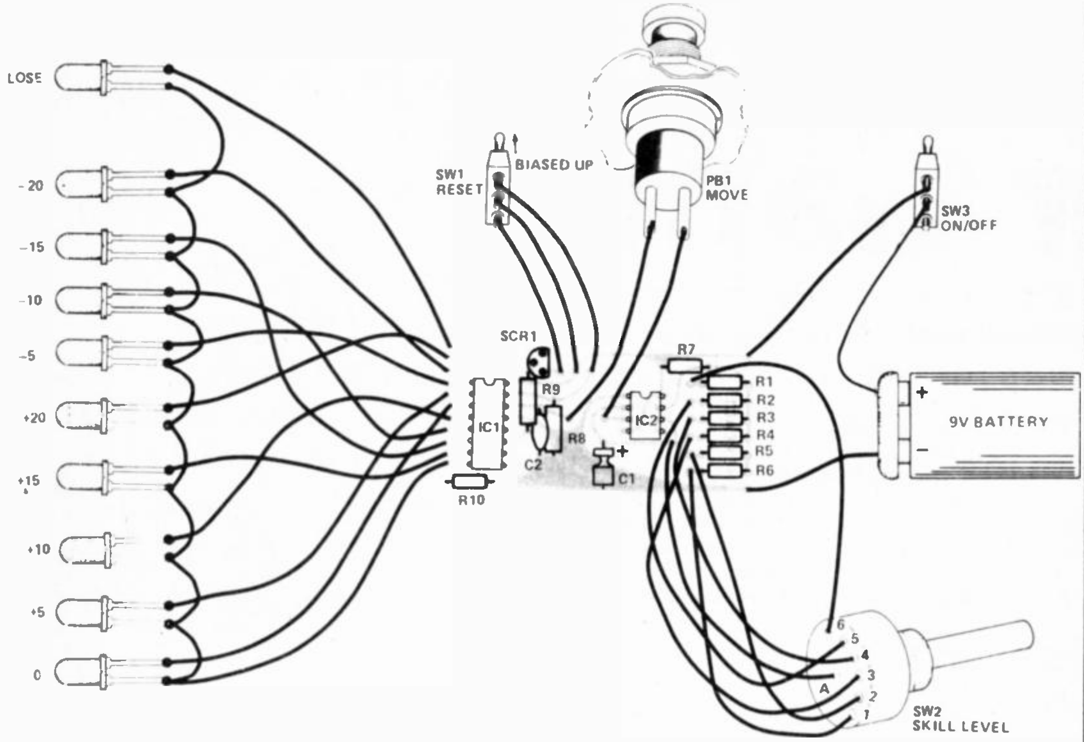
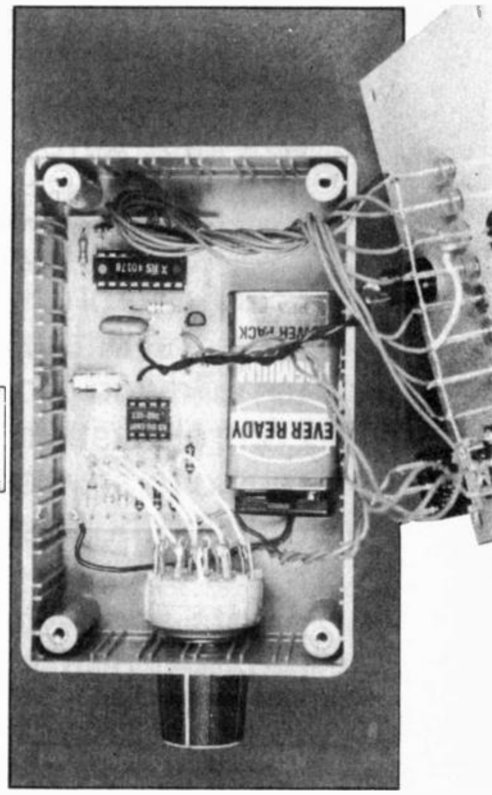


Figure 1. Circuit of the HE Reaction Tester Game





▲
Figure 2. PCB overlay and connection details of the project. From this you can see how one terminal of each LED (ie, their cathodes) are commoned and connected to resistor R10

Parts List

RESISTORS (All ¼ W, 5%)

R1	2k2
R2,7	10k
R3	18k
R4	27k
R5	39k
R6	47k
R8	22k
R9	820R
R10	470R

CAPACITORS

C1	1u, 10 V electrolytic
C2	100n polyester

SEMICONDUCTORS

IC1	555 timer
IC2	4017 counter
SCR1	C103 thyristor
LED1-4	0.2" green LEDs
LED5	0.2" orange LED
LED6-9	0.2" yellow LEDs
LED10	0.2" red LED

MISCELLANEOUS

SW1	single-pole, six-way rotary switch
SW2	single-pole, double-throw biased toggle switch
SW3	single-pole, single-throw toggle switch
PB1	single-pole, push-to-make release-to-break switch

