FOR EVERYTHING IN ELECTRONICS

Wireless world

JUNE 1983

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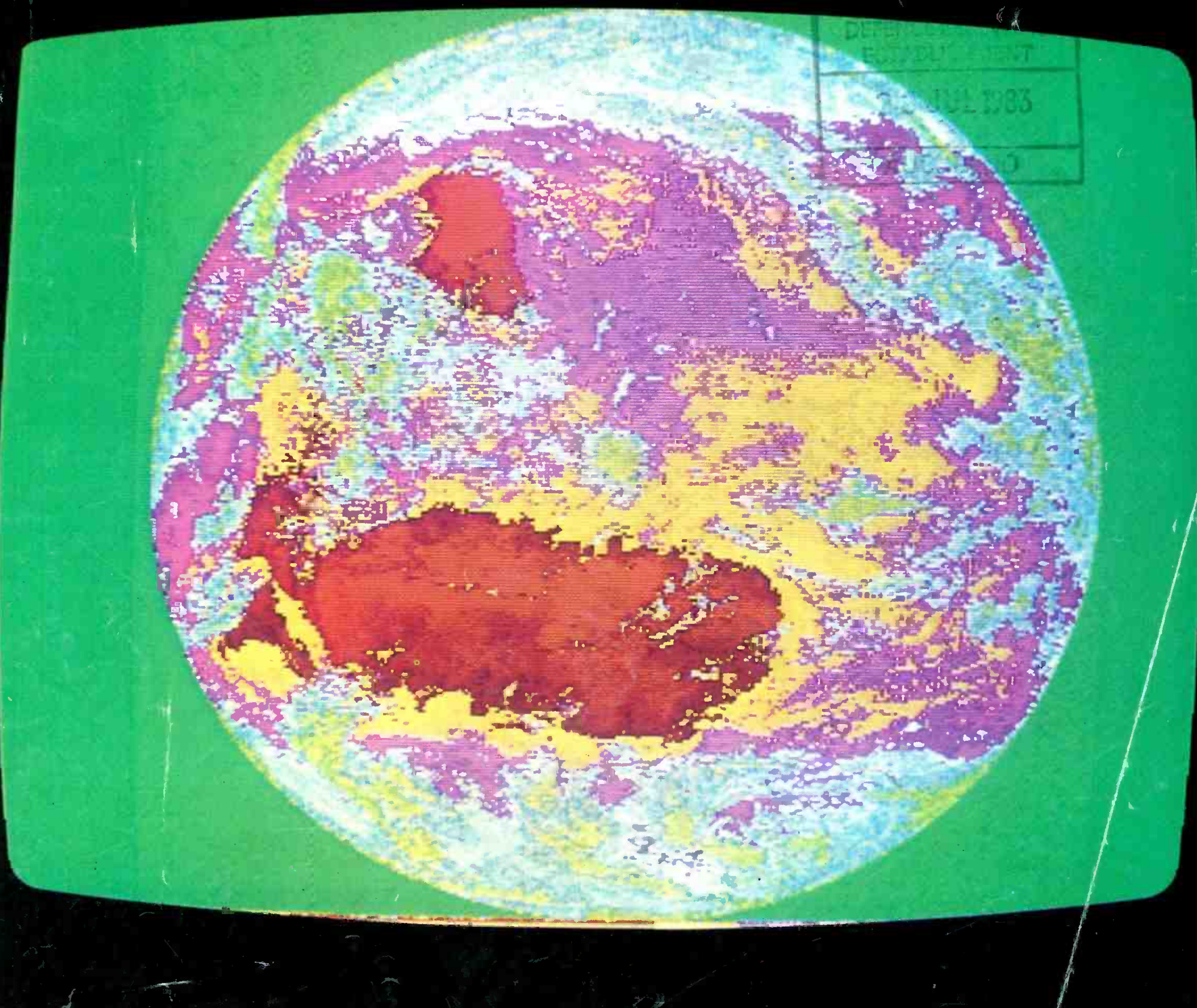

Wireless world

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JUNE 1983 VOL 89 NO 1569

Infra-red scan of the earth from Meteosat, by Mike Christieson, with the north at the bottom. Large red area is Sahara.

NEXT MONTH

Norman McLeod – one of the few radio engineers involved in campaigning for new stations outside the BBC and IBA – suggests how new radio services can be accommodated and up-dates technical thinking on the subject.

Direct coupling to the telephone line gives better security and lower error rate than acoustic coupling in a duplex modem design using standard data channel frequencies.

In "representing logic with mixed intentions", M. B. Butler argues that by emphasising the distinction between logic and voltage, mixed logic eliminates confusion caused by forcing a fixed relationship between the two.

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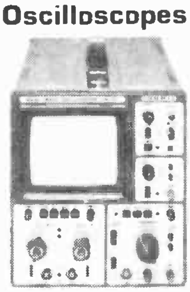
HAMEG Oscilloscopes



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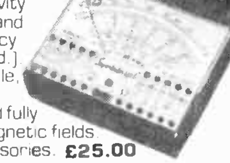

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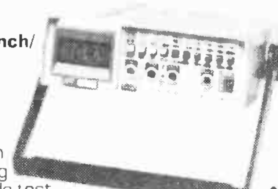

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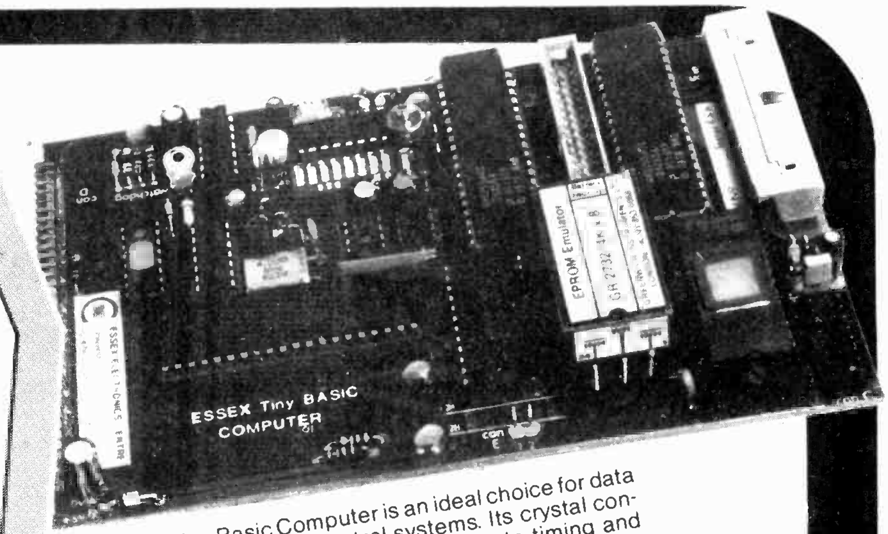
Essex Tiny Basic System



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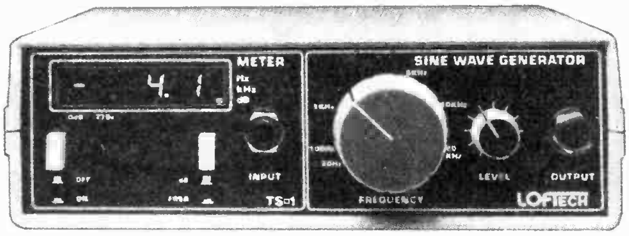

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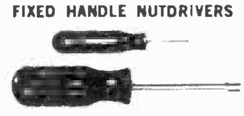

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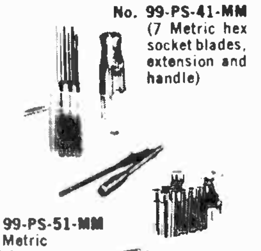

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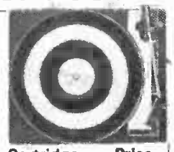

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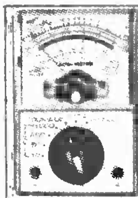

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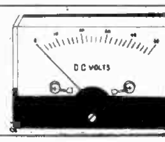

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1000mF 12V **20p**; 25V **35p**; 50V **50p**; 100V **70p**.
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4700mF 63V **£1.80**. 4700mF/40V **£1**.

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1mF 250V **25p**; 1.5mF 100V **25p**; 2.2mF 250V **30p**; 3.3mF 100V **40p**; 4.7mF 100V **40p**; 10mF 63V **40p**; 32mF 50V **25p**.

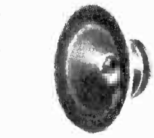
HIGH VOLTAGE ELECTROLYTICS

2/500V	45p	32+32+16/350V	90p	8+16/450V	75p
8/450V	45p	100+100/275V	65p	16+16/350V	80p
16/350V	45p	150+200/275V	70p	32+32/350V	85p
32/500V	95p	32+32+32/325V	75p	32+32/500V	£2
32/350V	50p	50+50+50/350V	95p	50+50/300V	50p
50/450V	95p	8+8/500V	£1	80+40/500V	£2

CAPACITORS WIRE END High Voltage
.001, .002, .003, .005, .01, .02, .03, .05 mfd 400V **10p.**
.1MF 400V **15p**. 800V **20p**. 1000V **25p**.
.22MF 350V **12p**. 600V **20p**. 1000V **30p**. 1750V **50p**.
.47MF 150V **10p**. 400V **25p**. 630V **30p**. 1000V **60p**.
TRIMMERS 30pF, 50pF, **10p**. 100pF, 150pF **20p**. 500pF **30p**.
MICROSWITCH SINGLE POLE CHANGEOVER 40p.
GEARED TWIN GANGS 365+365+25+25pF **£2**.
BRASS SPINDLE EXTENDERS 85p. Couplers **65p**.
VERNIER DRIVE DIALS, 36mm **£2.50**, 50mm **£3**
SLOW MOTION DRIVE 6:1 90p. Reverse Vernier drive **90p**.
TRANSISTOR TWIN GANG. Japanese Replacement **£1**
SOLID DIELECTRIC 100pf £1.50, 500pf £1.50

HEATING ELEMENTS, WAFER THIN (Semi Flexible)
Size 11×9×⅛in. Operating voltage 240V, 250W approx. Suitable for Heating Pads, Food Warmers, Convector Heaters, Propagation, etc. Must be clamped between two sheets of metal or ceramic, etc.
ONLY **60p** EACH (FOUR FOR **£2**) ALL POST PAID.

NEW baker Star sound



high power full range quality loudspeakers. British made. Ideal for Hi-Fi, music P.A. or discotheques. These loudspeakers are recommended where high power handling and quality is required.

MODEL	INCHES	OHMS	WATTS	TYPE	PRICE	POST
MAJOR	12	4-8-16	30	HI-FI	£16	£2
SUPERB	12	8-16	30	HI-FI	£26	£2
AUDITORIUM	12	8-16	45	HI-FI	£24	£2
AUDITORIUM	15	8-16	60	HI-FI	£37	£2
GROUP 45	12	4-8-16	45	PA	£16	£2
GROUP 75	12	4-8-16	75	PA	£20	£2
GROUP 100	12	8-16	100	Guitar	£26	£2
DISCO 100	12	8-16	100	Disco	£26	£2
GROUP 100	15	8-16	100	Guitar	£35	£2
DISCO 100	15	8-16	100	Disco	£35	£2

BAKER AMPLIFIERS BRITISH MADE

NEW PA150 MICROPHONE PA AMPLIFIER £129
4 channel 8 inputs, dual impedance, 50K-600 ohm 4 channel mixing, volume, treble, bass. Presence controls, Master volume control, echo send return socket. Slave sockets. Post £3.

BAKER 150 Watt AMPLIFIER 4 Inputs £99
For Discotheque, Vocal, Public Address. Three speaker outlets for 4, 8 or 16 ohms. Four high gain inputs, 20 mv, 50K ohm. Individual volume controls "Four channel" mixing. 150 watts 8 ohms R.M.S. Music Power. Slave output 500 M.V. 25K.ohm. Response 25 Hz – 20kHz ± 3dB. Integral Hi-Fi preamp separate Bass & Treble. Size – 16"×8"×5½". Wt – 14lb: Master volume control. British made. 12 months' guarantee. 240v A.C. mains or 120V to order. All transistor and solid state. Post £2.
100 Volt Line Model £114. MONO SLAVE £80.
New Stereo Slave 150 + 150 watt 300 watt Mono £125. Post £4.

Complete Disco 150W. Twin console + amplifier + twin speakers. £330. Carriage £30.

ELECTRONIC ECHO CHAMBER £85. Post £2
BBD Delay System 30 m/sec to 200 m/sec. Variable echo and direct sounds. Maintenance free. 240V AC.

DISCO GRAPHIC MIXER EQUALISER £95. Post £2
4 Channel stereo, 5 band graphic, red + green LED, VU display, headphone monitor, mic + override switch.

RCS offers MOBILE PA AMPLIFIERS. Outputs 4-8-16 ohms
20-watt RMS 12v DC, AC 240v, 3 inputs. 50K **£46** PP £2.
40-watt RMS 12v DC, AC 240v, 4 inputs. 50K **£75** PP £2
Mic 1; Mic 2; Phono; aux. outputs 4 or 8 or 16 and 100v line
60-watt RMS, Mobile 24 volt DC & 240-volt AC mains. inputs 50K. 3 mics + 1 music. Outputs 4-8-16 ohm + 100 volts line **£95** PP £2

Battery only Portable PA Amplifier 10w complete mike and speaker, OK for meetings, crowd control, stalls, fetes, traders, parties. Shoulder strap feature. **£25** post £2.

R.C.S. 100 watt R.M.S. VALVE AMPLIFIER

4 Channel mixing. Master treble, bass and volume controls. 5 Speaker outlets, suits 4, 8, 16 ohm. Disco group. **£125**. Carr. & ins. £15.
60 WATT VALVE AMPLIFIER,
3 mixer inputs, 4-8-16 ohm, 100 volt line. 5 controls, 2 mic inputs plus 1 input switchable for mic, phono, aux. Treble and bass 3 volume controls, 7 valves. £59. Post £3.

FAMOUS LOUDSPEAKERS "SPECIAL PRICES"

MAKE	MODEL	SIZE	WATTS	OHMS	PRICE	POST
WHARFEDALE	TWEETER	4in	30	8	£7.50	£1
GOODMANS	TWEETER	3½in	25	8	£4	£1
AUDAX	TWEETER	4in	30	8	£6.50	£1
AUDAX	MID-RANGE	4in	50	8	£7.50	£1
SEAS	MID-RANGE	4½in	100	8	£12.50	£1
AUDAX	WOOFER	5½	25	8	£10	£1
GOODMANS	HIFAX	7½×4¼	100	4/8/16	£27	£2
GOODMANS	WOOFER	8in	25	4/8	£6.50	£1
GOODMANS	HB	8in	60	8	£12.50	£1
WHARFEDALE	WOOFER	8in	30	8	£9.50	£2
CELESTION	DISCO	10in	50	8/16	£19	£2
GOODMANS	HPG	12in	120	8/15	£29.50	£2
GOODMANS	GR12	12in	90	8/15	£27.50	£2
GOODMANS	HPD	12in	120	8/15	£29.50	£2
GOODMANS	HP	15in	250	8	£69	£3
GOODMANS	HPD	18in	230	8	£80	£4

SPEAKER COVERING MATERIALS. Samples Large S.A.E.
B.A.F. LOUDSPEAKER CABINET WADDING 18in wide **35p** ft.

MOTOROLA PIEZO ELECTRIC HORN TWEETER, 3⅜in. square **£5**
100 watts. No crossover required. 4-8-16 ohm, 7⅜×3⅛in. **£10**

CROSSOVERS. TWO-WAY 3000 c/s 30 watt 8 **£3**. 100W **£4**.
3-way 950 cps/3000 cps. 40 watt rating. **£4**. 3 way 60 watt **£6**. 100W **£8**.
LOUDSPEAKER BARGAINS. Please enquire, many others.
4 ohm, 5in, 7×4in, **£2.50**; 6½in, 8×5in, **£3**; 8in, **£3.50**. 6½in 20W,**£7.50**.
8 ohm, 2¾in, 3in, **£2**; 5×3in, 6×4in, 7×4in, 5in, **£2.50**; 6½in, 20W **£7.50** 8×5in, **£3**; 8in, **£4.50**; 10in, **£5**; 12in, **£6**.
15 ohm, 2¼in, 3½in, 5×3in, 6×4in, **£2.50**.6½in 10W **£5**. 8in **£4**. 10in **£7**.
25 ohm, 3in, **£2**; 5×3in, 6×4in, 7×4in, **£2.50**. **120 ohm,** 3¼in dia. **£1.**

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS **£3.95.** Post 65p
All parts and instructions with Zener diode printed circuit, mains transformer 240V a.c. Output 6 or 7½ or 9 or 12V d.c. up to 100mA or less. Please state voltage required.

RADIO COMPONENT SPECIALISTS

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Books and Components Lists 32p stamps. (Minimum post/packing charge 65p.) Access or Barclaycard Visa. Tel: 01-684 1665 for SAME DAY DESPATCH. Cash prices include VAT.

WW-7

Industrial/ Commercial Power Amplifiers

BGW SYSTEMS

Specifications (Direct Output): BGW Model 620B

OUTPUT POWER:

200 watts minimum sine wave continuous power output per channel with both channels driving 8-ohm loads over a power band from 20Hz to 20kHz. The maximum Total Harmonic Distortion at any power level from 250 milliwatts to 200 watts shall be no more than 0.25%.

1kHz Power: 240 watts into 8 ohms per channel, both channels operating, 0.25% Total Harmonic Distortion

Intermodulation Distortion	Less than 0.06% from 250 milliwatts to rated power
Small Signal Frequency Response	+0, −3dB, 1Hz to 70kHz +0, −0.25dB, 20Hz to 20kHz
Hum and Noise Level:	Better than 100dB below 200 watts (unweighted, 20Hz to 20kHz
Damping Factor:	Greater than 120 to 1 at 8 ohms and 1kHz
D.C. Offset Voltage:	Less than 10 millivolts (at output terminals)
Load Impedance	Designed for any load impedance equal to or greater than 4 ohms

Specifications (Direct Output): BGW Model 320B

OUTPUT POWER:

100 watts minimum sine wave continuous average power output per channel with both channels driving 8-ohm loads over a power band from 20Hz to 20kHz. The maximum Total Harmonic Distortion at any power level from 250 milliwatts to 100 watts shall be no more than 0.2%.

1kHz Power: 105 watts into 8 ohms per channel, both channels operating, 0.2% Total Harmonic Distortion

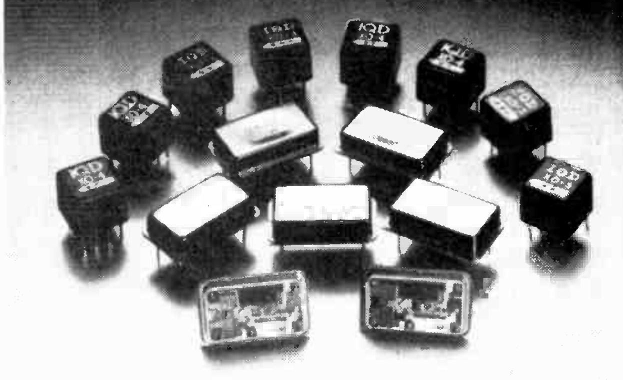
Intermodulation Distortion	Less than 0.05% from 250 milliwatts to rated power
Small Signal Frequency Response	+0, −3dB, 1Hz to 50kHz +0, −0.25dB, 20Hz to 20kHz
Hum and Noise Level	Better than 100dB below 100 watts (unweighted 20Hz to 20kHz)
Damping Factor	Greater than 150 to 1 at 8 ohms and 1kHz.
D.C. Offset Voltage	Less than 10 millivolts (at output terminals)
Load Impedance	Designed for any load impedance equal to or greater than 4 ohms

THEATRE PROJECTS

For further information on these and other BGW amplifiers, contact Nikki Antoniou **Theatre Projects,** 10 Long Acre, London WC2E 9LN. Tel. 240 5411

WW – 025 FOR FURTHER DETAILS

Quartz Oscillators



DIL compatible configurations
CMOS and TTL outputs
Wide temperature ranges
Frequencies one pulse per day to 60 MHz
Many standard frequencies from stock

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IQD

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Crewkerne
Somerset TA18 7JU

Crewkerne (0460) 74433
Telex 46283 inface g

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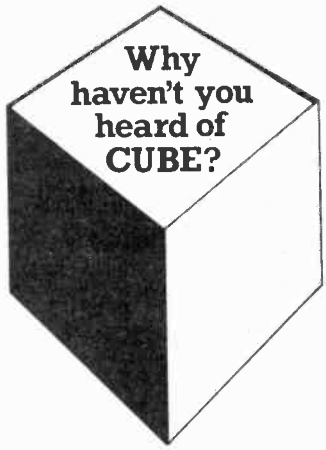

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ELECTRON GUNS TV TUBE COMPONENTS

If you are Rebuilding or Manufacturing TV Tubes – We are the leading suppliers of Electron Guns and TV Tube Components to the TV Tube Industry. We specialise in all aspects of Electron Mount Technology.

Our product range includes more than 250 gun types for Colour, In Line, Mono and Display Tubes along with Mount Parts, Bases, Getters, Sealoffs, and all other associated items for TV Tube Production.

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ENGLAND

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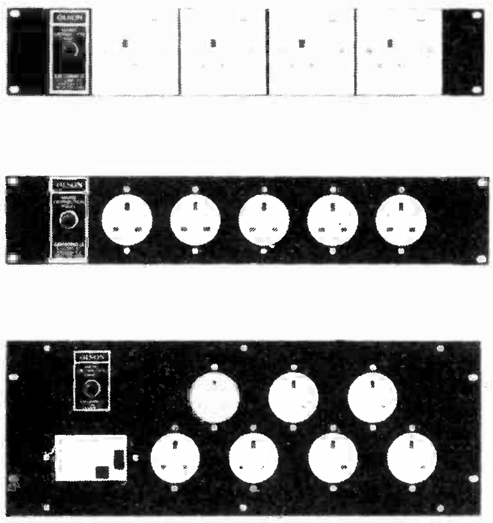
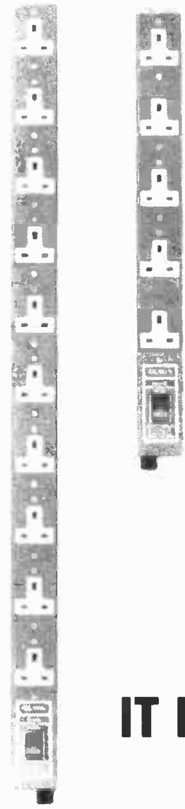
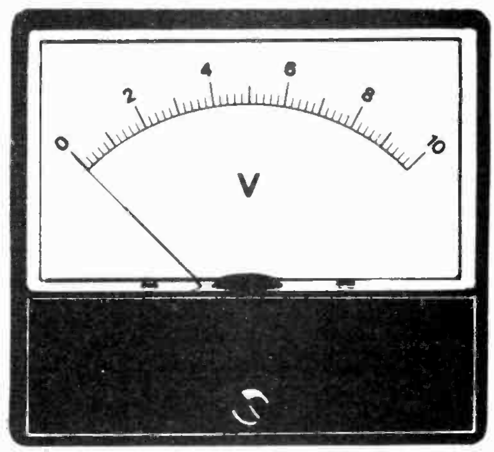
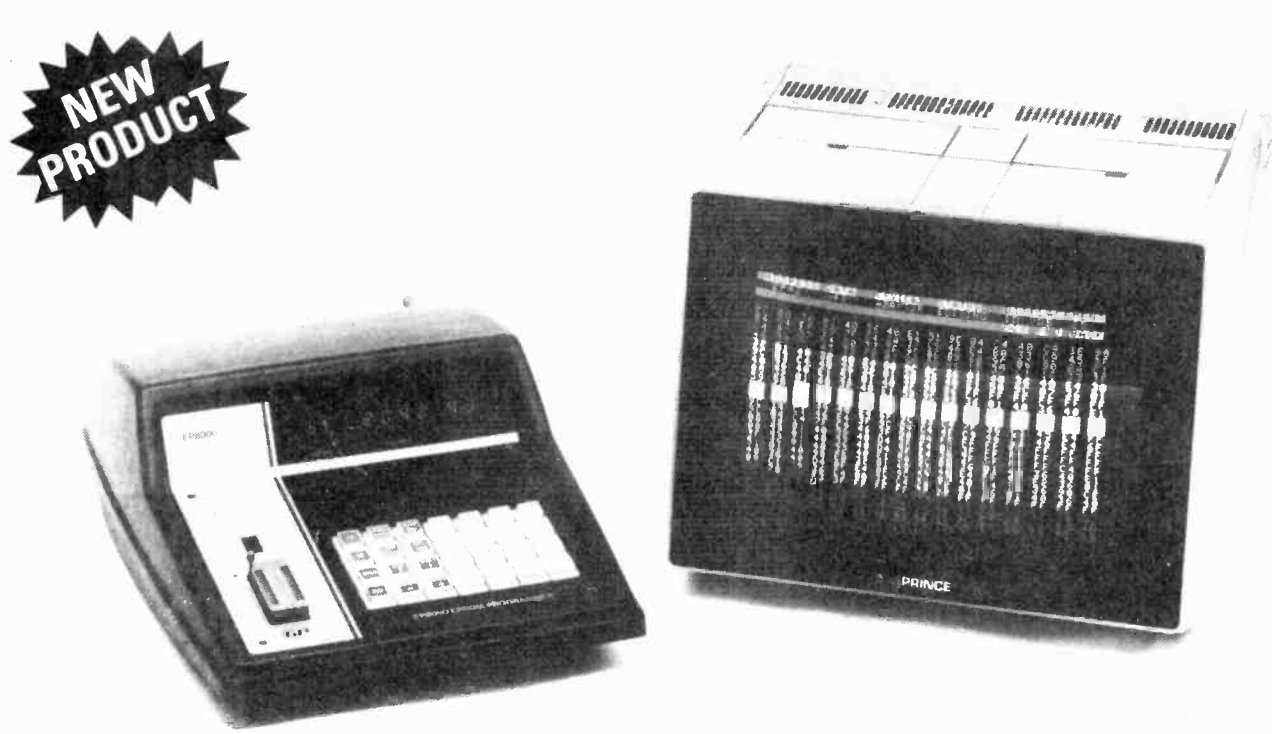





0
2
4
6
8
10
V

EP8000 EPROM EMULATOR PROGRAMMER



The new microprocessor controlled EP8000 Emulator Programmer will program and emulate all EPROMs up to 8k x 8 sizes, and can be extended to program other devices such as 16k x 8 EPROMs, Bipolar PROMs, single chip microprocessors with external modules.

Personality cards and hardware changes are not required as the machine configures itself for the different devices.

The EP4000 with 4k x 8 static RAM is still available with EPROM programming and emulation capacity up to 4k x 8 sizes.

FEATURES

- Software personality programming/emulation of all EPROMs up to 8k x 8 bytes including 2704, 2708, 2716(3), 2508, 2758A, 2758B, 2516, 2716, 2532, 2732, 2732A, 68732-0, 68732-1, 68766, 68764, 2564, 2764. Programs 25128, 27128 with adaptors.
- No personality cards/characterisers required.
- Use as stand alone programmer, slave programmer, or EPROM development system.
- Checks for misplaced and reversed insertion, and shorts on data lines.
- Memory mapped video output allows full use of powerful editing facilities.
- Built-in LED display for field use.
- Powerful editing facilities include: Block/Byte move, insert, delete, match, highlight, etc.
- Comprehensive input/output – RS232C serial port, parallel port, cassette, printer O/P, DMA.
- Extra 1k x 8 scratchpad RAM for block moving.

● EP8000 8k x 8 Emulator Programmer – £695 + £12 delivery ● BSC8 Buffered emulation cable – £49 ● SA27128 Programming adaptor – £69 ● SA25128 Programming adaptor – £69 ● EP4000 4k x 8 Emulator Programmer – £545 + £12 delivery ● BSC4 Buffered emulation cable – £39 ● BP4 (TEXAS) Bipolar PROM Module – £190 ● Prinz video monitor – £99 ● UV141 EPROM Eraser with timer – £78 ● GP100A 80 column printer – £225 ● GR1 Centronics interface – £65

VAT should be added to all prices

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GP Industrial Electronics Ltd.

Tel: Plymouth (0752) 332961
Telex: 42513

Unit E, Huxley Close, Newnham Industrial Estate, Plymouth PL7 4JN

WW – 042 FOR FURTHER DETAILS

P8000 – THE PRODUCTION PROGRAMMER THAT HANDLES ALL NMOS EPROMS

NEW PRODUCT

- Checks, Programs, Compares up to 8 devices simultaneously
- Handles all NMOS EPROMS up to projected 128K designs with no personality modules or characterisers – See list
- Easy to use, menu driven operation for blankcheck, program, verify, illegal bit check, checksum, self-test
- Constant display of device type, mode and fault codings
- Individual socket LED indicators for EPROM status
- Comprehensive EPROM integrity checks – Illegal bit check, data and address shorts, constant power line monitoring
- Full safeguard protection on all sockets
- Automatic machine self-test routine
- RS232C interface supplied as standard
- Powered down sockets
- Cost effective price – £695 + VAT
- Available from stock

Write or phone for more details

2704
2708
2716(3)
2508
2758A
2758B
2516
2716
48016
2532
2732
2732A
68732-0
68732-1
68766
68764
2764
2564
MK2764
25128
27128

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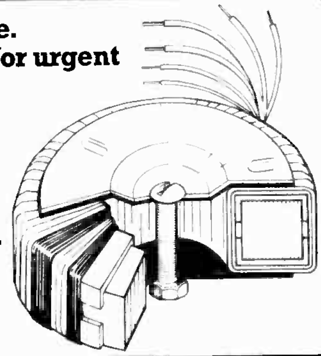
TOROIDALS



The toroidal transformer is now accepted as the standard in industry, overtaking the obsolete laminated type. Industry has been quick to recognise the advantages toroidals offer in size, weight, lower radiated field and, thanks to I.L.P., PRICE.

Our large standard range is complemented by our SPECIAL DESIGN section which can offer a prototype service within 7 DAYS together with a short lead time on quantity orders which can be programmed to your requirements with no price penalty.

***Gold service available. 21 days manufacture for urgent deliveries.**

***Orders despatched within 7 days of receipt for single or small quantity orders.**

***5 year no quibble guarantee.**

NEW! NEW! NEW!

TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
15 VA	0x010	6+6	1.25	£5.12
62 x 34mm	0x011	9+9	0.83	+ p&p £0.78
0.35Kg	0x012	12+12	0.63	+ VAT £0.89
Regulation 19%	0x013	15+15	0.50	TOTAL £6.79
	0x014	18+18	0.42	
	0x015	22+22	0.34	
	0x016	25+25	0.30	
	0x017	30+30	0.25	
(encased in ABS plastic)				
30 VA	1x010	6+6	2.50	£5.49
70 x 30mm	1x011	9+9	1.66	+ p&p £1.10
0.45Kg	1x012	12+12	1.25	+ VAT £0.99
Regulation 18%	1x013	15+15	1.00	TOTAL £7.58
	1x014	18+18	0.83	
	1x015	22+22	0.68	
	1x016	25+25	0.60	
	1x017	30+30	0.50	
50 VA	2x010	6+6	4.16	£6.13
80 x 35mm	2x011	9+9	2.77	+ p&p £1.35
0.9Kg	2x012	12+12	2.08	+ VAT £1.12
Regulation 13%	2x013	15+15	1.66	TOTAL £8.60
	2x014	18+18	1.38	
	2x015	22+22	1.13	
	2x016	25+25	1.00	
	2x017	30+30	0.83	
	2x028	110	0.45	
	2x029	220	0.22	
	2x030	240	0.20	
80 VA	3x010	6+6	6.64	£6.66
90 x 30mm	3x011	9+9	4.44	+ p&p £1.72
1Kg	3x012	12+12	3.33	+ VAT £1.26
Regulation 12%	3x013	15+15	2.66	TOTAL £9.64
	3x014	18+18	2.22	
	3x015	22+22	1.81	
	3x016	25+25	1.60	
	3x017	30+30	1.33	
	3x028	110	0.72	
	3x029	220	0.36	
	3x030	240	0.33	
120 VA	4x010	6+6	10.00	£7.42
90 x 40mm	4x011	9+9	6.66	+ p&p £1.72
1.2Kg	4x012	12+12	5.00	+ VAT £1.37
Regulation 11%	4x013	15+15	4.00	TOTAL £10.51
	4x014	18+18	3.33	
	4x015	22+22	2.72	
	4x016	25+25	2.40	
	4x017	30+30	2.00	
	4x018	35+35	1.71	
	4x028	110	1.09	
	4x029	220	0.54	
	4x030	240	0.50	
160 VA	5x011	9+9	8.89	£8.43
110 x 40mm	5x012	12+12	6.66	+ p&p £1.72
1.8Kg	5x013	15+15	5.33	+ VAT £1.52
Regulation 8%	5x014	18+18	4.44	TOTAL £11.67
	5x015	22+22	3.63	
	5x016	25+25	3.20	
	5x017	30+30	2.66	
	5x018	35+35	2.28	
	5x026	40+40	2.00	
	5x028	110	1.45	
	5x029	220	0.72	
	5x030	240	0.66	
225 VA	6x012	12+12	9.38	£9.81
110 x 45mm	6x013	15+15	7.50	+ p&p £2.05
2.2Kg	6x014	18+18	6.25	+ VAT £1.78
Regulation 7%	6x015	22+22	5.11	TOTAL £13.64
	6x016	25+25	4.50	
	6x017	30+30	3.75	
	6x018	35+35	3.21	
	6x026	40+40	2.81	
	6x025	45+45	2.50	
	6x033	50+50	2.25	
	6x028	110	2.04	
	6x029	220	1.02	
	6x030	240	0.93	
300 VA	7x013	15+15	10.00	£10.88
110 x 50mm	7x014	18+18	8.33	+ p&p £2.05
2.6Kg	7x015	22+22	6.82	+ VAT £1.94
Regulation 6%	7x016	25+25	6.00	TOTAL £14.87
	7x017	30+30	5.00	
	7x018	35+35	4.28	
	7x026	40+40	3.75	
	7x025	45+45	3.33	
	7x033	50+50	3.00	
	7x028	110	2.72	
	7x029	220	1.36	
	7x030	240	1.25	
500 VA	8x016	25+25	10.00	£14.38
140 x 60mm	8x017	30+30	8.33	+ p&p £2.40
4Kg	8x018	35+35	7.14	+ VAT £2.52
Regulation 4%	8x026	40+40	6.25	TOTAL £19.30
	8x025	45+45	5.55	
	8x033	50+50	5.00	
	8x042	55+55	4.54	
	8x028	110	4.54	
	8x029	220	2.27	
	8x030	240	2.08	
625 VA	9x017	30+30	10.41	£17.12
140 x 75mm	9x018	35+35	8.92	+ p&p £2.55
5Kg	9x026	40+40	7.81	+ VAT £2.95
Regulation 4%	9x025	45+45	6.94	TOTAL £22.62
	9x033	50+50	6.25	
	9x042	55+55	5.68	
	9x028	110	5.68	
	9x029	220	2.84	
	9x030	240	2.60	

ALSO AVAILABLE
Sizes up to and including 5KVA are manufactured to order.

The benefits of ILP toroidal transformers

ILP toroidal transformers are only half the weight and height of their laminated equivalents, and are available with 110V, 220V or 240V primaries coded as follows

IMPORTANT: Regulation — All voltages quoted are FULL LOAD. Please add regulation figure to secondary voltage to obtain off load voltage.

For **110V** primary insert "0" in place of "X" in type number
For **220V** primary (Europe) insert "1" in place of "X" in type number
For **240V** primary (UK) insert "2" in place of "X" in type number

Also available at Electrovalue, Maplin, Technomatic and Barrie Electronics.

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ILP TRANSFORMERS (a division of ILP Electronics Ltd)

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BROADCAST MONITOR RECEIVER 150kHz-30MHz

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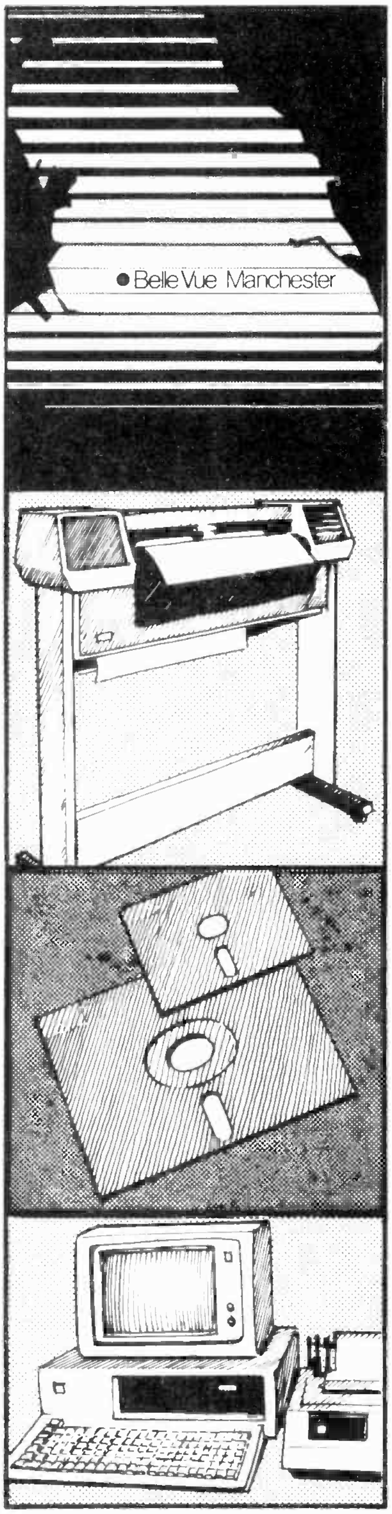

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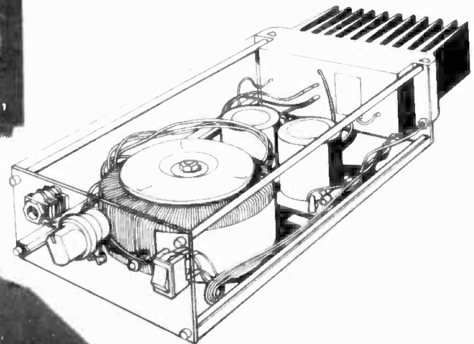

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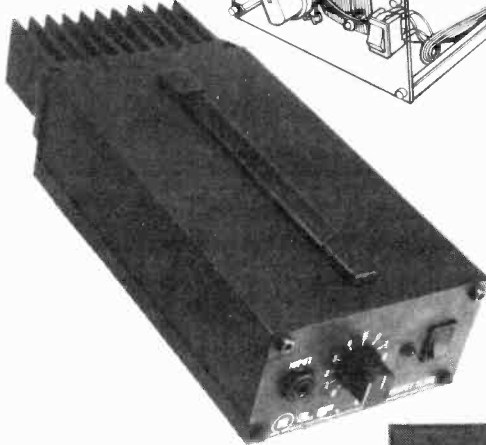

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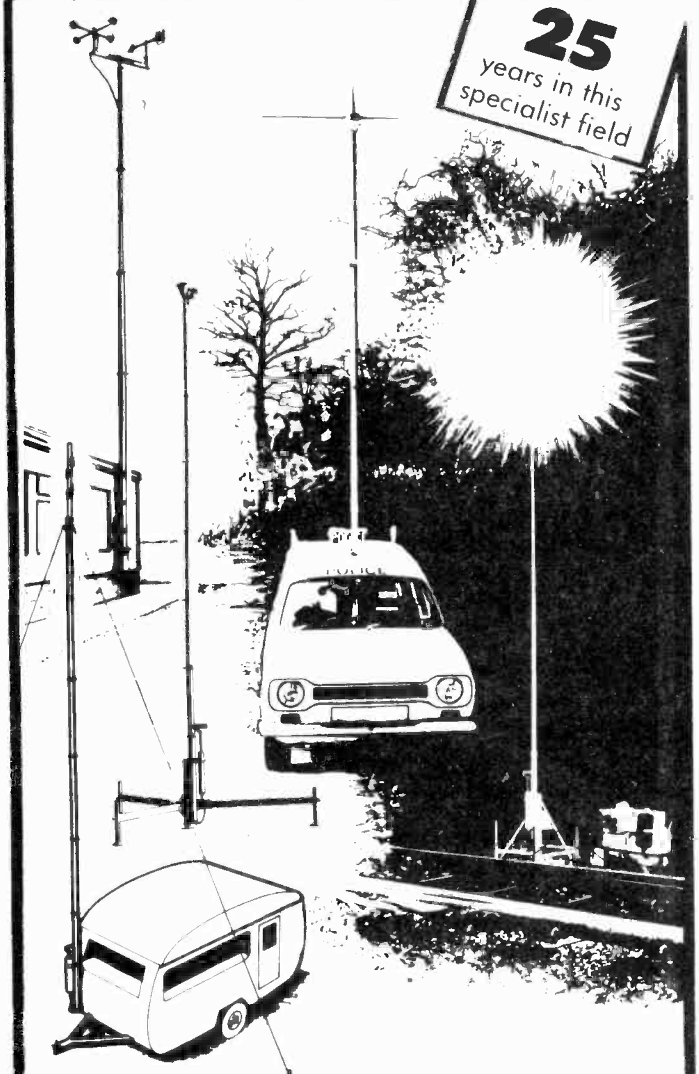

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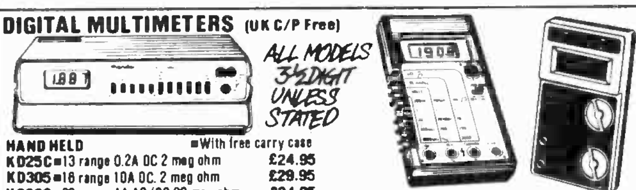

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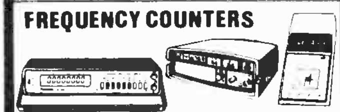

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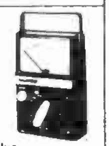

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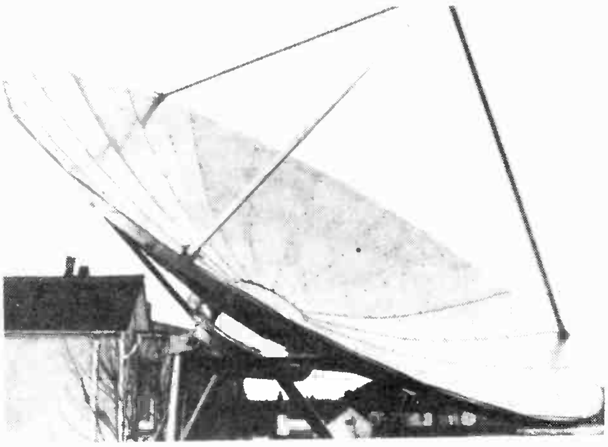

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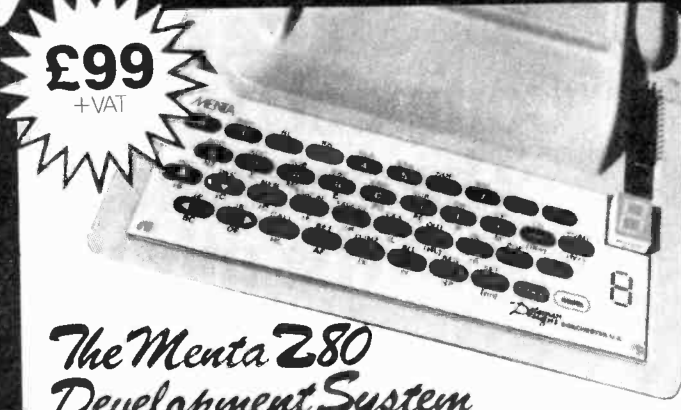

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Script – or ad lib?

Technology advances at such a rate, and the possibilities for changes in life-styles proliferate to such an extent, that the broad view of a new society – a perceived, intentional direction for development – scarcely exists.

There is discussion; books and articles are written, there is even a Minister for Information Technology – a term which seems to cover a great many activities only tenuously connected with information: yet no document in the public domain propounds any kind of lucid policy on future development in, at any rate, our own field.

In place of action, there is reaction; instead of assertion, there is reply; and it seems that there is a plethora of means, but no clearly defined end. A flood of affordable computing power has, in spite of at least ten years' notice, taken those who bear responsibility for the direction of effort by surprise, and the predictable result is that communication of all kinds – telephones, data, videotext – is developing in an amorphous, uncontrolled manner, which, if it is left alone for much longer, may be uncontrollable.

It cannot be said that there is an agreed, imposed policy, but what passes for it is nearly always drafted after the event in reply to a development that is already under way. Clearly, it is not only potential, if slow-moving, users of the new technology who need to be educated in its use, but also those who should be channelling development towards a goal.

Some of this may be the result of the 'solution seeking a problem' type of evolution in technique which is now common. For example, the emergence of teletext from its original role in transmitter control into the field of domestic information display was extremely slow, simply because a market for it had to be created: there was no perceived requirement for teletext before the possibility existed. Now it is available, but it is under-used and does not fit easily into any probable over-all scheme of communications.

In the same way, the somewhat aimless insistence that schools must possess microcomputers is a panic measure, taken several years too late, to cope with the entirely predictable availability of cheap computers. No one had demanded that computers should be designed to enable schoolchildren to be taught programming or logic. If that had been the case, it seems unlikely that we would now have thousands of future computer users who will have to unlearn Basic in favour of structured language.

We need a comprehensive, imaginative view of the future of society in which electronics technology is developed to order, in which demand comes before its satisfaction. If this does not come about, and since almost anything is (it seems) now possible, society will be ordered by technology: what engineers can do people will be required to employ.

To formulate a policy for the desirable exploitation of techniques that do not yet exist is not exclusively a political exercise. Technologists must be in consultation with government so that politicians are informed on what is possible and are able to take the broad view. Only after that should development of the technology begin, when there is a part for it to play. The play must come before the actors, and we need a good script.

Precision analogue voltmeter

Suitable for making measurements in a.c. and d.c. circuits and for some uses in audio, this design overcomes one of the drawbacks of conventional analogue instruments – drift.

Despite all the advantages, real and claimed, for the digital voltmeter, the analogue meter still has a definite role to play in radio and electronic engineering. Not that the author has anything against integrated circuits or digital displays, far from it; but it does seem all too easy to get carried away with the fashion instead of recognising the needs of the end user.

Yet there are some clear cases where the accuracy and fine resolution of digital meters offer a considerable step forward in measurement. Examples of some of these are strain gauges, weighing machines, temperature measurement and the indication of static or slowly varying quantities.

On the other hand, the digital meter is quite inappropriate when one is measuring a variable quantity where the rate of change may be as important as the absolute value of the quantity being measured.

Another situation in which the analogue meter has a decided ergonomic advantage is the one in which several similar quantities are being monitored simultaneously. One can quickly assimilate that all are about the same, the odd one out being immediately obvious and 'tweaked' as required. High-resolution digital meters would no doubt all read slightly differently and the odd one adrift would not be nearly so apparent.

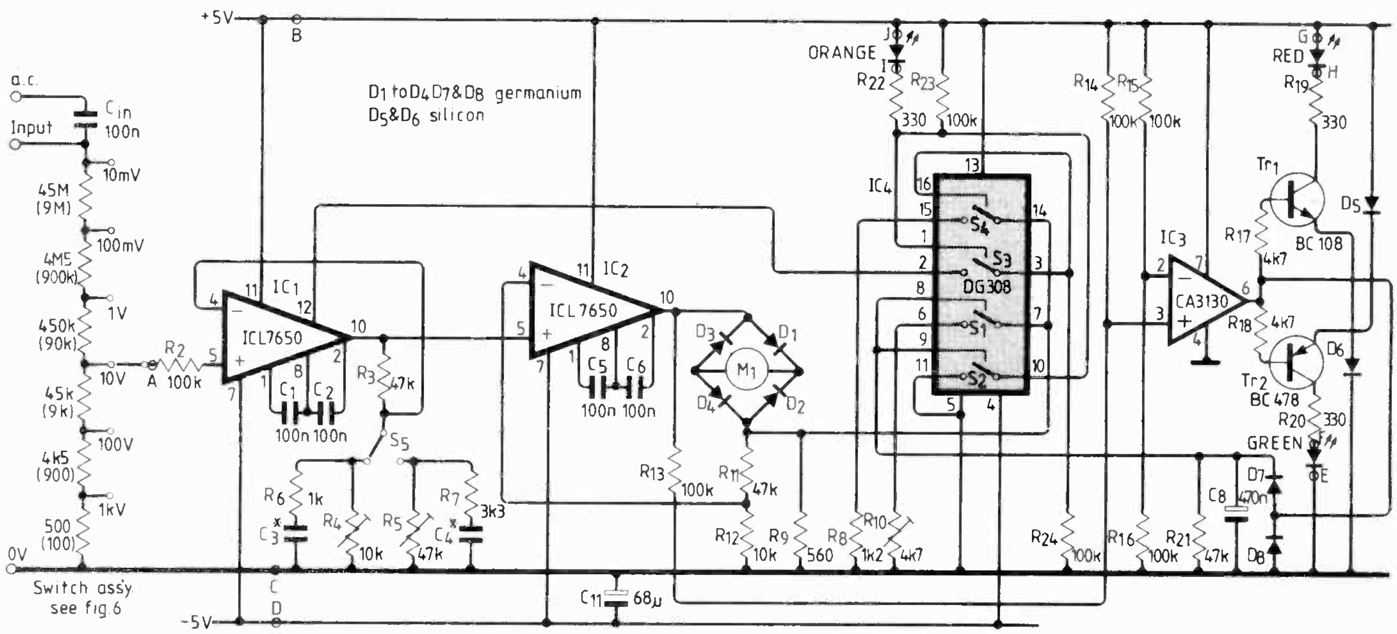
In the author's workshop both analogue and digital meters are used; and recently in the course of a general upgrading exercise it was decided to rebuild the equipment containing the analogue meter and to see if economic improvements could be made. The old instrument had given good service; it was based on a long-tail pair circuit

by W. J. Hornsby,
M.I.E.R.E.

using fets (*Wireless World*, May 1968). Its input resistance was 50 megohms which was quite adequate, but it was subject to zero drift needing frequent manual correction during an evening at the workbench.

The starting point of the new design was to list the advantages of the digital meter

Fig. 1. Complete circuit of the voltmeter. Component values for the input divider are shown for the 50MΩ version, with values for a 10MΩ version given in brackets. These resistors should be 1% tolerance types or better. C_{in} allows the meter to read a.c. signals standing upon a d.c. bias. The 7650 is a chopper-stabilised op-amp offering a low input offset voltage and wide bandwidth.



and the deficiencies of the analogue model and form a schedule of items requiring attention if the new analogue design was to be an improvement.

Generally, for good quality instruments of either type there are differences to a greater or lesser extent in price, robustness, accuracy, input resistance, establishment of polarity, zero-drift characteristics and power consumption.

The task therefore was to produce a new analogue meter circuit which retained all the good qualities of the old but offered a better degree of satisfaction in as many of these characteristics as possible.

Design aims

Three very important criteria had to be met. The final product had to be relatively inexpensive, it had to consist of readily available components in standard values and it had to be suitable for home construction.

The original input resistance of 50 megohms was probably as high as could be reasonably expected using standard switches and glass fibre p.c.bs. Nevertheless some users may prefer the industry standard of 10 megohms; and as will be seen later, there are certain advantages from adopting this or even a lower resistance. The design of the input divider should be such that a common shunt can

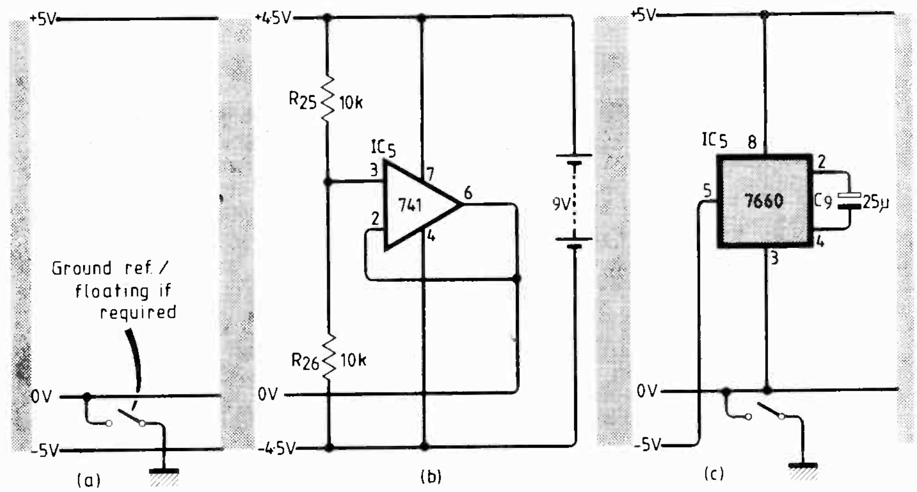


Fig. 2. *Power supply options for the voltmeter. The unit may be powered directly from a split supply, either ground-referenced or floating; from a 9V battery with an op-amp to provide a centre rail; or else from a single +5V supply, with a d.c.-to-d.c. converter i.c. such as the ICL7660 to generate a negative rail.*

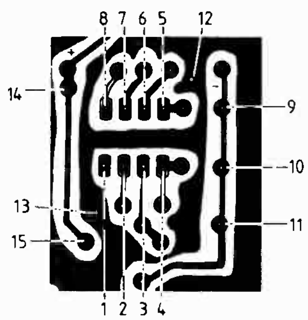


Fig. 3. *Any of the power supply options can by accommodated on the author's p.c.b. For a 9V battery supply, a 741 op-amp is fitted at the IC_5 position; R_{25} is connected between points 3 and 11, R_{26} between points 3 and 15; point 2 is linked to point 13, point 6 to point 12, point 4 to point 11 and point 7 to point 14. For a single-rail 5V supply, an ICL7660 is used for IC_5; C_9 should be fitted between point 2 and point 4, its positive terminal to point 2 (R_{25} and R_{26} are not required); and links should be added between points 3 and 13, 5 and 9, 8 and 14.*

be applied to the input for the measurement of current or to test dry-cell activity for instance.

One factor affecting both the price and robustness of moving-coil instruments is the quality of the meter movement. Traditionally, good quality instruments use sensitive movements giving f.s.d. (full-scale deflection) at low currents, but they are rather delicate. So what are the objections to using a more robust, higher-current movement with an amplifier?

Possibly the most annoying failure of active analogue meters is drift. The more one has to amplify small signals, the more one amplifies this undesirable effect. The most serious zero-drift errors occur at the front end because these are amplified by the remainder of the circuit. Therefore the first amplifier must be a good one. It must also have an input resistance several orders of magnitude greater than the input divider chain, and this is not easy to achieve. The author came to the conclusion that the digital boys had got it right with chopper front-ends, but the only chopper i.cs readily available had insufficient input resistance and the inverse feedback ratio would have meant that the meter would make an ideal signal injector! The next stage was to look for a self-zeroing chopper op-amp.

A search revealed an i.c. whose input current was guaranteed less than 10pA and was said to be typically of the order of 1pA. This looked a possibility but it was designed not for zero drift but for minimum offset between the input terminals (typically 0.7μV). However, in a feedback op-amp circuit if the offset is zero and one input is referenced to zero then one has a self-zeroing amp!

The other difficulty with the more robust type of meter movement is mechanical stiffness. This can be shown on a robust meter by slowly bringing it up to a set voltage and noting the reading, then bringing it slowly down to the same value. In all probability a difference in scale reading will be shown.

It is noticeable however that some instruments used for measuring alternating quantities are quite crude yet capable of following the signal quite well because the movement is 'kicked' every half-cycle by the input. A similar effect could be achieved in a d.c. meter by adding to the d.c. signal an a.c. component of low value but sufficient to overcome the stiffness. As an added bonus the chosen i.c. (ICL 7650) has its oscillator output conveniently brought out, an ideal starting point for this a.c. on d.c. "wobble".

The 7650 also has a facility for preventing saturation of its output by effectively pulling up one input pin with the other just before limiting occurs (implemented by connecting pin 4 to pin 9), thus improving the speed of recovery from overload. This facility should not be used here, since it is better to see that the meter is in overload than to suffer an incorrect reading.

Digital meters are self-polarising, allowing one-handed operation if one lead is clipped to a convenient reference point. An analogue meter could achieve the same advantage if it were designed as an a.c. type with the non-linearity usually associated with these meters removed, although some means of showing the polarity would then be required. This leads to the conclusion that a one-hand a.c.-d.c. design is possible leaving range-switching as the only manual operation. Even this could be automated, but this would present problems in maintaining the input resistance and would add appreciably to the cost.

If an a.c. signal to be measured stands on top of a d.c. bias, then a blocking capacitor is necessary at the input. This is most easily accomplished by adding an auxiliary input terminal buffered by a capacitor. This facility is not easily implemented automatically in this design and it was considered that further complication of what is essentially a simple circuit was not worth the expense. Remember that this capacitor must charge through the input divider and will take some time in view of the high input impedance. Also, during this time the meter will try to read the d.c. value of the bias. This may cause a temporary overload condition until the input capacitor has charged.

There is one further problem to be overcome in an a.c./d.c. design and that concerns form-factor correction. A simple meter and rectifier assembly will read the mean value of an alternating quantity, whereas it is usually the r.m.s. value which is required. In most electronic meters, including digital types, a separate gain-adjusted amplifier is provided for this purpose and has to be switched in. If this design is to be truly 'one-hand, no switching' then a means of detecting an a.c. signal and automatically adjusting the gain (at least for sine waves) must be provided.

Circuit description

The circuit diagram of the instrument is shown in Fig. 1. IC_1 is an operational amplifier which automatically arranges for minimum offset between its input terminals. Since one terminal is referenced to zero through the input divider the stage is self zeroing. It is arranged to have a gain of 10 or 3.3 to give the $\times 1/\times 3$ facility. This stage is essentially a preamplifier and can be frequency compensated.

IC_2 is the main amplifier feeding the rectifiers and the meter; its gain is set at about 5 by R_{11} and R_{12}. Since the rectifiers are in the feedback loop of the i.c., their forward voltage drop and non-linearity are reduced by a factor equal to the open loop gain of the amplifier, to negligible proportions.

Each time the output of IC_2 passes through zero it must jump a step voltage equivalent to the voltage drop of two meter diodes in series, and the time taken to do this is a function of the slew rate of the amplifier. When this time becomes a significant part of the signal being measured then overall accuracy suffers. It is for this reason (and to limit the output swing) that germanium diodes, not silicon, are recommended for the meter circuit. In the author's case a batch of surplus diodes was obtained and those with the best forward-to-reverse ratio were chosen.

IC_3 is a comparator obtaining its power supply from the 0 and 5V rails only. Its inverting input is centre-referenced between these supplies by R_{15} and R_{16}. Its non-inverting input is connected to the 5V supply by R_{14} and the output of IC_2 by R_{13} such that when the output of IC_2 is zero then IC_3 is balanced. If the output of IC_2 goes positive then IC_3 turns on Tr_1, which lights the red led, and at this time Tr_2 will be cut off. If the output of IC_2 goes negative Tr_2 will light the green led and Tr_1 will be cut off. D_5 and D_6 ensure that each transistor turns off fully when necessary (so that only one led will be lit at any one time). In this way the polarity of the input signal is indicated. The use of a single supply rail for IC_3 ensures that it will not be affected by any imbalance between the positive and negative supplies.

The output of IC_2 does not remain static at zero volts because it is constantly trying to self-zero around the meter diode voltage-drop, being prompted to do so by the small switching spikes at its output as a result of its internal circuitry. Since negligible current passes through the meter no reading results, but this 400mV swing at the output of the i.c. (though not across the load) triggers IC_3 and causes both leds to light, giving a useful 'on' indication. In addition because this swing is considerably in excess of any offset present in IC_3 it is not necessary to provide offset adjustment for IC_3; and because it is a comparator as distinct from an amplifier there is no need for the frequency compensating capacitor usually associated with this type of i.c.

A second output of IC_3 is taken to D_7 and D_8 where it is rectified and used to charge C_8. This voltage is used to operate the electronic switch IC_4. IC_3 must have a cmos output stage to give sufficient output swing for this purpose.

The operation of the electronic switch is as follows. Assume first the condition of either an a.c. input or the circuit in an idle condition. Both leds will flash at the signal rate or in sympathy with the self-zeroing efforts of IC_2. Now the DG308 requires cmos input conditions: that is, it will operate when the input to the switching terminals is about two-thirds of the supply voltage. In this circuit the DG308 is connected across the full positive and negative supplies but its switching terminals for switches 1 and 2 are already at half the supply (0V) because they are tied there by R_{21}. When C_8 charges from the output of IC_3 its voltage is added to this so that the potential is raised sufficiently to operate the switches.

S_1 connects R_{10} in parallel with the main load resistor R_9 to lower the load value and hence increase the current in the meter giving form-factor correction (×1.1) to convert the mean value reading to r.m.s. The output voltage of IC_2 changes only by the additional voltage drop across the meter; the voltage across the load does not change because this is determined by R_{11}, R_{12}. S_2 holds S_3 in the off condition to prevent its operation via R_{23}. LED_3 and R_{22} can be added to indicate that S_1 and S_2 have operated. This is something of a luxury, however (particularly in a battery operated model), although it can be useful during testing.

If we now assume that a d.c. condition is connected to the input then the output of

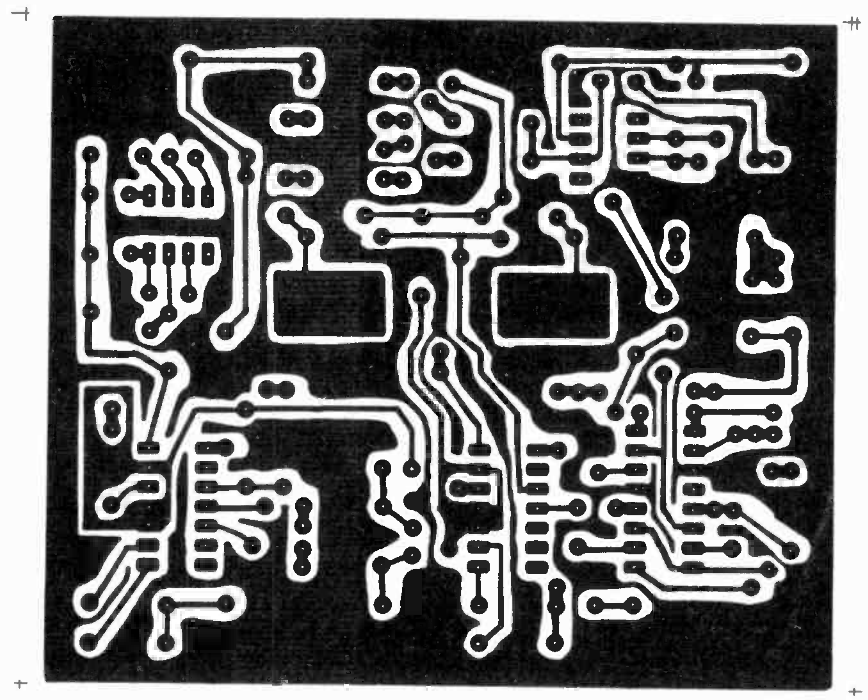


Fig. 4. The author's printed circuit, shown full-size. The large amount of copper left on the board helps to keep it stable; it also improves thermal tracking between components, minimising the effect of thermally generated e.m.fs. Note the guard-ring around the input pins of the 7650 to prevent current leakage from adjacent tracks. This ring is not at earth potential but at the feedback potential recommended by the manufacturers.

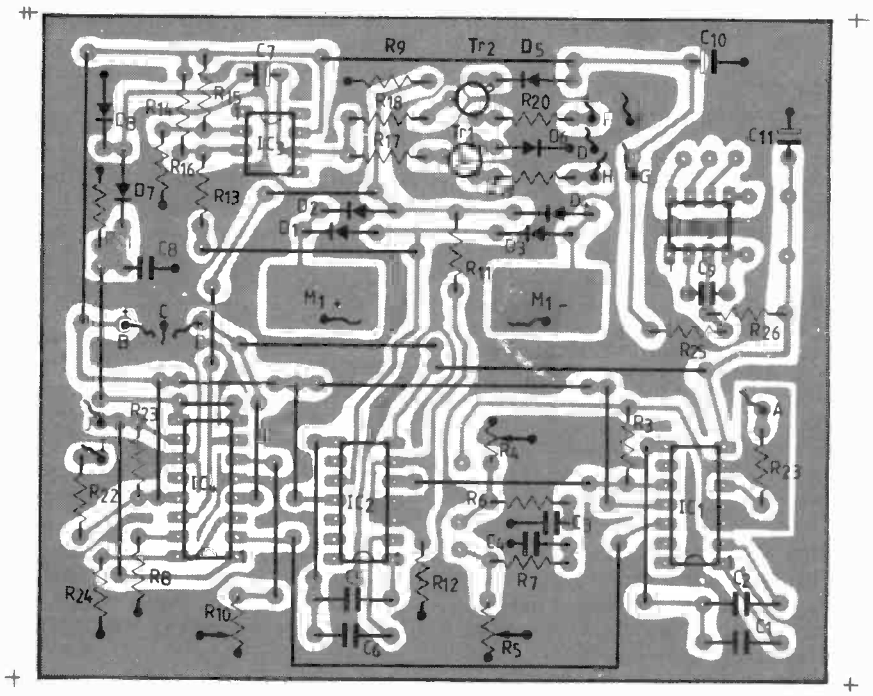
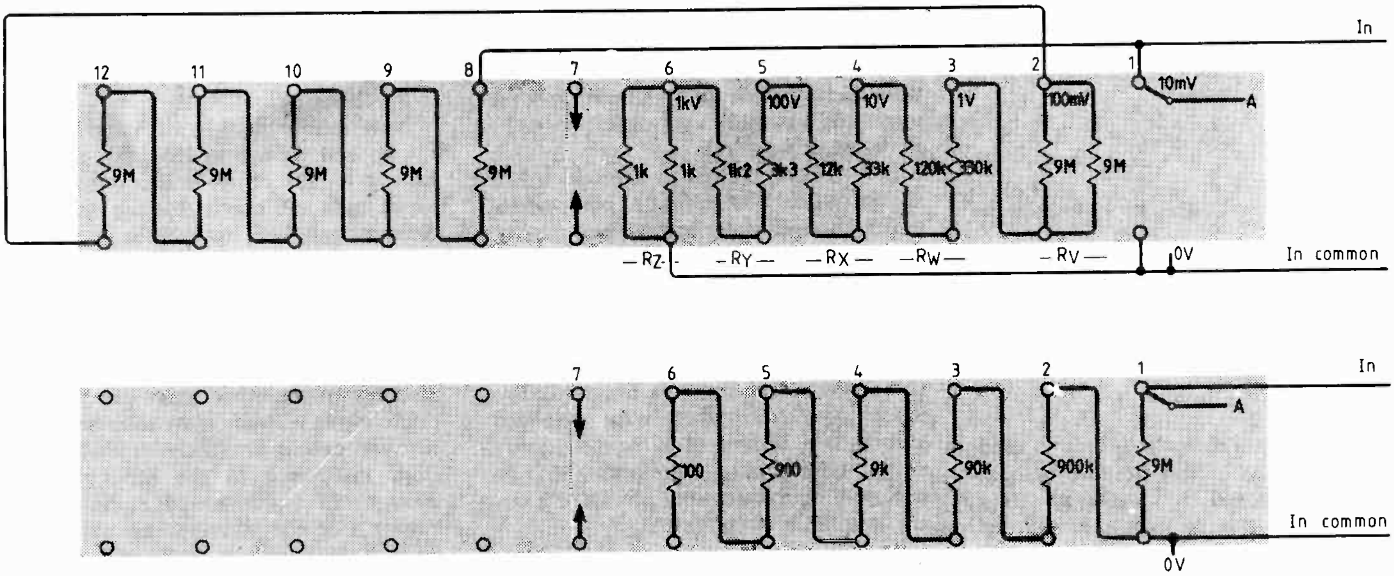


Fig. 5. Component layout for the printed circuit of Fig. 4.

IC_3 will be steady causing the appropriate led to light. In addition, C_8 will not be charged through D_7 and D_8 and as a result will discharge through R_{21} until it assumes 0V. In this case S_1 and S_2 will not be operated. With S_2 normal S_3 will operate to the 5V positive rail via R_{23}. S_3 connects the clocking oscillator from IC_1 (which swings from 0V to nearly 5V) to the control terminal of S_4 which will be caused to operate and release at the clocking rate of 200Hz. S_4 in turn connects and disconnects R_8 in parallel with the main load resistor R_9. This action imparts a 200Hz wobble to the meter although its effect is not observed by the user. This is used to overcome stiffness in the meter movement.

Once again the output *voltage* of IC_2 changes only by the change in voltage drop across the meter; the voltage across the load is still held constant by R_{11} and R_{12}. The current in the meter changes according to whether S_4 is operated or not at any instant. The mean value of R_8, R_9 is that at which the meter is calibrated.

The reader will notice that the value of the wobble current is proportional to the reading being observed. This is no prob-



lem however because if the reading is so low that the wobble is ineffective then it is time to change to a lower scale! It is essential that the wobble is reduced to zero at no-input to prevent its causing the slightest variation in the output of IC_2; this might otherwise feed through and trip IC_3 at low d.c. readings, changing the circuit over to the a.c. mode. It is for this reason also that the wobble cannot be applied any further forward in the circuit.

From the above it will be seen that the meter circuit assumes an a.c. input condition when idle. If a d.c. condition is input then C_8 must discharge through R_{21} to convert to d.c. measurement. The time taken to do this is a function of the voltage at which the DG308 switches release. If R_{21} is too low then C_8 may have difficulty in charging.

If the change over time is critical (for instance in assembly testing) then R_{21} could be made variable and adjusted to the optimum point. In the unlikely event that a DG308 is obtained which operates at the static half-way potential it will be necessary to connect the lower end of R_{21} to a high resistance potential divider across the whole supply so that under d.c. measurement conditions the potential on the DG308 switching terminals is just below the operating level. This condition was not met in the samples used by the author.

No meter movement protection was included in the circuit because under operating conditions the output of IC_2 limits at about twice the f.s.d. All the i.cs will withstand the full supply potential at their input terminals, so the only danger is overload at the circuit input terminals (which will withstand up to 5mA input current). Overall protection therefore is a function of the protection resistor R_2.

Variations on a theme

Now that we have seen the full circuit we can see also how it can be built in different versions.

The **utility model** for d.c. use consists of IC_2 and the meter with no rectifiers. R_{11}, R_{12} can be adjusted to give the gain required and only a single load resistor is required. There is no polarity indication and the input leads need to be reversed for the two polarities of input.

Fig. 6. Wiring the input selector switch S_1. It is essential to use switch-wafers with good insulating properties: a suitable choice is a pair of miniature wafers type 327-349 from RS Components, together with a shaft assembly 327-311. Position 7 on the switch is for use with the author's resistance-measuring unit.

The **economy model** includes the meter rectifiers allowing one-handed operation; but there is no polarity indication nor any form-factor correction.

The **popular model** includes IC_3, Tr_1, Tr_2 and the leds but nothing from C_7 onwards. We now have polarity indication but no form-factor correction.

The **GT model** includes IC_4 giving form-factor correction and wobble if the oscillator output of IC_2 is used. This circuit would be suitable for d.c. and a.c. measurements provided the frequency was limited to a few hundred hertz.

Finally there is the **de luxe model**, which incorporates the full circuit, giving an acceptable response well into the audio range.

Any of these versions may be built on the suggested p.c.b.

Input divider and preamplifier

Several factors including the input divider, the protection resistor, the internal roll-off and the device input capacitance restrict the gain at higher frequencies. Nevertheless, the performance particularly on one selected range can be extended well towards the top of the audio spectrum if both the first amplifier and frequency compensation are included.

To expect IC_2 to provide all the gain well into the audio range is not practical because of the low gain-bandwidth product of the device when driving the meter. It is necessary to reduce its gain and to add IC_1 to compensate. Both amplifiers because of their internal circuitry produce small switching spikes at their outputs, so it is desirable that the second of the two amplifiers should have the lower gain to reduce the possibility of the spikes produced by IC_1 being amplified by IC_2 to the extent that they look to the meter circuit like an a.c. signal.

For the best possible response, we also need to use the lowest acceptable value of input divider and if brave enough, dispense with the protection resistor R_2.

The p.c.b. includes spaces for fitting four components R_6,C_3 and R_7,C_4 across R_4 and R_5 respectively. These components effectively reduce the value of the lower feedback resistors as the frequency increases, thereby increasing the gain of the stage. This cannot be fully effective on all ranges because of the variable effect of the i.c. input conditions on the input divider.

To give the best margin of safety the author recommends that the circuit is built with both IC_1 and IC_2 fitted. Then for d.c. and 50Hz only, use either a 50MΩ or 10MΩ divider (whichever is preferred) and a 1MΩ protection resistor. If a.f. measurements are contemplated then use a 10MΩ divider or even scale down by 10; use no more than 100kΩ protection (or strap out the protection resistor and restrict the input switch to positions 2 to 6; and finally experiment with the feedback components to correct one range accurately. The feedback capacitors of course have no effect upon the d.c. measuring capability.

The author has built two versions. One is mounted in bench equipment for d.c. measurements only. It has an input divider of 50 megohms and 100 kΩ protection. The second, a portable model, includes the resistance measuring unit to be described in a later article. It uses a 1MΩ input divider and 10kΩ protection (50V on the lowest range). This input configuration means that a system switch can be used for voltage, current and resistance (Fig. 8 shows the connections). The response of this meter is reasonably flat up to about 6kHz on all ranges without correction. By making C_3 (×1) 820pF and C_4 (×3) 220pF the response on the 100mV range is better than 2% (one scale division) up to 20 kHz. With correction at this frequency the 1V range is 6% high and the 10mV range about 10% high.

Power supply options

There are three convenient methods of powering the circuit (Fig. 2.) and any may be fitted to the p.c.b. (Fig. 3). The simplest is to connect +5V, 0V and −5V supplies to points B, C and D respectively. This allows the circuit to be ground-referenced.

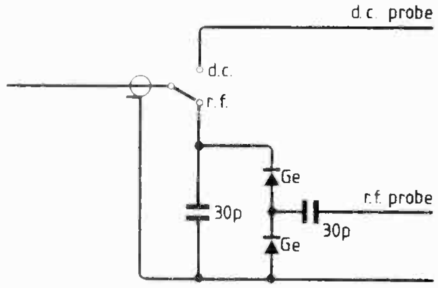


Fig. 7. Probes for r.f. and d.c. measurements. Components should be mounted as close to the probe tips as is practicable.

For the second option a 741 i.c. is used as IC_5. A 9V dry battery can then be connected across B and D. The non-inverting input of IC_5 is then referenced at half this supply (4.5V) and the i.c. is used as a unity gain follower, its output providing the 0V centre point. This method is convenient and inexpensive for portable instruments where ground-referencing to the supply is not required.

The third option allows the use of the instrument with a single 5V supply. In this case a 7660 negative voltage converter is used for IC_5. This i.c. mirrors the +5V supply to produce −5V. It contains an oscillator and rectifier assembly to produce a negative output which is adequate, though only under lightly-loaded conditions. It is for this reason that IC_3 and the leds are driven from the +5V supply directly. IC_5 has only to feed IC_1, IC_2, IC_4 and the 1mA meter current.

The whole circuit excluding the leds consumes 6mA at f.s.d. The total consumption is therefore a function of how high the user is prepared to push the value of the led series resistors to reduce the led current. Only one led is lit at a time, and with 330 ohms in series the total current is of the order of 12 to 15mA.

Construction

This design was centred around a 1mA meter. Those used by the author were surplus voltmeter types with the voltage multiplier resistors removed. Beware of current types, however: with their shunts removed, these are rarely found to have 1mA movements.

Although the component count has been kept to a minimum, the parts used should be of the best quality available. There is no point in having test equipment which is inferior to the items being tested. A glass fibre p.c.b. is essential and the input switch should be of ceramic construction or of a suitable modern insulating material especially if the 50 megohm version is contemplated. A suggested p.c.b. is shown in Fig. 4, the associated component layout in Fig. 5 and the input switch in Fig. 6.

A point to note about the p.c.b. is that the 7560 i.cs have a guard ring around their input terminals (pins 4 and 5) to prevent the possibility of leakage from adjacent pins. This ring is not at earth potential but at the feedback potential, as recommended by the manufacturers.

Although the circuit itself is stable it was found with the prototypes that there was pickup from the meter leads inside the plastic case when the p.c.b. was attached to the meter. To overcome this a screening board of ordinary p.c.b. material was fitted between the circuit p.c.b. and the meter and attached to the circuit board by soldering at the corners.

Construction is fairly straightforward. It is best to fit the links first to make access easier. In the prototypes the connections to the board were made by means of stand-up loops soldered to the p.c.b. Leads to the ×1/×3 switch were screened because they lay across the board; this was done by placing them inside the sheath of a piece of coaxial cable with the core removed. The input divider resistors were arranged around two wafers of a 1-pole 12-way switch. Careful siting or screening may be necessary to prevent stray pickup or interaction with the circuit board.

The author's bench model has a meter movement of the type that includes two mountings intended for small incandescent lamps to illuminate the scale. Two very small leds were mounted on stand up wires so that they just showed above the opaque part of the cover, bringing them into the same viewing area as the scale. Two lamp leads were already provided and two more were added. The leds were held close to their bodies and the leads bent forward and downward to get a 'soft' right angle turn. The bulb clips were removed from their mountings for soldering to prevent the plastic case melting.

Calibration

To calibrate the instrument, a good quality voltmeter (digital?) and a variable voltage source are required. In addition, if a.c. and audio facilities are to be provided then a signal generator with a calibrated output will be needed.

First set all the trimming resistors to half way and the ×1/×3 switch to ×1. Give the construction a final check and then power up the circuit. At this point both leds should glow as IC_2 hunts about its zero. Switch the input to the 10V scale and apply +5V to the input. The red led should light and the meter indicate some where about half scale. Adjust R_4 for exactly centre scale. If an oscilloscope is available and is connected between 0V and the output of IC_2 the wobble will be observed as the changing potential across the meter. The wobble should not be observed across R_{11}-R_{12} proving that the load voltage is held constant by these resistors and that only the current is changing due to the changing load R_9-R_8.

Now operate the ×3 switch and increase the applied voltage to 15V, this time adjusting R_5 for centre scale. Reverse the input leads and check that the reading is the same as before, but that the green led is now lit. Inequality between the positive and negative readings is more likely to be due to leakage in the meter rectifiers than to unequal amplification in the i.cs.

Using the same procedure check the readings on the other scales using appropriate input voltages. Any inconsistencies between ranges are likely to have arisen from inaccuracy in the input divider, leakage effects (especially in the 50MΩ version), or else stray pickup in the test leads. Some variation can be expected but this should not be too significant in a well constructed circuit.

To set up the a.c. ranges, begin with a low frequency (about 50Hz). To ensure minimum stray pickup, terminate the generator leads in a low impedance. Select a suitable range and apply the generator. Check that both the leds are lit, and that the meter reading is somewhere near that which is expected, then adjust R_{10} to give the correct reading (LED_3 if fitted will also be lit at this stage).

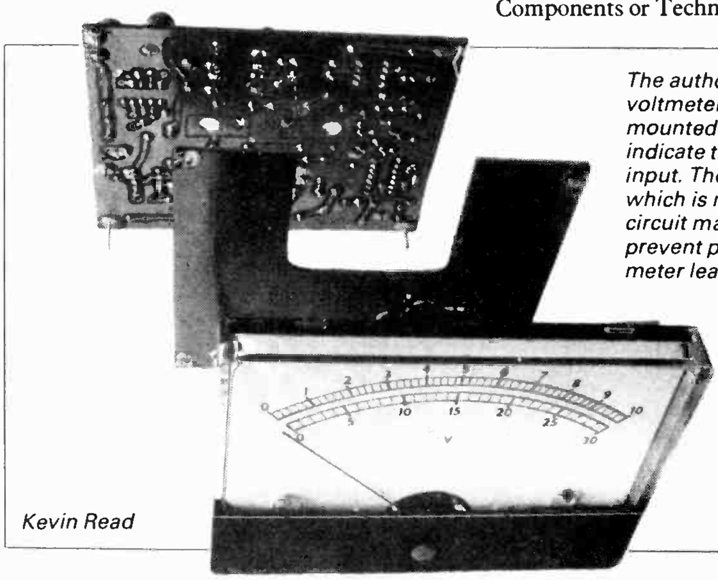
Calibration at the higher audio range will only be appropriate if suitable input divider and protection resistor are used. Switch to the chosen range, adjust the values of C_3 and C_4 to give the desired result, remembering to test with the meter in its final casing.

R.f. measurements

A useful addition for radio engineers might be the means to measure r.f. voltages. It is a simple task to construct an r.f. probe (Fig. 7); this produces a voltage equivalent to the peak-to-peak value of the signal.

Component notes

C_1, C_2, C_5, and C_6 should be radial-lead polycarbonate types. C_7-C_{11} are miniature tantalum bead capacitors. For the close tolerance resistors, a range of 0.5% metal film resistors is available from Ambit International. Cermet trimmers are recommended for the variable resistors. The integrated circuits may be obtained from RS Components or Technomatic. WW



The author's bench-model voltmeter. The two leds mounted on the meter scale indicate the polarity of the input. The U-shaped screen, which is made of printed-circuit material, helps to prevent pick-up from the meter leads.

Kevin Read

LETTERS

LIVING AND PARTLY LIVING

In your March editorial you write . . . "the performance of audio systems is at the stage where it takes a collection of instruments to measure the difference between the original and the reproduction". This may be true in Quadrant House, with its wall to wall waterfalls: out on the shop floor it is quite a different story, or lack of story.

After many years in a London garret I have moved to a mansion in the country. The equipment, rich in character, which I have been using has been banished and I am under orders to buy a conventional system.

Virtually no technical information is available from any dealer, either the smart store in SW1 or 3, or the specialists within a 10-mile radius of my home. The only loudspeaker response figure I have managed to find is 16dB down at, I think, 50Hz, making the 3dB point at 400Hz, or telephone quality.

The only listening room I have found was almost a cube, lined with peg-board. It brought back memories of long-dead aunts as the speakers were switched. Mellow, crisp, or the language associated with the days of Henry Hall.

I have designed, in my time, a lot of equipment for broadcasting authorities, and have never heard the words "it sounds all right". Is there any manufacturer of complete audio systems who is not fudging his data sheets?

T. Roddam
London.

DESIGN FOR LIVING

Have you noticed how difficult it can be for a person in a wheelchair to hold a coherent conversation with the person pushing?

In these noisy times it invariably entails the pusher having to bend over or pull the chair back, with the "pushee" craning his or her neck for both to hear.

I have wondered whether there is any mileage in producing a simple two-way device with throat microphone and earpieces to facilitate easy conversation in these circumstances. I am sure this can only make life easier for both the disabled and the people who have to push them.

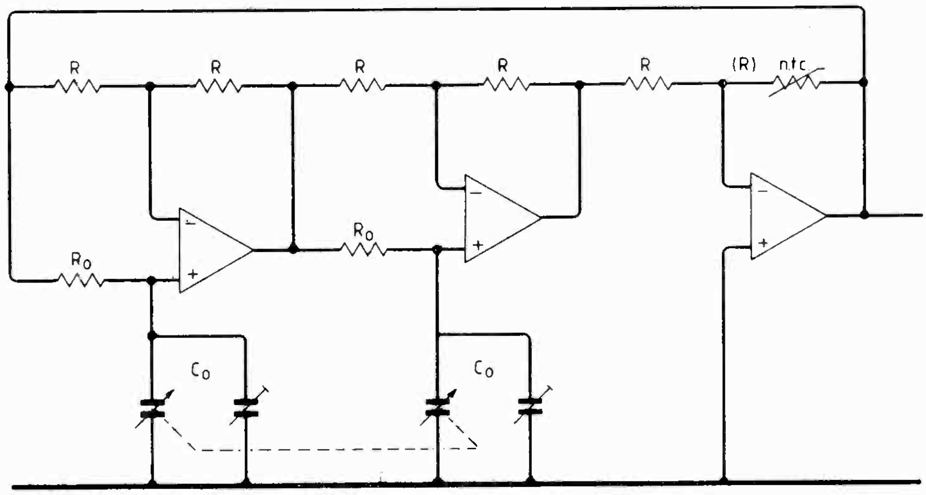
P. Sivers
London W10.

PHASE-SHIFTING OSCILLATOR

In the article in February 1982, Mr Rosens states that 'consumer-grade' variable resistors gave trouble owing to poor contact.

C_0 and R_0 in the all-pass, phase-shifting circuit can be interchanged. In the oscillator, this step allows an ordinary twin-gang capacitor to be used for the fine control of the frequency, as shown in the diagram. A welcome contrast with Wien-bridge and bridged-T oscillators is that the common connection (frame) of the capacitor does not have to be isolated from 0V. Resistors R_0 can be switched in decades (or semi-decades, if desired) for the coarse control. Close-tolerance resistors are more readily obtainable than are close-tolerance capacitors, facilitating the use of a common scale for all the frequency ranges.

If the maximum value of C_0 is 530 pF, for example, then R_0 must be 15MΩ for Mr Rosens's lowest frequency of 20 Hz. The operational amplifiers should have field-effect input stages.



W. Pleass
Saffron Walden
Essex

BBC ENGINEERING

May I quote from Pat Leggatt's interesting and informative article in the November issue, 'BBC Engineering 1922, onwards'. In the radio and television studios, and in outside broadcasts, producers have nearly all the technical facilities they need, with very satisfactory quality and reliability, to give their creative ideas full scope.

The word 'quality' struck a sore point. I have written on three occasions to the BBC regarding poor picture quality from video tape sources, and received only one, and that unsatisfactory, excuse. Perhaps Mr Leggatt or any other BBC engineer can explain through this journal how such degradation can occur.

It is the quality of video tapes and, more recently, the effects machines to which I object. The tapes exhibit poor bandwidth, chroma noise and dropouts. Many new items using the so called e.n.g. system are of worse quality than can be made by an amateur using his domestic video recorder. Perhaps this is excusable given the 'one off' circumstances of news items. Surely, however, it is inexcusable to occupy almost half the spectrum to 1GHz to put out four tv channels, capable of excellent quality, then bandwidth limit the signal source? Or to install high-power transmitters with large aerials and to coerce the public to use good aerials and receivers, then to transmit noisy programme material.

What has happened, why do we see sparkling quality from cine film then life through a juddery haze from tape?. The poor resolution from tape must produce fatigue, hence disinterest, even in a viewer who does not consciously perceive the inferior quality, as the eye continuously attempts to focus on an impossible subject. Could this be the reason many advertisers stick to cine film?

The BBC has an unsurpassed history of excellence and 'firsts', as Mr Leggatt describes, including the digital video recorder, and yet years after video tape was introduced into tv broadcasting the standards are actually falling, not improving. The independent channels have led the way to poor video, no doubt because of cash restraints.

I write this letter not because I dislike the BBC but because I greatly respect its standards and enjoy the product. Please, whoever is concerned with picture quality, don't stoop to the American level.

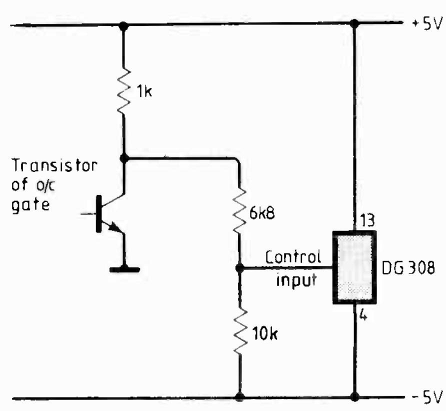
R. G. Brown
Notts

AUDIO SWITCHING

The design constraints Mr Robinson (Letters, January 1983) is working under are not fully known but there may exist usable means round his problem of switching audio at logic levels.

First choice might be to investigate the DG202,212,221 family (Siliconix often second sourced by Harris). Apart from the internal latches these perform as his diagram. The DG221 has internal latches but the switch sense is inverted.

Another way might be to try a DG308 and a resistive drive from an open collector output as in the sketch. It relies on the switching threshold of the device lying within the range of 3.5 to 5 volts. Indeed a similar trick may be possible with 4016/4066 types if the switching threshold lies within a similar range on a 10V supply.



Finally, if level shifting is required, the 74C907 open drain p-channel buffer could be used to replace the three resistors and transistor shifter which was shown.
Allen Mornington-West
Lockerley
Hampshire

BINAURAL RECORDINGS

For some time now the manufacturers of large portable stereo receivers have been offering some kind of processed stereo, with a variety of names implying width or depth. The effect is certainly interesting. I thought perhaps the arrangement described by J. H. Buijs (*Wireless World* November, 1982) might produce this, or similar, effect.

However, it was obvious from even a cursory glance that there is something odd about the circuit he provides. For example, why use three different kinds of op-amps, and why mix op-amps that use a single supply with those that require a dual supply? Further investigation reveals a number of other oddities, such as:

– The "power" transistors following the input stage are not needed. Mr Linsley Hood, for example, has been using TL072 amplifiers in a 600 ohm system without difficulty, and has described his work in *Wireless World*.

– The 1 microfarad capacitors driving the second pair of amplifiers are not needed. The input impedance of the stage is high, and the driving impedance is below 5 ohms. With dual-supply amplifiers in the first stage, the common mode voltage is essentially zero at this point.

– The corner frequencies for the second pair of amplifiers are both below 10 Hz. The 2k2 resistor could be replaced by the 330 ohm resistor and the circuit made frequency-independent without producing an audible difference.

– When the first stage amplifier is switched from inverting to non-inverting, its gain changes from −3 to +10/13, and not +3 as might have been expected. This will result in non-symmetrical cross-talk which cannot be corrected for by this circuit.

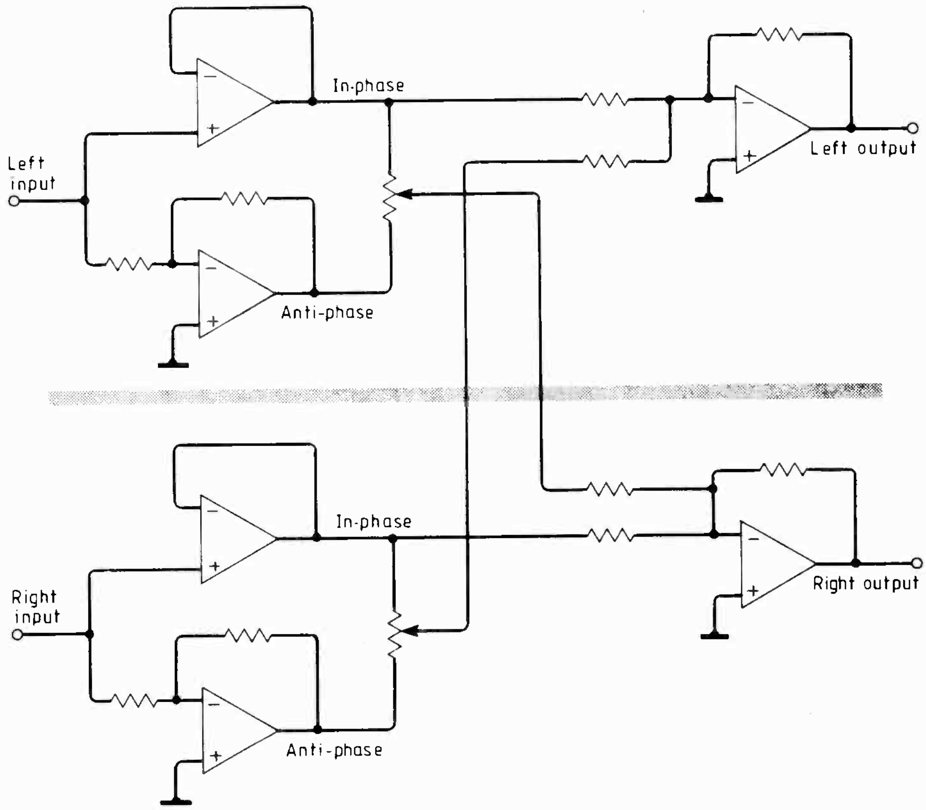
– When the third stage amplifier is switched from inverting to non-inverting, its gain changes from −1 to +1/2, not +1 as might have been anticipated. This does not correct the gain error in the input stage.

It may also be that the switch is labelled incorrectly – the author's discussion of the cross-talk circuit (Fig. 7) indicates that the required inputs for loudspeakers are L and −R. This would seem to indicate anti-phase cross-talk. With the input switch as shown, whether or not the gains of the various stages are correct, the cross-talk will be in phase when the switch is in the loudspeaker position.

In spite of these shortcomings, I was still interested enough to build the circuit. Rather than use a switch for headphones/speakers, I made two versions of the circuit, one with the phase inversions and one without, and with the stage gains kept symmetrical. Each version used the quad amplifier TL074.

With in-phase cross-talk the effect is scarcely detectable. With anti-phase cross-talk the stereo image seems a little wider, but the effect is very subtle.

To improve on this situation, I constructed the circuit shown. This circuit may be regarded as an op-amp version of the "sound source width" control given by Mullard in their Transistor Audio and Radio Circuits book. My version is adjustable from full in-phase cross-talk to full anti-phase, but as Mullard pointed out, more than about 25% anti-phase cross-talk is not needed; indeed it produces a decidedly odd sound.



For those who wish to try the compensation discussed by Mr Buijs, with a circuit that does not involve inductors and a whole variety of amplifiers, my circuit can probably be modified to give the same result. If the in-phase side of the potentiometers is grounded, and the inverting amplifiers in the input side given a low-pass characteristic – say a simple roll-off at 1kHz – it is very likely that the audible results will be similar to the arrangement given by Mr Buijs. With this method, however, the amount of cross-talk is adjustable.
Harold Kirkham
Sunland, CA
USA

ELECTROMAGNETIC DOPPLER

I believe I can give a simple and logical answer to Mr Kennaugh (*WW* March 19 '83). I don't think it is necessary either to dispute relativity or to draw a distinction between the acoustic and e-m cases. In all media the wave velocity is constant with respect to its own medium; what varies is the frequency and wavelength of the wave. This is a postulate – I do not offer proof. It is true of soundwaves.

Let c be the wave of velocity in the medium and let v_s and v_{eb} be velocities of a source and an observer, both with respect to the medium.

A wave which would be emitted by a stationary source at frequency f_o and wavelength λ_o is actually indicated at $\lambda_s=\lambda_o(1-v_s/c)$. And it is received by the observer at $\lambda_{ob}=\lambda_s+\lambda_{ob}\cdot v_{ob}/c$. Therefore $\lambda_o(1-v_s/c)=\lambda_{ob}(1-v_{ob}/c)$, and since $\lambda_o f_o=\lambda_s f_s=\lambda_{ob} f_{ob}=c$,

$$f_o/f_{ob}=\frac{c-v_s}{c-v_{ob}}$$

If, as in the e-m case, the velocities w.r.t. the medium are not known, it should be noted that if v_s and v_{ob} are much smaller than c, them by Binomial theorem,

$$\frac{c-v_s}{c-v_{ob}}=(1-v_s/c)\,(1+v_{ob}/c+\ldots)$$

$$\approx 1-\frac{(v_s-v_{ob})}{c}=\frac{c-(v_s-v_{ob})}{c}=\frac{c-v_{rel}}{c}$$

(If v_{re} is small, $f_{ob}\approx f_o$ even if v_s and v_{ob} are not small).

On the subject of Mr Kennaugh's point about destructive interference, surely photons don't fail to explain it any more than e-m waves do? The energy still has to escape somehow. As for polarization, why shouldn't photons be polarized somehow?.
D. Hall
Coventry

MODULAR PREAMPLIFIER

In November 1982 you published an article by Mr J. L. Linsley Hood on a modular preamplifier, using bootstrap filters with a 3rd order response, as described in the appendix on p. 64, giving four equations each for high and low-pass sections. Invevitably, these are duals of each other.

I liked these circuits and performed some algebra on them. In addition to considerable simplification, the algebra revealed that if Mr. Hood's recommendations for the design of these filters are followed, then one can come unstuck.