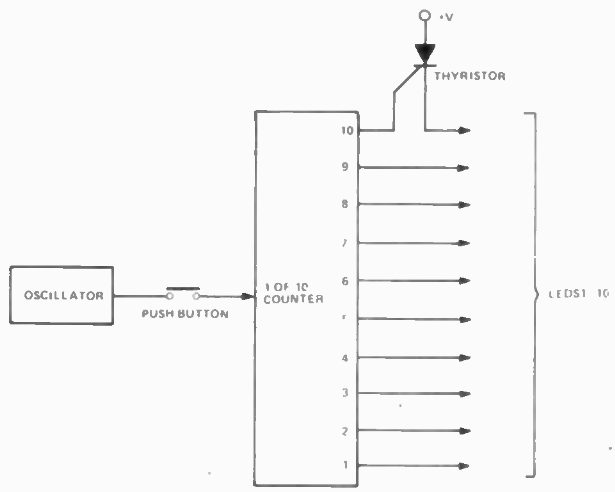
Case to suit
Knob to suit
Battery + clip

How It Works

An oscillator formed by an astable multivibrator continually oscillates at a set frequency.

Pressing the push-button connects the output of the oscillator to the input of a counter, the outputs of which are connected to a row of LEDs. On every positive pulse from the oscillator the counter counts on and lights the next LED.

When the '10' output of the counter turns on it fires a thyristor, which holds LED10 on, permanently, until power is disconnected.



The astable multivibrator oscillator is configured round a 555 timer. The frequency of oscillation is determined by one of the resistors R1-6, and the chosen resistor is switched into circuit by switch SW1.

A 4017 (IC2) is used as a '1 of 10 counter' and every time push-button PB1 is pressed, the 4017 counts the output pulses of the 555 oscillator. The first nine outputs of the counter directly drive LEDs which give an indication of the state of the count.

Output 10 is connected to the gate of thyristor SCR1 thereby turning on the thyristor on the count of 10. This thyristor drives LED10, the LOSE indicator.

Switch SW2 disconnects power from the thyristor, thus turning off LED10, and also resets the counter to a zero count.

HE

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A variety of news items from Rick Maybury this month: criminal CBers, flooded CB food, Hitachi CB, CB sloths, AM crack-down and musical CB

I'M ASHAMED! For nearly three years I have been doing my best to convince people that CB is a good thing. It wouldn't be used by criminals, it wouldn't be used by subversive or political organisations, and what happens? We hear through the media that CB is being used by various groups to co-ordinate riots, to help outwit the police and is generally finding applications for everything that I hoped CB would be useful *against*. All I can say is that anyone hearing messages that are obviously intended for people who are up to no good should pass these messages on to the police pretty sharpish, or we'll be playing right into the hands of the people who did their best to prevent us from getting any kind of CB system in this country.

Back to lighter matters. The CB restaurant I told you about last month has, by an unfortunate act of God, failed to open. The cause? A rather heavy downpour flooded the restaurant to a depth of several inches. All being well I will report on the destiny of this restaurant next month.

Preparations And Restrictions

Back on the serious side of CB, we have heard of no less than 20 different companies now preparing to set up full-scale production or importation of rigs. The big names are now starting to get interested and if I tell you that Hitachi, well known video and hi-fi manufacturer of this parish, is now dabbling a tentative toe in the CB market, you'll see what I mean.

On the slothful legalisation front things are still crawling along. By this time I had hoped to have details of the licensing restrictions and other news but there is still no word from the HO. Rumour has it that we will see some developments in the next few weeks — we shall see!

A word of warning from my spies at the Customs and Excise: there is a major campaign in progress to relieve CBers of their rigs. On the plus side I understand that prosecutions will not be sought unless, as one mole tells me, '...an excessive number of rigs are involved'.

This tale ties up with some other snippets that have come my way concerning a short training course which certain PO personnel are being sent on. Apparently this is an idiot's guide to CB and teaches you how to tell a CB from a legitimate two-way radio. It seems that there is going to be a considerable crack-down on the AM rigs in the next few months, so don't ring us up if you get busted — it'll be your own fault.

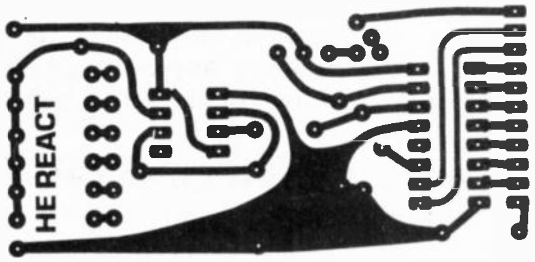
On A Musical Note

CB and music have always gone together in the USA but only now is it beginning to become respectable in this country. The trouble has always been the association of CB with Country and Western music, always a little out of the average Englishman's appreciative range. However, listen out for a purely British CB music album coming from a group called Citizens Banned. The music is good, the lyrics are superbly witty and very up-to-date. Country and Western influences are kept to an absolute minimum. Some of the tracks will never be heard on the Beeb but I can really recommend that you try and listen to a copy.