Dealing with the high-pass filter and re-arranging the third equation, a quadratic in $y(=R_1/R_2)$ is obtained, namely $y^2+y(2-C_2/(C_1.Q^2))+1=0$. Since the quotient of the coeffs of the y^2 term and the constant equals 1, it follows that the two roots are mutually reciprocal, i.e. that one should be able to interchange R_1 with R_2 (C_1 and C_2 for the low-pass), which was verified experimentally without *any* change in the performance of the filter.

Assuming that a Q of not much less than $\sqrt{2}$ is desirable for steepness of cutoff, for y real we get $C_2/C_1 \geqslant 8$. One can see immediately that a ratio of 10 would be advantageous, bearing in mind the cost of odd sized values of capacitors. Substituting $C_2/C_1=10$ it is found that, for y positive, $2<Q^2<2.5$, conveniently in the desired range.

With $C_2/C_1=10$ and solving for y, it is found that, for $Q^2=2-2.4$, there is a linear relationship expressible as $Q^2=(7.8-y)/2.6$, y lying between 1 and 2.62. A choice of $y=2.2$ is again advantageous, as 2.2 is a multiplier in all the 'series' and provides easy choice of resistors (capacitors for the low-pass). This value of y in turn fixes $Q^2=2.15$ with $Q=1.47$.

Summarising, we have : $C_2/C_1=10$, $R_1/R_2=y=2.2=R_2/R_1$, and $Q^2=2.15$, with duality defining the low-pass configuration as in Fig. 16 in the article. It is worth repeating here that equ. (i) imposes constraints on the C_2/C_1 ratio, reflecting on y, Q and the turnover frequency. Just selecting Q and y as indicated by Mr Hood can lead to an unrealisable filter.

After some small computation and defining $R_nC_n=1/(2.\pi.f_n)$ – 'n' standing for the normal roll off frequency/time constant relationship – and substituting for C_2 and R_1 (from their ratios) one obtains: $C_1R_2(HI) = C_nR_n/\sqrt{22}\ xQ^{1/4}$ and $C_1R_2(LO) = (C_nR_n/\sqrt{22})\ xQ^{1/4}$, the last term in Q being a 'correction factor' insisted upon by all the experimental filters! This construction gives a maximum peak of about 5 dB.

In addition, from equ. 1 and 4 of the article, by eliminating frequency, we have: $C_3R_3(HI)=C_1R_2(1+y)=3.2C_1R_2$ and $C_3R_3(LO)=C_1R_2(1+y)Q^2=6.9C_1R_2$.

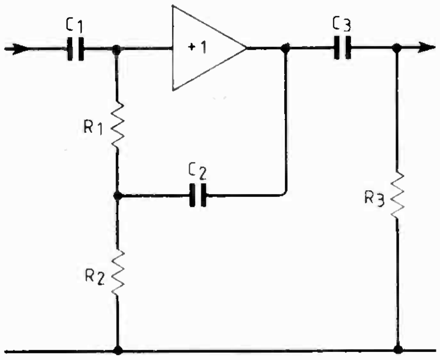
If maximum flatness is required in the response, then it is best to use a lower resistance for R_3 than obtained from the equations and use a trimmer pot, as the response peak is strongly dependent on the precise values of the two resistors and two capacitors – and their ratios – of the bootstrapped filter.

Construction: For a high-pass filter with a cutoff frequency f_n of 1250 Hz, $R_nC_n=127\mu s$, giving $C_1R_2=127/(\sqrt{22}x1.21)=22.4\mu s$ or 1nF and 22kohm. $C_2=10C_1=10nF$ and $R1=2.2R_2=48kohm$ (a high 47k). $C_3R_3=127x3.2\mu s$, or 22nF and 18k4, a 16k resistor and a 4k7 trimmer, say.

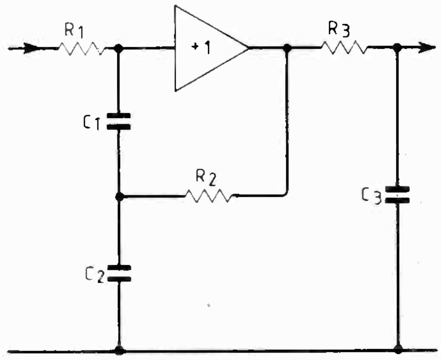
Finally, a band-pass filter using two bootstrap filters in cascade fit easily enough in terms of the relative interface impedances and can be constructed with a dual TL072 op-amp, over the audio frequencies and higher. Overall ripple can be within about 0.5 dB.

R_nC_n = Time constant of desired cutoff.
$C_1R_2=R_nC_n/5.68$
$R_1 = 2.2R_2$
$C_2 = 10C_1$
$C_3R_3=3.2C_1R_2$
$C_1R_2=R_nC_n/3.87$
$C_2 = 2.2C_1$
$R_1 = 10R_2$
$C_3R_3=6.9C_1R_2$

P. A. Duval
Theydon Bois
Essex



(a) High-pass



(b) Low-pass

The author replies:

I would like to thank Mr Duval for his comments, which I have read with interest. The summary of the design data which was given on page 64 of the November, 1982 *Wireless World*, was not intended as a complete design programme, though the equations quoted are correct and adequate.

The full mathematical anlysis of this circuit in its high-pass and low-pass forms was given by me in *Electronic Engineering* (July 1976, pp55-58), from which the design summary was extracted. The calculated and measured performance of these filters, as so described, was checked over a range of Qs and operating frequencies, with several different component relationships, and was found to agree with the predicted transmission within 0.2dB, which satisfied me that my calculations and formulae were indeed correct.

If it would be of interest, I have worked out a suitable programme to allow the performance of this filter to be calculated using either a Texas TI58/59 programmable calculator or a Hewlett Packard HP-65. For the sake of completeness, I have done the same exercise for the Sallen and Key design, which shows up the differences between these filters at the higher attenuation levels.

I would like to take the opportunity, while writing, to remedy some of the errors and omissions which had crept into this series of articles, and to which my attention has been drawn.

Power amplifier WW August 1982.
I had omitted the types of some transistors. Tr_1, $Tr2$=BC447. Tr_5, $Tr6$=MPSA–93 (the base connections of these were shown reversed on the p.c.b. layout Fig. 21) Tr_{12}=2SJ49. Tr_4, Tr_7=BF259. Tr_{13}=BC212. Tr_{10}=BC182 (not on output heat-sinks). I had also shown C_3 and its associated zener the wrong way round. Sorry! The supply line bypass capacitors can be made as large as the constructor wishes, and these can be bypassed by small non-polar capacitors (0.1µF) with advantage. The majority of these errors were corrected by *WW* in September 1982, p63.

On a more theoretical note, in my description of the design of the power amplifier, July '82, p66, I had referred to the need for a wide bandwidth and good linearity in an amplifier in which positive feedback was to be used, in that p.f.b. will worsen these characteristics. This is true. However, if any significant amount of p.f.b. is to be applied in a circuit using both p.f.b. and n.f.b., it is essential the bandwidth of the p.f.b. loop must be less than that of n.f.b. one, or otherwise the amplifier will oscillate at some frequency at which the n.f.b. has disappeared.

In the design shown, this p.f.b. bandwidth limiting function is performed by R_{26} and C_{15}. I am grateful to my correspondent, Prof. M. D. Cherry, of Monash University, for a reminder on this point.

Ls protection circuit
In the p.c.b. layout, Fig. 26, IC_1 (74C02) is shown viewed from the top, and pin 6 should be connected to pin 7, and to 0V. In the diagram this is obscure. However, since National Semiconductors, who appear to be the sole UK suppliers of the 74 compatible c.m.o.s. i.c.s. of this type, appear to be phasing these out in favour of the similar but much faster '74HC– –' series, and as an initial step have substantially increased the cost price, it is probably worthwhile to amend this p.c.b. layout to use the similar, but much cheaper CD4001 i.c., which has a different pin layout.

Microphone amplifier
Tr_{11}, which is not specified, should be a 2N5457

Rumble filter
C_{43}, the input bypass capacitor, should be 1000pF (1nF) not 1µF.

Finally, the overall performance, at 1kHz and 1V rms should have been quoted as 'less than 0.01%' – not 0.10.

DISCUSSING RELATIVITY

Should inquiry into relativity theory be encouraged? J. Kennaugh (Letters, March 1983) complains of the inaccessibility of the theory's consequences to mechanistic explanations. Could this not reveal a degree of misconception with regard to the theory's foundations? At the point of departure of the argument for the special theory are the two conjectures which Einstein dubbed "postulates" in his paper of 1905[1]. The first postulate, not at variance with the conventional laws of mechanics, is by Einstein's own admission, incompatible with the second, which offers utter frailty in the face of the challenge of potential empirical refutation. From these conjectures, the theory is developed under the constraints of mathematical rules, devised as an artifact of the intellect to form a closed, internally consistent logical system. Thus the theory is not necessarily matched to the realities of the physical world nor, indeed, to the requirements of concepts, which constitute intellectual effort, to accommodate to physical observations.

On encountering difficulties in adapting the consequences of the theory to the intrusion of facts we can adopt one of two approaches; we reject it as of no further assistance to our endea-

LETTERS

vours in interpretation and understanding, and seek to construct a new theory, or we contrive to protect the old theory. The adoption of the latter course may appear to be questionable if we would claim commitment to the scientific method, and might seem to imply some alternative concern as our motivation. The pursuit of this suggestion could prove of interest elsewhere, but for the present let us take note of a remark reported recently in the press, of Professor David Bohm: "But the question is whether physicists will regard explanation as important at all. The trend in physics at the moment is to discount concepts and only to take seriously what you can compute with equations"[2].

Now let us make a conjecture of our own. If astronomers employing refined techniques of measurement should acquire evidence which supported the contrary to the second postulate, i.e. that each emitting body is fixed in its individual medium of energy dispersion; if this should be brought about, or perhaps some other observations be made to the same effect, are we then to accept that a certain section of the scientific community would disdain from taking the reports seriously?

Could not J. Kennaugh and, indeed, many others, suffer from misconceptions not only of relativity theory, but of the expectations we have of physicists? These people receive considerable encouragement in material terms for their somewhat exotic and extravagant activities; but should inquiry into relativity theory be encouraged, as well? Could we hope to see the debate developing further in these pages, perhaps? The open-minded policy of the editorship would appear to be, indeed, encouraging.

Colin Francksen
Farnborough,
Hampshire.

References

1. "Zur Elektrodynamik bewegter Korper", A. Einstein, translation from Ann.d.Phys 17, 891-921 (1905), in "The Principle of Relativity", Dover Publications Inc., New York 1952.
2. "Why Einstein was wrong about light", Danah Zohar, *The Sunday Times*, London, 20 March 1983.

GRAVITATIONAL WAVES

Beginning with the publication in Wireless World (Oct. 1978) of Dr L. Essen's "Relativity and Time Signals", I had been following closely the lively discussion regarding the validity of certain postulates of Einstein's theory of relativity (the twin paradox, etc.) and other such important topics which you kindly had given space in your magazine. I, as well as many other of your readers, appreciate the fact that though *Wireless World* is essentially a technical publication it, nevertheless, is giving room – when other doors are seemingly closed – to writers of differing views particularly when the subject of discussion is fundamental theory. This is an excellent example for not separating practice from theory and thus involving technologists with current problems even if related indirectly to their fields.

Equally I congratulate you on the new series of articles by Dr W. A. Scott Murray dealing with the various problems of modern physics and the hidden contradictions seriously undermining its seemingly imposing outer structure. Certainly, this is the way to let the layman feel that all is not not the word of God and therefore lead him to question rather than to accept blindly as a word of faith, all the stuff pumped into his mind since early school days.

However, the real reason I am writing you concerns an article related to our discussion that had appeared in *Scientific American* (The Gravitational Waves from an Orbiting Pulsar, Oct. 1981) which should be of special interest if its conclusions are accepted to be true. In this article, the writers claim to have proved beyond doubts: the "existence of gravitational waves" and of settling the question of "relativity of time" or the "twin paradox" as it is known in popular relativity parlance. For over a period of six years they had been measuring the decaying orbits of the binary pulsar PSR 1913+16 and found the accumulated shift in the time of periastron passage amounts to be about 0.04 second a year. According to their argument (and relativity), the source of energy for gravitational radiation belongs to orbital motion. And if this loss of energy is very large, such as is the case with this pulsar system, then it leads to a measurable decrease in orbital period which they had successfully detected.

After further explanation of "time dilation" and how it was proved by experiments involving atomic clocks flown by jets, they conclude that this orbital decay is caused by gravitational radiation and not due to possible collisions with stellar gas or other matter such as is the case with an artificial earth satellite orbit decaying mainly because of collisions with molecules in the upper atmosphere. Also there is no mention of the fact that part of the decay can be caused by loss of mass by the pulsar due to ordinary conversion of mass into radiant energy or the mass lost through the agency of the mysterious and very strong radiowave pulses from the pulsar. The authors finally hint that other workers are trying to detect these very weak radiations in the laboratory when suitable equipment become available. Surely many await the results of these experiments as the factors mentioned above would then be ruled out.

I appreciate possible comments from Dr Essen or from other interested readers regarding this new development as I am personally still not in total sympathy with all the claims of Einstein's theory of relativity. Such responses may indeed be reassuring if only to keep the door open – which has been so, thanks to *WW!*

M. Zaman Akil
Safat, State of Kuwait
17th April 1983.

RED SHIFT

Nicholas Kirk's letter on the "Red Shift" (*WW* February 83) questioning whether it might not result from simple loss of energy rather than expanding universe is very interesting.

Had it not been for the semi-religious appealing idea that all things must have started from a single point, would all that effort have gone into the "expanding universe"? One can almost suggest starting a research which has as its starting point the assumption that light loses frequency in proportion to the distance it covers. And by a well-known amount too!

G. Kubba
Putney

Mr N. K. Kirk echoes exactly my own queries in his letter (*Wireless World* February) but for different reasons.

My first point is of general principle. We are told that there is no such thing as perpetual motion. Whenever there is relative motion between two things which have interaction between them (for example photons in gravitational fields) then energy is given up, which frequently manifests itself as loss of velocity.

My second point is connected with the experimental evidence to support Einstein's theory that light is refracted by very strong gravitational forces. The refraction of photons passing very close to the surface of the sun shows that photons are affected by gravity.

Can anyone conclusively demonstrate that the velocity of photons, as they pass through the gravitational fields of inter-galactic space more or less continuously for many millions of years is absolutely and utterly unaffected by so doing, because this is an essential requirement for the receding universe theory if it is to be based on observed spectral red shift.

On the other hand, if the velocity is reduced by some finite amount during its enormous journey, it would produce an apparent spectral red shift.

J. Snowden
Managing Director
Rediffusion Service (Singapore)

SENSITIVE?

I have come upon one or two cases of people who have acute sensitivity to electricity and to electrical devices, such as television sets, computers, radios, electric lights, etc. I would be very interested to hear from any readers who experience this effect, or who find even the presence of electricity disturbing. I wish to make a study of this condition and any reports that readers send me will be treated with complete confidentiality.

Michael Shallis
Department for External Studies
University of Oxford

CABLE AT MILTON KEYNES

Speaking as a user of the Milton Keynes cable tv system for the past two years, I have found the reliability of the system leaving a lot to be desired, since the system has failed on average once every two or three weeks. If it should fail after 6.00p.m., then it would remain out of service till next day, and even when it was working the quality was well below broadcast standard – as measured using Marconi tv a.t.e. For all this, every user contributes £12 p.a. towards its up-keep – the argument being that you get a better picture from the cable than "off air"; in reality this is not true. Although Milton Keynes is in a fringe area, it is still possible to get a better picture from a modest loft-mounted Yagi.

In addition to the overall poor picture quality, the system also radiates very badly into the 2m amateur band: most of this radiation comes from poorly screened distribution amplifiers.

It is to be hoped that the Milton Keynes system does not set a precedent for future systems and that others learn by its flaws.

Fibre optics would be the obvious answer to some of the problems, but the more complex a system gets, the more likely it is to fail, so all in all I intend to stick to my little Yagi in the loft (which cost me £5.50), to save myself £12 p.a. and still have a better picture.

Tim Forrester
Milton Keynes
Bucks

A programmable eprom eraser

Discipline for wayward eproms: a companion-piece for the eprom programmer described by the author in the April and May 1982 issues

by H. S. Lynes

Literature on programming eproms is readily available from manufacturers: timing, voltage levels, loading factors and so on are all well-defined. But on the subject of erasure there is only brief mention of the need to use hard ultra-violet . . . integrated dosage ten watt-seconds per square centimetre . . . and then there follows a warning to the effect that all locations must be fully erased before the device is reprogrammed. Several graphs are reproduced which purport to demonstrate the effect of under-exposure, but there is nothing to say what this means – or why it should be avoided.

Before an eprom can be re-programmed it must be exposed to ultra-violet radiation of a short wavelength (hard u.v.), which raises each memory cell to a logic 1 level. If an eprom is set to all-0 and then erased, it is not surprising that the logic 1 level is reached at different times during the u.v. exposure – particularly when one considers the very small dimensions of the conductors on the silicon. Figure 1 represents a novel way of demonstrating the program-cycle: the hysteresis curve normally associated with mechanics and the properties of magnetic materials. Under the influence of temperature and bus-loading, the threshold of logic will shift (as with most logic devices) and this is said to be the reason for the need to over-erase. The erasure rule is to give the eprom four times the clearing time (i.e. the time to reach logic 1 level). This is sometimes expressed as T + 3T, where T is the time taken to erase the least-eager bit. Thus if the slowest bit takes eight minutes, the correct exposure will be 32 minutes. Where eproms are to be reprogrammed regularly, it is recommended that they should be set to logic 0 and colour-coded for the time the slowest bit takes to clear.

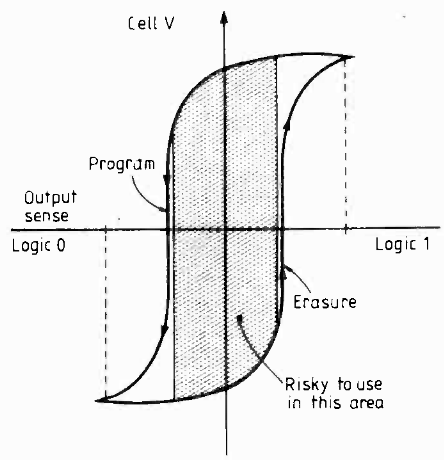


Fig. 1. The program-erase cycle of an eprom. The shaded area may vary with temperature, voltage and bus-loading.

Unfortunately it is difficult to check the logic-state of the eprom whilst it is in an eraser – they are usually just light-tight boxes with timers. It is possible that many eproms are 'under-erased' because of this and because time is always pressing.

The eraser described here can be made programmable – and it is perfectly feasible to make it intelligent so that the correct exposure may be given and data presented to the operator for future reference. There is plenty of scope for research into pattern sensitivity and it may be noted that some eproms do erase in alternate groups of 16 locations.

Construction

The author's eraser is shown in the photograph. The case can be metal, as the prototype, or wooden. An aluminium box 20cm by 7.5cm was covered with a sheet of paxolin to style the lid and to provide insulation for the steadying hand whilst the drawer is opened. The drawer slide and handle were obtained from a rack module, to simplify construction of the

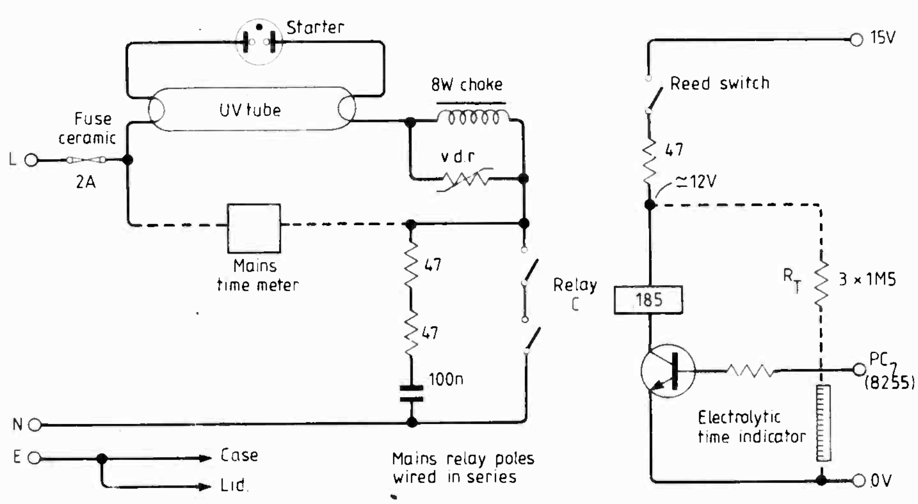


Fig. 2. The ultra-violet tube with its wiring and the relay interface. The two time indicators shown dotted are optional.

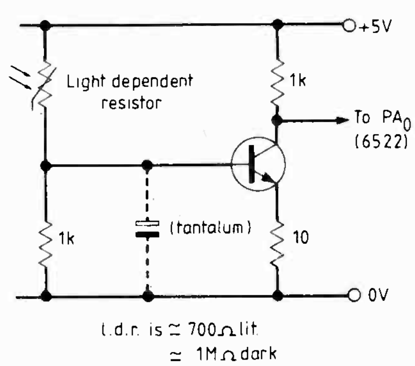


Fig. 3a. A light-dependent resistor monitors the output from the ultra-violet tube. The optional capacitor is a tantalum type.

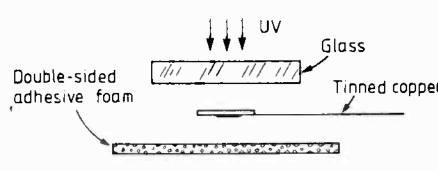


Fig. 3b. The light-dependent resistor assembly.

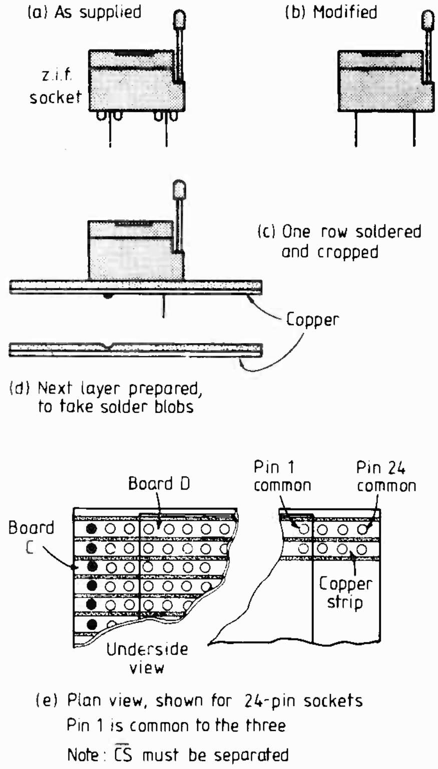


***Fig. 4.** Preparing the zero insertion force i.c. sockets for the author's do-it-yourself multi-layer circuit board.*

precision part. A flexible ribbon cable joins the z.i.f. (zero insertion force) sockets on the drawer to the switches, relays and electronics contained within the case. Mounting the choke for the u.v. tube externally on the side opposite the drawer provides some stability and reduces the effect of its magnetic field. Modern chokes, however, do get hot and it may be necessary to prevent hand-access. The choke is rated for 8W, although the most commonly available 'replacement' u.v. tubes are nominally 4W. They are estimated to have a useful life of 5000 hours and the effect of increasing their power will be to reduce this slightly – unlike conventional tubes they have no phosphor to overload or contaminate. Take care not to touch the quartz envelope as this will lead to premature failure. Suitable chokes can be obtained through trade electrical suppliers, usually 'to order' and at a cost of about £3. With an 8W choke the total erasure time will be in the order of 15 to 30 minutes. A v.d.r. transient-suppressor should be wired across the choke to reduce interference. For the same reason, the mains supply should be separate from that of the microprocessor if possible. The tube supply is switched by a 'continental' relay with both poles in series, protected by a CR network as shown in Fig. 2. This diagram also shows the port interface and the reed switch used as drawer interlock. A 47 ohm resistor is placed physically close to the reed to prevent line-capacitance problems, making it necessary to use a 15V supply.

It is usual to have a 'snap' action to the drawer over the last 5mm of closure – during this the interlock should operate. The action was achieved by a strong spring

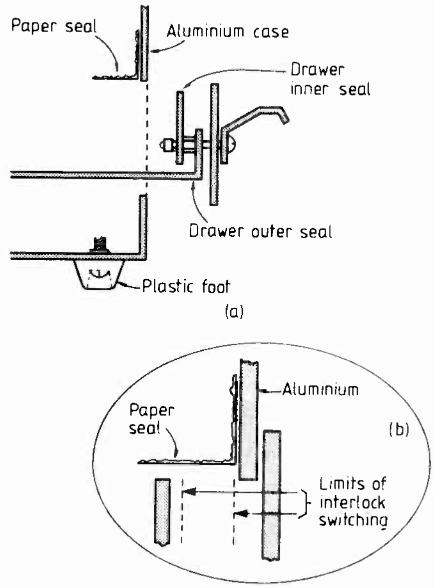


***Fig. 5.** Detail of the method of sealing the light-tight drawer. Good sealing is essential to prevent damage to the eyes and skin from the short-wavelength ultra-violet radiation.*

and a roller. It may be found necessary to strengthen the case to ensure the parts remain perpendicular throughout the travel. No provision has been made for the eraser to be used without the host processor since this would remove the safety aspect of the drawer switch. It is essential to have complete regard to safety since the tube radiation is harmful to eyes and skin.

In the prototype a motor-driven timer was wired across the tube circuit as a check on tube-life and also to calibrate the electronics. If only a tube-life check is required an electrolytic (mercury) indicator may be wired across the (12V) relay. As a further check on tube operation a light-dependent resistor was included (Fig. 3a) suitably buffered and protected from the effects of the u.v. by 2mm of glass. It should be placed close to the z.i.f. sockets – three sockets will fit under the tube. Although it is only a go/no-go indicator it must be fairly close to the tube since l.d.r.s do not respond greatly to the u.v. and blue parts of the spectrum. If possible shield the l.d.r. from the tube heaters, which could give a false indication since they will emit plenty of infra-red. When the tube is working the l.d.r. resistance will be typically 700 ohms. The dark resistance is about 1 MΩ.

Wiring the z.i.f. sockets

A neat solution has been found to the problem of wiring a large number of similarly-connected sockets: they can be wired on two layers of Veroboard stripboard, with the first row of pins connected to (say) the top board and the remaining rows to the bottom board. In the case of most i.c. sockets there is insufficient lead-length to reach the second board, but with care in purchasing it is possible to obtain z.i.f. sockets with longer leads. They must be dismantled and filed flat to remove the anti-wicking mouldings as this gives just sufficient lead-length for a neat solder connection. Fig. 4 shows the stages in construction. The finished 'layered' p.c.b. is strong and shows high insulation resistance after treatment with clear cellulose (car-paint type) where the second row connections pass through the first p.c.b. The connections to the $\overline{CS}$ pins have to be made separately so that the i.c.s may be enabled individually. Make certain the z.i.f. socket is working correctly when it is reassembled prior to mounting on the p.c.b. – removal is not easy!

The drawer seal (Fig. 5)

It is essential that the unit is made completely light-tight and it is recommended that the drawer be double-sealed so it may be safely opened beyond the point where the interlock operates. A double seal is achieved by making a second aperture about 6mm inside the main door – an inner door is shut against this by means of a flexible seal, for which black paper is ideal. The main door should be considerably larger than the drawer aperture and the facing surfaces should be matt black. It is important to light-proof the seams of the box: again, black paper or the backing from a roll-film may be used. Note that ozone is produced by the action of u.v. on oxygen – a means of ventilation should be provided if this would consitute a hazard.

Internal circuitry (Fig. 6-Fig. 8)

The prototype contains all the port buffers, several leds and a bleeper as well as the mains (u.v.) relay and the power supply relay. Another relay was incorporated as there were insufficient poles on the mode selection switch (this switch selects the power and $\overline{CS}$ pins for

Table A

Connections between the 6522 and 25-way "D" connector. The pin numbers are moulded on the connector. The sequence changes at PB_1 to aid wiring.

Pin 1	CA_1	Pin 11	CB_1	Pin 8	BIRQ (on backplane)
2	CA_2	12	CB_2	17	IRQ
3	PA_0	13	PB_0	16	–
4	PA_1	25	PB_1	15	0V
5	PA_2	24	PB_2	14	+5V
6	PA_3	23	PB_3		
7	PA_4	22	PB_4		
8	PA_5	21	PB_5		For concatenated timer operation PB_6 & PB_7 must be linked
9	PA_6	20	PB_6		
10	PA_7	19	PB_7		

Table B

Port designations for the 6522.

PA_7, PA_6	Mode-switch position
PA_5	Bleeper
PA_3	z.i.f. socket No 3
PA_2	" " No 2
PA_1	" " No 1
PA_0	Photo-detector
CA_1	Mode-switch interrupt

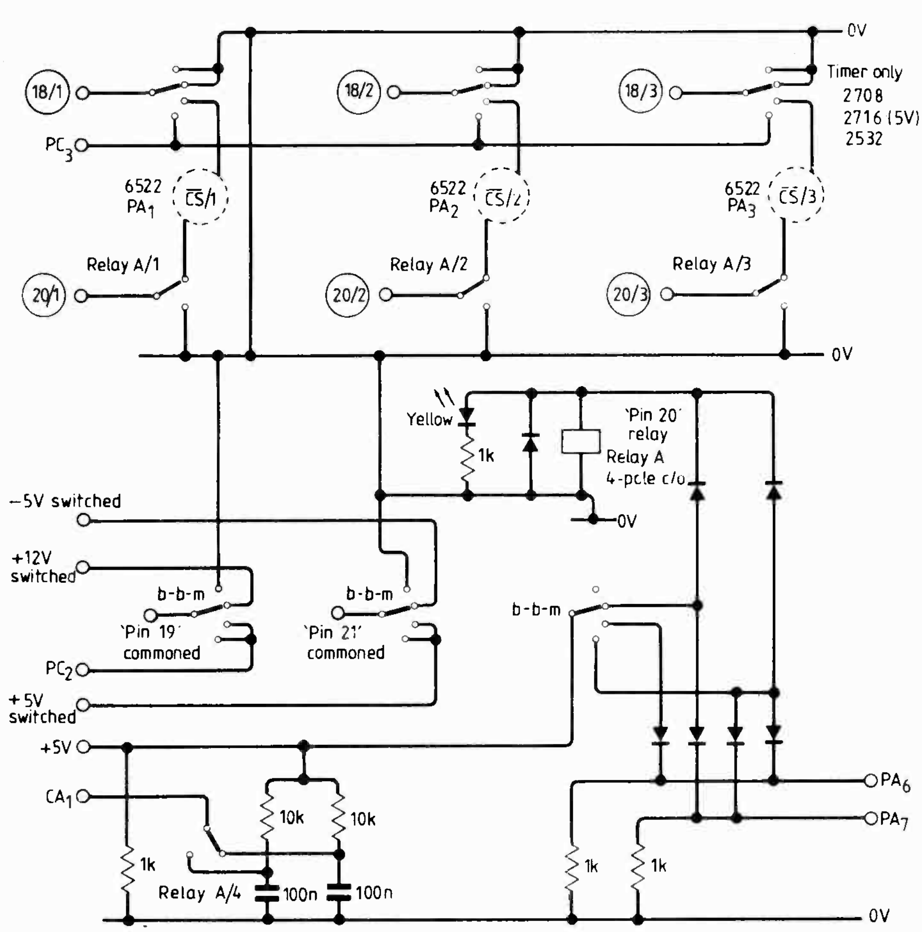


Fig. 6. *Wiring the mode selection switch. The numbers 18/1, 20/2 and so on refer to pin connections to the z.i.f. sockets. For example, 20/2 denotes pin 20 of the second z.i.f. socket. Relay A is a sensitive (high resistance coil) relay controlled by the switch: it provides a convenient means of switching pin 20 of the z.i.f. sockets and by means of a simple capacitor charging system it produces a positive-going CA_1 pulse. Relay A is shown in the energised state because the mode switch is drawn in the 2708 position. The switching associated with pin 19 and pin 21 of the z.i.f. sockets carries power supplies: the switch wafers used must be break-before-make types. The relay supply is not switched as it provides switch-position data by means of the four diodes associated with PA_6 and PA_7.*

Table C
40-way ribbon-cable identification. No. 1 is tracer.

1	PA4	13	PC0	25	PB2	29	PA7	mode selector switch
2	PA5	14	PA1	26	PB5	30	PA6	(truth table shown below)
3	PA0	10	0V	27	PB4	31	PA5	bleeper
4	PA6	16	PC1	28	PB3	32	CA1	
5	PA7	17	PC2			33	PA1	No. 1 select
6	0V	18	PC3	split		34	PA2	No. 2 select
7	PC7	19	PB7	ribbon		35	PA3	No. 3 select
8	PC6	20	−5V	here		36	PA0	photo-detector
9	PA3	21	+12V			37	+5V	parallel wiring necessary
10	+5V	22	PB0			38	+5V	because of cross-section
11	PA2	23	PB6			39	0V	of copper conductor.
12	+15V	24	PB1			40	0V	

1-28 inclusive go to 8255
29-40 inclusive go to 6522 via D-Connector, see also Table A.

Z.i.f. socket wiring to ports of 8255:

port	(ribbon)	2532	2716(5V)	2708
PA0	3	A0	A0	A0
PA1	14	A1	A1	A1
PA2	11	A2	A2	A2
PA3	9	A3	A3	A3
PA4	1	A4	A4	A4
PA5	2	A5	A5	A5
PA6	4	A6	A6	A6
PA7	5	A7	A7	A7
PC0	13	A8	A8	A8
PC1	16	A9	A9	A9
PC2	17	A10	A10	–
PC3	18	A11	–	–
Data bus:				
PB0	22			D0
PB1	24			D1
.				.
.				.
PB7	19			17
Miscellaneous:				
PC6	8	d.c. supply relay 0 = on		
PC7	7	a.c. supply relay 0 = off (see also Fig. 2)		

Truth table for mode switch:

PA6	PA7	mode
0	0	timer only
0	1	2708s
1	0	2716s
1	1	2532s

Notes: A10 is not useo with 2708s. A11 is not used with 2716s or 2708s

the three eprom types). The extra relay changes the $\overline{CS}$ pin connections and provides an interrupt if the switch is moved after the program has started. There is a fourth position of the mode-switch which prevents connection to the eproms so that different devices may be erased to save time, if necessary; this position is labelled "timer only" and the user is prompted to enter the desired time in the range of 1 to 99 minutes via the keyboard. The switch position is initially checked by program by means of the diode network connected to PA_6 and PA_7 of the 6522. Note that some switch-banks must be break-before-make types. Table C identifies the ribbon cable that forms the only connection between this unit and the microprocessor: it is conveniently split to 37-way and 25-way subminiature 'D' connectors.

Operating features

The following features were incorporated for convenience in operation and program development: one l.e.d. corresponding to each $\overline{CS}$, one l.e.d. corresponding to each supply rail, and a single l.e.d. to indicate when the appropriate supplies were connected to the z.i.f. sockets. A small self-oscillating bleeper was incorporated for prompting and a filtered direct-viewing window for the u.v. emission.

Software hints

Using the programmer described in my previous articles (*Wireless World* April and May 1982), I found that I had a lot of checking to do – ensuring that all locations are set to hexadecimal FF is not easy. A "Space?" program was developed to search for consecutive FF bytes. With 2716 and 2532 devices, blocks can be left blank and used later. For convenience in slotting-in data I arranged to make the program display the starting and stopping addresses of the blanks – but since FF can occur in a genuine program it is necessary to provide some form of user-control. This difficulty is overcome by asking the operator to define the minimum number of contiguous bytes to be found. Thus the screen is not cluttered up with odd FF locations when the data table is to be slotted in (requiring, say, five bytes).

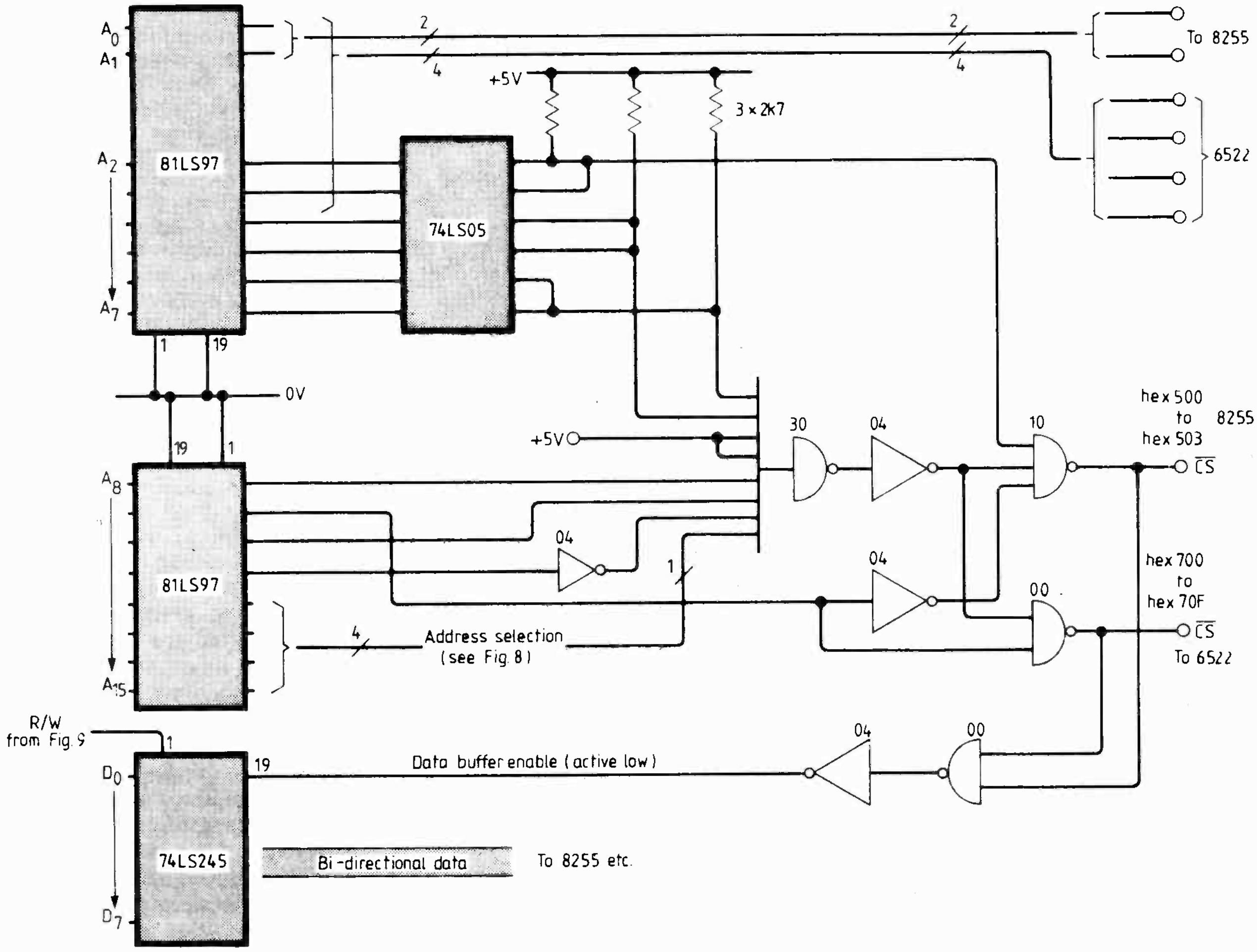


Fig. 7. Address decoding for the 8255 and 6522.

With care this same program can be used for checking the erasure of eproms by setting the number of contiguous bytes to 1 (unity) and also checking for any areas which are known to be faulty or which have failed to erase in a given time. This check will normally occur every half-minute and makes use of two facilities available in another peripheral outside the 6800 family – this is the 6522 versatile interface adaptor (v.i.a.) by Rockwell. Table A gives the port-designation for a 25-way "D" connector. The 6522 is used here as a peripheral port and a timer combined. Thus in this project two peripheral i.c.s are used: the 8255 for address and data and the 6522 for chip-selects, relay and interfacing as well as an interrupter by combining the two 16-bit ϕ_2 dividers. A further description of the 6522 is given in the appendix although readers are urged to obtain a copy of the Rockwell booklet which covers this i.c. The basic connections were given in the previous articles, but there are some additions; Fig. 7 and Fig. 9 cover both the 8255 and the 6522.

Appendix: the 6522

The 6522 versatile interface adaptor is a dual eight-bit bi-directional port, with two 16-bit presettable counters and a shift-register (which is not used in this application).

It features programmable interrupt which can be used to effect intervals from microseconds to hours if the two timers are joined. For longer delays it would be possible to use the longest interval to decrement a number set in ram and restart the interrupt time – however for intervals extending over several days a real-time clock is probably a better solution.

There are 16 registers which may be addressed 0-F; these are decoded from A700 to A70F. It is suggested that constructors should mark the Rockwell

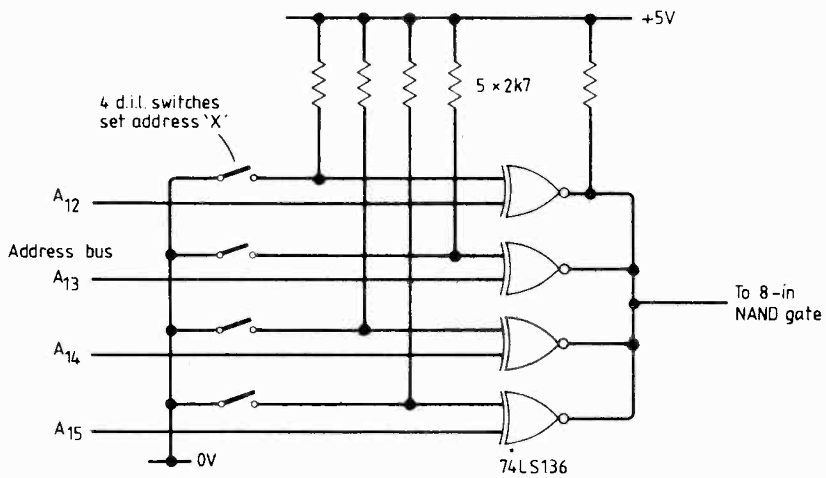


***Fig. 8.** Address selection switching: this fits into the address-decoding circuit of Fig. 7.*

H. S. Lynes was educated at Shiplake College, Henley-on-Thames and at Merton Park College of Further Education, where he obtained an HNC in electronics. After an apprenticeship at the Electrical Research Association, Leatherhead, he adapted to various roles in both sales and R & D including a short spell when he operated his own company. At present he is employed in technical sales for a large electronics company and is based in the Midlands.

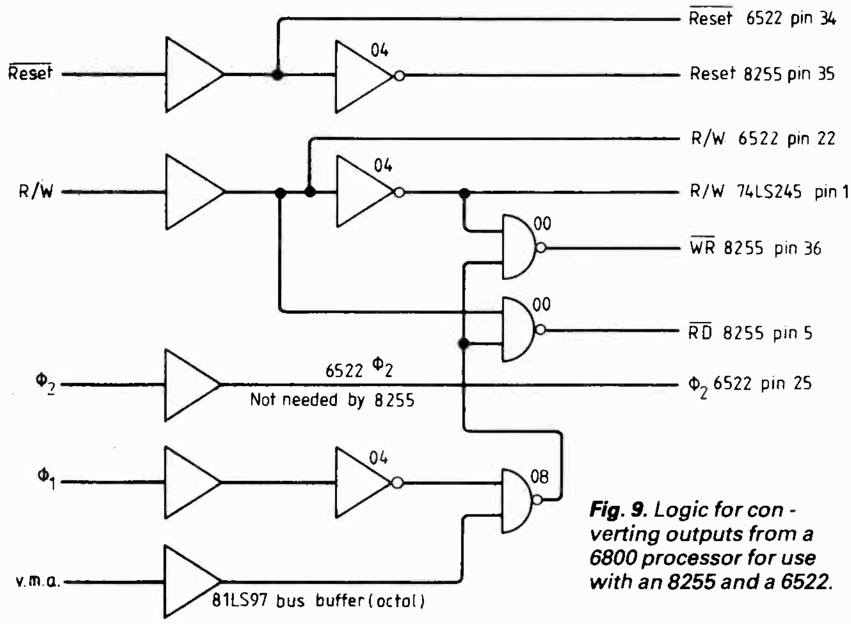


Fig. 9. Logic for converting outputs from a 6800 processor for use with an 8255 and a 6522.

booklet with the addresses against each register. Note that the booklet refers to decimal numbers for the registers and that register 11 (actually A70B) is described on p13 and p16. The 6522 requires a system clock signal ϕ_2, a $\overline{\text{RESET}}$, $\overline{\text{CS}}$ and R/W in addition to the data-bus and four low-order address lines, which connect to the Register Select pins. For interrupt control of the processor the $\overline{\text{IRQ}}$ output should be buffered as in Fig. 9 – the led output is useful for program development though not essential.

The two timers are each 16-bit and may be concatenated by a hardware link PB_6-PB_7 and by software using two registers: A702 (to make PB_7 an output) and A70B (to make timer 1 put a square-wave on PB_7 and timer 2 accept an input on PB_6). This takes two of the ports but is a small price to pay for the facility. Note that the timer accuracy is a function of the system clock alone, although very short delays will be modified by the software handling of the interrupt.

In the author's system ϕ_2 is 625kHz and this produces satisfactory delays from microseconds to over 1 hour. For systems with ϕ_2 at 1MHz, delays will be shorter by a factor of 0.625 if the same time-values are used. To keep things simple, timer 1 division is kept at $FFFF_{16}$ which represents a division of $65\,536_{10}$ making output at PB_7 about 9.5Hz. The necessary delays may be obtained by writing to timer 2 provided the v.i.a. and processor have been configured correctly. It is wise to determine a "time-factor" by entering a large division and determining the delay. For my system the timer 2 factor is 4.74 per second. Thus for a one minute delay the value to be written into timer 2 is $4.74 \times 60 = 284_{10}$. In hexadecimal this is $011C_{16}$, but this is not the value to be written to timer 2: Rockwell insist on reversing the time value, so the entered number will be $1C01_{16}$. With the system suitably conditioned and with a "service IRQ" routine there will be an interrupt one minute from the start of the countdown. Note that there is an interrupt flag register $A70D_{16}$ which contains seven source flags (only the one from timer 2 is used here) together with a master flag which only clears when all the other flags have been removed.

To guard against the possibility of the mode-switch being altered by mistake, it is wise to make use of the CA_1 interrupt line using the relay contacts shown at the bottom of Fig. 6. This puts a positive pulse on CA_1 and causes an interrupt to occur if A70C is properly configured with A70E enabled. WW

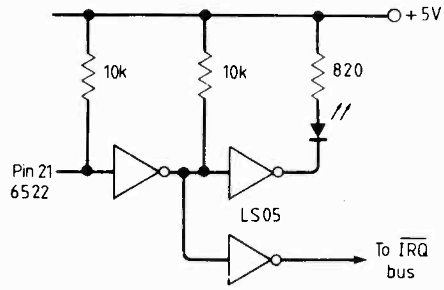


Fig. 10. Interface for Interrupt. The led is useful during program development.

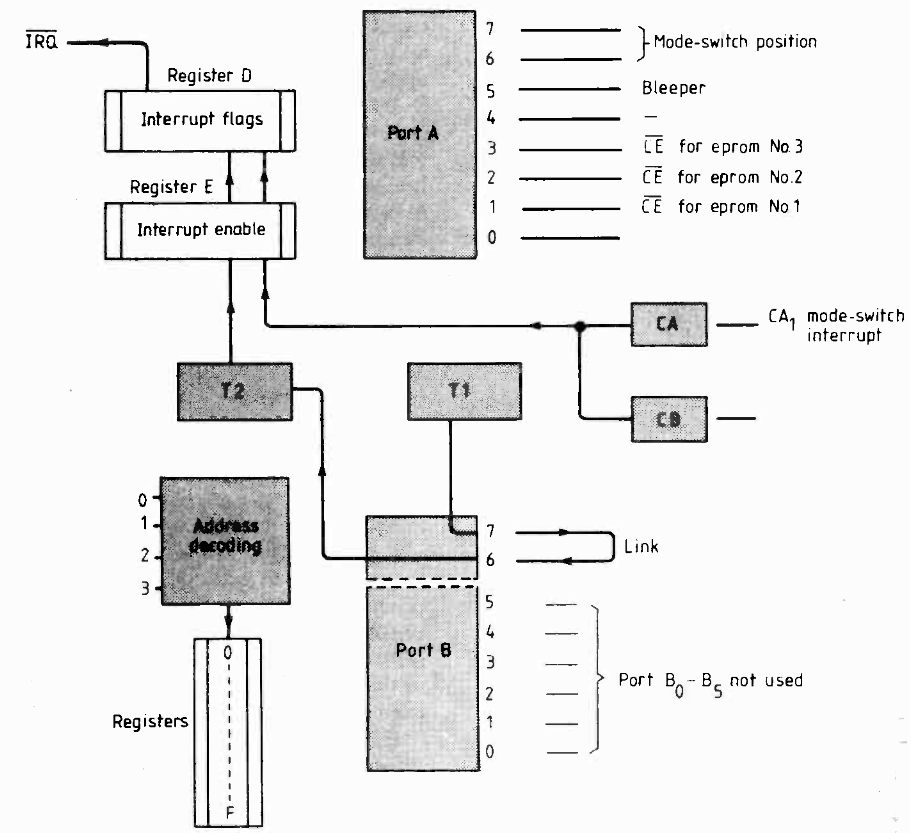
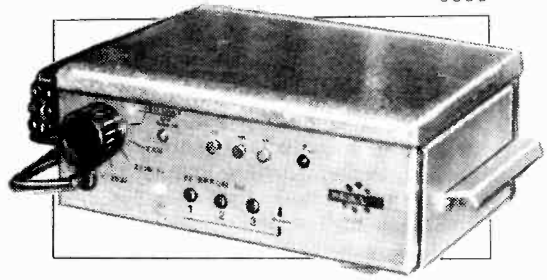


Fig. 11. Block diagram of the 6522 "versatile interface adapter" showing features used in this project. Note that both ports may be bit-programmed as inputs (although PB_6 and PB_7 are 'lost' to the timer function). The interrupt lines CA_{1-2} and CB_{1-2} are not all bi-directional. The input to $timer_1$ is from the system clock and it is essential that this is not prescaled since it is used to enter register data along with CE and R/W (see also Fig. 9).



The author's eprom eraser. On one end of the cabinet is the handle of the light-tight drawer; on the other is mounted the choke for the ultra-violet tube.

Footnote

Since the earlier articles appeared, Fairchild have ceased to supply the 2708. Perhaps it was not made clear that the 25V program pulse is only critical when programming 2708s; however, there may be some improvement in reliability through adhering to the rise and fall characteristics which the buffer circuit ensures.

COMPETITION (£8,000 IN PRIZES)

There's still time to enter

To design an electronic device to help the disabled was the brief we gave our readers in setting the competition; and from the entry registrations already received, it seems clear that a good number of ideas of real value to the handicapped are on the way.

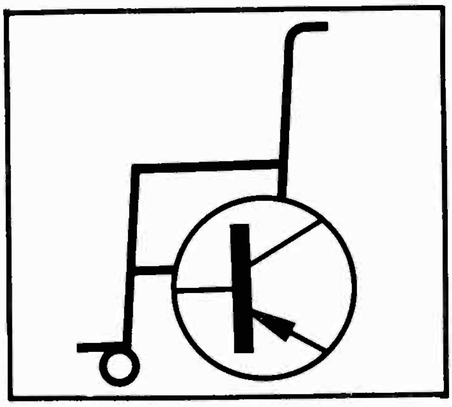
One entrant who is himself disabled is Mr Bernard Nock, of West Bromwich. Mr Nock, an electronics teacher, has some difficulty in getting around; although not perhaps in the way you might at first think. His difficulty, he says, is operating the rather fiddly dashboard switches in his car. He's working on a solution, and it will probably come in the shape of a kind of hand-held key-pad which would plug in to the wiring loom of the car, perhaps underneath the bonnet, to extend the electrical controls of the vehicle to somewhere more accessible. The advantage of a plug-in unit would be that it could be removed easily when the time came to sell the car. However, Mr Nock may not be confining himself just to straightforward logic devices and relays: with speech-synthesis chips and voice recognition techniques developing so fast, he is day-dreaming about the possibility of a voice-controlled car. There are cars that talk now, so why shouldn't they listen too?

The ability to get about is something that many disabled people cannot take for granted; and so cars and mobility feature in quite a number of proposals. Among them, no doubt, will be the entry from Mr Frederick Box of Yardley Wood. Mr Box is a former Lucas employee who started his own business, Autronics Ltd, when he was made redundant; and he tells us he has a number of bright ideas under consideration for the competition.

In Porthcawl, Mr Gerald Don is busy dealing with an everyday frustration for many arthritic people – the business of getting in and out of their front doors. Most door locks require fairly nimble fingers to open and close them, but if you have arthritic hands it can be difficult even to get hold of the key. Mr Don's project is a simple conversion for a standard Yale or similar type of lock, enabling it to be opened by a hand-held infra-red transmitter. Additional receivers inside the house would enable the user to let visitors in without having to get up and go to the door. To ensure security, the user would have a secret code-number to punch in.

Some related problems are being tackled in an entry to be submitted by Hudson-Gillen Associates of Ipswich. Tony Hudson and Pat Gillen are working on an automatic control system to help disabled people within the home. The system is to include an assistance alarm for use in emergencies. And Mr Martin Roantree, an electronics engineer who works in Harlow, is designing a 'sound sensor' to help the blind in what he hopes will be a wide variety of ways.

Several competitors are putting in useful work on what might be termed navigational aids for the blind. Guide dogs may be an effective aid to getting about, but they are quite expensive to train and maintain. Whether electronics can render them obsolete yet remains to be seen; but among the bids



so far are an electronic direction finder from Mr John Wheable of Stanstead Abbotts, a microprocessor-based ultrasonic guidance system from Dr Tony Heyes of the Blind Mobility Unit at Nottingham Universty, and an electronic 'blind man's compass' from computer consultant Mr Charles Laine of Marlow.

An aid for the blind of a different sort is being devised by electronics engineers David Joseph and Graham Norman of Applied Robotics Ltd in East London. This one is to enable blind people to identify the contents of tins and packages before opening them, without the use of braille.

The cost of microcomputer chips has lately fallen to the extent that it makes economic sense to use them even in relatively trivial applications, and computer techniques will undoubtedly be evident in many of the entries to the competition. The physically disabled are as interested in computers as anyone else; and a project which promises help for some of them is going on at the Department of Biomedical Physics and Bioengineering at the University of Aberdeen. Dr Michael Bolton and his colleagues are developing a device which will enable people without the use of their hands to operate a conventional computer by mouth-pressure.

Behind the entry from Mr Phil Pickersgill, an electronics engineer who lives in Wokingham, was in approach recently from a speech therapist who needed an aid for patients suffering from a disability known as continuous speech. These people are unable to put in the pauses which should separate their words and their speech is hard to understand. An hour of training with the speech therapist every week does help but it is often not enough. With the therapist's co-operation, Mr Pickersgill is now testing prototypes of his device, which allows the patient to practise at home. If he forgets to pause, it buzzes a gentle reminder.

If all this has prompted some ideas for a contribution of your own, there may still be time to send in your entry. We have asked competitors to register their wish to take part by June 30th, 1983, although they have until October 1st to complete their designs and submit them to the Editor. Registering an entry does not commit you to any particular project – and indeed several of our entrants are still keeping their options open.

One stipulation we make is that the device must be an electronic one. In other words, new kinds of tin-opener are not eligible; unless, that is, they involve something like robotics perhaps. With computer projects, we would want to see more than just the software. More information, together with a list of the rules and an entry form, appears on page 98 of this issue.

Entry is open to all, including individuals, schools, colleges and professional design teams. The prizes are substantial enough to be an encouragement even to the busiest engineers, whether professional or amateur; but we hope that the real winners will be the disabled themselves. In that sense, even the unsuccessful entries may be successful.

Network design by calculator

Using a TI-59 calculator to design equalizing networks for filters

by Kamil Kraus

Equalizing networks are frequently desirable to provide equalization for filter characteristics in transmission systems. This article gives a new program which computes the component values of the equalizer in the form of a bridged-T network of any structure. A circuit suitable for lowpass and bandpass filters respectively is given in Fig 1. According to the theory of four-terminal networks, the bridged-T may be considered in the form as given in Fig. 2, since the values of L_2 and C_2 are the dual of C_1 and L_1 respectively. With a little computation, the attenuation $\alpha(\omega)$ of the equalizing network can be put in the form

$$\alpha(\omega) = 10 \log \frac{[2K_5 + (K_3^2 + \omega^2 K_4^2)]^2 + (2\omega K_4 K_5)^2}{4[K_3^2 + (\omega K_4)^2]}$$

Here, the parameters K1, . . . K5 may be computed according to the network applied. For the networks as given in Fig. 1, the expressions for K are summarized in Table 1, where all components are normalized to the resistance Z.

The program is based upon the approximation of two normalized values. R_1 and C_1 are used in the first case, whereas in the second case the approximation of three values are taken R_1, C_1 and L_2, supposing only the attenuation α at a given frequency ω is known. The initial guess of parameter values influences how rapidly the iterations converge. In the first case considered, the iteration process takes about 11 minutes and about 18 minutes in the second one. The program encounters 431 steps.

To be able to examine the program quickly the following example is given.

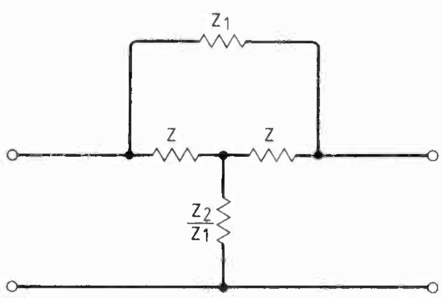
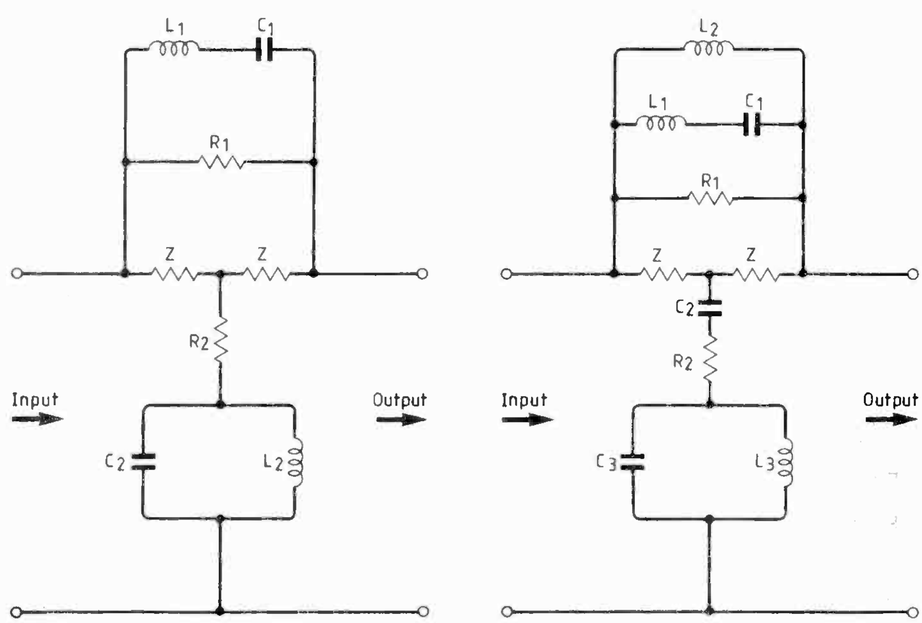


Fig. 2. *Duality of L and C allows bridged-T to be shown in this standard form.*



(a) (b)

Fig. 1. *Suitable circuit to equalize lowpass (a) and bandpass (b) filters, using bridged-T network.*

Input values

STO 00 : 0
STO 03 : $\omega_0 = 6.912455.10^5$ rad/s
STO 04 : $\omega = 6.725680.10^5$ rad/s
STO 05 : $C_1 = 1.10^{-9}$
STO 14 : $\Delta C_1 = 1.10^{-10}$
STO 15 : $\Delta R_1 = 0.01$
STO 16 : INV 2nd log 0.085
/ $\alpha = 0.85$ dB /
$\Delta = 1.10^{-7}$ to X≥t

Computed values

$R_1 = 85.5$	Ω
$C_1 = 4.47.10^{-11}$	F
$L_1 = 0.0468$	H
$R_2 = 263.2$	Ω
$C_2 = 2.082.10^{-6}$	F
$L_2 = 1.005.10^{-6}$	H

$\omega_0^2 = 1/L_1C_1$

Program to compute component values of network for lowpass and bandpass filters

```
LRN
RCL 1
INV 2nd X≥t
A
D
2nd Lbl A
2nd St. Flg 0
RCL 4 : RCL 3=X²−1=±STO 6 X² STO 7
RCL 0×RCL 4×RCL 5=X² SUM 7
RCL 6×RCL 0= : RCL 7=STO 7×RCL 6=
STO 8+1=STO 10
RCL 0×RCL 5×RCL 7=STO 9
2nd A'
2nd Lbl 2nd A'
RCL 9×RCL 10×RCL 4×2=X² STO 11
RCL 4×RCL 9=X² STO 12
RCL 8 X² SUM 12
2×RCL 10=SUM 12
```

continued on page 54

Table 1
Constants for expression of attenuation $\alpha(\omega)$

Fig. 1(a)

$$K2 = \frac{KIR_1}{KI^2 + (\omega C_1 R_1)^2}$$

$K3 = K1\ K2$
$K4 = K2C_1R_1$
$K5 = 1 \times K3$

Fig. 1(b)

$$K2 = \frac{KIL_2}{(K1 - \omega^2 C_1 L_2)^2 + (K1\omega L_2/R_1)^2}$$

$K3 = \omega^2 K1K2L_2/R_1$
$K4 = K2(\omega^2 C_1 L_2 - K1)$
$K5 = 1 + K3$

Timing data transfer

A simple technique for measuring the speed of data transmission between microcomputers.

by Philip Barker Ph.D.

Undoubtedly, although fibre-optic transmission systems are growing rapidly in importance, the most popular techniques for interlinking localized computers are still based upon the use of some form of wire cabling. The speed of transmission that can be achieved with cable systems depends upon the type of cable used, the nature of the interface circuits that are employed and higher level factors such as the type of software data exchange protocols and error checking that is performed on the data.

We have recently been involved in the interlinking of a variety of different microcomputer systems[1,2]. The work that has been undertaken was orientated towards an investigation of the use of multiple microprocessor networks as a means of improving the user interface with microcomputer database systems: experiments designed to measure the speed of data transmission between some of the component computers arose as an ancillary interest and gave rise to a simple technique for measuring data transfer speed.

Measuring procedure

During the transmission of data between two micros, one acts as the transmitter while the other acts as the receiver of data. A third microcomputer, attached to the transmitter, can be used to measure the duration of the data transmission transaction, and is referred to as the timer. The experimental arrangement is depicted schematically in Fig. 1(a). Communication between the timer and the transmitter is via an appropriate i/o port within the latter: if such a port is not available, a specially designed memory-mapped interface can be fitted. For simplicity, the systems to be described are all based upon a suitable i/o port within the transmitter and, in all cases, the ports that have been used provide t.t.l. compatible signal levels. Most of the experiments have involved the use of a MOS Technology 6522 Versatile Interface Adapter (VIA)[3].

The measuring process depends upon the transmitter changing the status of an i/o line just before the commencement (and just after the termination) of data transmission – see Fig. 1(b): a program running in the timer monitors the status of this i/o line. When it detects the high-to-low transition it starts counting upwards from zero, continuing until the program subsequently detects the low-to-high transition which indicates the end of data transfer. The value of the count contained within the timer can then be used to compute the data transmission period, T, which may be achieved by the use of a previously prepared calibration graph(s). Alternatively, the known execution times of the program instructions can be used to calculate a loop cycle speed for the timer program, which can then be used as a multiplicative conversion factor.

The timer program used in the measurements is shown in Table 1. It is written in 6502 assembler code, which is subsequently run on a Commodore PET microcomputer[4,5]. It could easily be converted to run on other 6502 based systems (KIM, APPLE, AIM, etc.) by changing the addresses of the data direction register (DDR), user port (USER), print subroutine (PRINT) and the value assigned to the location counter at the start of the assembly.

The program uses the PET's 6522 VIA pin (PA0) for its connection to the transmitter. Zero page locations 0, 1 and 2 are used to store the count value. Once the program has been activated, it goes into a wait state until the status of pin PA0 goes low: as soon as this happens it enters its counting state until forced out of this when PA0 goes high again. Notice that prior to entering the wait state the program disables all interrupts (using the SEI instruction) to prevent the c.p.u. being called upon to perform any other ancillary tasks (for example, keyboard scan, clock update) while the data transmission period is being measured. Once the timing loop has terminated, system interrupts are again enabled (via the CLI instruction).

To test the program, an arrangement similar to that shown in Fig. 1(c) was used. The timer program was employed simply to measure the length of time for which a debounced switch circuit was held on: after each timed interval the contents of memory locations 0, 1 and 2 were examined and a total count value then computed. The results of some typical experiments are presented in Table 2(a). A graph of the total loop count was then plotted against the elapsed time as recorded by the stopwatch, these results being shown in Fig. 2(a). The timer program's loop execution time, as derived from the graph, is thus $36/(22.7\times10^5)$ which is equivalent to 1.6×10^{-5} seconds.

The alternative approach to estimating the timer program's loop cycle time depends upon a knowledge of the speed of execution of each of its component instructions. These are usually tabulated in programming manuals or hardware system specifications[6] for the 6502 chip. For the instructions involved in the timer program the relevant values are:

LDA	4 cycles
AND	2 cycles
BNE	2 cycles
INC	5 cycles
BNE	3 cycles
Total:	16 cycles

The BNE instruction can take 2, 3 or 4 cycles – depending upon whether the branch is taken and whether the branch operation involves crossing a page boundary. Since no page boundaries are crossed the values to be used in this case are 2 and 3. A value of 2 is used for the first BNE instruction since this branch is never taken – at least, until the end of the interval

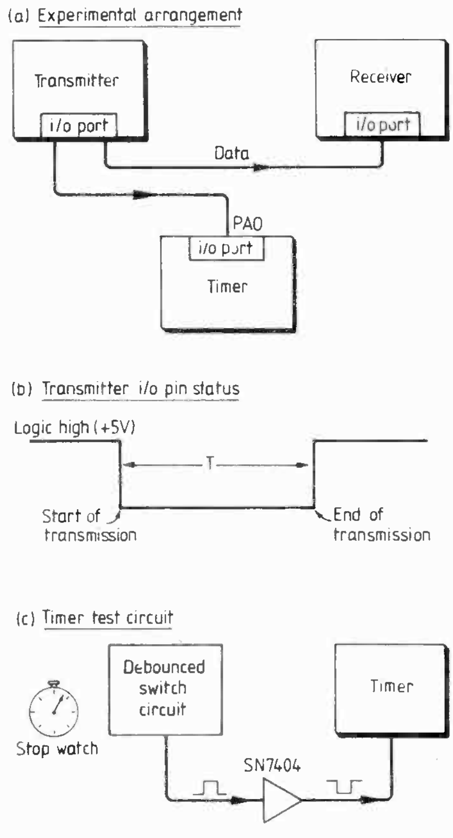


Fig. 1. Measurement technique using microcomputer as timer. Changes in status of i/o time at (b) determine counting period, test circuit for timer being shown at (c).

Department of Computer Science, Teeside Polytechnic.

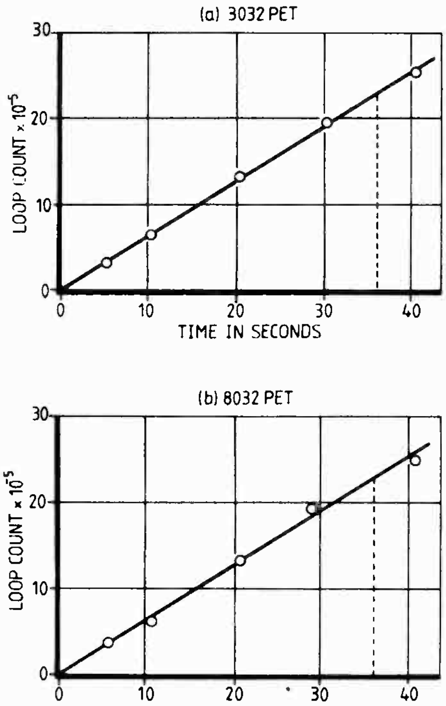


***Fig. 2.** Graph of time against total loop count gives loop execution time for 3000 and 8000 series PET micros.*

being timed. A value of 3 is used for the other BNE instruction since this branch is virtually always taken – except when SUMH and SUMU are incremented.

The approximations used in the above formulation for the total number of cycles are reasonable since, if one assumes that the microcomputer clock speed is such that one cycles takes one microsecond, then the loop cycle time is easily calculated to be 1.6×10^{-5} seconds. This is in reasonable agreement with the value derived by the graphical approach.

In the data transmission experiments both a 3000 and an 8000 series PET have been used as a timer. Converting the 3032 program (see Table 1) for operation on the 8032 computer only required changing the address of the PRINT routine from $CA1C to $BB1D. Timing experiments analogous to those performed with the 3032 computer could then be conducted with the 8032 system. The results are shown in Table 2(b) and are presented graphically in Fig. 2(b). From this graph, the loop cycle time can be estimated as $36/(22.9\times10^5)$, that is, 1.6×10^{-5} seconds. This agrees closely with the value observed for the similar program running on the 3032.

From the experiments described in this section it is easy to see that the timer program offers a convenient means of measuring data transmission speeds. It is limited, however, in that the smallest time interval it could measure would be about 16 microseconds, which means that in our experiments we could not measure transmission speeds faster than about 16 Mbytes/s (PET-to-INS8060 transfer) or 2048 Mbytes/s (PET-to-PET transfer). However, because the transmission speeds involved in our systems are well below these limits this inherent limitation of the timer is of little concern.

Some data transfer measurements

Three different examples of microcomputer interconnection are described here. Two of these involve the use of parallel interfaces: in one case the standard IEEE-488 port is used[7] while in the other the direct linking of i/o ports is employed. The third example involves the use of a serial interface involving the use of a one byte buffer.

PET-to-PET transfer. The arrangement of the equipment for this transfer operation is shown schematically in Fig. 3. In this experiment, the data lines associated with the IEEE port of the 8032 were directly linked to the corresponding data lines of the IEEE port on the 3032 PET. A third PET system, another 3032 (not shown), was used as the timer. The transmitter then used its PA6 output line to interconnect with the timer's PA0 input pin. Some of the other user-port lines within the transmitter and receiver were employed as control lines to effect the handshaking of the data presented on the lines of the IEEE port. Four control lines were used: DAV (data valid), EOT (end of transmission), ACK (data acknowledge) and RFD (ready for data), implemented via user port connections PA0, PA2, PA1/CA1, and PA3 respectively. In the case of the ACK signal a choice between CA1 and PA1 at the transmitter end of the link could be used to decide whether this was (CA1) or was not (PA1) latched.

The details of the transmitter and receiver programs (in both BASIC and assembler) are given elsewhere[1], and may be used to send the contents of memory locations $2000 through $2FFF across the data link from PET1 to corresponding locations within PET2. Inspection of locations 0,1 and 2 in the timer yielded the results shown in Table 3(a). The transmission experiment was repeated five times giving an average count value of 26369, which gives a transmission time for the experiment of $26369\times1.6\times10^{-5}$, or 0.422 second. Since a total of 4096 bytes was transferred during this interval, the average transmission speed was therefore 9706 bytes/s.

PET-to-INS8060 (SC/MP) transfer. The experimental arrangement for this transfer is shown in Fig. 4. Notice that the pins used for interfacing the INS8060 are t.t.l.-compatible[12,13] and so could be directly connected to the appropriate user port pins of the PET. This approach was not used because we wished to investigate the additional programming overhead associated with using a serial-in-serial-out (siso) register as a buffer.

The way in which this interface works is as follows. The PET uses its serial shift register (which is a part of the 6522 VIA) to put data (serially) into the SN74LS91 buffer. When this operation has been completed, the PET signals 'data valid' to the SC/MP through the latter's SENSE-B input line. The SC/MP then generates clock pulses (on its FLAG-0 line) and strobes the data out of the buffer into its extension register via its serial input pin (SIN). After eight strobe pulses, the SC/MP acknowledges receipt of the data via its FLAG-1 line, which is attached to the PET's PA1 input pin. When the transmitter has passed across all the data, it signals the end of transmission by driving the EOT line high, which causes an interrupt in the SC/MP, causing it to jump to a special interrupt handling routine. Notice that because of the SC/MP architecture (and the mode of operation of the PET shifter) the passage of a data byte from transmitter to receiver causes bit reversal. Thus, it is important for the transmitter to reverse the bit pattern of all the data bytes before they are transmitted. This is done (for all of the data) prior to entry to the data transmission loop and so the time required to do this does not contribute to the data transfer interval. The programs for the transmitter (in 6502 assembler) and the receiver (in INS8060 assembler) are presented elsewhere[1].

The SC/MP system used for the experiments had available only 256 bytes of ram in which to store data. In view of this, only a limited volume of data could be transferred to it. The results for the transfer of 256 bytes of data from the PET (locations $2000 through $20FF) to the SC/MP are presented in Table 3(b): the average value for the count is 12443 which corresponds to a data transfer interval of 0.199 and, since only 256 bytes were transmitted, the average data transfer rate was thus 1286

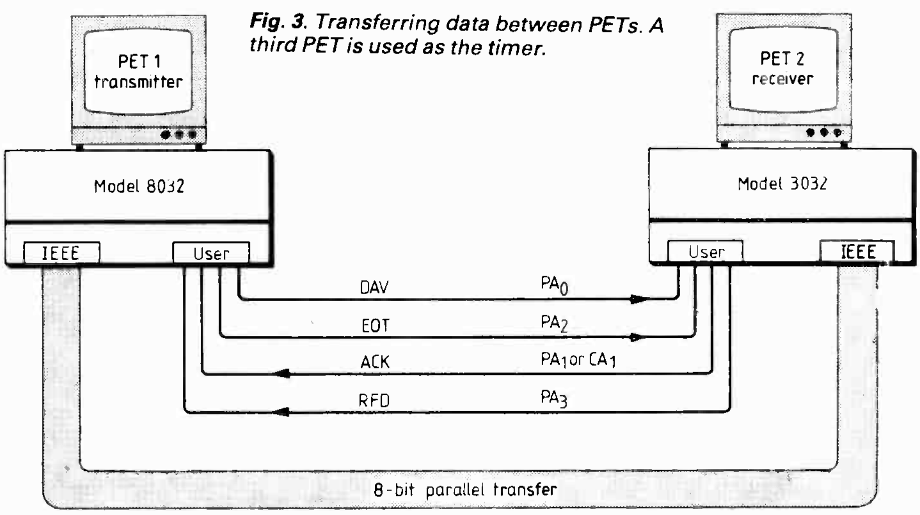


***Fig. 3.** Transferring data between PETs. A third PET is used as the timer.*

bytes/s. Notice that the ratio of 9706 (parallel transfer) to 1286 (serial transfer) is 7.55. As might be expected, byte serial transfer is about eight times slower than byte parallel exchange.

Z80-to-PET transfer. For these experiments a SOFTBOX system was used[10]. This is essentially a plug-in hardware device that is designed to provide the PET microcomputer with access to the CP/M operating system[2]: the control software necessary to run the system is supplied on a 5.25in floppy disc: a disc unit is thus essential in order to use the SOFTBOX interface. The way in which the unit attaches to the PET's IEEE bus is illustrated schematically in Fig. 5. As can be seen from this diagram, for these experiments, an 8032 PET was used as a timer – interconnection of the two PETs was achieved via the PA0 user port line on each of the machines.

Within the SOFTBOX is housed a Z80 microprocessor that runs at a clock speed of 4MHz. In addition, there are 60 Kbytes of ram and rom to store the CP/M BIOS code[2]. The Z80 communicates with the PET's IEEE bus via two Intel 8255 peripheral support chips[11], the interconnections between the PET and the Z80 being illustrated in Fig. 6. When the Z80 system become active, it takes over control of the PET's disc drive and printer (see Fig. 5). The PET itself then acts as a dump terminal to the Z80 system.

In addition to storing the CP/M BIOS code, the rom contained in the SOFTBOX provides many other useful routines. They may all be accessed by user programs running on the Z80 memory space via a series of jump vectors located at address $F003 and above. Two useful entry points within the rom store are PEEK and POKE – the POKE routine transfers data from the Z80 memory space across to that of the PET via the IEEE bus, and PEEK is complementary to POKE. This entry point can thus be employed to move data in the reverse direction – from the PET back to the Z80. In both cases, the Z80 register pairs BC, DE and HL are employed to hold the relevant transfer parameters: B and C specify the size of the memory image involved, while the relevant source/target addresses are held in DE (for the PET) and HL (for the Z80). Details of the architecture of the Z80 (and Intel 8080) are given[3]. A simple program for performing timed data transfer from the Z80 across to the PET is depicted in Table 4.

The program is written in 8080 assembler. First, a 4096 byte region of memory is initialized. Each byte within the defined area (with base address SBDATA) is set to the arbitrarily selected value $AB. The POKE entries immediately following the initialization loop then set the data direction register of the PET and also put the signal level on PA0 to logic high. The call to the dynamic debugging tool (DDT) is then used to check that the data area has been set up correctly; it also provides a processing interrupt that enables the timer program running on the 8032 to be put into a wait state. When the program in the Z80 is restarted it uses a series of POKE commands to (a) start the timer counting, (b) pass across the data to the PET, and subsequently, (c) switch off the timer by forcing the 3032's PA0 line into a high logic state. As in the previous experiments, processor interrupts are disabled prior to the data transfer steps and re-enabled immediately after it.

The timer count values extracted from the 8032 zero page locations (0, 1 and 2) are presented in Table 3(c). As was the case in the other experiments, measurements were repeated five times in order to check their reproducibility, giving an average count value of 40273. The data transfer interval calculated from this value is thus 0.644s which corresponds to a transfer rate of 6360 bytes/s.

The program presented in Table 4 runs within the environment of the CP/M dynamic debugging package[2], which was used to take advantage of the interrupt

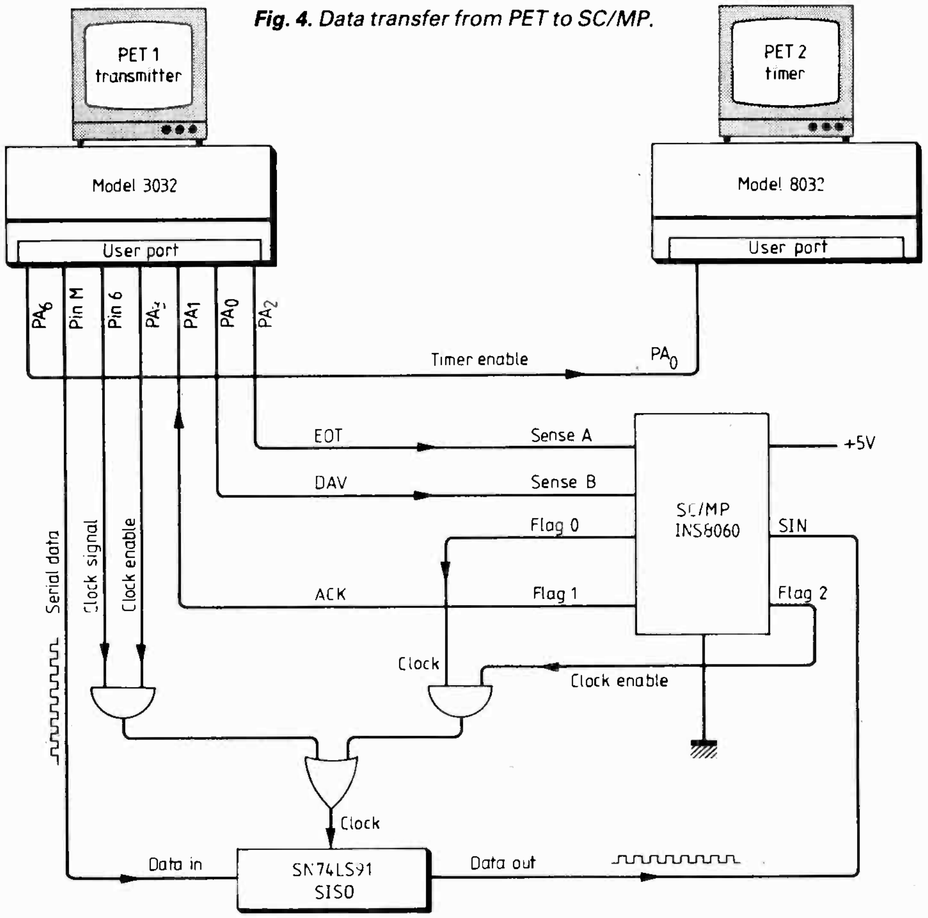


Fig. 4. Data transfer from PET to SC/MP.

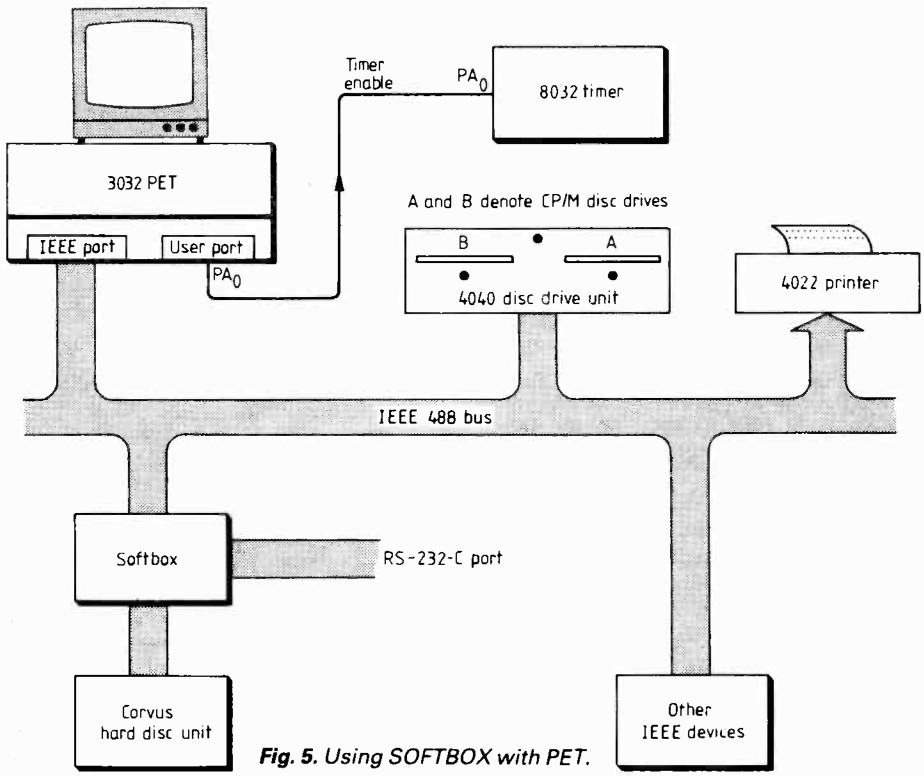


Fig. 5. Using SOFTBOX with PET.

Table 1. Program for using PET as timer, convertible for use with other 6502 micros.

```
0000                    ;TIMER
0000                    ;*****
0000                    ;
0000                    ;USING PET AS A TIMER
0000                    ;
0000                    DDR=59459
0000                    USER=59471
0000                    PRINT=$CA1C
0000                    SUML=$0000
0000                    SUMH=$0001
0000                    SUMU=$0002
0000                             *$5000
5000  A9 00             START    LDS   #$0
5002  8D 43 E8                   STA   DDR     ;ALL PINS AS INPUT
5005  A9 00                      LDA   #$0
5007  85 00                      STA   SUML    ;ZEROISE LOW COUNT
5009  85 01                      STA   SUMH    ;ZEROISE HIGH COUNT
500B  85 02                      STA   SUMU    ;ZEROISE ULTRA COUNT
500D  78                         SEI           ;DISABLE INTERRUPTS
500E  AD4F E8           WAIT     LDA   USER
5011  29 01                      AND   #$01    ;WAIT FOR PA0
5013  D0 F9                      BNE   WAIT    ;TO GO LOW
5015  EA                         NOP
5016  AD4F E8           TIMER    LDA   USER
5019  29 01                      AND   #$01
501B  D0 15                      BNE   END
501D  E6 00                      INC   SUML    ;INCREMENT LOW COUNT
501F  D0 F5                      BNE   TIMER
5021  E6 01                      INC   SUMH    ;INCREMENT HIGH COUNT
5023  D0 F1                      BNE   TIMER
5025  E6 02                      INC   SUMU    ;INCREMENT ULTRA COUNT
5027  D0 ED                      BNE   TIMER
5029  58                         CLI
502A  A9 3B                      LDA   #<ERR
502C  A0 50                      LDY   #>ERR
502E  20 1C CA                   JSR   PRINT
5031  00                         BRK
5032  58                END      CLI
5033  A9 59                      LDA   #<TUP
5035  A0 50                      LDY   #>TUP
5037  20 1C CA                   JSR   PRINT
503A  00                         BRK
503B  0D                ERR      .BYTE $D,$A, 'ERROR – INTERVAL TOO
                                 LONG',$D,$A,$00
503C  0A
503D  45 52
5056  0D
5057  0A
5058  00
5059  0D                TUP      .BYTE $D,$A, 'END OF TIMES INTERVAL', $D,$A,$00
505A  0A
505B  45 4E
5070  0D
5071  0A
5072  00
5073                             .END
```

facilities provided by the RST 7 instruction. To prove that the environment provided by DDT did not influence the speed of transmission, a further experiment was conducted. This necessitated re-writing the transfer program in such a way that the RST 7 calls could be dispensed with. Instead, the same effects were achieved through appropriate use of the CP/M BDOS routines for console output (CONOUT) and input (CONIN). CONOUT was used to display a prompt character on the 3032 screen. The Z80 processor then went into a wait loop until a pre-defined escape character (*) was typed on the 3032 keyboard. When the prompt character was displayed, the 8032 timer was started and the escape character then typed – thereby releasing the Z80 for its data transfer activity. The results obtained using this approach are listed in Table 3(d). As there is no significant difference between the results in Tables 3(c) and 3(d) we conclude that the DDT package did not influence the speed of execution of the program shown in Table 4.

A final set of experiments was conducted to see if the speed of transfer for PET-to-Z80 transmission was the same as that which was observed for Z80-to-PET transfer. To do this a new program was written, similar to that shown in Table 4, except that, instead of using the SOFTBOX POKE entry, it used the PEEK routine for block data transfer. The results of this set of experiments are presented in Table 3(e). Comparing these results with those of Tables 3(c) and 3(d) suggests that transfer in this direction is about 10% slower – probably due to the different ways in which the PEEK and POKE firmware is implemented within the SOFTBOX unit.

It is interesting to observe that parallel data transfer using the standard IEEE-488 bus (Z80-to-PET) is about 30% slower than that encountered in the other parallel transmission technique (PET-to-PET) that was used. This discrepancy is probably due to the additional overhead associated with the need to specify listener/talker addresses when transmitting data over an IEEE bus.

The maximum speed of transmission that can be measured using this simple method is given by the relationship $S=V/1.6\times10^5$ bytes/s, where V is the volume of data (in bytes) that is passed.

In the experiments that have been described above a fairly expensive timing element was used – far too costly to dedicate solely for timing measurements. However, where such machines are used as general laboratory tools[12] an approach of this type is not unreasonable. Indeed, in the machines used in our laboratory the timer software shown in Table 4 is permanently

Table 2. Results of timer calibration.

(A) 3032 PET

TIME	SUMU	SUMH	SUML	Total	Rounded Total $\times 10^{-5}$
5	04	BE	38	310,840	3.1
10	09	AB	19	633,625	6.3
20	13	96	77	1,283,703	12.8
30	1D	1F	A3	1,908,643	19.1
40	26	04	97	2,491,543	24.9
Weight	65,536	256	1		

(B) 8032 PET

TIME	SUMU	SUMH	SUML	Total	Rounded Total $\times 10^{-5}$
5	05	17	6B	333,675	3.3
10	09	75	64	619,875	6.2
20	13	32	8C	1,258,124	12.6
30	1D	25	79	1,975,673	19.7
40	26	36	AB	2,504,363	25.0
Weight	65,536	256	1		

Table 3. Results of timing data transfer.

A: PET TO PET TRANSFER

Expt. No.	SUMU	SUMH	SUML	Total
1	00	66	FE	26,366
2	00	67	00	26,368
3	00	67	00	26,368
4	00	67	00	26,368
5	00	67	00	26,368
Weight		256	1	26,369 (Av)

B: PET TO SC/MP TRANSFER

Expt. No.	SUMU	SUMH	SUML	Total
1	00	30	A1	12,449
2	00	30	96	12,438
3	00	30	9B	12,443
4	00	30	95	12,437
5	00	30	A1	12,449
Weight		256	1	12,443 (Av)

C: SOFTBOX TO PET – CASE A

Expt. No.	SUMU	SUMH	SUML	Total
1	00	9D	5B	40,283
2	00	9D	4F	40,271
3	00	9D	4F	40,271
4	00	9D	4D	40,269
5	00	9D	51	40,273
Weight		256	1	40,273 (Av)

D: SOFTBOX TO PET – CASE B

Expt. No.	SUMU	SUMH	SUML	Total
1	00	9D	49	40,265
2	00	9D	51	40,273
3	00	9D	4A	40,266
4	00	9D	4B	40,267
5	00	9D	61	40,289
Weight		256	1	40,272 (Av)

E: PET TO SOFTBOX

Expt. No.	SUMU	SUMH	SUML	Total
1	00	B1	C2	45,506
2	00	B1	B2	45,490
3	00	B1	CC	45,516
4	00	B1	D5	45,525
5	00	B1	BF	45,503
Weight		256	1	45,508 (Av)

held in a rom module fitted to the microcomputer's memory-expansion sockets. This rom module also contains a variety of other useful firmware that is frequently required for other laboratory applications; for example, terminal emulation, data smoothing, pattern matching and so on.

Those situations that do not permit the use of a general purpose laboratory microcomputer (as described above) would require a less costly approach – easily achieved through the use of less expensive single board microsystems. Indeed, we have used a KIM micro[13] to perform exactly the same measurements that were undertaken by the 3032 and 8032 timer systems – at about one seventh the cost. If need be, further substantial cost reductions for the timer system could be achieved by simply wiring up a 6502 c.p.u., a 6522 VIA, some rom and a simple read-out system.

The author is grateful to Small Systems Engineering Ltd (UK) for their encouraging help and invaluable assistance during the preparation of this paper. He is also

continued on page 58

The author

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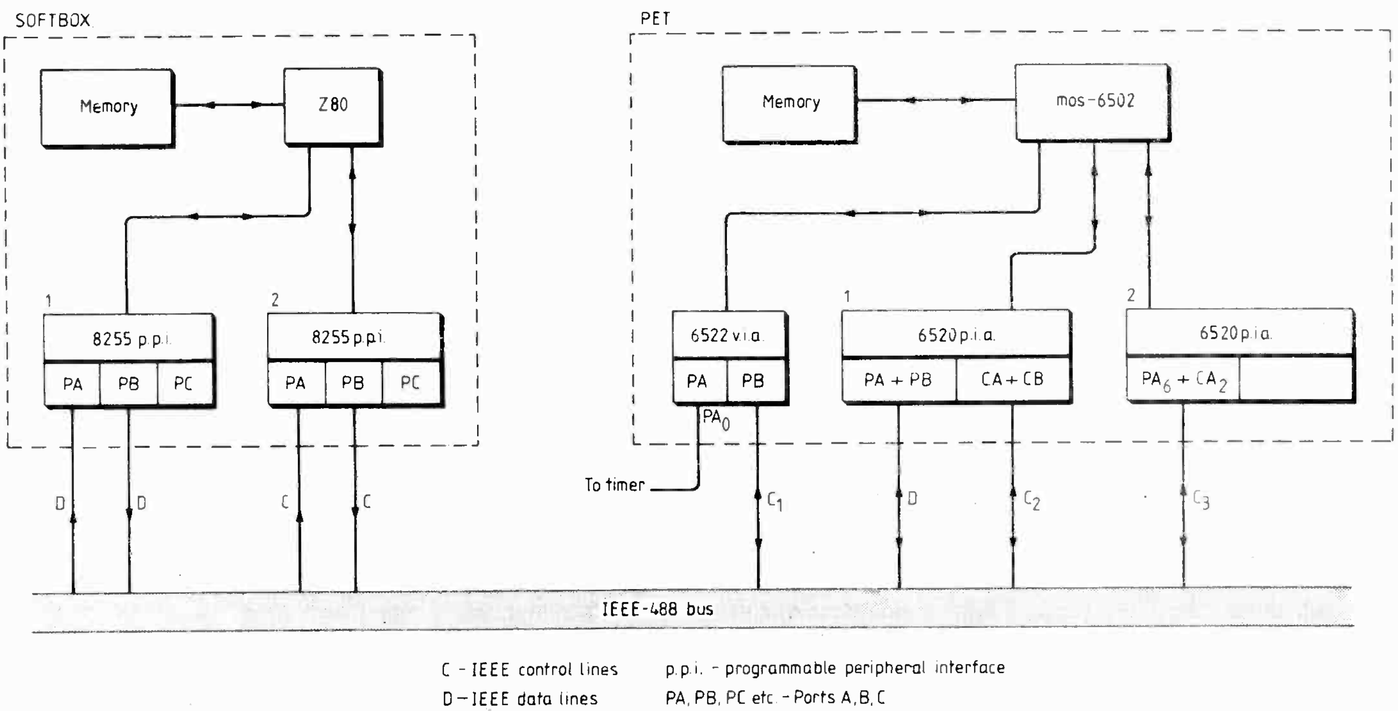
Table 4. Program for timing transfer from 280 to PET.

```
3000 =              TOPET   EQU  3000H      ;TARGET ADDRESS FOR DATA
2000 =              SBDATA  EQU  2000H      ;SOURCE ADDRESS OF DATA
E84F =              UPORT   EQU  59471      ;PET USER PORT ADDRESS
E843 =              DDR     EQU  59459      ;PET DATA DIRECTION REGISTER
0001 =              N1      EQU  1
F069 =              POKE    EQU  0F069H     ;SOFTBOX POKE ROUTINE
1000 =              NSEND   EQU  4096       ;NUMBER OF BYTES TO SEND
0100                        ORG 100H
0100  3E30       BEGIN      MVI A,30H       ;GENERATE TEST DATA
0102  210020                LXI H,SBDATA    ;LOAD SOURCE ADDRESS
0105  36AB       FILL:      MVI M,0ABH      ;MOVE VALUE TO MEMORY
0107  23                    INX H
0108  BC                    CMP H           ;ALL DONE?
0109  C20501                JNZ FILL
                 ;
                 ;INITIALISE TIMER
                 ;
010C  010100                LXI B,N1
010F  1143E8                LXI D,DDR
0112  215101                LXI H,DDRVAL
0115  CD69F0                CALL POKE       ;SET PET DDR
0118  010100                LXI B,N1
011B  114FE8                LXI D, UPORT
011E  215201                LXI H,TMRSTOP
0121  CD69F0                CALL POKE       ;SET PA0 HIGH
0124  FF                    RST 7           ;CALL TO DDT
0125  00         BRK1:      NOP             ;PUT TIMER IN WAIT STATE
                 ;
                 ;SEND DATA TO PET MICROCOMPUTER
                 ;
0126  F3                    DI              ;DISABLE INTERRUPTS
0127  010100                LXI B,1
012A  114FE8                LXI D, UPORT
012D  2155301               LXI H,TMRGO
0130  CD69F0                CALL POKE       ;START TIMER
0133  010010                LXI B,NSEND
0136  110030                LXI D, TOPET
0139  210020                LXI H,SBDATA
013C  CD69F0                CALL POKE       ;SEND DATA TO PET
013F  010100                LXI B,1
0142  114FE8                LXI D,UPORT
0145  215201                LXIH,TMRSTOP
0148  CD69F0                CALL POKE       ;STOP TIMER
014B  FB                    EI              ;ENABLE INTERRUPTS
014C  FF                    RST 7           ;CALL DDT
014D  00         BRK2:      NOP
014E  C30000                JMP 0           ;WARM START
0151  01         DDRVAL:    DB   1
0152  01         TMRSTOP:   DB   1
0153  00         TMRGO:     DB   0
0154                        END
```

Fig. 6. Arrangement for transferring data between 280 in SOFTBOX and 6502 in PET.