Well, time's up once again — the next few months will see the run-up to legalisation and we can expect a number of very interesting developments to materialise, so keep your eyes peeled and start saving for that legal rig now. **HE**

PCB Foil Patterns

PCB pattern for HE Power Pack (see page 42)



PCB pattern for HE Reaction Tester Game (see page 58)

HE

1st NATIONAL CB Citizens' Band SHOW!

Have you heard about CB? Citizens' Band radio is to be legalised this Autumn; yes, that's right, our very own personal two-way radio system that can be used in the car, the home — anywhere. As you can imagine, CB will be a real boon to the motorist, the housebound, those who go for outdoor activities — and don't forget that CB can save lives!

With all this in mind **Citizens' Band** magazine, the country's leading CB publication, will be holding a **major** CB exhibition in September, timed as closely as possible to coincide with legalisation. If you want to know more about CB, or you are a CBer, come along to the Royal Horticultural Hall on 11th, 12th, 13th September and see Britain's biggest ever CB show.

There will be stands and exhibits from many of the country's leading CB accessory dealers plus, for the first time ever, working examples of the new legal rigs that will be on sale this Autumn. That's right, a number of manufacturers and importers will be on hand to show the new CB equipment that almost anyone can buy and use.

There's something for everyone, CBers old and new. The latest accessories and antennas, gadgets — in fact everything connected with CB including the new equipment.

Come along in September and see what CB can do for you. Even if you've never heard of CB, you soon will, so don't miss out — whether you're a motorist or a small businessman with an eye to the future, CB is for you! CB is the future of two-way communications . . . .

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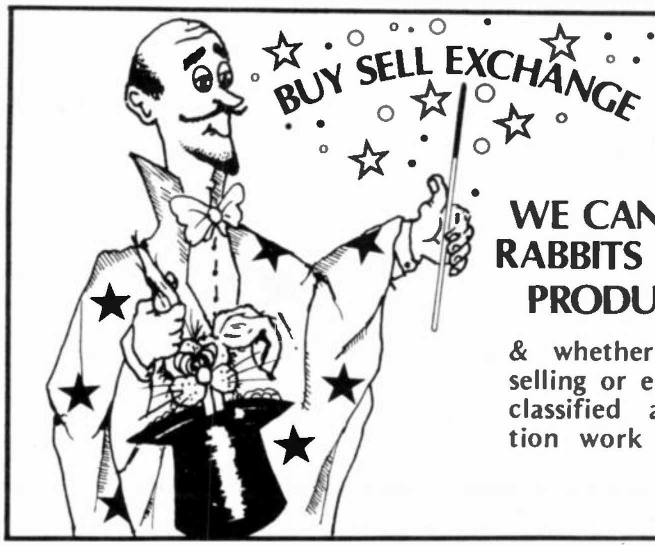

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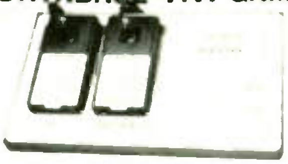

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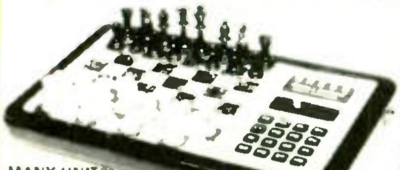

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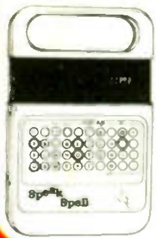

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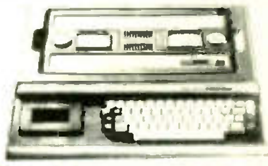

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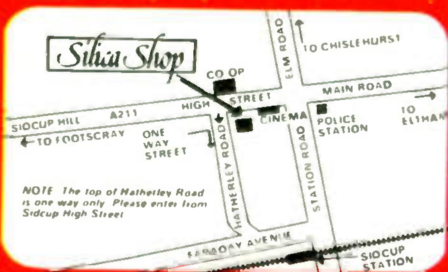

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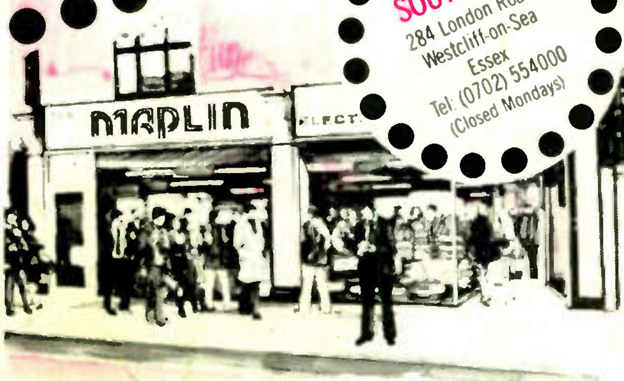

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