Enigma

A detailed examination of the German World War II cipher machine and the cracking of the code.

By D. W. Rollema, PA0SE

In 1974, Group Captain Winterbotham was authorized to publish The Ultra Secret War. This book[1] – and a stream of publications following it – revealed that during the Second World War the Government Code and Cipher School at Bletchley Park (BP) had managed to decrypt a substantial part of all the messages sent by the Germans via radio. How the information so obtained was put to use for the Allied Forces under the code name Ultra has been well documented by Ronald Lewin[2]. Most of these intercepted radio messages were encrypted by using the Enigma cipher machine. The German High Command had an even more complicated and safer device than Enigma, called *Geheimschreiber* (secret writer) which was an on-line encryption unit combined with a teleprinter. Plaintext was typed in and appeared as printed plaintext at the other end. The *Geheimschreiber* was intended to be used on land-lines which were available in most cases between the more or less permanent locations of the High Command. The system could be used via radio as well. Nevertheless, it can be safely stated that the majority of messages BP operated on were in Enigma-cipher. The publicity that has been given to the work at BP has made Enigma a well-known device, although the descriptions of Enigma that can be found in literature remain rather superficial, e.g. by Jones[3].

Enigma, how it works

Explaining the principles of cryptography is outside the scope of this article. An introduction into this fascinating field has been given by Hawker[4], and very thorough treatment with lots of historical background is provided by Kahn[5]. Modern developments in cryptography are discussed by Diffie and Hellman[6] who provide an extensive bibliography. It suffices to state that Enigma works on the principle of substitution: for every letter in the plaintext a different letter is substituted as ciphertext. An extra feature is that the alphabet, from which the substituted letters are taken, is changed with every step.

The machine is housed in a wooden box measuring 34 cm x 28 cm x 15.5 cm and weighs 12 kg (Fig.3). According to Bauer, the wooden box indicates that the machine described here was used by the German Navy; the Army and Air Force had their Enigmas in metal boxes. Figure 4 shows Enigma with the lid in the upright position, ready for use.

The data to be encrypted is entered via the keyboard. It is to be noted that the keyboard contains no keys for figures: where these appear in the plaintext, they are first written out in letters. When a key is depressed, the letter to be substituted in the ciphertext is indicated by a glowlamp illuminating one of the letters in the round windows. So when key D is depressed, for instance, an O may light up as the substitution.

The electrical path between the keys and the glowlamps is not a straightforward one, and changes every time a key is depressed as shown in Fig.5, taken from the operating manual, Fig.2. Here key Q is depressed. Current from the battery flows via contact 46 of key Q to a pair of jacks, also marked Q (see also Fig.6). When no plugs are inserted, the jacks are jumpered by contact 45. The current now continues through contacts on a set of five static and moving rotors 44, the ones on the extreme right and left being the static ones, called *Eingangswalze* (entry rotor) and *Umkehrwalze* (reversing rotor) respectively. The current is returned here and traverses the rotors again and on to another pair of jacks E. Here the plug at the end of a cord is inserted. The plug at the other end guides the current via jack pair W on to glowlamp W and from there finally back to the battery.

So depressing key Q in this example lights up lamp W. By following the current path the reader can easily discover that


H. Dv. g. 13
L. Dv. g. 13
Prüf-Nr 9875

Geheim!

Gebrauchsanleitung
für die
Chiffriermaschine Enigma
Vom 12. 1. 1937

Unveränderter Nachdruck

Berlin 1940
Gedruckt in der Reichsdruckerei

Fig. 2. *Instruction manual for the use of Enigma.*

Fig. 1. *Mr Arthur Bauer, PA0AOB, in his shack at Diemen near Amsterdam. He is the owner of the Enigma machine that forms the subject of this article. For his amateur radio contacts, Mr Bauer uses exclusively German World War II communication equipment. Here he is seen typing on a "Hellschreiber" teleprinting machine. Behind the Hellschreiber, a 1937 transmitter can be seen.*

Fig. 3. The author's daughter Jolande carrying Enigma in one hand and a box with two extra rotors in the other.

depressing key W would result in lamp Q being lit. This mutual relationship between keys and lamps is essential in the process of decrypting a ciphertext.

Figure 6 shows the arrangement of jack-field and cords (*Stecker*). There are 26 pairs of jacks and 13 cords to connect them. In practice only ten of the cards would be used: the six jack pairs without a plug inserted are automatically jumpered, as shown for jack pair Q in Fig.5. The plugs have two pins of different diameter so they can be inserted in only one way. All the rotors (*Walzen*) can be removed from the machine, except for the entry rotor, as can be seen in Fig.7: this has 26 contact pads arranged in a circle. The reversing rotor is normally left in the machine and has 26 contact pins that protrude from the surface under the action of springs, as symbolically indicated in Fig.5. It sits on the shaft that can be seen in Fig.7 on the left.

Between the entry rotor and the reversing rotor, a set of three other rotors is inserted, taken from a total of five. The two remaining rotors are kept in a small wooden box (Fig.3 and 4). The rotors are first rigged on the shaft (Fig.8) and then inserted in the machine: Fig.9 shows the rotors in place on their shaft. By moving the lever on the extreme left in Fig.9, the complete set of rotors is compressed together so that the sliding contact pins on one side of a rotor touch the contact pads on the adjacent one. Each contact pin on one side of a rotor is internally connected to a contact pad on the other side. The arrangement of these internal connections is different for each of the five rotors.

As mentioned earlier the current path between keys and lamps is changed at each key depression. Each time a key is depressed, the rotor on the right moves one twentysixth of a revolution. That means that all contacts move up one step. After 26 key depressions the rotor has made a complete turn and at that moment

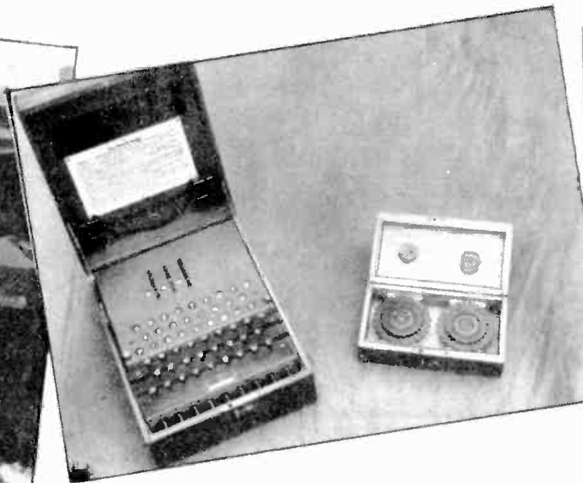


Fig. 4. Enigma ready for use with the box for extra rotors on the right.

the rotor in the middle moves one step. When the middle rotor also has completed a revolution, the rotor on the left moves one step, so that after $26^3=17{,}576$ key depressions, a certain combination of rotor setting will he repeated. Figure 7 shows the mechanism. Three levers, each having a forked shape at their top end, move upwards when a key is depressed. The fork of a lever can engage the toothed wheel at the side of a rotor and move this wheel one step (see Fig.10), which happens with the right rotor every time a key is depressed. For the middle and right rotors the levers are prevented from engaging with the toothed wheel. To engage these, the forked lever not only has to move upwards, but inwards – towards the shaft of the rotors – as well. Excessive inward motion is prevented by the lever coming to rest against a ring on the adjacent rotor to the right of it. In Fig.8, this ring can be seen on the side nearest the matchbox. The lever is free to move in only one position of the rotor to the right of it, where the ring is notched in figure 08 in Fig.8.

Apart from the fact that three rotors have to be selected from five and each of the three rotors can be put into each of the three possible positions in the machine, the Germans introduced one more variable. If the rotor shown in Fig.8 is placed in

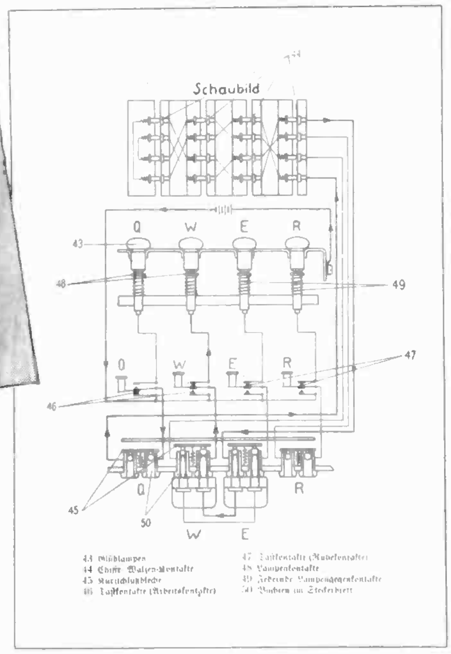


Fig. 5. This page from the instruction manual shows the path of the electric current in Enigma.

the machine in the position on the right, it is clear that when the lever for the middle rotor is at position 08, it can move the middle rotor one step. Now there is not a fixed relationship between the ring with the numbers and the body of the rotor carrying the contacts: the ring can be turned with respect to the rotor, as shown in Fig.11. It is obvious that this then changes the relationship between the inner wiring of the rotor and the notch position at which the adjacent rotor is moved one step forward.

Figure 8 also shows a knurled wheel that protrudes through the metal top that normally covers the mechanism of Enigma when in use (Fig.4). By means of these wheels, the cipher clerk can move the rotors to any starting position, indicated by the figures on the rings showing in the windows next to the wheels. This permits the operator to set the key for a message to be enciphered, as explained later.

As has already been mentioned, Enigma operates only on letters; nevertheless, figures are used to indicate the position of the rotors and also the keys used for encipherment. Here a simple one-to-one relationship exists between the 26 letters of

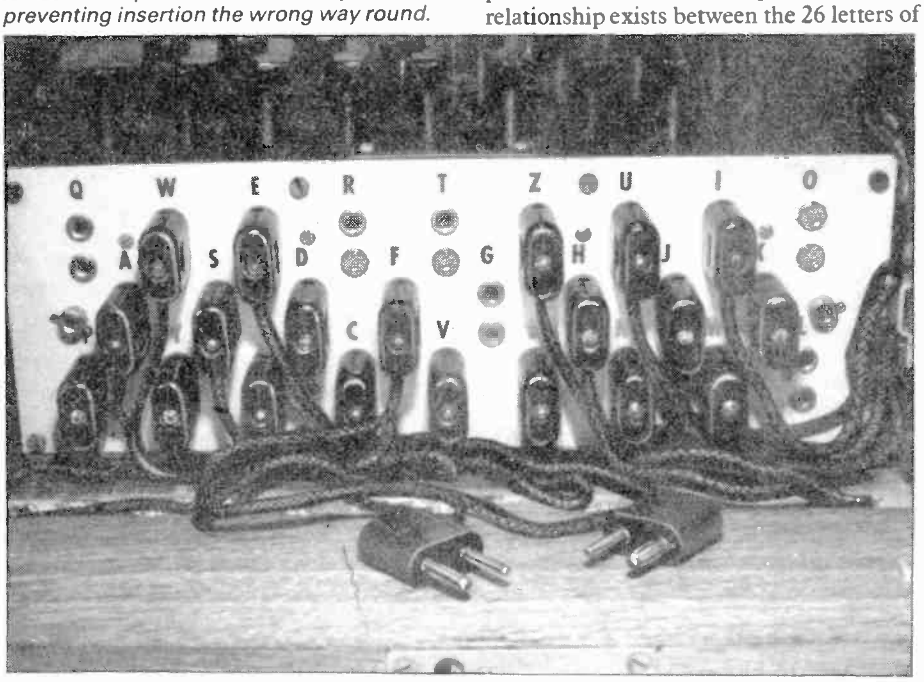


Fig. 6. Arrangement of plugs and jacks. Note contact pins of different size jacks preventing insertion the wrong way round.

the alphabet and the figures 1 to 26. To help the cipher clerk, this relationship is put on the instruction card inside the lid of the machine (Fig.12).

Using Enigma

The cipher instructions for using Enigma were changed from time to time and different procedures could be in use within the Air Force, the Army and the Navy. Figure 13 shows the title page of the instructions for Enigma, issued on January 12, 1940. For each month, a list was issued with *Tagesschlüssel* (keys of the day); one for each day. Figure 14 shows part of a page from the encryption manual with an example for the fourth day of the month. The key of the day contains three elements. The first is the *Walzenlage* i.e. the numbers of the rotors (I to V) to be used and the position where they are to be put in the machine. In this example, rotors I, III and II are to be used in that sequence from left to right. Then there is the *Ringstellung* (setting of the rings on the rotors); in the example the rings are to be set to 16, 11 and 13. The third element is the *Stecker* (plugs and jacks). The example shows which pairs of jacks are to be connected by cords, ten of the thirteen cords being used. This completes the key of the day. All Enigmas that were used in a radio network were set to the same key at 0000 hrs, according to these instructions.

When the cipher clerk is handed a message to be encrypted, he first replaces all figures by letters (e.g. *drei* for 3). The clerk now selects one of the *Kenngruppen* (marker groups) shown in Fig.14 bottom right; the group OPW for instance. He may change the sequence e.g. into POW and add two fill-in characters, purely arbitrarily chosen. The resulting group of five letters is entered on the message form. In the example, the group might be ZAPOW.

The clerk now selects a *Grundstellung* (initial setting) of three letters, e.g. WEP. This corresponds to figures 23 05 16 and he sets the three rotors accordingly. This setting is different for each message and for each part if the message consists of more than one part (it was forbidden to select as settings groups such as AAA . . .ZZZ, words, abbreviations, call-signs, traffic indications such as QRM, letters that follow each other on the keyboard such as ERT or those in alphabetical order e.g. ABC or CBA). The cipher clerk then selects a *Spruchschlüssel* (message key), also of three characters, for which the same rules apply, say XFR (24 06 18). This group is keyed in and the three letters that are indicated by the glowlamp (e.g. HFI) are entered at the top of the message form, together with the three letters of the *Grundstellung*. So this group may look like WEP HFI. Finally the cipher-clerk resets the three rotors according to the message key XFR and starts typing the text to be encrypted. He reads aloud the lamps lighting up and an assistant enters the ciphertext on the message form. He does so by arranging the ciphertext into groups of five letters. The form can now be handed to a radio operator for transmission.

The cipher-clerk at the receiving end first has to set his Enigma to the key of the day used for encryption of the message. This may be a different day from the one on which the message was encrypted. The cipher-clerk therefore looks for the marker group ZAPOW that was transmitted from the top of the message form. He deletes the fill-in characters Z and A. The remaining group POW is put into alphabetical order OPW. Referring now to his table of keys of the day, he finds that the marker group belongs to the fourth day of the month. He then proceeds to set his Enigma according to the day key for day 4.

He now sets the three rotors to the initial setting WEP (23 05 16) which he also reads from the received message. Now he types in the group HFI, that follows the *Grundstellung*. He then reads the message key XFR from the lamps. The rotors are next set according to the message key XFR (24 06 18). Engima is now ready for decrypting the message and the cipher-clerk text is typed in, group by group. The plaintext is read from the glow lamps and an assistant enters it on a new message form.

The complicated system of initial setting and using a message key does not add any more security to the system than that already provided by the key of the day, because once the key of the day is known, all information regarding initial setting and message key can be found immediately from the received message. It must be assumed that the Germans added the complications of initial setting and message key to confuse an intercepting cryptanalyst trying to find the key of the day from the contents of the message.

The procedure outlined in the manual of 13 January, 1941 contained at least two modifications from the one issued on 8 July, 1937, according to Lt. Col Lisicki in ref.7. It is possible that issues before that on 8 July, 1937, have also differences. In accordance with that older instruction manual, the initial setting formed part of the key of the day and was taken from the table for the relevant date. It remained the same for 24 hours, and was not sent with the message. Instead, the cipher clerk, after setting Enigma to the key of the day, adjusted the rotors according to the *Grundstellung*, read from the table, e.g. 01 12 22. He now selected a message key, say XFR and entered this *twice* on the keyboard. This yielded two cipher groups of three letters, e.g. HFI KLB and these were written on the message form to be transmitted. Then he reset the rotors according to the message key XFR (24 06 18) and proceeded to key in the plaintext. Decryption proceeded as described previously, except that the *Grundstellung* was not read from the message as received, but from the table of keys of the day. After setting Enigma accordingly the group HFI KLB was keyed in and this provided XFR XFR, twice the message key. Decryption started after setting the rotors according to the message key. The double encryption of the message key turned out to be a blessing to the Polish and British cryptanalysts, as we will see later.

Lisicki[7] states that on September 15, 1938 the German Army and Air Force

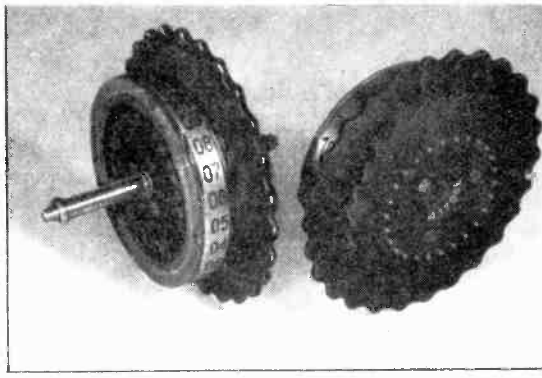


Fig. 7. The shaft with three rotors has been removed from Enigma. The actuating levers and entry rotor at the right can now be seen.

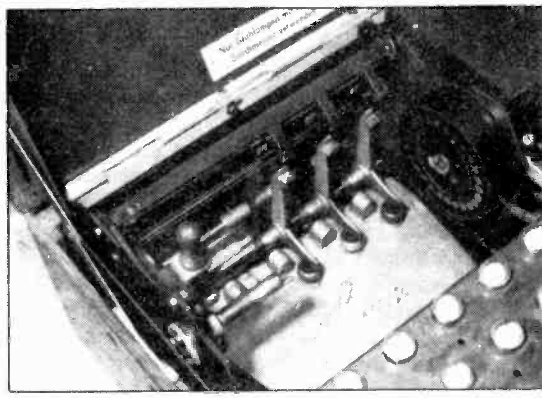


Fig. 8. Rotors with contact pins on one side and pads on the other. Note the notch in the ring with the numbers at position 08.

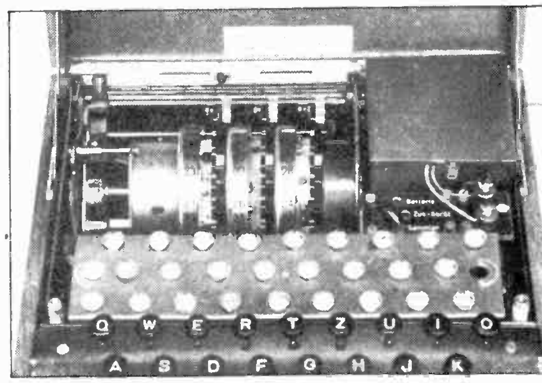


Fig. 9. Looking into Enigma with the cover lifted. The shiny cylinder to the left of the rotors is the reversing rotor.

changed the system. The *Grundstellung* was no longer used for the whole day, but the cipher clerk chose a different one for each message which he entered on the message form in plaintext. The rotors were then set to this *Grundstellung* and the message key was entered twice, as before. The resulting encrypted message key was also entered on the message form. When the war started, the double encryption of the message key was replaced by a single one.

Not being a cryptologist, I fail to see how the *Grundstellung*, changed for every message, but transmitted in plain text, could be an improvement over the 1937 system. There the *Grundstellung* was not sent and had to be found out by the intercepting cryptanalyst, even though that once found, it could be used for the whole day and not for just one message.

History of Enigma

The principle of Enigma was patented in 1919 by a Dutchman, Hugo Alexander Koch. The ideas developed by him were feasible, but not very practical. The true pioneer was an engineer from Berlin, Dr Arthur Scherbius. By July 1923, Scherbius was on the board of the *Chiffriermaschinen Aktiengesellschaft* (Cipher Machines Corporation), which had been established at 2 Steglitzer Strasse, Berlin, to make and market the invention which Scherbius christened Enigma[2]. The Scherbius model, which went through various stages of improvement, contained many of the basic concepts finally incorporated in the Germans' military versions. David Kahn[5] has recorded that Scherbius exhibited the Enigma at the 1923 Congress of the International Postal Union, and the following year got the German Post Office to exchange Enigma-enchiphered greetings with the Congress.

Scherbius produced an elaborate sales pamphlet in English under the title "The Glow-Lamp Ciphering and Deciphering Machine Enigma". Unfortunately the commercial world in the twenties had no use for ciphers: the businessmen of the world, to which Scherbius' pamphlet was addressed, showed no enthusiasm. Scherbius himself went bankrupt and his patents passed into other hands[2].

The German military forces were the first to detect and exploit Enigma's possibilities for the purpose of making her military communications more secure. They had good reasons. In the years following her 1918 defeat and the Treaty of Versailles, Germany had a good deal to hide. A system which enabled military messages to be transmitted in an apparently unbreakable cipher was irresistible. So on 9 February, 1926 the latest Scherbius model was introduced into the German Navy. It is logical that the Navy came first, as radio is the only way for ships to communicate and is open to interception by the enemy. The Army can always use the telephone. In 1928 the German Army also adopted Enigma, although the machine did not possess the jackfield at that time: this feature was introduced by the Army in 1930 and the Navy followed in 1934. In 1935, the Air Force adopted Enigma as well. By that time, the commercial model of Enigma had been withdrawn from the market.

It is dangerous to use a cipher system over a long period and so it is necessary to make alterations to prevent interceptors finding ways to crack the cipher. The instructions for using Enigma were revised from time to time, but the machine itself was regularly updated as well. Three rotors were used up to 15 December, 1938. Then the German Army and Navy added two rotors, enlarging the number of possible combinations. There are ten ways of selecting three rotors to be placed in the machine out of a total of five and the three selected can be put in the machine in six different ways. The Navy added a seventh rotor in 1938 and shortly before the outbreak of war even an eighth one. Five were kept in the box and three in the machine. Three rotors can be selected out of eight in 56 different ways.

As the war progressed, further modifications were deemed desirable, especially for the radio traffic with submarines in the Atlantic. These were attacking the Allied convoys and were directed entirely by radio by Grand Admiral Dönitz from his submarine command centre. It was, of course, vital that these command lines were not compromised by the Allied forces cracking the cipher. Therefore, the German Navy introduced a new version of Enigma on February 1, 1942, which had provision for a fourth rotor, to the left of the three existing ones. In this fourth position, and only there, was inserted what the Germans called a "Greek rotor", designated "Alpha". From March 1, 1943, a second Greek rotor, "Beta", which could change places with 'Alpha', was put into operation. "Gamma" followed later that year and so increased the number of "Greek rotors" to three. The fourth one came in 1944.

By the end of the war, several new models of Enigma were under test. for instance, a new standard machine to be used by the Army, model "M-5" and a considerably improved model "M-10" for the Navy. I have found no evidence that these new versions were actually introduced.

Cracking the Enigma cipher

Before we turn our attention to the ingenious ways that were found to decrypt Enigma-enciphered messages without knowing the key of the day and the message key, it is interesting to get some idea of how many different keys Enigma can provide. German wartime cryptologist Waldemar Werther gives the following estimate.

For each setting of the three rotors, the period after which the same current path through the rotors reappears is given by $26^3-26^2=16,900$.

The number of permutations with three rotors is six. The three rings can be set in $26^3=17,576$ different ways. From the 13 cords with plugs only ten were actually used; the number of different cord connections is about 150.7×10^{12}. The total number of keys is, of course, the product of these figures and this works out at the astronomical figure of about 4.5×10^{22}. Note that this is with only three rotors! When the number of rotors is increased the number of combinations rises considerably (as we have seen, the Navy finally used up to eight rotors plus four "Greek" rotors).

Some people think that with a modern digital computer it should be possible to "test" all of these possibilities to find the correct one used for a message, but even with a very fast machine this would take decades to accomplish. This is quite apart from the question of how the computer, without any human intervention, is to know when the correct setting has been found.

No, this was not the way cryptanalysts tackled the problem. Their approach was a more subtle one in which certain peculiarities of Enigma were exploited to the full. We will mention two. As the same key setting was used both for encryption and decryption reciprocity had to exist between cleartext and ciphertext. If for instance, encrypting the character "A" resulted in an "S" in the ciphertext, then an "S" in the clear text would have become an "A" when enciphered (provided it had been in the same place in the text, of course). Similarly a character can never become itself when encrypted.

The first cryptanalysts who succeeded in

Fig. 10. One of the actuating levers engaging a tooth on the left rotor.

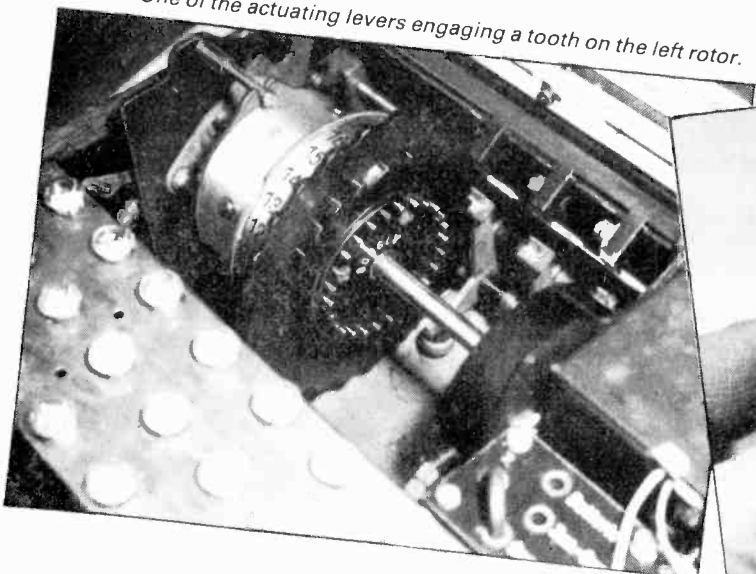
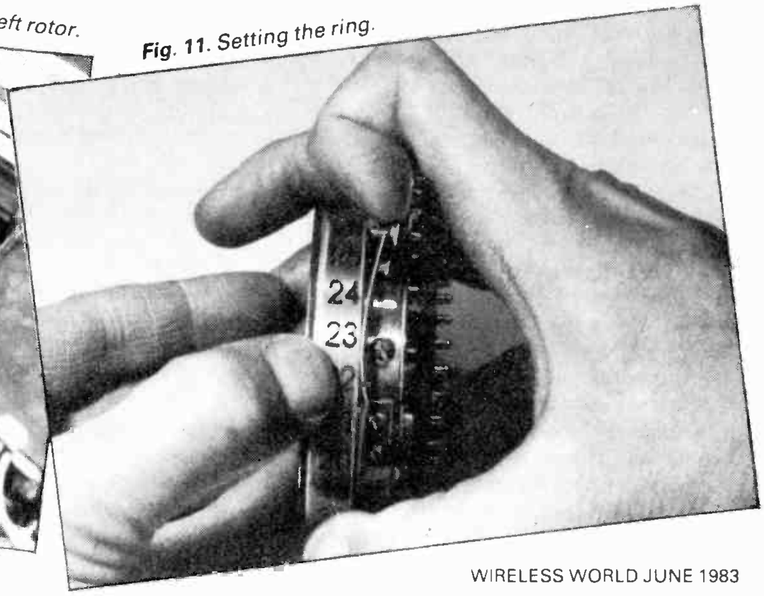


Fig. 11. Setting the ring.



cracking the Enigma cipher were Polish: Lt. Colonel Dr. Tadeusz Lisicki was personally involved and he gives a fascinating account of it[7]. It is a little known fact that the Polish secret service had no difficulty in reading the Russian ciphers used in their military wireless communication during the war between Russia and Poland (1918 to 1920). The resulting information was used by the Polish High Command in a way very much like Ultra was in the North African battle during World War II, and proved to be instrumental in bringing victory to Poland. The Polish cryptanalysts were also at home with the ciphers used by the German Army and Navy from 1918 onwards. This comfortable situation for Poland lasted until the Germans introduced Enigma. For several years the Polish cryptographic service struggled to find ways to crack the Enigma machine cipher, but all currently known methods failed. It was then decided to reinforce the department with young men, not hampered by traditional thinking and with a good knowledge of mathematics and the German language. The university of Posen ran a special course on cryptography and this was attended by twenty students who were in their last two years of mathematics. Three of these bright young students joined the Polish cryptographic service in 1932 and already by early 1933, had succeeded in decrypting German messages sent by radio!

It should be realised that the civilian model of Enigma had been on the market for some years and such a machine was in the possession of the Poles. Nevertheless, the military version had several new features and certainly the internal wiring of the three rotors was unknown to the Polish cryptanalysts.

Crucial for the success was the German encipherment procedure at that time in which the *Tagesschlüssel* (key of the day) also contained the (initial setting) which remained the same the whole of that day. The cipher clerk picked a *Spruchschlüssel* (message key) of three characters for each message. As mentioned earlier, this three-character message key (XFR in the previous example) was keyed in *twice*, with the machine set according to the key of the day: the resulting cipher group of six characters was sent as the beginning of the ciphertext. This meant that the first and the fourth character originated from the same character of the message key. The same applies for the second and the fifth and the third and the sixth character. The German cipher clerks in those days often used message keys like AAA, ABC, etc., which were later forbidden. Given a sufficient number of messages sent with the same key of the day, this enabled the Polish cryptanalysts to find the message keys and also the plaintexts.

The internal wiring of the rotors was determined in a similar manner. This was accomplished using the fact that keying in the message key twice meant that the rotor on the right moved six steps. The middle rotor moves only after 26 steps of the right one. So there is a chance of 21 in 26 or about 81% that typing in the message key moved only the rotor on the right. The middle, left and fixed reversing rotor in that case can be considered as a fixed current path. It certainly was not as easy as it may seem from this simplified story (it would be out of place to go into details here, as they are so well explained by Lisicki[7] but the young Polish experts succeeded in finding the internal wiring of the rotor on the right. The three rotors often changed places and so eventually all of them had been in the right position often and long enough to allow their inner secrets to be solved.

As already mentioned, the encipherment procedure was changed in 1938 (initial setting changed with every message, but entered in the clear on the message form) and later that year, a fourth and fifth rotor were introduced. This posed new problems for the Poles. Two methods were introduced to find the rotor settings and plug and jack arrangement for a series of messages. One was a mechanical device called "Bomba" and the other was based on the use of stacks of punched cards.

Lisicki relates how the Germans made a characteristic cryptographic blunder that enabled the Poles to find out the internal wiring of the fourth and fifth rotor. The SD (*Sicherheitsdienst*) also used Enigma, but the plaintext was first encrypted using a hand cipher before it was submitted to Enigma. The Poles could not read the decrypted Enigma messages and concluded the SD was using a different system, unknown to them. This situation continued until the word *eins* ("one") popped up in one of the decrypted texts. The Poles realised that the cipher clerk had been given a ciphertext containing the figure "1": as Enigma cannot operate on figures, "1" was written out in full and then encrypted. The Poles very quickly succeeded in cracking the hand cipher and from then on the SD messages could be read as well. When the German Army and Air Force introduced the fourth and fifth rotor in 1938 the SD did the same, *but without changing the encipherment procedure*! That is to say, the SD kept on using a fixed initial setting for a whole day. So there were two different systems used side by side and this enabled the Poles to find out the inner connections of the two new rotors.

Failure by the enemy to stick to the ground rules of cryptography is often the key to success for the intercepting cryptanalyst.

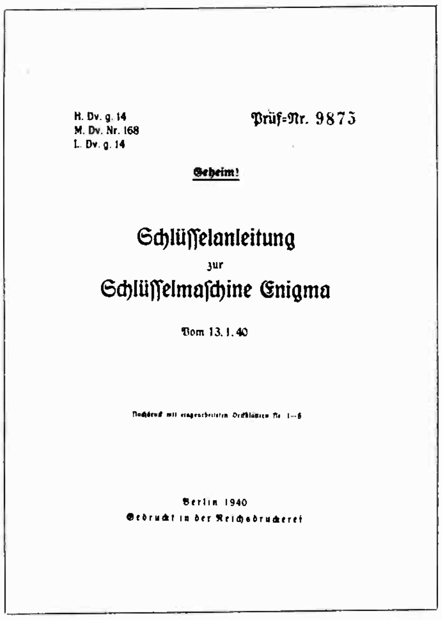
Another failure in the same category as the one just related is for a message to be sent by radio in a relatively simple hand cipher, for instance by a secret agent on enemy territory, and then retransmitting the same message in a higher-level cipher over a radio network. This is a basic mistake that should never be made in cryptography, but it happened in WW II. A third example also stems from WW II. The German commanders had to send in daily reports on the condition of their unit; e.g. logistics, etc. If nothing particular had happened, the commander might send *Nichts zu melden* (nothing to report). Of course the signal was encrypted by Enigma. If Bletchley Park next day received a message of the same length from that unit and which was known not to be

Fig. 12. Inside the lid of Enigma. From top to bottom we can see the holder for spare lamps. Then a dark green glass for covering the lamps in bright sunlight to improve readability. The white sheet containing instructions for the maintenance of Enigma and a conversion table from letters to figures at the bottom. Finally two spare cords with plugs.

involved in any action, then a good guess might be that the message was again *Nichts zu melden*. If the guess was right, it would be a simple matter to find the key used. The cryptographical mistake made here is that such short messages should always be stuffed with meaningless characters to increase the length.

We return now to the Polish secret service. With war becoming imminent, the Poles decided to share their knowledge with the French and British Secret Services. This happened in a series of meetings. The British and French each received a Polish-made Enigma as well. The one for the Government Code and Cipher School arrived on the evening of 16 August at Victoria Station, carried by the Frenchman August Bertrand, and it was personally handed over to Colonel Stewart Menzies, the then Deputy Head of the British Secret Service[2]. So when the war broke out a few days later and the GCCS moved to its wartime station at Bletchley Park, it started its operations on a firm base. Not only was it familiar with the strategies developed by the Poles for cracking the Enigma cipher, it also had details of the "Bomba" and an actual Enigma machine.

There still remained a lot of work to be done. To be able to crack a cipher or code, a certain minimum number of messages in that cipher or code is required. Cryptologists call it the "critical mass". The more messages that are sent using a certain cipher, the greater the chance it will be



H. Dv. g. 14
M. Dv. Nr. 168
L. Dv. g. 14

Prüf-Nr. 9873

Geheim!

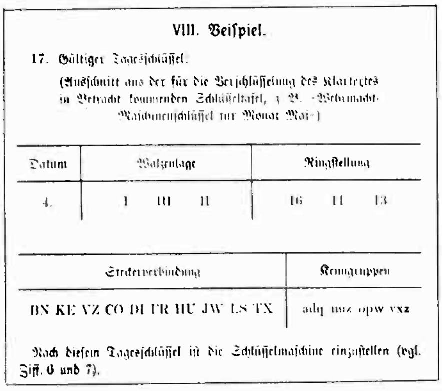
Schlüsselanleitung
zur
Schlüsselmaschine Enigma

Vom 13. 1. 40

Nachdruck mit eingearbeiteten Deckblättern Nr. 1—6

Berlin 1940
Gedruckt in der Reichsdruckerei

***Fig. 13.** Instruction manual for encryption using Enigma.*



VIII. Beispiel.

17. Gültiger Tagesschlüssel.

(Ausschnitt aus der für die Verschlüsselung des Klartextes in Betracht kommenden Schlüsseltafel, z. B. „Wehrmacht-Maschinenschlüssel für Monat Mai".)

Datum	Walzenlage	Ringstellung
4.	I III II	16 11 13

Steckerverbindung	Kenngruppen
BN KE VZ CO DI FR HU JW LS TX	adq nuz opw vxz

Nach diesem Tagesschlüssel ist die Schlüsselmaschine einzustellen (vgl. Ziff. 6 und 7).

***Fig. 14.** Page from the encryption manual showing an example of the Key of the Day.*

cracked by the enemy cryptanalysts. It is therefore mandatory not to use the cryptosystem for too long a time. As we have seen, the Germans made changes to the system several times, before and during the war, while Enigma was in use. One such change occurred when the number of rotors was increased from five to eight for Enigma encrypted signals between submarines in the Atlantic and their home base in Germany. This made Bletchley Park "blind" until May, 1941. On the seventh of that month, a German trawler called *München* was captured. This ship transmitted weather messages from off the Lofoten. Enigma was destroyed by her German crew, but the instruction manuals for its use fell into the hands of the British. Two days later, 9 May, 1941, an even better catch was made. After having attacked an outbound convoy south of Greenland, German submarine U110 was forced to the surface and Captain Julius Lemp surrendered. A boarding party retrieved intact the eight-rotor Enigma and cipher documents from the submarine. Bletchley Park now possessed the Enigma settings for the next two months. By the end of that period, the "Bombs" at Bletchley Park (developed after the Polish "Bomba") had been adapted to the 336 different rotor positions that are possible with eight rotors instead of the 50 with five rotors. This meant that BP was no longer "blind" to the *Hydra* cipher, as it was called by the Germans.

Another black-out occurred on 1 February, 1942. On that date cipher *Triton* was introduced with the submarines in the Atlantic. This meant that a fourth rotor, called "Greek rotor alpha", was added to the left of the existing three rotors in Enigma, increasing the period after which Enigma returned to the same substitution alphabet from 16,900 to 439,400. No wonder BP was in trouble! It was eleven months later, at the beginning of December, 1942, that the cryptanalysts succeeded in breaking the *Triton* cipher for the very first time. There were initially long delays in deciphering, but from January 1943 onwards, decrypts became faster and more regular. As already mentioned, another "Greek" rotor, *Beta*, was introduced on 1 March, 1943. The progress in the art of cryptanalysts that had been made at Bletchley Park can be demonstrated by the fact that this new cipher was broken into by the twentieth of that same month!

Prof. Rohwer[7] gives a fascinating analysis of the Battle of the Atlantic. He shows that at each black-out of Bletchley Park, convoy losses increased dramatically. To understand this one should know that the extensive Anglo-American radio traffic with convoys was conducted in *Naval Cypher 3*, an old hand code that was used for too long and as a result was broken into by the Germans. Grand Admiral Dönitz therefore knew exactly when convoys were to sail and what courses they steered.

Acknowledgement

This article could not have been written without the help from Mr Arthur Bauer, who made his Enigma machine, together with the instruction books, available to the author for inspection and photography.

Mr. Horst Werner, DJ2HN, of Grefrath, Germany, brought ref.7 to the attention of the author. This book contains the conference papers read at an international convention in Germany in November 1978 under the theme Die Funkaufklärung und ihre Rolle im Zweiten Weltkreig (Radio Reconnaissance and its Role in World War II).

Finally, the author thanks Mr A. R. Crook, who reviewed the manuscript and corrected his Dutchman's English where necessary.

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continued from page 43

```
RCL 12 X^2 SUM 11
RCL 9×RCL 4=X^2 STO 12
RCL 10 X^2 SUM 12
RCL 12×4=STO 12
RCL 11 : RCL 12=STO 13−RCL 16=±
INV 2nd X ≥ t
C
B
2nd Lbl B
2nd If Flg 0
2nd C'
2nd D'
2nd Lbl 2nd C'
RCL 14 SUM 5
RCL 15 SUM 0
A
2nd Lbl 2nd D'
RCL 14 SUM 5
RCL 15 SUM 0
RCL 2 SUM 1
D
2nd Lbl D
RCL 4 : RCL 3=X^2−1=±STO 6×RCL 1=STO 7
RCL 4×RCL 6×RCL 1 : RCL 0=X^2 STO 8
RCL 4 X^2×RCL 5×RCL 1−RCL 6=X^2 SUM 8
RCL 7 : RCL 8=STO 7
RCL 4 X^2×RCL 6×RCL 7×RCL 1 : RCL 0=STO 8
RCL 4 X^2×RCL 5×RCL 1−RCL 6=×RCL 7=STO 9
1+RCL 8=STO 10
2nd A'
2nd Lbl C
2nd If Flg 0
2nd B'
E
2nd Lbl 2nd B'
RCL 5 : RCL 17=STO 5            C1
RCL 0×RCL 17=STO 6              R1 −low−
RCL 3 X^2×RCL 5=1/X STO 7       L1   pass
RCL 17×X^2 : RCL 6=STO 8        R2
RCL 17 X^2 : RCL 7=1/X STO 9    C2
RCL 17 X^2×RCL 5=STO 10         L2
R/S INV SBR R/S
2nd Lbl E
RCL 0×RCL 17=STO 0              R_1 band-
                                pass
RCL 5 : RCL 17=STO 5            C_1
RCL 1×RCL 17=STO 6              L_2
RCL 3 X^2×RCL 5=1/X STO 7       L_1
RCL 17 X^2 : RCL 0=STO 8        R_2
RCL 17 X^2 : RCL 6=1/X STO 9    C_2
RCL 17 X^2 : RCL 7=1/X STO 10   C_3
RCL 17 X^2×RCL 5=STO 11         L_3
R/S INV SBR R/S
LRN
```

Input

STO 00 R_1
STO 01 L_2
STO 02 ΔL_2
STO 03 ω_0
STO 04 ω
STO 05 C_1
STO 14 ΔC_1
STO 15 R_1
STO 16 $10^{0.1\alpha}$
STO 17 Z

Δ to $X \geq t$. By a bandpass L_2 must be less than Δ.

Forth computer

In describing memory and i/o interface circuits surrounding the 6809 microprocessor, Brian Woodroffe introduces more features of his FIG Forth computer in this second article.

The system may be used in partial form. Operating-system and language software exist in eprom, so the computer will work without a floppy-disc drive. Many computers use eprom as a bootstrap to load an operating system from disc, making a disc drive mandatory. Although omitting the disc drive reduces cost by almost half, virtual-memory features of Forth are lost, resulting in a significant degradation of performance. Fewer than one third of the memory devices are essential. Parity-error checking may be omitted. When the system is turned on, it only demands 16K of ram and as more is added the memory map is changed on line, Table 1 (see over).

Circuit description

Memory. Eproms containing fixed instructions of the Forth machine and M6809 peripherals pose few problems. These devices occupy the top 16K memory locations because the 6809 reset vector is in this area and decoding is simple using a dual two-to-four-line demultiplexer i.c. (LS139). Dynamic ram occupies the remaining 48K addresses from 0000 to BFFF. Logic i.cs used to glue the main items together are low-power Schottky devices, chosen for their speed and low power consumption. Standard t.t.l. parts could be used, except in the timing chain for the dynamic rams and on the microprocessor memory and address buses; nmos microprocessor parts have very low driving capability and low-power Schottky inputs require less current than standard t.t.l.

Dynamic rams consist of an X-Y matrix of capacitor storage cells. Access to a bit (storage cell) is gained by first addressing the matrix row. This address is clocked in by the falling edge of the row-address strobe (RAS) and data from all 128 cells in the row are transferred to row buffers. When the column-address strobe (CAS) is true, i.e. low, the column address on the address pins selects one of the row buffers, causing its data to be passed to the output pin. Timing constraints on these actions are fortunately not stringent relative to the time available in a processor cycle

Multiplexing of the 14 address lines onto the seven address pins is done with an I3242 multiplexer. In this design, writing is carried out by the early-write cycle. Within the early-write cycle the write signal is made true before the column-address strobe acts. When CAS becomes true, data on the data input overwrites that of the selected row buffer. Then when the address strobes become false, data from the row buffers are returned to their res-

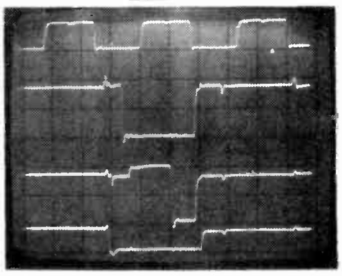
by Brian Woodroffe

pective cells, so writing the input data into the X-Y matrix.

Two clocks, E and Q, divide the 6809 processor cycle into four parts. The first quarter of the cycle is used to precharge the rams and as dynamic rams consume most power when the row-address strobe is applied, the selected bank of rams only receives this strobe on the rising edge of clock Q. The address multiplexer is then switched by a delayed Q-clock edge to apply column addresses, leaving sufficeint settling time before the E-clock acts.

During a reading cycle the column-address strobe is made true half way through a cycle (rising edge of E Clock) so that data may be made available by the RAS-selected rams, through the LS245 buffer, to the M6809 before its set-up time. All of the rams receive CAS but only those receiving RAS pass data to the bus.

Write cycle



E 5V/div

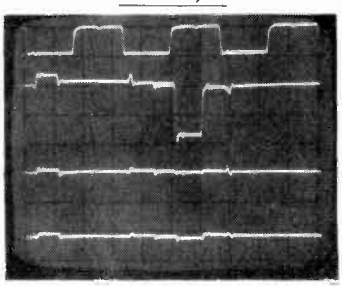
RAS 2V/div

CAS 2V/div

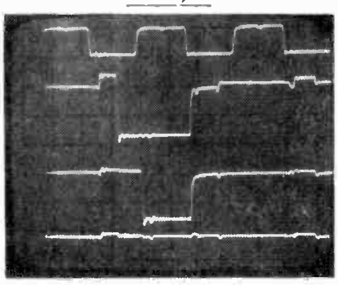
R/W 5V/div

200ns/div

Refresh cycle



Read cycle



During a writing cycle data is not made available by the M6809 until the second half of the cycle so CAS is delayed until the falling edge of the Q signal.

Refresh generator

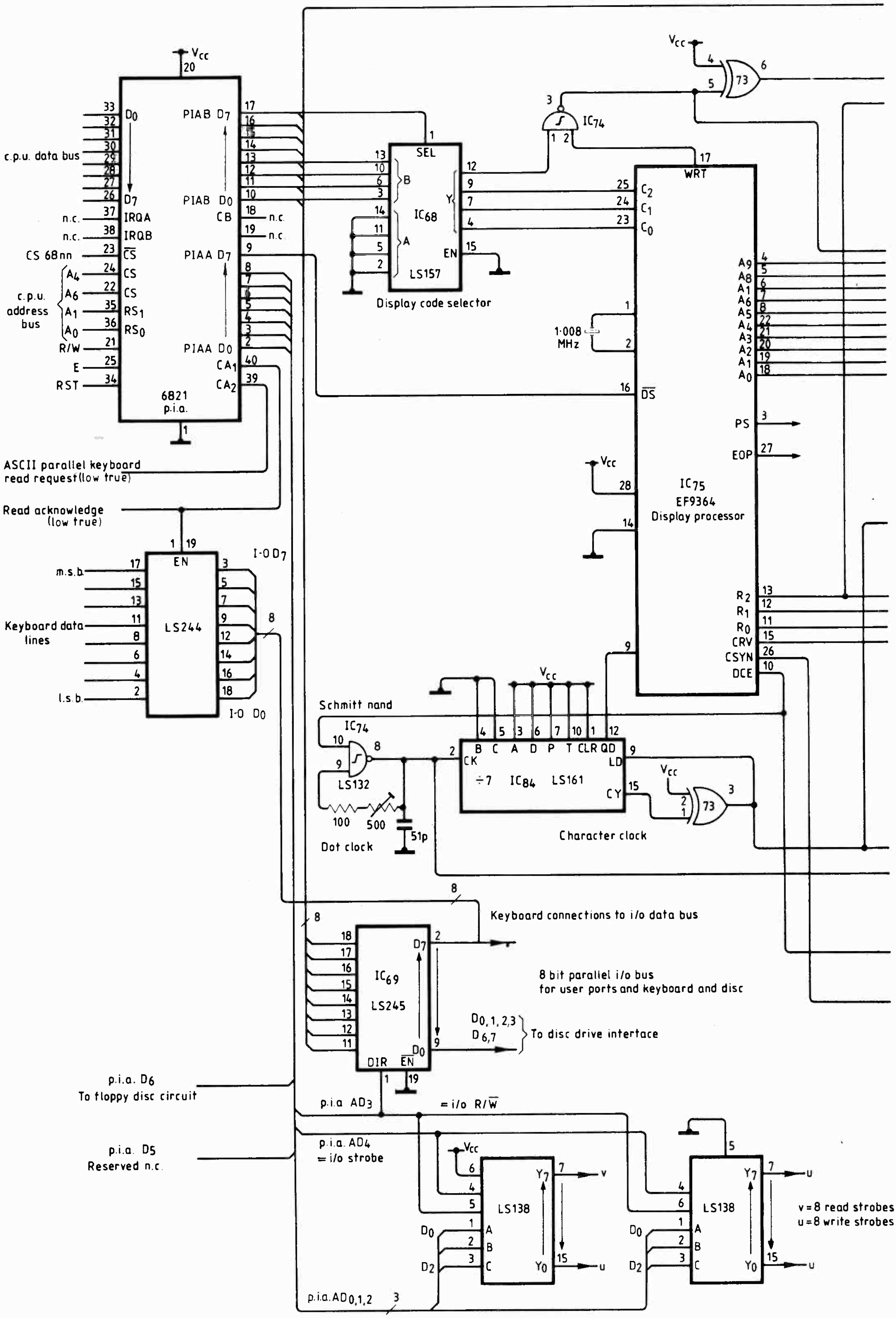
Storage cells in dynamic rams, being capacitors, lose their charge so they must be 'refreshed'. Any memory action refreshes the selected row through data being read into the refresh buffer and returned at the end of the cycle. Unfortunately, program flow will not normally refresh all the ram rows in the allotted time of 2ms and a refresh generator is required.

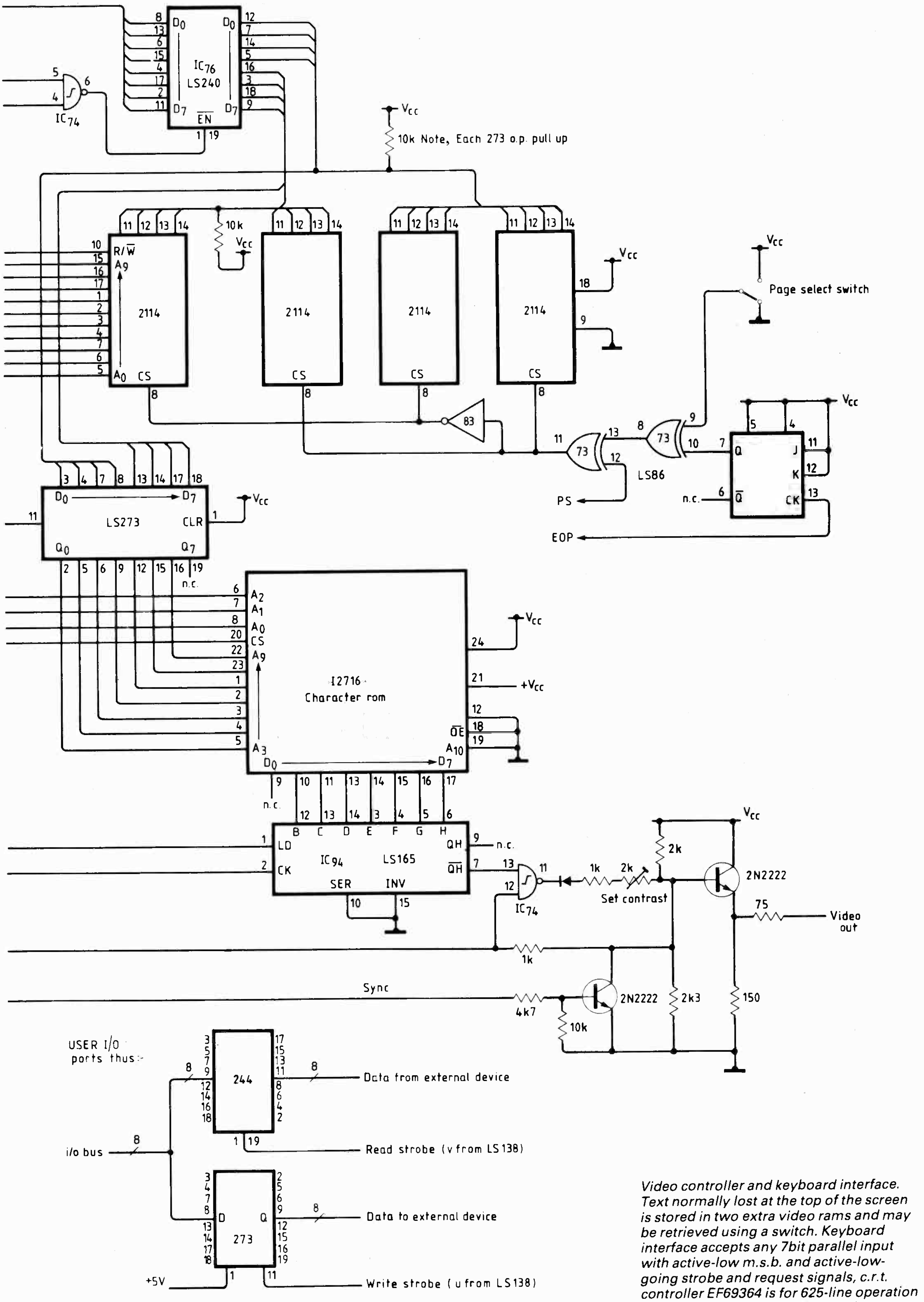
There are three ways of refreshing rams. In burst refresh, normal processor action is suspended and the refresh generator cycles through all 128 rows (for a 16K ram) and returns control to the processor for the remainder of the 2ms. This results in the processor stopping for 128 memory cycles (85μs at the clock speed used). Such a time lapse is unacceptable in this application for the disc drive can require communication with the microprocessor once every 32μs during sector read/write operations.

So, distributed refreshing is required, that is, each successive row is refreshed at 14μs intervals. Distributed refresh generators demand that the processor does not have access to memory while the row is refreshed. The processor may be stopped for this period but a more efficient method is to use a circuit that recognizes when the processor is not using memory and performs what is called a distributed hidden-refresh cycle. This method was chosen.

The refresh generator divides time into 14 cycle quantums using an LS163 counter and generates a refresh-request signal once each period (14μs × 128 cycles = 1.7ms). By monitoring address lines $A_{14,15}$ during the first quarter cycle, the generator knows when the processor does not require access to memory. Having recognized this it generates a refresh-request signal and the I3242 multiplexer places the refresh address on the ram address lines and all row-address signals are set true for a quarter of a processor cycle. During the refresh cycle the column-address strobe is false to inhibit the rams. The address multiplexer advances for the next address and the generator does not demand further refreshes since a flip-flop is set.

It is unlikely that the M6809 will make 14 consecutive memory cycles since all instructions except NOP, SEX and DAA provide non-memory cycles. Should this happen, the refresh flip-flop being reset


c.p.u. data bus
n.c.
CS 68nn
c.p.u. address bus
R/W
E
RST
D0
D7
IRQA
IRQB
CS
RS1
RS0
PIAB D7
PIAB D0
CB
PIAA D7
PIAA D0
CA1
CA2
6821 p.i.a.
Vcc
ASCII parallel keyboard read request (low true)
Read acknowledge (low true)
m.s.b.
Keyboard data lines
l.s.b.
EN
LS244
I-O D7
I-O D0
SEL
IC68
LS157
Display code selector
IC74
73
WRT
C2
C1
C0
1·008 MHz
DS
IC75
EF9364
Display processor
A9
A8
A7
A6
A5
A4
A3
A2
A1
A0
PS
EOP
R2
R1
R0
CRV
CSYN
DCE
Schmitt nand
LS132
100
500
51p
Dot clock
CK
CLR
QD
LD
CY
÷7
IC84
LS161
Character clock
Keyboard connections to i/o data bus
IC69
LS245
DIR
8 bit parallel i/o bus for user ports and keyboard and disc
D0,1,2,3 D6,7
To disc drive interface
p.i.a. D6
To floppy disc circuit
p.i.a AD3
= i/o R/W
p.i.a. D5
Reserved n.c.
p.i.a. AD4
= i/o strobe
LS138
Y7
Y0
p.i.a.AD0,1,2
v = 8 read strobes
u = 8 write strobes



Video controller and keyboard interface. Text normally lost at the top of the screen is stored in two extra video rams and may be retrieved using a switch. Keyboard interface accepts any 7bit parallel input with active-low m.s.b. and active-low-going strobe and request signals, c.r.t. controller EF69364 is for 625-line operation but a version is available for 525-line tv.

Table 1. Example of how the memory map may be changed when more than 16K of ram is used.

```
FORTH HEX
SMAX DUP @ 4000 + SWAP !            ( allow more data stack)
S0 DUP @ 4000 + SWAP !              ( move data stack)
SP! SMAX DUP @ 4000 - SWAP !        ( reset data stack)
R0 DUP @ 4000 + SWAP !              ( move return stack)
TIB DUP @ 4000 + SWAP !             ( move terminal input buffer)
' FIRST @ DUP @ 4000 + SWAP !       ( move Forth virtual memory buffers)
' LIMIT @ DUP @ 4000 + SWAP !       ( IE 'FIRST' and 'LIMIT')
FIRST DUP PREV ! USE !              ( point virt. memory pointers to virt. memory)
DPMAX DUP @ 4000 + SWAP !           ( move limit of dictionary up)
DECIMAL                             ( return to decimal arithmetic)
```

and the counter carry being set (refresh quantum finished), processor action is suspended by a dummy direct-memory-access cycle which guarantees a non-memory-access cycle.

Parity checking

Capacitance used to store data in dynamic rams is so small that naturally occurring charged particles (alpha particles) have a charge great enough to corrupt data should they hit a cell. Improved coatings on dynamic-ram dies have reduced this effect to give an error rate below 0.1%/1000h for 16K dynamic memories[5]. It is impractical to include error correction in small 8bit memories but parity checking to halt the processor when an error occurs is not.

An odd-parity bit, generated by an LS280 parity checker when a byte is written into memory, is stored with the other eight bits. During the write-cycle the parity-ram data output is in its high-impedance state and the floating EO input is high. The parity device output is clocked into the ram input and correct parity is looked for when memory is read. On reading, the data output drives the parity checker and the error signal is passed to the error latch with the row-address strobe signals. If an error exists, the RAS line concerned is latched, a led indicates which memory bank contains the error, and the processor halts.

Memory speed and drive

Input characteristics of dynamic ram are quite different from those of t.t.l. Ram inputs are capacitive, which especially affects signals common to many inputs like RAS, CAS and WE, and they require little direct current. When driven directly from low-power Schottky t.t.l. these inputs can cause considerable overshoot that can result in exceeding device specifications and longer access times through the time taken for the voltages to level out.

To reduce ringing, some form af matching is required. Series matching is most appropriate since it does not increase static loading. The ideal driver would produce a slightly under-damped response but because t.t.l. drive characteristics are asymmetric a compromise had to be made in the resistance value. Control signals are driven from LS37 clock drivers to ensure adequate drive toward the 5V rail. Resistance values are not critical for this relatively slow memory and the original even worked faultlessly with no damping resistors and standard LS00 drive.

On analysing the timing requirement of the ram/M6809 interface I noticed that the most readily available 200ns rams leave a lot of spare time – so much so that these devices could theoretically be run with a 666ns cycle time instead of the standard 1μs. This was, of course, tried. Not only was it tried with the faster M6809A processor but also with the standard device. In both cases functioning was faultless. This is not to say that all 1MHz parts will run at higher speeds but certainly 200ns access time rams will work at 1.5MHz. So for the cost of a new crystal the through-put of the system was improved by 50%.

Peripherals

To ensure that 1MHz peripheral devices such as the 6821 peripheral-interface adapter and the 6850 communication-interface adapter operate correctly, the memory-ready signal (MRDY) is used. Whenever peripherals are addressed MRDY is held false by an LS122 monostable multivibrator which extends the memory-access time. An M6850 communication device forms the RS232 interface and the clock frequency for it is crystal derived. Currently the 1.5MHz c.p.u. clock only allows 1800bit/s and an external baud generator is an attractive proposition. Both −5 and +12V supplies are used for the RS232 interface. Current from the −5V supply is so low that the RS232 driver has an active current limiter; the +12V drive is resistive.

Many of you will not have an RS232 terminal and will wish to use a separate keyboard and domestic tv. The keyboard interface will accept any 7bit parallel input signal with active-low most-significant-bit and active-low-going strobe and request signals. Two spare hand-shake lines on the p.i.a. and an output port could form a Centronics-type printer port.

An EF69364A video i.c. provides timing signals necessary for a 625-line tv; a 96364B device will provide signals timed for 525-line tv. Control code for the video i.c. is supplied through an LS157 quad two-to-one-line multiplexer and for normal display characters (p.i.a. B D_7=0) a fixed control code is set. When control characters (hexadecimal 0 to F) are used the p.i.a. supplies the relevant code through the multiplexer (p.i.a. B D_7=1) to the EF69364. As the c.r.t. gun scans the screen, the EF69364 selects the character to be displayed from the display ram and latches it into an LS273.

The video i.c. was designed for use with ram that has separate data input and output lines (2101 ram) so the circuit was modified to allow 2114 rams with common i/o to be used. Character-code from LS273 and row information from 69364 is supplied as an address to a character rom (a specially programmed 2716 eprom). Each character position is allocated a 7-wide-by-12-high character block.

Referring to last month's article, the signal name at pin 6 of IC_{41} is active low and should read $\bar{R}$, as should the signal name at the junction of IC_{47} pin 2 and IC_{45} pin 3. On page 57, pins 13, 12 and 5 of the LS175 should be labelled Y_0, Y_1 and Y_2 respectively.

A set of three programmed roms is available from Brian Woodroffe at 632 Queensferry Road, Edinburgh for £23.50 inclusive. Technomatic (see advertisers' index) will supply all i.cs mentioned in this article.

Disc-drive interfacing is described in the next article.

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continued from page 48

indebted to Keith Frewin, who wrote the SOFTBOX software, for providing roms 385 and 386.

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Assembly language programming

With the aid of examples, Bob Coates describes further instructions for the 6805 microprocessor. Memorizing these is not important – some instructions are hardly ever used – but being familiar with them will help later.

Instruction ADD adds the contents of the accumulator to the contents of a specified memory location. For example

```
AE00     LDX  #0
A613     LDA  # $13
D60785   ADD  $785,X
83       SWI
```

will add the accumulator to the contents of address 785. As previously shown, this is AE so the result in the accumulator should be C1 after SWI and the C bit should be clear.

Add memory/carry to accumulator, ADC. Analogous to ADD, this instruction adds the contents of the memory location and the carry bit of the condition-code register to the accumulator contents. The carry bit will normally have been set by a previous ADD or ADC instruction. This allows numbers of greater than 8bit to be added together and is often referred to as being multiple precision.

To demonstrate, the program shown in Table 1 adds two 16bit numbers by placing the first number in address locations 50 and 51 and the second in locations 52 and 53 then placing the result in locations 54 and 55. Of the two bytes required for each 16bit number, the most significant is placed in the lower memory location and the least significant above it. Before running the program, place the two numbers to be added in locations 50 to 53. Using 12C4 and 5678 as the two numbers, the result in locations 54 and 55 should be 693C (check using the Picotutor mo function).

The program works by adding together the least-significant digits in locations 51 and 53 first and storing the result in location 55. ADD is used here since the carry bit contains no relevant data, but the bit will be set by the instruction in this case through, the result of adding C4 and 78 being 3C and a carry indication. Next the two most significant bytes are added together along with the carry bit. Adding 12 and 56 will give 68 but with the carry bit this becomes 69.

This principle can in theory be extended to add any number of multiples of eight bits, adding the least-significant byte first and working upward; this is how computers perform arithmetic operations on very large numbers. Correct operation of this program relies on the fact that STA and LDA instructions between the ADD and ADC instructions do not affect the condition-code register. How various instructions affect this register must be taken into account when writing a program. Effects of instructions on the condition-code register are shown in the instruction table and one can see that STA and LDA do not affect the carry bit (C).

by R. F. Coates

Subtract memory from accumulator, SUB/SBC. These instructions, the latter subtracting memory from the accumulator with a borrow indication, operate in a similar way to the addition instructions. With SBC the carry bit is used to indicate a borrowed digit from the previous subtraction step. Two 16bit numbers can be subtracted as in Table 2 and the program may be extended to operate on any number in multiples of eight bits as with the addition program of Table 1. Here the 16bit number in locations 52 and 53 is subtracted from the number in locations 50 and 51, the result being placed in 54 and 55. For example, subtracting 1234 from 5612 gives 43DE.

Addition and subtraction programs for 16bit numbers using 6800/6809 and Z80 microprocessors are shown in Tables 3 and 4 respectively. These processors have 16bit addition and subtraction facilities which make multiple-precision arithmetic much faster using shorter programs.

These four instructions perform logical operations on data in the accumulator.

AND. Accumulator and memory or an immediate byte are subjected to an AND operation and the result is stored in the accumulator. Bit Z in the condition-code register is set only if the operation results in all zero bits and bit N of the c.c.r. is set if bit 7 of the result is set, i.e., the result is negative.

BIT. Bit test is the same as AND but only the condition-code register is affected; the accumulator holds its original content.

ORA. Accumulator and memory or an immediate byte are subjected to an OR operation and the result is in the accumulator. Bits N and Z of the condition-code register are set or cleared as appropriate.

EOR. Accumulator and memory or an immediate byte are subjected to an exclusive-OR operation and the result is in the accumulator. Bits N and Z are set or cleared as appropriate.

A short example of the AND instruction is as follows.

```
030   A655   LDA  #$55
032   A40F   AND  #$0F
034   83     SWI
```

The operation is clearer when the numbers are converted to binary form.

1st number	0101 0101	$55
2nd number	0000 1111	$0F
result of AND	0000 0101	$05

A bit in the result is only set when corresponding bits in the two numbers are set. If the Picotutor register key is used to examine the registers after running the program, both N and Z bits in the c.c.r. will be clear (represented by a dash) and the accumulator will contain 05.

Now change the AND op-code in the program to ORA (A4 to AA) and run it again. If a bit in either or both numbers is set, that bit will be set in the result, i.e.

1st number	0101 0101	$55
2nd number	0000 1111	$0F
result of OR	0101 1111	$5F

Finally, change ORA to EOR (AA to A8). If a bit in one number but not the other is set, that bit will be set in the result.

1st number	0101 0101	$55
2nd number	0000 1111	$0F
result of EOR	0101 1010	$5A

CMP, CPX. These instructions compare the accumulator and the index register respectively, with memory. N, Z, and C bits of the c.c.r. are set or reset as appropriate. The operation subtracts the memory content from the accumulator or index register value but the register is not modified, e.g.

A643	LDA	#$43
A143	CMP	#$43
83	SWI	

loads the accumulator with 43 and 43 is subtracted from it by the CMP instruction. The result of the subtraction is zero and so the Z bit is set and N and C bits are cleared; the accumulator still contains 43.

Two jump instructions complete this section. These instructions are used when the normal sequence of program execution is to be broken and execution continued from some other point.

Jump unconditional, JMP. We have already used JMP to terminate examples and restart the monitor program.

BC80	JMP	$80	jump to monitor start

This example uses direct addressing. Extended and indexed addressing may also be used but immediate addressing may not.

AE80	LDX	#$80
FC	JMP	0,X

would have the same results as the first example.

Jump to subroutine, JSR. A subroutine is a separate section of program which may be called from different places in the main program, as expalined in the February issue. The jump part of the operation is the same as for JMP, but the address of the instruction directly after the JSR is stored on the stack so that at the end of the subroutine the program knows where to return to. Examples of this will be given.

Read/modify/write instructions

Addressing modes are different when studying these instructions. For extended and indexed addressing modes, 16bit offsets are not used although theoretically there is no reason why they shouldn't be (16bit offsets are used on the 6809). But this group is used for modifying memory or i/o locations and since these locations are all below FF on the 6805, offsets greater than eight bits are unnecessary.

Two addressing modes, inherent (A) and inherent (X), are used to modify the accumulator or index register rather than memory. The following programs demonstrate all the instructions in this section. After execution the register key should be used to examine the appropriate register and the C bit in the condition-code register if it is affected by the instruction. Ram location 60 will contain the result in the third example.

Inherent (A)

030	A680	LDA	#$80
032	4C	INCA	
033	83	SWI	

Inherent (X)

040	AE80	LDX	#$80
042	5C	INCX	
043	83	SWI	

Direct

050	A680	LDA	#$80
052	B760	STA	$60
054	3C60	INC	$60
056	83	SWI	

Increment, INC. The three previous examples illustrate use of the increment instruction, incrementing the accumulator, index register and memory location 60 respectively. In the last case memory location 60 is loaded with 80 before being incremented. In all cases the result should be 81. The condition-code register carry bit is not affected by this operation but if bit seven of the result is one, bit N is set, and the Z bit is set if the result is zero. Changing the first line operand from 80 to FF results in wrap around, i.e. incrementing FF gives 00 and consequently the Z bit is set.

Code for this set of instructions must be carefully written. Direct and indexed modes are represented as expected with the mnemonic in the op-code/mnemonic field and the direct address or offset and suffix in the operand/address field, i.e.

INC	$60
INC	$60,X

but with inherent modes the register representation should directly follow the instruction mnemonic and the operand field left empty, i.e. INCX. A computer assembler will interpret INC X as INC 0,X which is indexed, no-offset mode, and convert the instruction to machine code 7C instead of 5C.

Further instructions in this section can be seen in operation by inserting them in place of INC in the previous three examples.

Decrement, DEC, is the reverse of increment and decrementing 00 will result in FF. Clear, CLR, results in 00 being written into the specified register/memory location. With complement, COM, the state of each bit in the register or memory location is inverted, e.g.

	$46	0100 0110
becomes	$B9	1011 1001

Negate, NEG, calculates the two's complement of a number by subtracting the register or memory content from zero, e.g. 00−02=FE. Logical shift left, represented by LSL, shifts all bits in the register or memory location to the left, i.e. bit 7 of the number goes into the c.c.r. C bit, bit six of the number replaces bit 7, bit 5 replaces bit 6 and so on until a zero goes into bit 0. While trying out this example it may help to convert the hexadecimal numbers to binary form on paper; use different numbers, some with bit seven set, others with bit seven cleared, to see the effect on the condition-code register.

Rotate left, ROL, is similar to shift left but instead of zero being entered into bit zero of the register or memory location, the original content of the c.c.r. C bit is entered. If two ROL instructions are performed bit seven will first enter the c.c.r. carry-bit position and on the next ROL the carry-bit, originally bit seven, goes to bit zero of the register or memory location – hence the term rotation. Nine consecutive rotate-left operations give a full rotation and conditions are the same as they were at the start.

Logical shift right, LSR, and rotate right, ROR, are similar to LSL and ROL respectively but they work in the opposite direction. Arithmetic shift right, ASR, is the same as LSR but instead of a zero entering bit seven, the original bit seven status is retained. Shift and rotate instructions are illustrated in the instruction tables shown on page 64 of *Wireless World*, April, in the Boolean operation column.

Test for negative or zero, TST, only affects the condition-code register. N and Z bits are set or cleared according to whether the register or memory-location value is negative (bit seven is one) or zero.

Control instructions

Only inherent addressing mode is used with control instructions. Inherent instructions require no operand so they are only one byte long.

Transfer A to X, TAX, duplicates the content of the accumulator in the index register and TXA duplicates the index register in the accumulator, e.g.

A655	LDA #$55
AEAA	LDX #$AA
83	SWI
97	TAX
83	SWI

In this example the first SWI provides a break after loading the accumulator and index register so that the register key may be used to confirm the operation. Pressing the cn key continues the program after the first SWI. Now the register key may be used to check that both registers contain 55. TAX may be replaced with TXA and its operation examined in the same way.

Set carry bit, SEC, and clear carry bit, CLC, allow the condition-code register carry bit to be altered. With the return from subroutine instruction, RTS, if a subroutine is called by a jump or branch instruction (JSR or BSR), the return address is stored on the stack and the stack pointer is moved down by two bytes; the return address is the address of the instruction immediately following JSR or BSR.

A return from subroutine instruction, always the last instruction in a subroutine, causes the stack pointer to return to its original position by taking from it the return address. The return address is placed in the program counter and program execution proceeds. In this way the main routine is always restarted at the correct point even though the same subroutine may be called at different points in the program.

Reset stack pointer, RSP, sets the stack pointer to address 07F. When the power is turned on the stack pointer is automatically initialized with 07F, which is the highest ram address in the 6805. Normally, manipulation of the stack pointer is not required.

No operation, NOP, does nothing but use two bytes of memory and take two clock cycles to execute. Despite that it is useful. In precise timing applications, no operation can be used to set a period to within two clock cycles (1.9μs at maximum clock frequency) and it can be used to provide gaps in programs under development so that further instructions may be added later.

The last four instructions in this section concern interrupts. An interrupt discontinues the normal program flow to execute a program section called an interrupt-service routine (similar to a subroutine) and is used when a function outside the normal program requires immediate attention. When an interrupt occurs all the registers are stacked (saved) so that the main program can continue from where it left off after the interruption has been dealt with; an interrupt can occur anywhere in the program. A 'vector' or address of the start of the service routine is taken from an eprom location. The location of the vector is specified by the manufacturer.

Three types of interrupt are possible with the 6805. As will be explained later, the processor has its own timer that may be used to interrupt programs. Secondly a software-interrupt instruction, SWI, causes an interruption resulting in the registers being stacked and the program counter being loaded with the vector at eprom addresses 7FC and 7FD; in the Picotutor these locations hold the monitor program starting address. When the continue key is pressed the monitor takes the register content from the stack and continues running the program keyed in.

The third type is called a hardware interrupt. If the INT pin of the 68705 is taken low, program execution is stopped after completion of the current instruction, the registers are stacked, and the program counter is loaded from addresses 7FA and 7FB. These will have been programmed with the starting address of the interrupt-service routine. Hardware and timer interrupts may be masked if the main program is too important to be broken off, bit I in the condition-code register indicating the mask status. If bit I is set, any interrupt from the INT pin or internal timer will be inhibited. Interrupts are dealt with immediately if the I bit is clear.

Clear interrupt mask, CLI, and set interrupt mask, SEI, are two instructions that allow the c.c.r. I bit to be altered by a program. Sections of a program that may not be interrupted are preceded with SEI and terminated with CLI.

An interrupt-service routine always ends with a return from subroutine instruction represented by RTI. This instruction is similar to RTS but as well as taking the return address from the stack, RTI also takes the contents of the accumulator, condition-code and index registers.

Branch instructions

The power of microprocessors lies in their ability to take one course of action if certain conditions exist or another course of action if they don't exist. Conditional branch or jump instructions allow this by examining bits in the condition-code register. When a specified condition is not true sequential programming continues, but if the condition is true, control is passed to an address specified in the instruction operand, e.g.

```
        LDA     #$05
LOOP    DECA
        BNE     LOOP
        SWI
```

This program loads the accumulator with 05 then decrements the accumulator (DECA) so that it contains 04. Branch-if-not-equal-to-zero, represented by BNE, causes a branch if the last instruction affecting the c.c.r. Z bit did not result in zero. As shown in the instruction table, DEC affects the N and Z bits according to the result of the decrement but other c.c.r. bits are not affected. Only if the result of the decrement is zero is the Z bit set; the BNE branch instruction examines this bit and causes a branch if the Z bit is clear. When the Z bit is set the program carries out the software-interrupt instruction SWI.

Where the program branches to is indicated by the source-code label in the operand field of the branch instruction, here called loop, and the program will branch to the instruction where this label appears in the label field. This is on the line of DECA so this instruction will be executed again, decrementing the accumulator value from 04 to 03. The branch instruction is again encountered and the Z bit checked and so another branch back to DECA occurs. Looping continues until the accumulator is decremented to zero, resulting in the Z bit being set. Branching will now not occur and the software-interrupt instruction passes control back to the monitor program. Although it means the same thing, this type of instruction is referred to as a conditional jump in Z80 and 8080 microprocessor terminology, rather than a conditional branch.

The way in which the processor is told where it must jump or branch to in machine code has yet to be resolved. With the 8080 this is straightforward; the single-byte op-code for the jump instruction is followed by two bytes containing the jump address. An additional form for the Z80 is a relative jump. Motorola processors only have this form of jump.

In relative jumps a single byte following the op-code is an offset value representing the number of bytes to be branched backwards or forwards from the current program-counter position (the program counter points to the instruction after the branch). In the example the branch instruction requires two bytes and the decrement-accumulator instruction one byte so to branch from the SWI address to the address of DECA requires an offset of −3. Byte two of the branch instruction contains this value.

So far only 8bit bytes containing unsigned values from 00 to FF (0 to 255 decimal) have been considered. But it is possible to indicate the sign of any binary number using the state of the most-significant bit. In signed binary, 1111 1111 represents −127, 0111 1111 represents +127, 0000 0001 is +1 and 1000 0001 is −1. Signing eight-bit numbers in this way limits their magnitude to 127 though.

To calculate the address to which a branch instruction must branch to, the signed-binary offset must be added to the program counter after it has been incremented to point to the instruction after the branch. Signed-binary addition of the numbers eight and five is as follows.

0000 1000	(+8)
0000 0101	(+5)
0000 1101	(sum, +13)

And addition of eight and minus five,

0000 1000	(+8)
1000 0101	(−5)
1000 1101	(sum, −13)

Clearly this is incorrect. To add signed-binary numbers correctly the processor would have to perform extra actions depending on the sign of the number, which would result in valuable processing time being wasted. Representing the signed-binary number in two's complement form solves this problem.

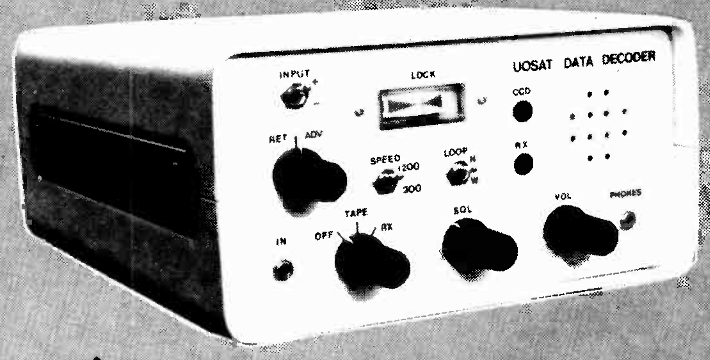
One's complement

In one's complement representation all positive integers are represented in their correct binary form, i.e. +6 is represented by 0000 0110. But the number's complement, -6, is represented by complementing each bit. Each zero is changed to one and each one to a zero so −6 is 1111 1001. The addition of +8 and −5 is now

0000 1000	(+8)
1111 1010	(−5)
0000 0010	(sum, +2 with 1 carried)

which is nearer but still incorrect.
Two's complements and the ins and outs of branching are subjects of the next article.

UOSAT data decoder



Correction: Data decoder for UOSAT. In Fig. 11 of J. R. Miller's article (May 1983), IC_3 and IC_{12} (which should both be 40161 c.m.o.s. counters) were incorrectly shown with pin 8 connected to the +12V rail. Pin 8 is in fact the V_{ss} terminal and should be connected to the 0V rail. It is pin 7 which should be at 12V.

Satellite TV aerial alignment

A microcomputer program for field installation engineers to use on site

by N. L. H. Cresdee

The coming of direct television broadcasting by satellite is likely to present considerable difficulties for aerial installers. It has been found (for instance, by early users of the Canadian Anik satellites) that positioning dish aerials by hand is certainly possible; but guesswork alone will not obtain the pointing accuracy of 0.5 degrees which is generally accepted as the required standard. In Europe, one interested group took two weeks to locate OTS-2 using blind search methods. Another group depended upon an outside contractor to make North-South markings on the aerial site prior to their own arrival. The markings were eventually found to have a massive error of 15 degrees and repeated observations had to be made to correct it. Other groups, however, have found that a search may take as little as a few minutes if the satellite is a powerful one – such as those in the Soviet Gorizont series. A spectrum analyser may often be the sole means of alignment or the primary means of alignment.

A further problem is that it is desirable to align dish aerials to the assigned position of the satellite rather than its actual position. Satellites now in orbit are allowed to drift up to 0.1 degrees from their assigned positions before thrusters are fired to bring them back. Although errors here may not disrupt reception of a satellite transmission they will degrade the quality of the picture.

To align satellite receiving aerials systematically, it is necessary to know the precise position of the receiving site. From this it is possible to calculate the azimuth and elevation of the required satellite. Consulting maps could be a laborious process, however, for a professional engineer installing aerials on a large scale. An alternative might be the use of a marine satellite navigator. It is now possible to buy one for under £1000; and in view of the fact that it could be used for several generations of satellites, the engineer might look upon it as a vocational investment. Another possibility is a magnetic compass or a gyro-compass; but for a magnetic compass it would be necessary to make corrections by consulting current lists of angles of magnetic declination. There might be local magnetic irregularies to take into account, such as the electricity board's transformer next door.

The single biggest problem is transferring bearings to the aerial system. If a compact gyro were placed on the aerial platform and true North located using the gyro read-out, this would probably resolve the difficulty.

When accurate co-ordinates for the re-

continued on page 71

```
  80 REM "DOMSAT"
  85 PRINT AT 10,10;"**********"
;AT 12,0;"  SATELLITE TV AERIAL
ALIGNMENT         by N.L.H.Cresde
e";AT 15,4;"Wireless World,June
1983";AT 17,10;"**********"
  90 PAUSE 100
 100 REM INPUT DISH POSITION IN
DEGREES, MINUTES AND SECONDS
 105 CLS
 110 PRINT AT 0,10;"**********";
AT 0,26;"PAGE 1";AT 2,0;"Input a
erial latitude in three  separat
e steps - each as whole  numbers
 - i.e. degrees, minutes and sec
onds.  N.B.  If latitude is sout
h of the equator then   inputs
must be prefixed negative";AT 10
,10;"**********"
 115 BEEP 0.25,0: INPUT "ENTER D
EGREES NOW ";LATDEG
 120 BEEP 0.25,0: INPUT "ENTER M
INUTES NOW ";LATMIN
 125 BEEP 0.25,0: INPUT "ENTER S
ECONDS NOW ";LATSEC
 130 LET LAMDEC=LATMIN*0.016667
 135 LET LASDEC=LATSEC*0.000278
 140 LET LAT=LATDEG+LAMDEC+LASDE
C
 145 CLS
 150 PRINT AT 0,10;"**********";
AT 0,26;"PAGE 2";AT 2,0;"Input a
erial  longitude in three separa
te steps - each as whole  number
s - i.e.  degrees,minutesand sec
onds.  N.B.  If longitudeis east
 of Greenwich then inputsmust be
 prefixed negative.";AT 10,10;"*
*********"
 155 BEEP 0.25,0: INPUT "ENTER D
EGREES NOW ";LNGDEG
 160 BEEP 0.25,0: INPUT "ENTER M
INUTES NOW ";LNGMIN
 165 BEEP 0.25,0: INPUT "ENTER S
ECONDS NOW ";LNGSEC
 170 LET LOMDEC=LNGMIN*0.016667
 175 LET LOSDEC=LNGSEC*0.000278
 180 LET LNG=LNGDEG+LOMDEC+LOSDE
C
 900 LET A$="ORBITS AT "
 910 LET C$=" DEG"
 920 LET D$="AZIMUTH "
 930 LET E$=" TRUE"
 940 LET H$="ELEVATION "
 945 LET I$="OR "
 950 LET M$="RANGE "
 960 LET Q$=" N.MILES"
 970 LET Y$="km"
1010 REM "RAS" IS IN INTERNATION
AL NAUTICAL MILES.  "RUK" IS IN
BRITISH NAUTICAL MILES.  "RKS" I
S IN KILOMETRES.
1020 LET K=6.61
1030 LET RAS=22767.4
1032 LET RUK=22754.9
1035 LET RKS=42164.9
1036 LET RSM=26200
1040 LET RAD=PI/180
1050 LET DEG=180/PI
1110 CLS
1120 PRINT AT 0,26;"PAGE 3";AT 1
0,10;"**********";AT 12,6;"ONE M
OMENT PLEASE";AT 14,10;"********
**"
1130 PAUSE 100
1140 CLS
1150 PRINT AT 0,10;"**********";
AT 0,17;"PAGES 4 THRU 14";AT 1,0
;"FIGS FOR LAT ";LAT;AT 1,18;" L
ONG ";LNG;AT 1,30;"  ";AT 2,10
;"**********";AT 3,4;"SAT INFO B
EING PROCESSED";AT 4,10;"*******
***"
1160 PRINT
2000 DATA "INLST-5D"
2010 DATA "INLST-5B"
2020 DATA "INLST4AE"
2030 DATA "GORZNT-1"
2040 DATA "RADUGA-4"
2050 DATA "RADUGA-6"
2060 DATA "RADUGA-9"
2070 DATA "PALAPA-2"
2080 DATA "INLST-5E"
2090 DATA "ARABSAT1"
2100 DATA "ECS-2"
2110 DATA "ECS-1"
2120 DATA "OTS-2"
2130 DATA "INLST-4A"
2140 DATA "SYMPHN-1"
2150 DATA "SYMPHN-2"
2160 DATA "TELECOM1"
2170 DATA "GORZNT-4"
2180 DATA "INLST4AA"
2190 DATA "INLST4AB"
2200 DATA "SIRIO-1"
2210 DATA "INLST-5C"
2220 DATA "INLST-4C"
2230 DATA "RADUGA-7"
2240 DATA "INLST-5A"
2250 DATA "INLST4AC"
2260 DATA "INLST-4B"
2270 DATA "TDRS-2"
2280 DATA "INLST-4E"
2290 DATA "INLST-4D"
2300 DATA "SATCOM-7"
2310 DATA "GALAXY-2"
2320 DATA "TDRS-3"
2400 DIM S$(33,8)
2420 FOR I=1 TO 33
2430 READ S$(I)
2440 NEXT I
2500 DATA -62.81
2510 DATA -60.15
2520 DATA -59.97
2530 DATA -61.47
2540 DATA -37.16
2550 DATA -34.20
2560 DATA -35.96
2570 DATA -40.14
2580 DATA -26.05
2590 DATA -18.00
2600 DATA -13.00
2610 DATA -10.00
2620 DATA -4.94
2630 DATA -3.09
2640 DATA 11.86
2650 DATA 11.24
2660 DATA 10.00
2670 DATA 14.13
2680 DATA 18.53
2690 DATA 21.76
2700 DATA 24.24
2710 DATA 24.47
2720 DATA 0.65
2730 DATA 26.30
2740 DATA 27.48
2750 DATA 34.44
2760 DATA 49.58
2770 DATA 41.00
2780 DATA 52.86
2790 DATA 46.79
2800 DATA 66.00
2810 DATA 74.00
2820 DATA 79.00
2900 DIM Z(33)
2910 FOR A=1 TO 33
2920 READ Z(A)
2930 NEXT A
3500 FOR N=1 TO 33
3510 LET U=RAD*Z(N)
3520 LET F=RAD*LNG
3530 LET G=RAD*LAT
3540 LET L=F-U
3550 LET X=(COS (G)*COS (L))
3560 LET ACSN1=-ATN (X/SQR (-X*X
+1))+PI/2
3570 LET J=ACSN1
3580 REM T=TRUE AZIMUTH
3590 LET V=(-TAN (G)/TAN (J))
3600 LET ACSN2=-ATN (V/SQR (-V*V
+1))+PI/2
3610 LET T=ACSN2
3620 IF L<0 THEN LET T=2*PI-T
3625 LET TDG=DEG*T
3630 REM "ELV" IS ELEVATION BEAR
ING IN RADIANS
3640 LET ELV=ATN ((COS (J)-(1/K)
)/SQR (1-COS (J)*COS (J)))
3650 LET B=DEG*ELV
3660 LET RNM=RAS*SQR (((1-(0.302
57*COS (J))+0.0228574)))
3670 LET RKM=RKS*SQR (((1-(0.302
57*COS (J))+0.0228574)))
3680 PRINT TAB 0; INK 2;S$(N);TA
B 9; INK 0;A$;TAB 19;Z(N);TAB 25
;C$;TAB 41;D$;TAB 49;TDG;TAB 56;
E$;TAB 73;H$;TAB 83;B;TAB 92;C$;
TAB 105;M$;TAB 111;RNM;TAB 120;Q
$;TAB 143;I$;TAB 146;RKM;TAB 156
;Y$;TAB 202;"
                **********";TAB 235
3690 NEXT N
```

***Program listing from a ZX Printer.** The screen display asks for the latitude and longitude of the receiving site. It then produces a scrolling list of satellites together with the calculated ranges and aerial bearings. From these the user can make a selection.*

Microcomputer organ interface and music editor

Alphanumeric entry format for organ music is capable of handling the conventional deviations from the musical score, together with other elements of musical expression. Data representing music played on the organ may also be recorded and edited.

by D. R. Easson

This interface connects a Nascom 2 Z80 microcomputer to an electronic organ or pipe organ with electric action, and allows three modes of operation.

Read. Music played on the organ is stored in "data format" within the computer ram (memory requirement about 2K bytes per minute).

Play. Music stored in data format can be replayed by the computer, with speed and registration changed if desired. Simultaneously, the organ may be played normally, enabling a player to practise duets.

Translate. Music typed in on the Nascom keyboard direct from score using the "entry format" described is translated by the computer into data format. "Pages" of up to 11 lines in entry format can be edited on the v.d.u. and up to ten such pages can be stored for later recall.

Recordings can be edited at various levels in any of the three modes. In particular, any section of a recording in data format can be corrected, deleted, repeated or replaced by a section of another recording, during play mode. The three modes of operation may be interchanged to produce a continuous recording.

Music played on the organ is read from a cascade of 4021 registers (read mode). Data is recorded only at an "event", when the status of a register changes, and comprises the numbe and revised status of the appropriate registers together with the "duration" (the number of frames) between successive events.

Play mode operates the organ via a cascade of 4094 registers. Thus, for example, 24 pairs of registers provide a 192bit-wide bidirectional bus to the organ console. The c-mos registers accommodate a range of console operating voltages.

The computer is interrupt-driven by an external oscillator which defines the frame rate. Connection to the computer is via two peripheral i/o ports.

Software comprises about 5K bytes written in Z80 machine code. Some use is made of the Nascom 2 monitor (NAS-SYS 3). In the software listing, the play and read routines are designated AP, the translate routine MC and the edit routines E. Various software manipulations are listed in Appendix II.

Hardware

The circuit has two modes, read and play, set by RD(M) or PLY(M). RD(M) reads 23 bytes per frame from the 4021 registers via port A. PLY(M) reads 24 bytes via port B to the 4094 registers (the first byte of the 24 is spurious and is lost, but the extra byte allows the c.p.u. output to be timed by FP). The byte counter can be rearranged, in general, for counts of N and N+1, where N is the number of register pairs.

Fig. 1 shows how the cascades of registers convert the eight-bit parallel ports A and B of the Nascom 2 into an 8N-bit parallel interface to the organ console. The electronic organ for which the system was developed uses 12V switching of a matrix of 1,500 transistor switches for the tone keying, whilst the stop and piston switching is via t.t.l. (part of a piston capture system). The 4094 registers, divided between a 12V board and a 5V board, can drive both sets of switches without extra buffers. Diodes prevent conflict between the register outputs and console keying contacts, allowing duets to be played by the organist and the microcomputer.

The serial data transfer is accomplished by signal CP (Fig. 2), from a 4047 astable at about 0.5MHz. The frame rate is controlled by FP from another 4047. The two oscillators do not need to be locked and FP is given a range of 20-120Hz to allow variation of replay speed. It takes about 0.5ms to transfer one frame of 23 bytes. The speed of the software is such that this could be halved by increasing CP to 1 MHz, but except on a much larger system only a purist would bother about this. (The BSX20 pull-ups between the boards introduce a delay of about 0.25μs which could easily be reduced. As it is, the circuit will run up to about 0.7MHz CP).

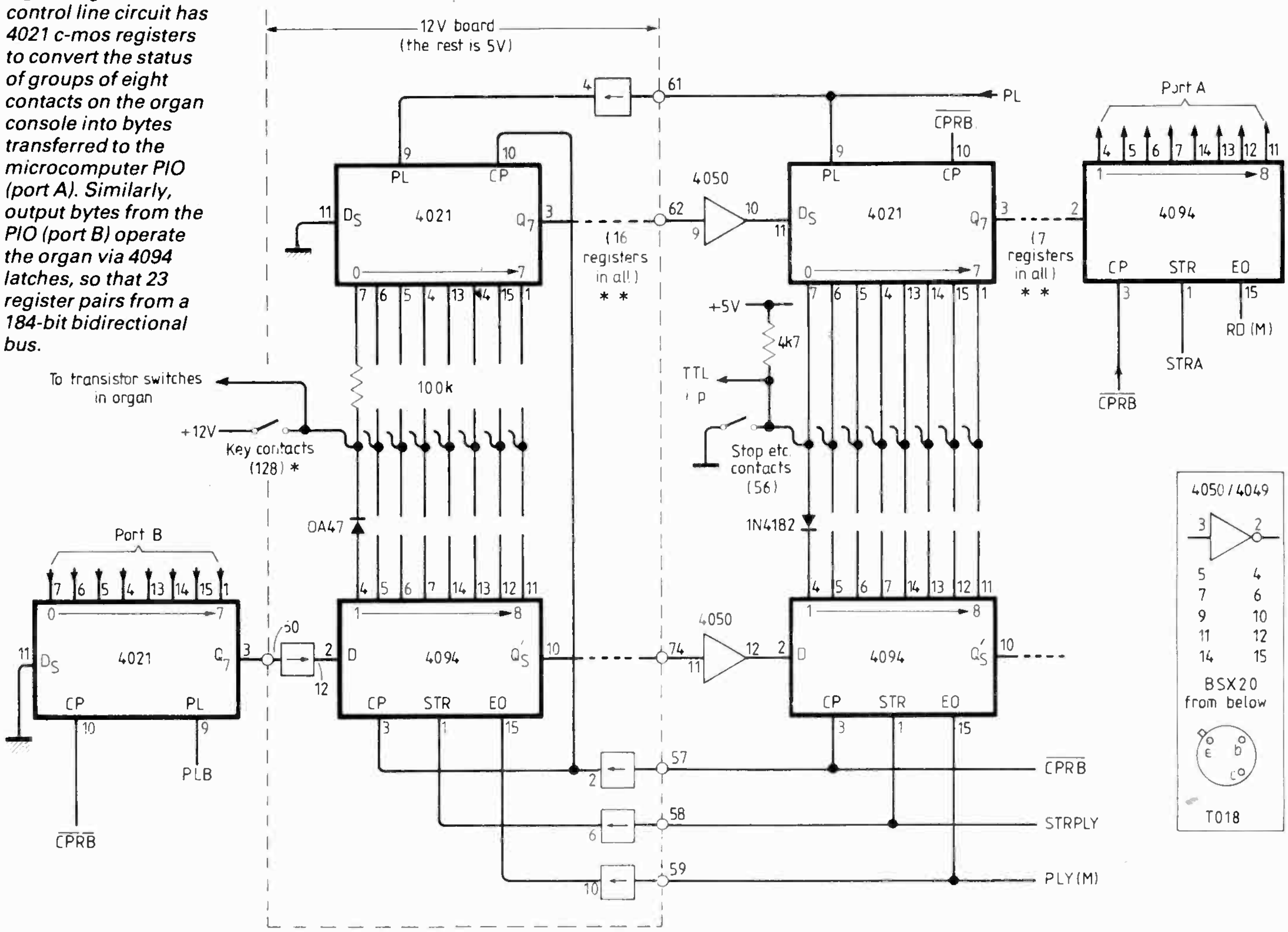
The c-mos parts should have buffered outputs, as in the Signetics HE4000B device family, for example. Devices with unbuffered outputs can cause excessive delays.

The circuit is synchronized to CP by 4013(1) when enabled by FP on its data input. Signal $\overline{CPRB}$ rises half a CP period later and this causes a serial shift towards and into port A (read mode). After eight periods of CP the first byte is in port A

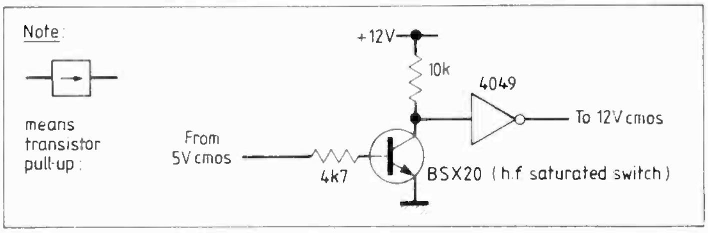
Interface and music editor

- The Nascom 2 or 3 is ideal for this interface but it could be easily adapted for any Z80A machine with two parallel ports. A good machine code monitor is helpful.
- Frequent scanning of the computer keyboard in play mode is required for the edit functions, achieved on the Nascom 2 by using the NAS-SYS 3 monitor routine IN (DF 62H) as part of the frame output routine.
- Pages in entry format can be saved as a high-level source code, suitable for later re-working. A disc-based system would be more convenient for such use.
- Entry format is easy to learn. The two-character note codes (C3 for middle C etc.) are an established standard for organ music. Most of the stop and note value codes are obvious.
- The standard manual compass for organs is now five octaves, C1 to C6 (61 notes) on each of two or more manuals; Pedal compass is about 2½ octaves C1 to F3 or G3 (30 or 32 notes). The organ that the interface was designed for was built to simulate an earlier classical instrument for which its four octave compass would be typical, but the additional registers could easily be accommodated.
- Two-character codes are converted by a look-up table. A conversion factor is added to or subtracted from the ASCII codes to keep the table reasonably compact. Converted codes are two-byte addresses in the table, the contents of which are the corresponding register and bit numbers.
- The most recent development of this device is a Forth vocabulary which works on a theme in data format to produce polyphonic extemporizations. Some harmonization rules are included.

Fig. 1. Register and control line circuit has 4021 c-mos registers to convert the status of groups of eight contacts on the organ console into bytes transferred to the microcomputer PIO (port A). Similarly, output bytes from the PIO (port B) operate the organ via 4094 latches, so that 23 register pairs from a 184-bit bidirectional bus.



4021	PL low for serial shift, high to load parallel (asynchronous)
4094	EO enable when high (tri-state)
4094	STR data to storage register when high (asynchronous)
*	2×49 note keyboard plus 30 note pedal
**	or as required



register, whilst count eight in the bit counter produces count one in the byte counter. Count eight also strobes the first byte asynchronously into port A latch.

Further bit counts are inhibited by $\overline{\mathrm{STR\ A}}$, and 4098 (B) produces a negative-going $\overline{\mathrm{STROBE}}$ handshake pulse to the Nascom MK 3881 PIO working in input mode (mode I). The rising edge of this pulse activates the interrupt request. The i/o READY line is then reset (low). When the c.p.u. has read the data the READY line is again raised and this sets 4013(2). This enables the bit counter to be cleared on MRA when $\overline{\mathrm{CP}}$ is high. The first $\overline{\mathrm{CPRB}}$ of the next byte is therefore delayed by at least half of a CP period, which ensures that timing is not critical.

When the 23rd byte has been read into the port A latch, 4013(1) is cleared by the byte counter on CD_1. The circuit stays inactive, apart from the clearing of the byte counter by $\overline{\mathrm{FP}}$, until the next frame.

In the play mode, operation is generally the same except that an extra byte is allowed so that the c.p.u. output can be initiated and timed by interrupts generated by FP. The Nascom PIO (port B) operates in output mode (mode O). In this mode, the output cycle is started by the execution of a c.p.u. output instruction. The first byte read into the first 4094 play register is spurious and eventually lost, but the corresponding READY from the Nascom PIO enables it to accept $\overline{\mathrm{STROBE}}$ from the interface. Thus the usual PIO output logic is reversed and the interface requests data from the c.p.u. And with this arrangement the handshake lines are commoned in pairs, as shown in Fig. 2.

The signal which clears the bit counter also forms PLB, which loads the data from the PIO into the port B 4021 after the handshake READY goes high. Signal $\overline{\mathrm{FP}}$ also forms STRPLY which strobes the 4094 play registers into their latches (each frame is held in the latches for one FP period, i.e. until the end of FP).

Data format

The data format is (starting at 1343 or 3343)

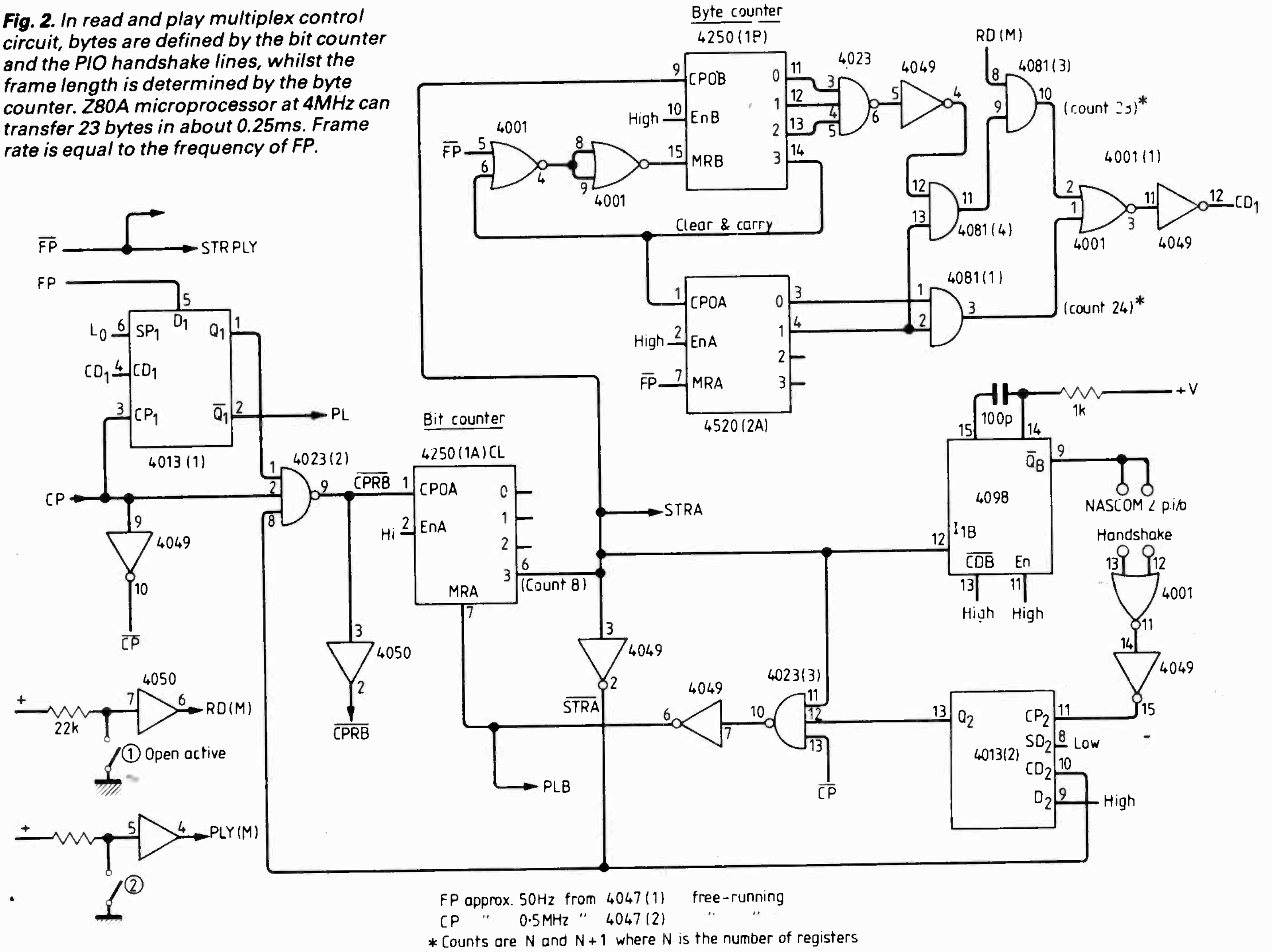
FF MM NN pp1 qq1 pp2 qq2 . . . FF

and where FF is the frame byte, MM, NN are the most and least significant bytes of the null frame count (NFC) between events (thus duration is represented by NFC +1), pp_n are the numbers (single-byte addresses) of registers to be reset after delay MM NN (delay after the final frame byte is always AA AA), and qq_n are updated statuses of registers pp_n.

In read mode, each frame defines an event and has at least one set of register data pp qq. Register statuses may be defined more than once during a frame (only the final status will be output when the event occurs).

The null frame count and the frame byte provide a relative time code. Frame byte addresses are used as edit points (see Editing).

Fig. 2. In read and play multiplex control circuit, bytes are defined by the bit counter and the PIO handshake lines, whilst the frame length is determined by the byte counter. Z80A microprocessor at 4MHz can transfer 23 bytes in about 0.25ms. Frame rate is equal to the frequency of FP.



Entry format

There are two types of entry. One defines events, which may be any number of notes to be played and/or released, stops to be drawn or cancelled, thumb pistons to be pressed or released (don't forget to release them!). Care is needed not to release notes which are not on – the organ isn't good at playing negative data. (An exception is the entry L for lift which releases all keys and pedals which may be on). And the other defines durations between events in terms of note values.

Events are defined by

- directory character (e.g. P, H, R, T or S for Pedal, Hauptwerk, Rugpositiv, Thumbpiston or Stop respectively)
- two-character note, piston or stop code (e.g. C3, GD or P8 for Middle C, the General Disable or Prinzipal 8′ respectively)
- further character for black notes to indicate sharp (Z) or flat (])
- final – if the event is a release (i.e. subtract).

Examples

PC1	Play pedal C1
HC3Z–	Release Hauptwerk C3♯
RA3]	Play Rugpositiv A3♭
TE3	Press Thumbpiston 3 in group E
SHP8	Draw Hauptwerk Prinzipal 8′
TGD	Press Thumbpiston General Disable
TGD–	Release Thumbpiston General Disable
L	Release all keys and pedals (this is useful but introduces redundant data if the registers are reset in the same frame).

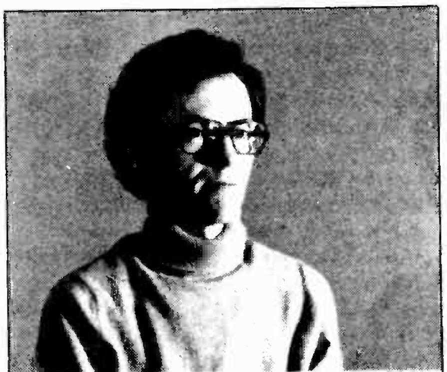
A page may be repeated using ED77 (having escaped from play mode if used by the direct command ".") or edited on the v.d.u. before the repeat if desired.

Durations are indicated by the directory character type ";" and defined by the appropriate note value between events at a rate of 16 or 32 frames per quaver. + and – add or subtract one frame each and thus allow agogic accents. Examples:

;Q.	indicates a dotted quaver (see comment* below)
;C.+++	indicates a dotted crotchet plus 3⁄16 or 3⁄32 of a *quaver*
;M–––	indicates a minim reduced by 3⁄16 or 3⁄32 of a *quaver*

Note values are H, D, S, Q, C, M, R (for semibreve) and B, but dotted breves are not permitted at 16 frames per quaver, nor are dotted semibreves at 32 frames per quaver. *Each group must end with a *space*. (Elsewhere, spaces are optional between code groups). The number of minus signs must not reduce the duration to zero or negative frames, e.g. H––– at 16 frames per quaver is not permitted. Rests are indicated in the same way.

The end of a page is indicated by ":". This is translated as the final delay AA AA. The appearance of the screen with a two-octave chromatic scale in entry format and all edit indicators is shown in Appendix 2.



Roy Easson, B.Sc(Econ), M.Inst.P., spent the early part of his career at the Royal Aircraft Establishment and then moved to industry, mainly with Standard Telephones and Cables Ltd. In 1970 he joined the staff of the National Research Development Corporation where he has been associated with the sponsorship of projects ranging from the Sinclair flat cathode ray tube to the suppression of noise from gas turbine exhausts by active methods ("antisound"). The activity described in these articles has been recreational.

Operation

The software is entered from the back-up store between locations 0C80 and 2000H. Execution from 0D40 (by typing ED40) displays a series of options, after the first of which part of the program is transferred to the top of user ram (F600-FFFF). The address FFFF is then displayed in the K block position (see Editing section). For each option, type the appropriate single character response. The options are:

1. Play from 1343 or 3343? (The last-mentioned allocates 8K of ram if required for storage in entry format).
2. Play, read or translate?
3. (If play) Manual 1, manual 2 or both? (If translate) Save or restore? Which leads to:
   Save (restore) which page (0-9)?

You may escape from any mode to the NAS-SYS 3 by typing ".". Subsequent execution from 0D40 returns to option 2 above. Save and restore also return to NAS-SYS 3 to allow on-screen editing. Translation into data format is effected by executing from 0D74 for the first page and subsequently from 0D77. Invalid directory entries or duration codes (see entry format section) abort the translation and display the error message ER on the bottom line.

For editing, several memory location addresses are displayed during operation:

Read	– address of the frame byte following the last event
Play	– address of the frame byte following the last event (four successive frame byte addresses are scrolled)
	– addresses of up to four frame bytes at selected edit points (see later)
	– address of the top of a block of data temporarily saved by K (see later)
Translate	– address of the frame byte (in data format) at the start of the relevant page (i.e. after execution from 0D74 or 0D77).

Editing during play and read modes is effected by a number of direct commands, summarized in the next section. Software manipulations are summarized in the Appendix.

During the preparation or editing of a recording, data should be saved in the back-up store, at prudent intervals, from address 1340 up to the final address displayed in play mode, plus 2 (the two extra bytes always comprise the duration AA AA, used as an indication to prevent some of the edit routines from chewing up the program). Ten pages in entry format are included (between 140A and 21B9). It is therefore straightforward to continue the translation of a piece from a cold start, some of which is in the back-up store – even if it is partly in data format and partly in entry format.

Editing

Entries in entry format can of course be edited under NAS-SYS 3. The user may translate, listen to and edit a page in entry format repeatedly if desired, using the direct command A (Again – see Appendix I for descriptions of this and other direct commands).

Recordings in data format are edited in play mode by noting edit points (using the direct commands S, 2 and N, aided if necessary by P, I, D, B, F and C). Once the edit points have been noted sections of recordings can be deleted, repeated or replaced by sections of other recordings, not necessarily of the same length, using the direct commands J, M, K and E.

Any part of a recording may be altered or corrected note by note using the note code tables in the program listing and the NAS-SYS 3 M command.

The direct commands for read mode allow a recording to be made in episodes by a player, with rehearsals of or repeated attempts at each episode. (Translate mode can be used for any really troublesome episodes!)

Direct commands

Play mode

.	Full stop (return to NAS-SYS Monitor)
B	Backward jump by about one line, or to start if appropriate
F	Forward jump by about one line (protected against end of data field by AA AA)
R	Restart from the beginning (or from address set at 1055/6) (MSB at 1056)
P	Pause (indicated by P on screen)
I	Increment to next event (including during P or S or 2)
D	Decrement to previous event
C	Continue after pause
S	Slow down to ⅓ speed and note an extra address
2	As for S but with another noted address (address 2≥ address S)
N	Normal speed (after S or 2) leaving the extra address
K	Keep the block of data between addresses noted at S and 2, starting at D000 and displaying address of top of block kept
M	Memorize two addresses noted by S and 2 (for use with E)
E	Edit. This inserts a block stored by K between two further addresses noted by S and 2. (The "further addresses" may be noted first and memorized by M.) If the two addresses of the insert point are the same, E may be repeated for multiple insertions of the kept block.
J	Join between addresses noted at S and 2 the upper bound being set to C000 (K before J is optional but of course without K the intermediate data is lost), see note below.
0	Transfer to read mode starting from the point in the datafield where you leave play mode
5	Introduce irregularity (each duration is incremented, decremented or left unaltered without changing the average speed. Use N to restore to normal. This command provides an indicator on the display).
A	Prepare to translate Page Again (sets PDP and CF to start of page, with delay AA AA after the start-of-page address)

Read mode

.	Full stop (return to NAS-SYS monitor)
R	Restart (i.e. try again) from last C unless . is used
0	Transfer to play mode, starting from the address set at 1055/66 (normally 1343 or 3343 as address of first register to be recorded)
P	Pause (this disables read mode without returning to the monitor – see C and R)
C	Continue after P (see R)

Note If J is used after K but it is then desired to restore the data to the original, set 1018/9 to displayed block length (=XXXX−D000) l.s. bit first, set S and 2 to the required point; type E.

Software to operate the interface in read, play and translate modes will be described in a later article.

Appendix 1. Software manipulation

Routines directly executable from NAS-SYS 3

ED40	Initiate play, read or translate modes
ED74	Translate first page in entry format
ED77	Translate subsequent pages in entry format
E1030	Play mode
E11B0	Read mode
E112A	Block transfer to lower address
E11AA	Block transfer to higher address
EF999	Clear screen and retitle

Note Block transfer routines are used by the direct commands K, J and E but may also be used independently (e.g. for making room for an additional register change during an event) by setting the scratchpad as indicated:
1010/1 (BB,AA) lowest source address AA BB
1012/3 (HH,GG) highest source address GG HH
1014/5 (DD,CC) lowest destination address CC DD.
Highest destination address is displayed and stored at 1016/7 (l.s.bit first). Block length is stored at 1018/9. Transfers include both of the limiting addresses.

Modifications

- Check or alter PDP: inspect or change scratchpad entries at the following addresses (l.s. bit first);

Play mode	1055/6
Read mode	F645/6
Read mode	F627/8 (after pause and continue)
ED74	FD04/5
ED77	10A4/5 (as also set by "." from play mode)

- Set date: see MC21*
- Cancel scrolling address in play mode: delete CD 60 FA at 107B/D (Substitute 00 00 00, see AP32*)
- Enable play mode to operate without routines held at top of ram: cancel scrolling address (see above)
- Cancel decoded PDP in Read Mode: delete CD 60 11 at 12A8/A (substitute 00 00 00, see AP39*)
- Reduce short durations with the direct command S: insert 2B at 12F2 (substitute for 00 (NOP) see E3*)
- Vary size of jump with direct command F: alter number at FEOC (see E6*)
- Vary speed ratio with direct commands S and 2: alter number of 19s at 12EA/FO (one for 2:1, see E3*)
- Vary frames per note in entry format: alter values as shown on MC6*
- Insert routines "clear screen and retitle" after ED40: insert CD 88 F9 at FEA5/7 (don't do this if you want to save pages in entry format), see AP39.5*
- Alter upper bound for direct command J: alter m-s.bit of upper bound address at 1001 (see E5*)
- Make ED74 and ED77 return to NAS-SYS 3: alter 0F08/A from C3 D8 F5 to DF 5B 00 (see MC7 and AP39.5*)

*Numbers refer to pages in the software listing.

Appendix 2 Screen display

```
Nascom Organ Interface  DRE 08/08/82

                    D077  354E
              340E  3539  3555
              3397  34DC  355C
                    404F  3563

HC1 ;Q L HC1Z ;Q L HD1 ;Q HD1- HE1J ;Q L HE1
;Q L HF1 ;Q HF1- HG1J ;Q HG1J- HG1 ;Q HG1- HA1J
;Q HA1J- HA1 ;Q HA1- HE1J ;Q HE1J- HE1 ;Q L HC2
;C L HD2J ;Q L HD2 ;Q L HD2Z ;Q L HE2 ;Q L HF2
;Q L HF2Z ;Q L HG2 ;Q L HG2Z ;Q L HA2 ;Q L HA2Z
;Q L HE2 ;Q L HC3 ;C L :
```

CIRCUIT IDEAS

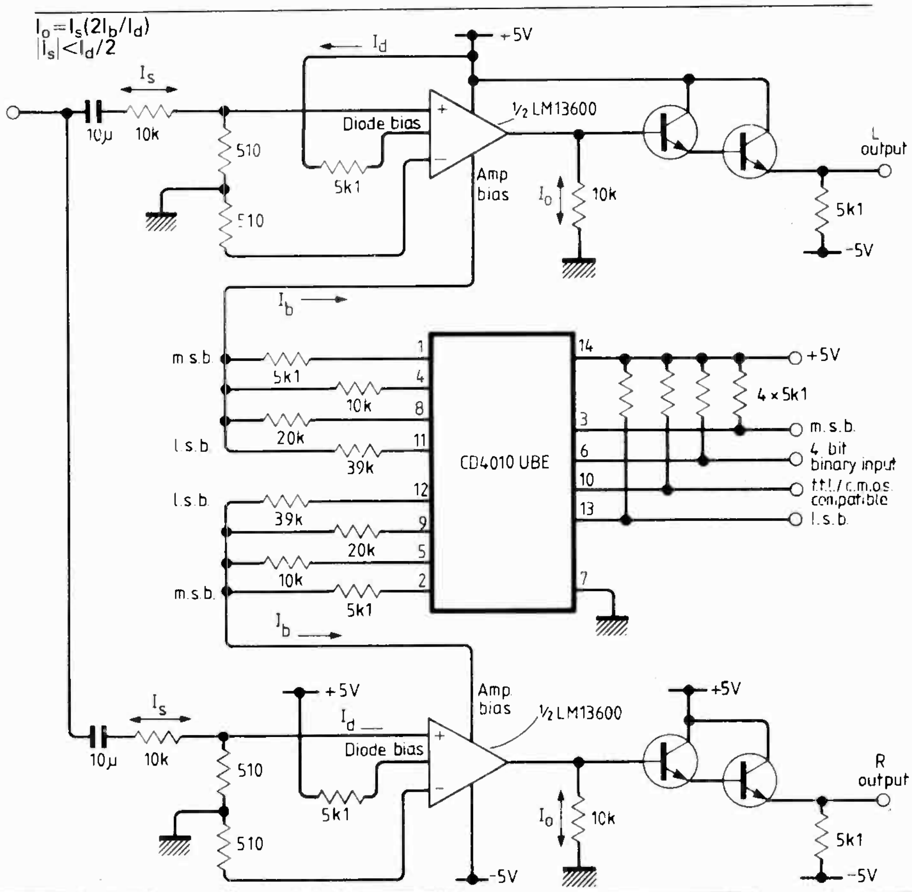
Programmable panpot

Designed for microprocessor control, this panpot steers a monophonic signal into two channels, depending on the value of a four-bit binary word. This gives 16 sound-stage locations. One i.c. is a quad true/-complement buffer with resistors added to form a digital-to-analogue converter, and the other i.c. has two transconductance circuits operating as current-controlled amplifiers.

Circuit behaviour shown is for resistor values derived from theory; these have yet to be confirmed as the best in practice. This design could possibly be extended to four channels – any suggestions on this would be most welcome.

John Lawson
Cheltenham
Gloucestershire

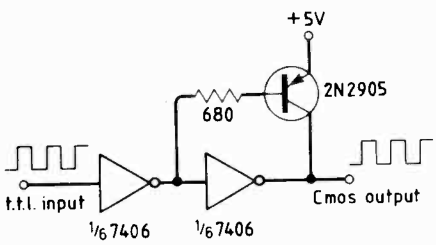
Binary input m.s.b.			l.s.b.	Gain (× 1/16) I_o/I_s L	R	
0	0	0	0	0	15	full right
0	0	0	1	1	14	
0	0	1	0	2	13	
0	0	1	1	3	12	
0	1	0	0	4	11	
0	1	0	1	5	10	
0	1	1	0	6	9	
0	1	1	1	7	8	centre
1	0	0	0	8	7	
1	0	0	1	9	6	
1	0	1	0	10	5	
1	0	1	1	11	4	
1	1	0	0	12	3	
1	1	0	1	13	2	
1	1	1	0	14	1	
1	1	1	1	15	0	full left



T.t.l.-to-cmos converter

Output of this circuit for driving cmos devices using a t.t.l. signal swings to within 0.2V of the 5V supply rail and will satisfy clock requirements of a microprocessor. The output load of a 7406 is formed by a p-n-p transistor whose base is driven by the inverter-input signal.

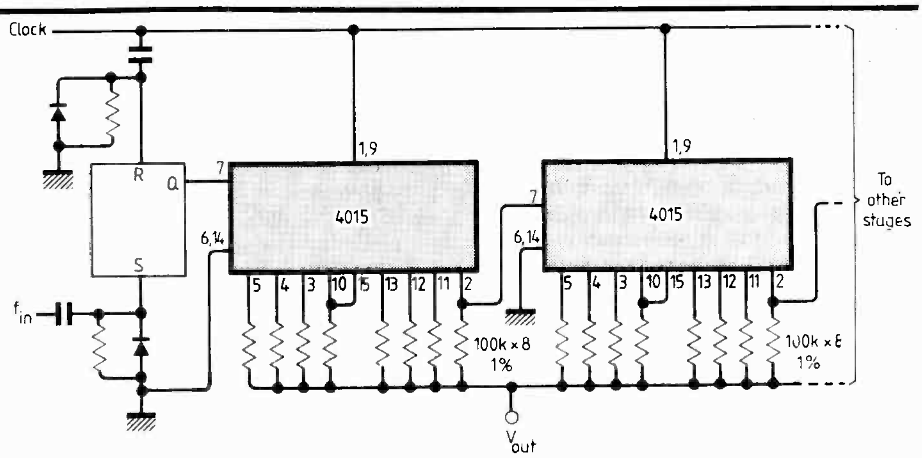
Paul Thompson
Department of Psychology
Glasgow University



Frequency-to-voltage conversion

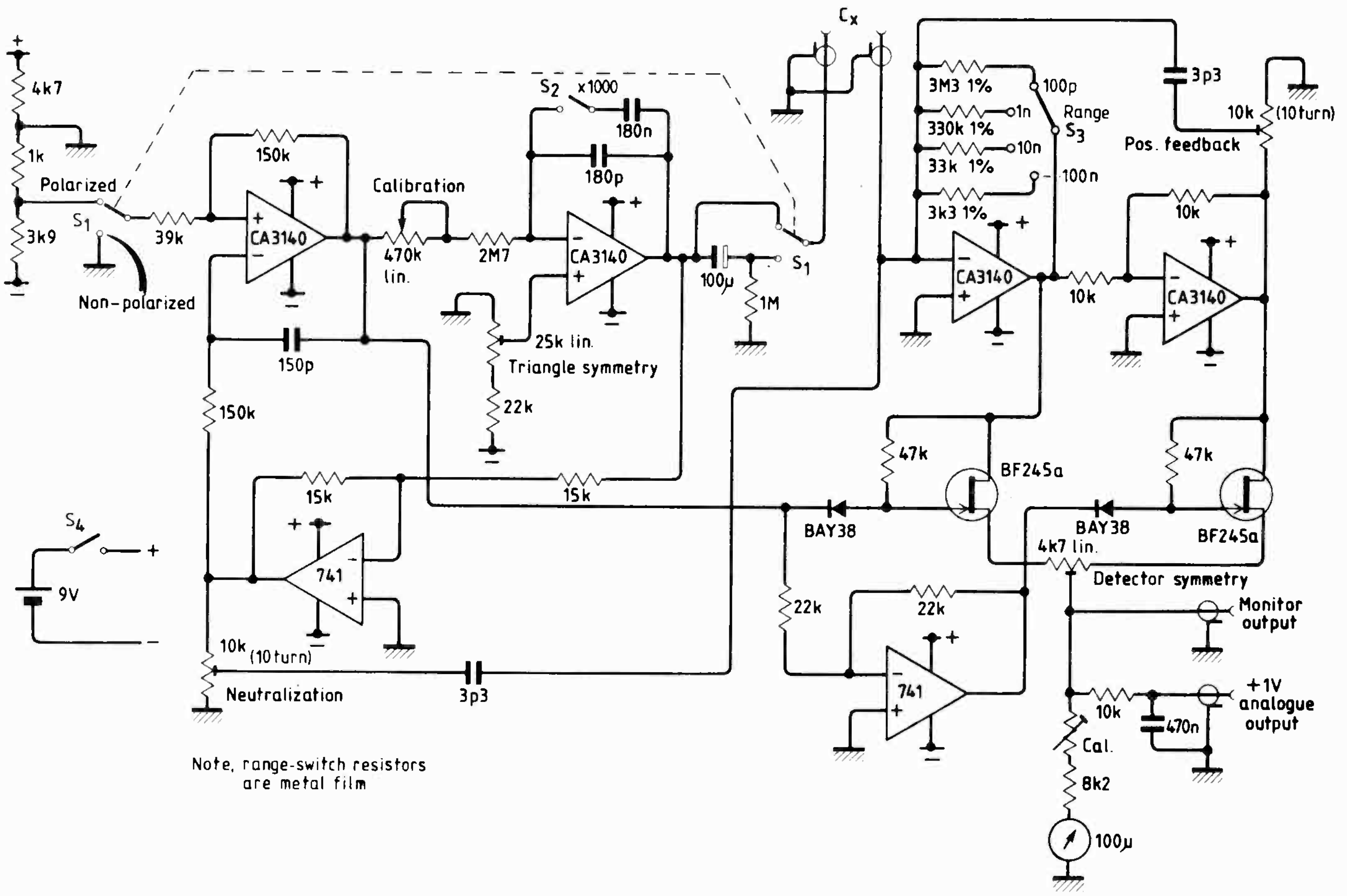
This versatile circuit for frequency-to-voltage conversion at frequencies too low for analogue conversion can be used for frequency-ratio measurements, energy-to-power conversion, etc. A clocked shift-register chain sees a logic 1 if the input signal caused a rising edge in the previous clock cycle, so the ratio of 1s to 0s in the register, represented by the analogue output, will be proportional to the ratio of the clock and input frequencies.

For frequency-to-voltage conversion the clock would be a reference frequency of, say, 1Hz and the input frequency would be less than 1Hz. If the register supply voltage is 10V then each volt at the output represents 0.1Hz. Resolution is determined by the number of shift-register stages and accuracy of around 99% can be achieved with the circuit shown; precision resistors and a stabilized supply can improve this figure.



Originally this circuit was designed for energy-to-power conversion with a pulse representing 5kWh occurring at most once every three seconds and at least once every 15 seconds to give an output proportional to power consumption at any time.

P. Chappel
Tintern
Gwent



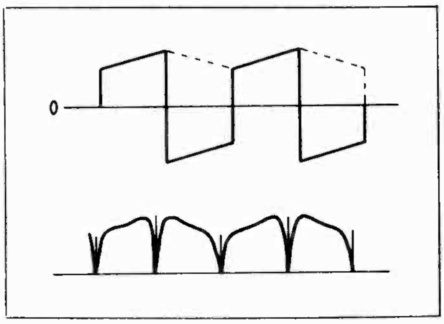
Capacitance-to-voltage converter

Designed to allow capacitors to be measured using a digital multimeter, this circuit uses synchronous detection with fet switches and gives good linearity with high noise immunity. Resolution on the 100pF range is 0.1pF with a 3-digit meter. Most digital meters operate with a 50Hz ramp so the frequency applied to the capacitor-under-test is 1000Hz or 1Hz to avoid display flicker. Four-terminal connections for the unknown capacitor eliminate stray capacitance effects and a neutralizing control allows nulling, even with no test capacitor connected on the 100pF range; two standard 50Ω cables of one metre long may be used.

Three i.cs on the left form a function generator giving a triangular waveform with rounded tops. For polarized capacitors and measuring the capacitance of reverse-biased semiconductor junctions the output signal may be lifted above the zero line using S_1. The second part of the circuit forms the measuring amplifier and synchronous detector. Driven through the capacitor, the measuring amplifier differentiates and inverts the ramp giving a trapezoidal output. An inverter is added to give full-wave synchronous rectification. Fet switches are driven by the hysteresis multivibrator and a further inverter provides balanced switching. Three decade steps are set in the measuring amplifier section and S_2 in the function generator divides the measuring frequency by 1000.

Output of the detector is made symmetrical by a potentiometer in the fet drains to stop 2Hz jumps in the d.m.m. connected to the analogue output. Stray capacitance between the generator and measuring amplifier is neutralized through a 3.3pF capacitor using the neutralizing control; if need be, the capacitor may be made slightly larger. The same arrangement reduces capacitive feedback of the measuring amplifier. Overcompensation here results in instability and perfect compensation is not achieved because of op-amp imperfections and stray feedback but this is not a problem in practice. Final setting is regulation of the generator output using the calibration control and a 1% capacitor on the 100pF range.

Semiconductor junctions may be measured which makes the instrument suitable for matching diodes for say, diode mixers. Ideally, with a triangle waveform at the input of the differentiator, a normal capacitor will give a squarewave output whose amplitude is proportional to the capacitance value but if a linear voltage-dependent capacitor is introduced the output waveform will have sloping tops (first waveform). After rectification the output is a linear triangle waveform superimposed on d.c. so the voltage/capacitance characteristic can be monitored by connecting an oscilloscope to the wiper of the detector symmetry control. In practice the voltage/-



capacitance characteristic has square-law properties due to field-effect phenomena (second waveform). Diodes are matched when their oscilloscope patterns are the same.

Parallel damping of the unknown capacitor does not influence readings because the synchronous detector is phase sensitive and 90° out of phase results in zero d.c. output. Resulting ripple is harmful on the 1Hz range but not using 1000Hz unless parallel damping is too high in which case the detector will overload. This condition is detected by turning the range switch. Wiring capacitance around the range switch should be kept as small as possible.

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Netherlands

Existing technology to speed up cable tv

Three of four draft standards for cable tv are now complete and reasons for delay of the fourth are announced. Speaking at the opening of the Applications of Fibre Optics Conference in London, Mr John Butcher MP junior Industry Minister said "draft British standards for multi-channel downstream (outgoing) PAL-1 tv with sound and teletext, multi-channel downstream f.m.-stereo radio channels and upstream tv signals using PAL-1 have been sent to the British Standards Institute and will shortly be available for public comment".

These standards are drafted for application to coaxial cable systems and according to DoI, systems based on optical fibres can readily meet standards defined for the interface at the head end and at the subscriber's equipment, but additional standards may be needed as optical-fibre technology advances.

Speaking earlier at the press launch of the International Cable and Satellite Television Conference, John Butcher outlined aspects of Government policy without, he said, revealing what is in store in the White Paper on cable tv due in April or early May. He said "We have been urged from several sources to insist on the use of fibre-optic cable, which is a British invention. In the longer term there is no doubt that fibre optics will predominate, but it is still an infant technology with a long way to go. It needs considerable development work. . . .

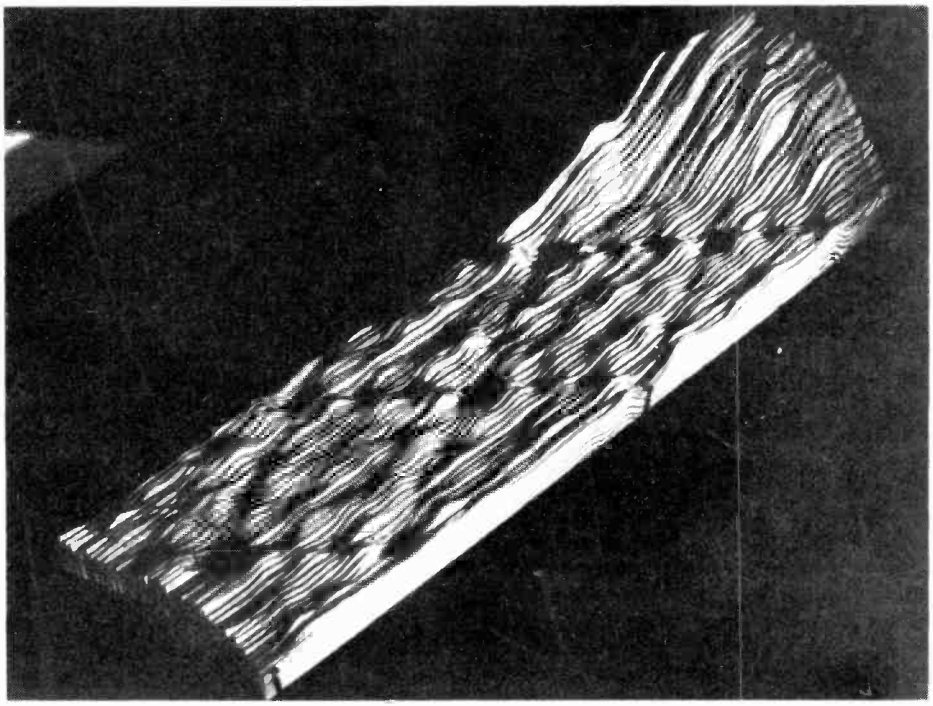
"There are no services envisaged in the wideband cable systems which cannot be provided on coaxial cable. If the expansion of cable is to happen it must be funded by commercial interests, so we can hardly insist on optical fibre where it is not economical or has no practical justification. We are supported in this view by the UK cable manufacturers.

"The real argument is about network design – the tree and branch, the system used in the USA, or the alternative approach, the star-switched system where this country is a world leader. The star-switched system looked more flexible and better able to provide the most advanced services, but unfortunately the switches at the heart of this technology exist only in laboratories and in one or two pilot schemes. It is not yet clear that they can be manufactured in sufficient numbers to make switched systems economically viable, given that they may be between a half and one and a half times more expensive than tree and branch systems."

As to the view that satellite broadcasting and cable tv are competitors, Mr Butcher says "I see them as complementary." BT said that it would make the best out of any decision that was made on cable tv and that it was not annoyed that coaxial cable might be used.

The Technical Working Group set under the chairmanship of Dr Eden has not been able to complete draft standards for handling signals used by direct broadcasting by satellite because "it was not until November that the decision was made to adopt MAC-C for UK satellite broadcasting and the decision has led to the need to study the application of this signal over wideband cable systems" says the DoI.

Provision of draft standards for two-way data is complicated by the wide range of such services being developed. Draft standards for two-way data channels "which appear to have the most immediate application", such as the BT Packet Switchstream service, Teletex and Prestel, are expected to appear over the next six months.



Compiled from two-dimensional images produced by scanning-tunnelling microscopy, this picture shows a silicon surface with hills and valleys 0.6nm apart that have never been seen before. Two rhomboidal cells can also be seen. The technique gives a vertical resolution of 10^{-11}m and was developed at IBM's Zurich Research Laboratory in Switzerland to show surface topographies of solids down to atomic level in three dimensions. Future applications include studies of electronic properties of surfaces, the structure of absorbed molecules, growth, structure and electrical properties of thin overlayers such as oxides and the imaging of magnetic structures.

Mobile services

The World Administrative Radio Conference for the Mobile Services, WARC-MOB-83, completed its updating task on 13 March after three weeks of deliberation. A main task of the conference was to review radio-regulatory provisions for mobile and mobile-satellite services, last reviewed by WARC 79. New regulations take effect from January of 1985.

Considerable changes have been made concerning distress and safety at sea, mainly with regard to the Future Global Maritime Distress and Safety System (FGMDSS) developed by the International Maritime Organization for introduction in the 1990s. Provisions for frequencies required by this new system have been made, resulting in changes in frequency allocations and regulations concerning distress and safety calls. An emergency position-indicating radio beacon for satellite characteristics of other emergency beacons have been reviewed. Detailed regulatory and operational provisions for the FGMDSS have not yet been introduced and responsibility for the system rests with IMO.

Further changes have been made to accommodate, among other things, digital selective-calling of ships and coastal stations for distress alerts ans traffic control, and the introduction of the aeronautical mobile satellite service.

A larger World Administrative Radio Conference for the mobile services is planned for 1987. Two smaller conferences, possibly early in 1985, will concern Region 1 (Europe and Africa).

Government money for computer research

Government backing for the £350m Alvey computer research programme is approved, but with the reservation that all work carried out in industry should receive 50% funding as opposed to Alvey's recommendation that some projects should attract 90% backing. In a statement to the House of Commons on 28 April, Industry Secretary Patrick Jenkin MP said "we have considered this last recommendation closely, but have decided that 90% government funding does not secure sufficient industrial commitment and could lead to the programme becoming divorced from industry's needs."

The report of the Alvey Committee (see Factories of the Future, *Wireless World*, December 1982) recommends a programme of collaborative research between industry, the academic sector and other research organizations, concentrating on four main areas of 'advanced information technology'. These areas are software engineering, v.l.s.i., man/machine interfaces and artificial intelligence.

The extent of the Government's contribution to the Alvey project depends on industry making its contribution and upon the programme's technical progress. Mr Jenkin said, "the Alvey report proposed that academic institutions should carry out some £50m of research over five years, and industry the remaining £300m. The full cost of this to the government would be around £200m. This money will be provided by the DoI, the Department of Education and Science and the Ministry of Defence. The Department of Education and Science will fund research through the Science and Engineering Research Council, mainly in the Universities. The DoI will provide the major portion of the Government's funds and will carry overall responsibility for the management of the programme".

A new Directorate within the DoI headed by Mr Brian Oakley, currently Secretary of the SERC, will coordinate the programme. Staffed by people from industry and supported by SERC and appropriate Government departments, the Directorate will report to a small supervisory board chaired by Sir Robert Telford, head of Marconi.

Satellite tv from two directions

Two seven-year agreements have recently been signed for use of Britain's first commercial communications satellite – one by the BBC and the other by British Telecom. The satellite concerned, Unisat, is to be used by both companies for tv distribution but on different bases. BBC will use the satellite for broadcast tv on two separate high-power channels – there are only two high-power channels available – and BT will use part of Unisat's telecommunications capacity for distributing cable tv programmes.

The BBC says that Unisat will provide enough power to broadcast to the UK and parts of western Europe and that reception in the UK will be possible using a dish of less than 1m diameter. Of the two channels available, DBS1 will be a subscription channel carrying mainly feature films and DBS2 will have an "international flavour".

Not keeping all its eggs in one basket, BT said that the satellite will be but one of the facilities used by it to distribute tv programmes and feature films to local cable-tv networks. The company will also use the telecommunications channel for video-conferencing and data, facsimile and telephone speech/data transfer. In signing the agreement, Mike Ford, British Telecom International's chief executive for international business services said "we are looking at ways in which other organizations could use part of our capacity in Unisat." United Satellites Ltd (Unisat) is jointly owned by BT, British Aerospace and GEC.

Unisat, or strictly speaking Unisat 1, consists of three satellites, only one of which will be operational. A second satellite will orbit the earth on standby and the third will stay on earth as a safeguard. The two space-bound satellites will be launched into a 36 000km orbit during the second and fourth quarters of 1986 but the decision on how to launch the spacecraft has yet to be made; one option is Europe's Ariane and the other an American apparatus called the space-shuttle.

Cable tv white paper

The following are extracts from a statement made by Home Secretary Mr Whitelaw concerning the Government's White Paper on the Development of Cable Systems and Services published on 27 April.

"The White Paper sets out a plan of action for future cable development. Central to this plan is the creation of a new statutory Cable Authority. Work is now starting on the preparation of a Bill to be introduced at the earliest practicable date. The Cable Authority will have two main roles: to award franchises to cable operators for the provision of cable services, and to exercise supervision over those services in the manner which the White Paper describes in detail. I wish to stress five particular aspects.

"First, pay-per-view. The Government has decided not to follow the Hunt Report in excluding this method of financing cable services. Cable operators have made it clear that they attach much importance to it and we believe that over a wide field, pay-per-view can be allowed without damage to BBC and ITV services and the many viewers who rely and will continue to rely on them. To protect the interests of those viewers, the Cable Authority will have the duty to exclude from pay-per-view events customarily covered by BBC or ITV.

"Secondly, that restriction is in addition to the ban which, adopting the Hunt recommendation, we propose on the acquisition by cable of exclusive rights for the great national sporting events, such as the Cup Final.

"Thirdly, advertising. We follow the Hunt report in proposing that the Cable Authority should adopt an advertising code which in essential particulars would follow the existing IBA code. Arrangements for clearing the copy of advertisements would follow broadly the pattern for those on independent broadcasting. On the amount of advertising, we depart from Hunt in preferring to limit advertising on cable, on channels broadly comparable to ITV, to the amount allowed on ITV – currently six minutes an hour on average. Channels wholly or mainly devoted to classified or other advertising will however be allowed, and these limits will of course not apply then.

"Fourthly, foreign programme material. Here we intend that there should be from the outset more stringent obligations than Hunt proposed on the use of British programme material. The Cable Authority will be required to see that a "proper proportion" is shown on each channel as appropriate; to work towards a progressive increase in that proportion as United Kingdom production capacity grows; and to report progress regularly to the Government. We are anxious to maintain and develop the strong national production capacity which the BBC and ITV have helped to create.

"Fifthly, the Government is anxious that the Cable Authority should ensure high standards of cable programme services. The same rules regarding good taste and decency as apply to BBC and IBA programmes will apply to all cable channels. There will be no exception for channels with electronic locks. As the White Paper says, so-called adult channels have no place on the sort of cable systems which the Government wishes to see develop.

"Finally, in the period before the legislation is enacted we are anxious to maintain and continue the momentum for cable development, through interim arrangements, of two kinds. First, the Government will be prepared, under existing powers, to authorise a limited number of new cable systems – not more than 12 –

as pilot projects, each covering a maximum of about 100,000 homes. Projects will be chosen for offering a positive contribution to advanced technology, a comprehensive range of programme services and a capability of interactive services. Secondly, we propose to allow cable relay operators to offer new programme services over their existing systems for a transitional period. Where necessary the obligation to relay BBC and ITV services on the cable will be dropped, provided operators offer their customers alternative means of reception at no extra cost. No application under either of these interim arrangements will be entertained until Parliament has debated and approved the White Paper.

"Mr Speaker, the Government believes that the White Paper offers an acceptable and well-balanced set of proposals. This will give cable an excellent opportunity for development, with the stimulus that this will provide for advanced technology. At the same time they will protect public broadcasting services and those who rely on them. I commend them to the House.

Areas expected to be covered by the BT automatic-Radiophone service before the end of this year. Users of the service can make telephone calls directly from their cars.

Stereo-sound tv tests – BBC looks again

Following stereophonic-tv test transmissions using a second sound carrier the BBC is looking into an alternative method using digital techniques. Based on the method used for stereo tv in Germany, the two-carrier system transmitted outside service hours toward the end of 1982 (see News, December 1982) was said to be 'workable' but the BBC feels that the digital system might be better.

"Preliminary assessments indicate that the digital option could give a better compromise between compatability and ruggedness" says the BBC (ruggedness presumably refers to the digital signal's chances of survival). There's no hurry, though, for the BBC also say that stereo tv sound via broadcast satellite in 1986 could precede terrestrial two-channel sound with television.

Results of the 1982 tests, in which the second f.m. sound carrier is around 7dB below the main sound carrier some 300kHz away, confirm expectations that sound-channel crosstalk is not a problem and that patterning caused by beats between the carriers can be kept to a tolerable level. But the method can cause buzzing on some existing receivers regardless of the second-carrier level and this fact seems to account for the not over-enthusiastic statement that "All in all it appears that a system of this type might give a largely satisfactory service, but investigations into alternatives are continuing".

Direct-dial carphones

Paving the way for the introduction of the cellular mobile telephone service in 1985, BT is to supply automatic radiophone sets to allow motorists to make telephone calls directly from 14 April. The company is also extending its automatic radiophone service to the south east in what it calls the first step in setting up a national network.

Much of Britain is expected to be covered by the new service before the end of this year (grey areas on map). Phasing out of existing operator-based carphone services will then begin in these areas ready for 1985. Equipment for Telecom Emerald, as the service is called, will be supplied to BT by Marconi and cost around £2250. In London, the mobile Radiophone service waiting list is not expected to end until cellular radio gets underway.

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ceiving site have been obtained it is possible to calculate the required azimuth and elevation figures very rapidly with a home computer. The program presented here for the Sinclair ZX Spectrum (16K) will calculate values for 33 satellites in about half a minute. The program may be expanded or contracted as required and it could be adapted to run on other computers. The read-out could be recorded by a mini-printer and hard copies given to the customer for future reference.

Computer program

Line 80 is a REM statement to enable the computer to search for the program, which may be kept on a standard C5 cassette. Lines 110 to 125 ask the user to input the latitude of the receiving site in degrees, minutes and seconds. An audible prompt is provided. The figures are converted into radians by lines 130 and 135. Line 140 represents the latitude in its complete decimal form. The procedure is repeated for the longitude by lines 150 to 180.

Lines 900 to 970 define the various string variables to be used. Line 1020 is a constant used in computing the elevation and range of the satellite; and lines 1030 to 1036 are the various range constants measured from the centre of the Earth. Line 1150 indicates the number of pages of information to follow: a 'scroll?' prompt allows each to be viewed in turn. The names and positions of other satellites may be substituted for those listed in the DATA statements, but the names should be abbreviated if necessary to a maximum length of eight characters to avoid cramping the display.

Lines 3510 to 3530 convert the satellite longitude and the receiving station co-ordinates into radians. Lines 3550 to 3625 compute the azimuth bearing of the satellite and convert it to degrees and the lines following do the same for the elevation. Lines 3660 and 3670 give the range in nautical miles and kilometres and line 3680 displays the complete results.

The program will hold, in practical terms, for receiving points at up to 81° North (or South), or points up to 77° if angles of elevation below 5° are excluded. It does not take account of the fact that the Earth is not a perfect sphere; however, the most prominent gravity gradients resulting from this are at 79°E and 101°W, neither of which will affect calculations relating to satellites that can be observed from the UK.

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COMMUNICATIONS

Using the sun

Since the earliest days of radio the major problem for installations in remote locations or intended for mobile or portable operation has been less the generation of the radio-frequency power, whether by spark, valve or transistor, than economic provision of the basic electrical power.

Disposable and rechargeable batteries and even fuel-cells; hand, pedal, wind, water, petrol, diesel generators; thermoelectric generators, gas or solid fuelled; small nuclear generators, etc: all have been used, but all tend to impose limitations of cost or weight or logistics, or reliability. The main thrust of current effort is towards further exploitation of solar power, both for space and terrestrial applications, despite its inherent limitations when used in day/night situations.

While conversion efficiencies are gradually improving, most recent developments are aimed at new fabrication techniques to reduce cost compared with high-purity single-crystal silicon. Although initially amorphous and semicrystalline photovaltaic devices provided lower conversion efficiencies, recent developments are beginning to reverse the situation. One major attraction of amorphous silicon is that large-area cells can be fabricated.

Matsushita Electric have developed a new screen printing process which is claimed to be half the cost of Sunceram 2 solar cells and provides a conversion efficiency of 12.8 per cent.

In laboratory work, the American company Semix Inc claims to have developed semicrystalline silicon devices with conversion efficiencies of 17 to 18 per cent, equivalent to the maximum figure for single-crystal silicon (more typically 12-13 per cent) and compared to about 10 per cent for thin-film amorphous-silicon. Again, this fabrication technique should, it is claimed, halve the cost of photovoltaic diodes.

A different approach to solar energy, still at an early stage, is photo-assisted electrolysis of water with the aid of semiconductors. Two recent developments could make this technique a serious rival to the photovoltaic silicon cell: better semiconducting photoelectrodes and improved treatment of electrode surface to stabilize it against deterioration. The renewed interest in photoelectrolysis has been led by Bell Labs who are responsible for several of the key inventions.

For terrestrial applications, solar generators are ineffective from dusk to dawn unless used to keep charged large-capacity storage batteries. The UK is at a disadvantage, compared with some countries, in annual sunshine statistics and, perhaps more importantly, the average hours of peak sunshine. Both the IBA and BBC have experimental solar-power systems for low-power television relays, but in each case including a wind generator. The IBA installation at Bossiney, Cornwall includes a solar-array providing some 780-watts in full sunlight, and has functioned satisfactorily for over 18 months.

In New Zealand, the Broadcasting Corporation of New Zealand (BCNZ) began using photovaltaic generators, in conjunction with storage batteries, for low-power tv transposers as early as 1976. Both BCNZ and the US Department of Energy have reported some failures with silicon encapsulated panels, mainly due to green spot corrosion between cells, although with some failures of individual cells. However the storage batteries have presented rather more reliability problems than the 30-watt solar array. BCNZ admit that the batteries have sometimes run down during winter. They had been assured by local inhabitants that the area chosen for the first installation was ideal for solar power; only later did they discover that the location was notoriously subject to heavy fogs and had the local nickname of "Little Siberia".

Practical use of solar generators for recharging batteries for military manpack h.f. Clansman transceivers is currently being evaluated by the British army with American-fabricated silicon solar cells in Plexiglass-protected arrays designed by Tactical & Navigational Systems Ltd. Two 12 by 9 inch panels can charge 28V batteries at 400mA in bright sunshine falling to about 200mA in dense cloud. For tactical or infiltration communications advantages of solar generators are the absence of noise and their "invisibility" to infra-red target sensors etc.

J. M. Osborne, G3HMO, of the South London Science Centre, recently reminded me that what is believed to have been the "world's first" sun-powered transmitter/receiver system was used successfully by him as long ago as September 1954 when with a single point-contact transistor as a crystal-controlled oscillator and a two-transceiver receiver he made contact with amateur stations a few miles away on 1.8 MHz. Power came from an array of 16 selenium photo cells which provided just 4.5 volts at about 3mA.

Chip receivers

The trend towards packaging the entire heart of radio receivers on to a single chip continues. For paging receivers, including the selective-call facilities, at least two manufacturers have adopted direct-conversion techniques to overcome the difficulty of forming i.f. bandpass filters directly on the chip. However a new i.c. device (Mullard/Philips TDA 7000) retains the superhet approach but with the unusually low i.f. of 70 kHz, permitting the use of simple resistance-capacitance i.f. filters that are integrated on to the chip. A feedback technique reduces wide-deviation, broadcast-type signals (±75 kHz) to a more manageable ±15kHz deviation. Apart from the device, a complete receiver requires only one tunable resonant circuit, 14 ceramic capacitors and (for loudspeaker output) an audio amplifier. It is claimed that receivers for f.m. broadcast, two-way or paging applications can be made small enough to fit into a wrist-watch, pen, calculator or key ring.

The bipolar TDA7000 is suitable for carrier frequencies between 1.5 and 110 MHz, and has some 280 integrated circuit elements. With 4.5 volts, consumption is 8mA with the audio section able to deliver 70mA into a 22 kilohms load. A lower-voltage, lower-consumption version (3-volt nominal) is promised soon.

Rather more orthodox is an alternative device (TEA5570) intended for a.m./f.m. domestic or car radios featuring very simple switching (one d.c. contact to ground) between a.m. and f.m. For a.m. signals, the device incorporates a double-balanced mixer suitable for h.f. reception to 40 MHz.

The 13th Montreux

Technical sessions planned for the 1983 Montreux television conference (May 28 to June 2) put much more emphasis on "round table" panel discussions than in the past, with fewer individual papers to be presented. The sessions reflect current topics of interest with emphasis on cable tv networks and home terminals, 12 GHz direct broadcast satellites, high definition and enhanced tv systems, digital studio and recording systems. Many of the papers offered have been designated "supporting papers" and will be published in the conference book. The organisers list some 175 firms participating in the exhibition. Sunday, May 29, is to include a series of six high-definition tv demonstrations from six European broadcasting organisations – SSR Switzerland; ORF Austria; SFP France; TSS USSR; BBC UK; and RAI Italy.

Figures issued recently by BREMA underline the remarkably buoyant state of the tv and video market with a record 2.934-million colour tv sets delivered to the UK market in 1982 (2.57-million in 1981) including 571,000 teletext type sets predominantly UK made. Video recorder UK deliveries in 1982 at 2.235-million (1981 1.035-million) even exceeded US sales.

COMMENTARY

AMATEUR RADIO

Syledis and 432 MHz

The problem of spectrum sharing between pulsed radio-navigational and radar signals and communications and broadcast signals has existed for many years. Loran on 1.9 MHz has now been phased out in the North Atlantic (although an experimental sea-surface radar uses this frequency off the Welsh coast). The Russian "Woodpecker" over-the-horizon radar continues to follow the m.u.f. up and down the h.f. band. In recent years there has been increasing mutual interference between radio amateurs using the 432 MHz band and the Syledis system of precise position location which functions over an extended u.h.f. range by means of tropospheric scatter propagation. Syledis, developed by Sertel, has been proving very attractive for North Sea oil and gas field operations, including seismic surveys, platform installation, pipe-laying and other sub-sea installations and inspections. These are all operations that require accuracies of about ± 5 metres at up to 200 miles from land, considerably greater accuracy than is normally provided by Decca Main Chain and Pulse 8 systems.

Syledis coverage is roughly twice line-of-sight, using beacon equipment that can be installed on the platforms. Although a hyperbolic-mode receiver was introduced in 1981, the usual mode of operation is direct range/range measurement with beacons switched on by the mobile unit when a fix is required.

The system began to be used in the North Sea about 1977-78 and in 1979 it was decided to establish Syledis chains covering the northern, central and southern areas of the North Sea. The Home Office designated 431 to 434 MHz for the North Sea operations, primary frequencies being 432.563 MHz (central), 432.513 MHz (Southern) and 432.463 MHz (northern) with secondary frequencies 432.383, 432.303 and 432.144 MHz.

In the southern sector, the Dutch PTT first authorized the use of 432.563 MHz but later, following mutual interference with radio amateurs, changed first to 408 MHz, where further problems arose, and then to 437.5 MHz.

British radio amateurs have access, but only on a "secondary" basis, to 430 to 440 MHz (with a number of restrictions). Not only are they obliged to accept the broadband Syledis interference, which unfortunately is mainly in the weak-signal, long-distance 432 to 433 MHz sector of he band, but also since Syledis is a "primary user" they have an obligation to avoid using the six frequencies listed above for the North Sea chains, where transmissions could cause interference.

Syledis is clearly a system that will stay and expand. The Home Office has rejected an RSGB request to change the "secondary" status of British amateurs or to allocate different frequencies to Syledis.

Telecoms history

Everyone interested in the development of technology will find exhibits of real interest in "Telecommunications – a technology for change" galleries on the first floor of The Science Museum in South Kensington. The new galleries, opened on March 15 by Prince Charles have been made possible by financial support from STC. This year marks the centenary of the setting up of a small London office of their original parent company, Western Electric. The new exhibits, however, range widely and are by no means a "company-sponsored" type of display. It covers selectively some 150 years development, the pre-Morse electric telegraph systems of Oersted, Wheatstone and Cooke, the whole span of telephony, radio, television and data transmisssion.

One notes nostalgically the gleaming brass and ebonite of early radio and cable, early magazines including a *Wireless World* cover for February 1915, wartime equipment such as the German airborne E10K (FuG10) and the British time-division-multiplex microwave No 10 set as well as early and current (Yaesu) amateur radio equipment, including the National 1-10 super-regen v.h.f./u.h.f. receiver of about 1936. A National h.f. HRO receiver however is dated as "circa 1935" which would apply to the original HRO-Senior but not to the HRO-MX exhibited. This used the 6.3-volt metal valves and was a 1940-44 model. A German "suitcase" clandestine transmitter-receiver appears to be an early wartime model similar to the model used to illustrate a leaflet showing the police the appearance of German equipment. It would be extremely interesting to know its history since it could well have been the set left at Victoria Station in 1939 for Arthur Owens ("Snow").

It was by using the equipment meant for Owens that the "Double-Cross" operation was initially set up and lasted throughout the war, with virtually the entire German spy network controlled by the British Security Service.

Here and there

An Amsat-UK question on home computer ownership to its 1500 members produced over 300 replies. Three models accounted for almost 50 per cent of the computers: Acorn-BBC Model B (61); Sinclair ZX81 (60); and Sinclair ZX-Spectrum (31). Other models that reached double figures were: E.A.C.A. Genie (19); Dragon Data "Dragon" (16); Commodore Pet (14); Nascom 2 (10); and Tandy TRS80 (10). The total of 316 home computers represented some 30 different models from 24 firms plus 5 homebuilt units.

John Graham, G3TR, a former president of the RSGB and a pioneer of British air traffic control (licence number 13), has died, aged 75.

The 80-strong Bromsgrove club is to operate a 24-hour station at the Foxlydiate Hotel, Tardebigge on June 21 with the special call GB1BOY to mark the first birthday of Prince William. It is the first time a local club has been authorized to use the GB1 prefix.

A new h.f. beacon on 10.144 MHz has been set up by DARC at Norden, West Germany specifically to provide information on auroral propagation conditions on v.h.f. It will operate in A1A mode daily from early afternoon to late evening. Transmissions will include a series of long dashes, 20 second dashes indicating no auroral observed, 10 seconds when auroral propagation is expected.

In brief

Over 1500 attended the 1983 National VHF Convention at Sandown Park, Esher, an increase of about 300 on 1982 . . . The San Marino prefix is now T77 instead of M1 or 9A1 . . . The reciprocal licensing agreement made between UK and Rhodesia has recently been cancelled by the Zimbabwean telecommunications authorities . . . A new six-metre beacon, ZS1SIX is now operating from Piketbere near Cape Town on 50.945 MHz (16 watts power to ground-plane aerial, 807 metres above sea level) . . . An Amateur-Television exhibition organised by the British Amateur Television Club is being held at The Post House, Leicester on Sunday, May 22, 1983 and will include demonstrations of fast- and slow-scan and narrow-bandwidth tv and the BATC outside-broadcast unit, trade and book stands etc . . . A Malta "9H" group of v.h.f./u.h.f. enthusiasts have organised a 144 MHz contest for the period June 1 to June 15 with the possibility of Sporadic E contacts with UK amateurs . . . The Danish Society EDR have their 1983 summer camp about 10km from Grenaa, July 9 to 17 . . . June mobile rallies include: June 5 Spalding; June 13 Elvaston Castle, near Derby and HMS Mercury, near Petersfield; June 19 Skelmanthorpe, near Huddersfield; and June 26 Longleat.

PAT HAWKER, G3VA

Judgment and prognosis

Modern physics has suffered from 50 years of domination by mysticism, in the belief that the success of the statistical quantum mechanics provided evidence of the soundness of the Copenhagen "quantum theory". Once that myth is exploded the achievement of a simpler, more realistic, physical theory of matter becomes a possibility. Surely it is worth a try?

The classical theories of matter and mechanics have been demonstrated by experiment to be incomplete when applied on the microphysical scale. The misnamed "wave mechanics" is a disciplined calculus of probabilities of a particular kind, appropriate to the prediction of particle motion on a statistical basis from given initial conditions, and it is not a physical theory in the true, accepted sense. The indisciplined, non-physical wave theory of matter, as expressed in the Copenhagen doctrines analysed in the series, has been thoroughly disproved, is not credible, and should be rejected. Thus we physicists now discover to our surprise, interest, horror, or shame, depending on our temperament, that today *we do not possess a fundamental theory of matter* on which we can rely.

Wanton disregard of the scientific method, leading to its replacement by uninhibited mathematical speculation, enabled the insidious philosophies of Copenhagen to take root in modern physics. The wave theory of matter excuses its many obvious and abject failures by means of a dogma of its own transcendental correctness, more after the manner of a religion than a science. Students are actually taught that "for fundamental reasons" its basic precepts cannot be tested by experiment, and that it is in some way improper to ask questions about fundamental matters. Science must henceforward be content with statistical descriptions of physical events, because on its own admission the One True Faith can provide no explanations of them: they are to be accepted as miracles. The cheerful evasion of logical rules, disdain for concepts and conceptual models, and complete subservience to mathematical formalism, are symptomatic of our present disease.

When Michael Faraday began his life's work electricity was mysterious and magnetism a separate mystery. Today one is surrounded instead by all-pervading, mystical "waves", by an indeterminate Nature, and, worst of all, by a general attitude of acceptance of the logical contradictions which have followed on inevitably from indisciplined thinking. This widespread, uncritical acceptance can be overcome only by a conscious effort of will; yet given the will to recover, our present problem seems neither more nor less difficult than was Faraday's. His approach was that of the true scientist, carefully and systematically clearing a path through a jungle of mysticism. His understanding of Nature violated no principles of logic and became as sound as could be achieved before the discovery of the electron. Let us emulate him. *Experimental test must be the arbiter.* We have seen the disastrous consequences which have followed from believing otherwise: the present-day conceptual obscurity in the fundamentals area has been very largely man-made. We have been warned.

by W. A. Scott Murray
B.Sc.Ph.D.

A few simple, key experiments are asking to be done, all of them relevant to the practical verification of the more obvious consequences of the quantum hypothesis. Naturally this writer would be delighted to see results which confirmed the general line of argument as presented, for the route which has been mapped out has the advantages of simplicity and directness. We might already be very nearly home. But there is no cause for dismay if we are not; one has no reason to expect one's guesses to be right first time. The important point is that experiments of this kind should now be performed and their results studied with care and an open mind. One cannot predict the outcome of any one of them, since the questions embodied in them have not been asked in quite this form before, but one *can* predict with confidence that a fresh approach in this area will lead to a succession of invigorating surprises. Nature has a habit of responding to sensible questions, even though her response may not always be quite what we expected. That is why natural philosophers throughout the centuries have remained dedicated men.

What, then, constitutes a sensible question? The current confusion in our fundamental theory and thought is so great that *we cannot tell* whether or not any question is "sensible" until it has been put to experimental test. Thus the existence, unresolved, of the duality paradox in light tells us that this is an area in which we do *not* know all the answers beforehand. Such experiments are long overdue. It is not just a matter of deciding between the rival wave and corpuscular theories of light, because without substantial modification neither theory can meet the demands of previous experiments. The line taken in the fourth article (*Wireless World*, December 1982) was a compromise but a consciously biased one. It carried the photon hypothesis to a conclusion and faced the consequences of so doing: "If light consists of photons but behaves like waves, then here is a possible mechanism and these are the results to be expected from our proposed experiments". It may be that the concept of a discrete photon is completely false, in which case we must look elsewhere for a truer concept. But whatever the truth of the matter may be, we shall never go forward if we do not ask such questions.

We are probably even further from the truth in our conventional concept of the nature of matter, because the Copenhagen doctrines have been even more strongly developed, and accepted, with respect to matter than with respect to light. Indeed, their dogma flatly forbids us to ask questions about the nature of matter; to do so would overstep the competence of the Quantum Mechanics and therefore be "improper". Consequently, as I remarked earlier, we are today entirely without a fundamental theory of matter: the nearest thing we now have to a conceptual model of an electron is the Copenhagen "wave-packet", a thoroughly-disproved and misleading flight-of-fancy and (although perhaps no more fanciful than the mathematical electron of Dirac, that foresees its own future)! That this state of affairs should have been allowed to persist for the past 50 years does not speak too well of the performance of our professional leaders – the so-called "scientific establishment" – over those same 50 years. We desperately need at least *some* theory of microphysical matter, preferably one that we can believe in . . .

What form would such a theory be likely to take? It would seem that it must acknowledge the essential granularity of microphysics which is so clearly indicated by experiment, and that in consequence it may not involve, except perhaps by way of macroscopic approximation, the old field-theory concepts of spatial continuity or of "waves". Im short, it must be a true Quantum Theory from the outset, rather than an illogical amalgam of continuity and discontinuity. Likewide, bearing in mind what we have discovered about the difference between inanimate physics and animate metaphysics, we may also require it to be a Physically Realistic theory, strictly consistent both externally and internally with the conservation laws: no more "virtual processes" and non-physical working parameters, *please!* There is much to be said for returning to older, firmer ground and this time completing, rather than superseding, neo-classical mechanics; that is, accepting concepts which are post-Planck but pre-Copenhagen.

The crux of the matter is one's attitude of mind. Consider the following dictum:–

> "The continued success of the wave-mechanics proves the soundness of the Wave Theory of Matter, of which the wave-mechanics is the mathematical formulation."

That statement expresses the currently-accepted, "received" view. It seems to be an axiom (self-evident truth) until one notes that although the statistical quantum mechanics is capable of providing superbly accurate predictions of the measurable results of scientific experiments, the Copenhagen quantum theory or wave theory that apparently underpins it is, frankly, not credible as a theory in physics. Here in one sentence we have two contradictory aspects of current thought, one very positive, the other very negative, as far apart as the concepts of waves and particles. It is important to understand what this contradiction really means, so let us take a topical example.

"Sandy" Murray retired from the Scientific Civil Service in 1982. Having served in the Royal Navy during the second half of World War II, he took a first degree with honours in physics at Manchester under P. M. S. Blackett and a second in radio astronomy. In the course of obtaining the first UK radar echoes from the moon at Jodrell Bank, he discovered the Faraday rotation of radio waves in the ionosphere. He joined the Royal Radar Establishment in 1954, where the most enjoyable of his tasks was designing, and for ten years directing, the 45ft Malvern satellite-tracking radar, all of whose activities were at the frontier of unmanned space-flight. That project itself was one consequence of a joint experiment with the Post Office, in which the first-ever transatlantic satcom signals were received in England via Echo I; its other consequence was the Goonhilly Downs station.
Thus Dr Murray, although a lifetime professional physicist, has never been an academic. The subject-matter of this series has been under development steadily and in detail ever since his undergraduate days, but it is only in the past few years that he has found enough spare time to consolidate it. He believes that the job needed doing, but that in the nature of things it could only be done by an informed outsider.

At the time when this article goes to press there is much excitement among physicists, because it is thought that Dr Alain Aspect in Paris, working with Professor Bohm of Birkbeck College, London, may at long last have resolved a paradox that was first mooted by Einstein, Podolski and Rosen (E-P-R) in 1935. According to one report, Aspect's team "has proved that quantum theory is right and relativity theory is wrong". The short answer to that claim is that it is unfounded: Special Relativity theory is not actually under test in such experiments, because in them nothing *physical* is ever required to move at or faster than the speed of light. (I find it amazing that people who should know better go on ignoring this simple, fundamental point, but ignore it they do, and in so doing they happily perpetuate the contradiction we are now examining.)

E-P-R experiments are no more than two-particle variants of Heisenberg's "reduction of the wave-packet", which as I have previously suggested is not really a puzzle at all (*Wireless World*, March 1983). The story went like this, you will remember. Since you know – and don't ask me how you know, ask Heisenberg – that only one photon is involved in your experiment, and if you have already detected a photon at one place, then you can deduce for sure that neither you nor anyone else will be able to detect that same photon elsewhere. Such an obvious deduction doesn't seem all that clever, but Heisenberg introduced imaginary "ψ-waves" to explain it in his own peculiar way, and found himself left with an apparatus full of ψ-waves when the real photon was detected. Getting rid of those time-expired ψ-waves proved embarrassing to those people who believed in them and helped to sort out the metaphysicists from the physicists, in this case the Bohrs from the Einsteins.

In the E-P-R case we are concerned with the behaviour of closely-related particles, such as the pair of identical photons that radiate away from an electron/positron annihilation. Experimentally, presumably because of their common origin, it is found that if one of these photons has the property "x" or "y", so has the other. It follows that if I have detected one of them and found it to have been an "x", I can tell my colleague on the other side of the lab. that his photon was an "x" too. Again that doesn't seem to be particularly clever; no prediction is involved, and no physical action is postulated between the photons. But Bohr argued that by the in flight act of observing my photon I have tampered with a ψ-wave system which is common to both photons – and that in doing so, by some kind of remote "action", I have *altered the physical behaviour* of my colleague's photon. Einstein *et al* disagreed, and used Copenhagen's own "quantum" arguments to prove their point in a famous thought-experiment. Dr Aspect and his team now hope to support Bohr by demonstrating a physical action that travels faster than photons. Question: what physical action?

What it amounts to is this. As formulated, the statistical quantum mechanics does not acknowledge the existence of any physical mechanism that could cause a physical event to take place – anywhere. Therefore, although its mathematical operations seem in some as-yet unexplained way to be correlated with phenomena that occur in Nature, they cannot be concerned with causes. Nevertheless, physical science could very reasonably be asked to explain that correlation, which is an observational fact. (It is simply not good enough to assert that photons will be detected somewhere "because the probability-amplitude for detecting photons there is greater than zero". Television sig-

Present and future

The belief that the statistical quantum mechanics was the mathematical formulation of the Copenhagen wave theory has hitherto served to conceal the fact that we now have no fundamental physical theory of matter. It is not sufficient merely to ignore this state of affairs: mysticism, even if it be adhered to with a quasi-religious fervour, is no substitute for intellectual honesty and the scientific method. *Experiment* is required. Senior scientists are so certain that they know all the answers (and non-answers) that they no longer bother to perform fundamental experiments; the consequence is the continued existence of the duality paradox in light and the present chaos in particle physics, neither of which reflects much credit on the professional leadership. At least one can determine what the statistical quantum mechanics does *not* do. Since no current theory of matter exists to be supplanted the field is wide open, and one can almost forecast the form that a future Realistic Quantum Theory might take. The quest for such a theory does not appear to be by any means a hopeless task, if in the traditional way of science one does not deny the existence of theoretical discrepancies but tries to make use of them. The physical problems would seem to be soluble in principle, given an open mind and the will to solve them. The human problem which gave rise to the twentieth-century aberration is understandable if not excusable, and there are signs that it may be beginning to solve itself.

nals *still* don't reach my roof aerial because of Maxwell's equations!) What the quantum mechanics actually can do, without violating any old conservation laws or even overriding the much-maligned but ancient human faculty of common sense, is to *quantify the precision of our knowledge* about natural events. It does this very well indeed. But every attempt to attribute a capability for physical action to its mathematical "operators" leads straight into absurdity, so consistently that it cannot be due to coincidence. That is the evidence.

Now the idea that the quantum-mechanical "wave function" ψ does not in fact describe the behaviour of microphysical entities, but only the limits of human knowledge of their behaviour, is anathema to every quantum theorist for reasons that are not difficult to understand. While sympathising, one should not allow such sensitivities to stand in the way of progress. The positive indications are just as significant as the negative ones. For example, the field-theory type mathematical formulation of the quantum mechanics is well suited to handling the transmission within its field of the imprecision of knowledge – a metaphysical quantity which is distributed and continuous in space and time. So that aspect at least of the theory's success can readily be explained: "probability" dissipates into space and time exactly like a wave-system!★

The inverse aspect is also worth examining. The master-texts of the quantum mechanics, the Schrödinger equations, explicitly incorporate the conservation laws of classical physics. That is their link with physical reality. And then, as a byproduct of their original "wave" ideas – which are no longer necessary or relevant – they superimpose upon these laws of motion certain variations or "spreads" which correspond to the essential indeterminacy of physical measurements. That makes sense, too, as a description of our knowledge. Yet, if one subtracts out the indeterminacy (on the ground that one is now seeking to evaluate physical facts, rather than the limits of our knowledge about them), it seems that *something more than the classical laws may remain*, concealed within the "quantum" formulation. What is that something?

Specifically, in what systematic, underlying way do the experimentally-verified predictions of the quantum mechanics – an interestingly small proportion of all its "predictions", by the way – differ from those of updated neo-classical physics? (Surely in the 1980s we can stop comparing our newest, tentative, exploratory ideas with Victorian electromagnetic theory?) My guess is that the difference between neoclassical physics and "quantum physics" when properly reconciled will be found to be very small indeed, but that every one of the concepts revealed as differences between them will turn out to be fundamental and tremendously important. These differences will represent or embody the laws, principles, and physical forces, at present unknown and unsuspected by us, in accord with which the *real* world of microphysics operates.

With these thoughts in mind I have looked again, critically and very carefully, at places where the experimental evidence of microphysics diverges from the classical mechanics of Galileo and Newton, only a few high points of which have been mentioned in these articles, and the following are my provisional findings. I have encountered no justification for the currently-established view that the fundamental workings of Nature are mystical and necessarily incomprehensible by mankind. The law of causality would seem to be obeyed straightforwardly by all inanimate matter; the Copenhagen myth to the contrary arose out of a confusion of thought that can be identified. The striking phenomenon of quantisation (type two), as it appeared in Bohr's original quantisation of the atom, occurs much less frequently than is commonly supposed: maybe it predominates in four places, maybe five, in all microphysics. It has nothing to do with indeterminacy or "probability", but on the contrary it is a precise process. I believe it to be explainable generally by postulating the existence of a powerful short-range force, which is almost certainly allied to the known "strong" force of nuclear physics (whose law may not be negative-exponential with distance), and which is to be *superimposed upon* the operations of classical long-range electric and magnetic forces rather than to replace or supersede them. This proposed "quantum" force would seem to be in some way cyclic in its nature, and to be associated intimately with the dynamic mechanical structure of material particles.

Such concepts can be provided with substantial support on both theoretical and experimental grounds. Much of the crucial experimental evidence is already to hand, requiring only reinterpretation, while more evidence is there for the gathering, given the will to gather it. It is a question of attitude of mind. Then the concepts need to be put together, to form a theory – a realistic quantum theory – in which the proposed quantum force would be a physical force, not a metaphysical force, and the electron dispensing it would be a real, physical entity, not a ghost. We would then have to deal with physical theories, not miracles. So why do we not simply accept that the elementary particles of physics really are particles, not waves, and get on with the job?

★ ★ ★

The question of the nature of matter and radiation, which lies at the core of fundamental physics, is but one facet of a much broader problem in natural philosophy. Since the crisis has two levels I conclude on a more general note. It is probably no accident that the great reaction away from realism in physics had its origin during the post-war period 1925-1935, that same decade during which European music, art and poetry also kicked over the traces of their classical disciplines and entered a phase of irrationality from which they are only now beginning to recover. That context may help to explain the aberration, but it does not excuse it. All the indications explored in this series support the view that the Copenhagen myths, although undoubtedly propounded by their originators in complete sincerity, constitute one of the biggest hoaxes of self-delusion of the twentieth century: and that we have not only allowed ourselves to fall for them but have *continued* in them, fascinated by their mystique while in our hearts knowing them to be nonsense. We really have no excuse for this, today.

★Howbeit, it is a wave-system of a very unusual kind. The method of transport of "probability" (in the form of $\psi \times \psi$★) through a Schrödinger field – according to Schrödinger's own mathematics – is not that of wave-propagation, but of flow. Accepting that, his analogy is every bit as good as Maxwell's. But the "flux" in an electrostatic field is not in physical motion as is the water in hydrodynamics; such theories are not explanations of Nature, but analogies that happen to employ similar mathematics.

NEW PRODUCTS AT AES

Rather grandly we thought that we must try to catch the 'spirit' of the exhibition, to look for trends and test the health of the electronics industry. After visiting each stand in turn, the general impression was that there were a lot of switch-mode power supplies and membrane-switched keyboards. There was little indication of any specific trend apart from the obvious ones; integrated circuits are getting even larger, microprocessors are getting into more diverse applications. Many of the exhibitors seemed to be sitting on their laurels, or have not chosen to launch new products at the AES. However here are some exceptions.

Several new opto-electronic products were on display at the **AEG-Telefunken** stand; particularly **led bargraph displays**. These include a control i.c. and require only a supply voltage and an analogue input voltage to operate. **WW300.**

Low cost metal-film resistors, and various multi-turn trimming potentiometers were featured on the **Allen Bradley Electronic**'s stand. **WW 301.**

Among the standard 19in racking systems offered by **Alusett UK Ltd**, were some new **cooling fans** mounted to fit into the racks. One-unit high assemblies can draw 90m^3 air per fan to give optimum cooling performance in the minimum space. **WW 302.**

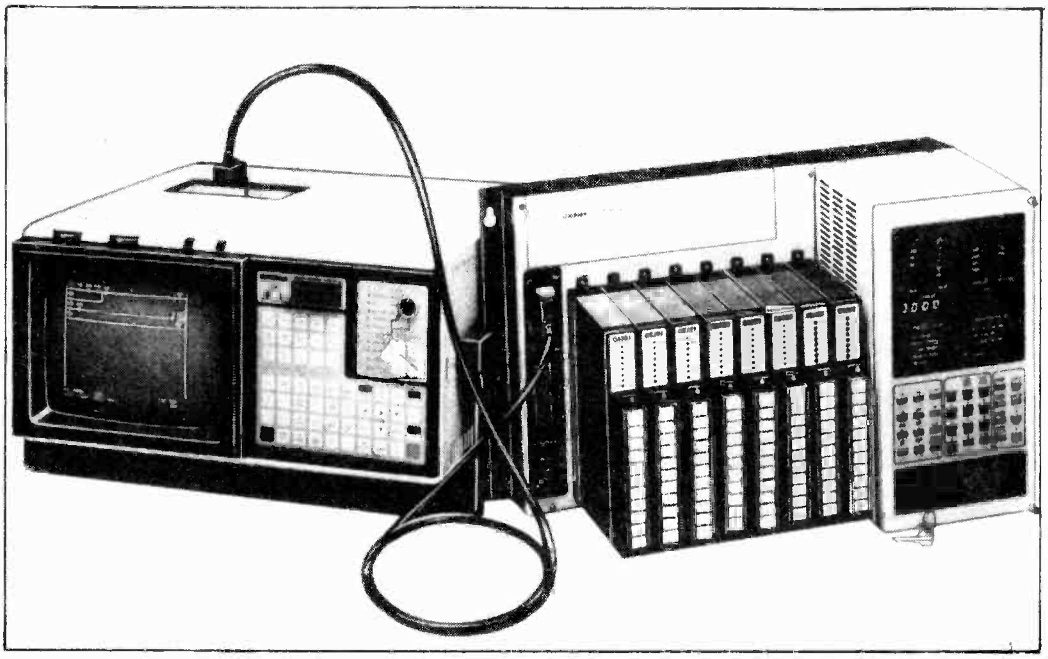
New to the **Ambar Components Ltd** catalogue were some Fujitsu **64K cmos eproms** which are available at only £4.98 each (as long as you buy one thousand). **WW303**

Up to 5,000 2-input gates can be incorporated in the 3-micron family of **semi-custom gate arrays** from **AMI Microsystems Ltd**. They have also produced a 16-bit integrated work station for i.c. development. **WW304**

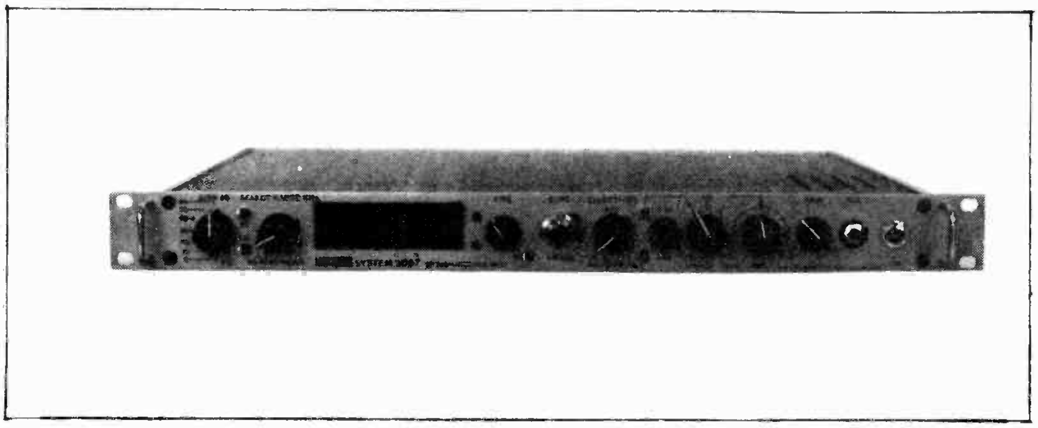
A range of **switch-mode power supplies,** based on standard p.c.b. sizes, are manufactured by Power Products in Youghal, Ireland. The multi-output supplies offer a claimed efficiency of greater than 75% and may have overvoltage, crowbar or power foldback protection. Particular attention has been paid to isolating the input and output circuits by separating the tracks on the p.c.b.s. The supplies are available in the UK from **Amplicon Electonics** who also can provide supplies which fit into the available space in a product. **WW305**

Astralux were displaying an improved **point-to-point wiring** pen for the Quick-Connect system. The features which are claimed to give more reliable and faster wiring are the provision of positive location for the wire which passes through an eye in the top of the pen; the system allows the operator to see that the wire has engaged properly, and the head of the tool provides tactile feedback to prevent the user from pushing too hard. Astralux also manufacture data acquisition reed relays and market telecom jacks and sockets. **WW306**

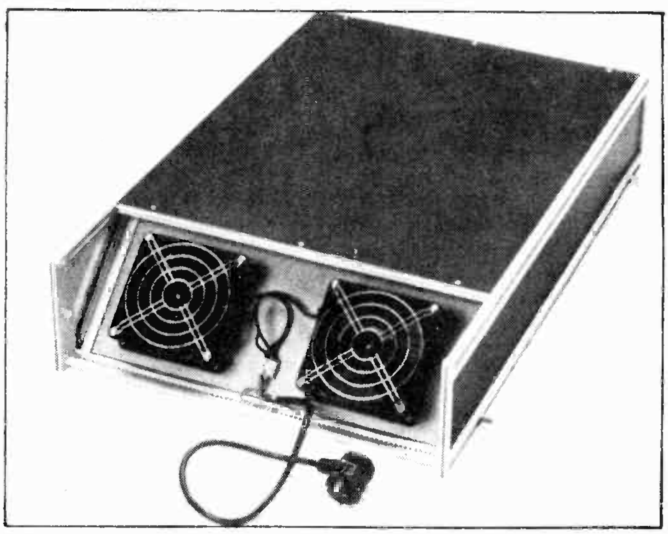
Cetronic make a wide range of mains interference suppression filters, and **wound components**



WW 320



WW 323



WW 302

NEW PRODUCTS

and are now offering to design and make filters, chokes, hand-wound toroids, r.f. and ferrite-cored transformers to a customer's specification. **Cetronic Components Ltd. WW307**

Compstock were very proud of the latest edition of their **catalogue**, with passive capacitive and resistive components from Matsushita, Allen, Bradley, STC, Filmcap, WIMA and Union Carbide. **WW308**

Another range of **switching power supplies**, made in the UK, come from **Coutant**. They offer a standard ML range of multi-output supplies, and the SL 1 to 1.5kW range. They can produce a prototype for a supply not already available, in seven days. **WW309**

The Datacapture data acquisition range has been expanded to include the **Thermalog** which can monitor 16 thermistors with ±0.2°C accuracy. The Digilog input data logger has 48 parallel binary inputs, four 12-bit counter inputs, two 24-bit counter inputs and four opto-isolated external trigger inputs. Both units include software for display, read and write routines. **Datacapture Ltd. WW310**

A wide range of **keyboards**, including the aforementioned membrane keyboards were on display at the **Cherry Electrical Products Ltd** stand. Emphasised was their willingness to custom-design keyboards. **WW311**

EEV's stand featured Lucid **liquid crystal displays** of both the twisted nematic and the dye phase change variety. There were a number of custom l.c.ds and a 5×7 matrix display suitable for many applications. Also on display was their latest c.c.d. tv camera of use for industrial, security and robotic applications. **English Electric Valve Company Ltd. WW312**

Miniature loudspeakers with Mylar diaphragms are newly produced by **G. English Electronics**. They have a stated frequency response of 20 to 20kHz with 30 and 100mW versions. They can be incorporated into headphones, portable receivers, domestic and office audio sound reproduction systems. G. English also had Mylar capacitors and were offering to make up cables for interconnecting equipment to any required specification. **WW313**

Among the vast array of **l.s.i. circuits from Ferranti** (anything from a t.t.l. circuit to a 16-bit microprocessor, as well as all the custom-designed u.l.a. facilities) what caught our attention was the ZN415, a single chip radio which only needed six external components to receive medium- and longwave transmissions and drive headphones. Now all we need is an f.m. version with a stereo decoder – all on one chip, of course! Also on the Ferranti stand was a 3½-digit **digital voltmeter i.c.** ZN451 which could be used with a signal conditioning circuit to remove zero errors and give readings with 1μV resolution. There were also a number of new telecom i.cs including the ZNPCM3 a single channel coder/decoder that has digital filters, time-slot assignment capability and operates from a single 5V supply all within a 28-pin package. **WW314**

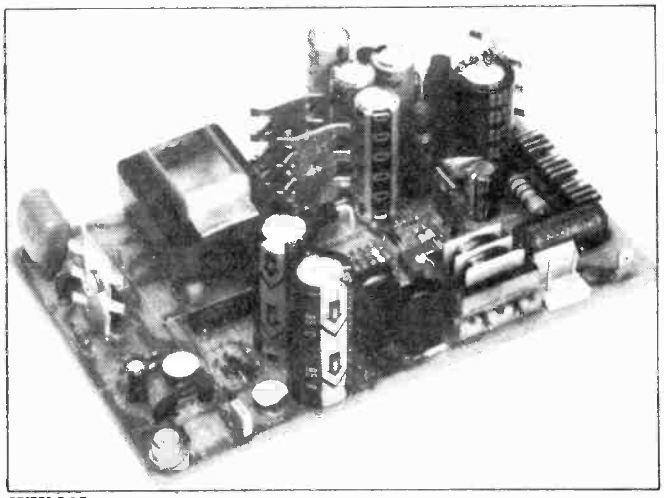
Electrically alterable roms that can be changed a word at a time were featured on General Instruments Electronics' stand; also new to their catalogue was a voice synthesiser module and the PIC1654 microcomputer which has a built-in 512×12-bit rom, on an 18-pin chip. This is said to be especially suitable for control management. **WW315**

Gresham Powerdyne Ltd have extended their range of power supplies to include a number of **open-frame switch-mode supplies** as well as variable output supplies and power products in DIN cassette and Eurocard format. **WW316**

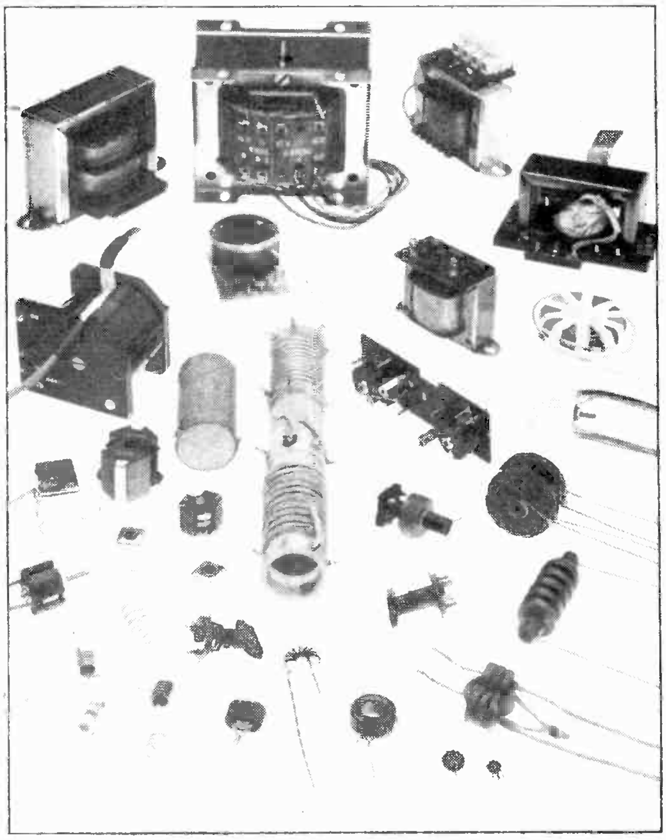
Harris-MHS have signed an agreement with Intel and are producing the **16-bit cmos 80C86 microprocessor** which rose to fame through its use in the IBM micro. **WW317**

Several new ranges of switches were on show at the **Hamlin Electronic Europe Ltd** stand, particularly a range of **miniature solid state switches**, Mini-Mos, which use v-mos circuits and opto-coupling to give high-speed switching with 2.5kV input-to-output isolation; all within a 6-pin d.i.l. miniature package. **WW318**

Recording instruments are appropriately the speciality of the **House of Instruments (Anglia) Ltd**, who offer more than 20 oscilloscope models, flat bed and strip chart recorders, as well as a wide range of meters and signal generators. On their stand, they featured the **Houston Omniscribe strip chart recorder** which uses a direct pen-drive servo that improves servo response and eliminates gearing. Versions are available for one or two channels, automatic pen lift, remote chart control, imperial or metric versions and multiple span. Charts are 297mm wide and up to 30m long. **WW319**



WW 305



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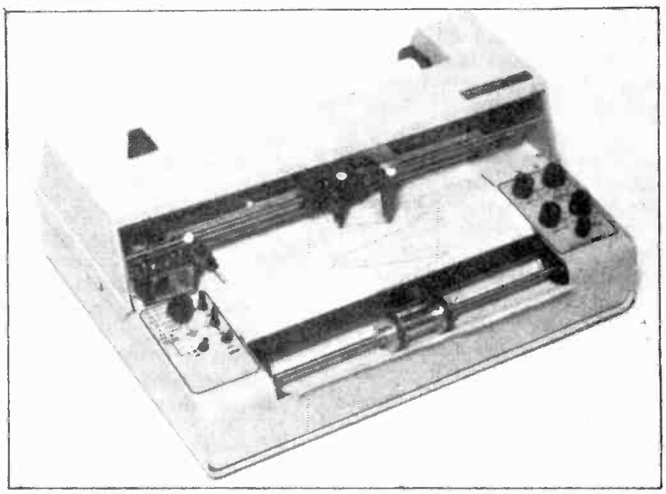

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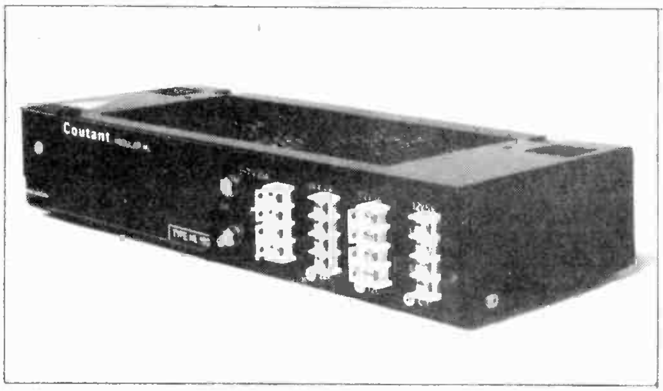

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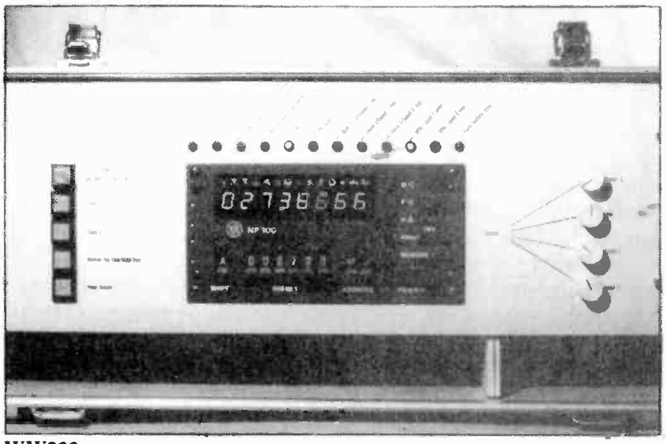

WW322

WW312

WW 324

Up to 512 input or output circuits may be controlled with the **Omron MIR programmable controller** which has an integral keyboard for programming with 26 different program instructions. The input/output modules may be selected from a wide range which includes a-to-d and d-to-a converters and fast counters. A typical system with 112 input/outputs which may be mixed control and data recording modules, and with 4K-words of eprom program costs less than £1,800. **IMO Precision Controls Ltd. WW320**

International Rectifier announced at the Show additional ranges to their Hexfet series of power mosfets. A low profile TO-39 series which conforms to British and American military specifications. The four-pin d.i.l. mosfets are now rated at up to 200V. They may be stacked end-to-end to make up arrays of switches in automatic test equipment, or to drive displays and solenoids. **WW321**

A new range of push-button code switches, including a miniature switch with a built-in display, was on display at the **IVO Industries Ltd** stand. IVO have also announced a **microprocessor-based control unit**, the NP 100 which may be used for monitoring, calculating and recording as well as controlling machinery. **WW322**

Noted for their range of variable filters, which has now been expanded to include a number of computer-controlled Butterworth, linear phase and elliptical filters, **Kemo Ltd** have used their expertise in filters to build a **low-frequency communications receiver.** The Metcom receiver operates in the 0.1 to 100kHz band and it boasts a resolution of ±1Hz. The receiver functions as a frequency-selective voltmeter with variable bandwidth, and -3dB bandwidths of 250Hz, 1kHz, 4kHz and 8kHz. Output s/n ratio is typically 60dB. **WW323**

New from **Marconi Instruments** was a **'true-RMS' voltmeter** which was microprocessor controlled to give direct digital readout of voltage signals between 5Hz and 25MHz. Its autoranging capability allows it to measure voltages from 2mV to 700V and it offers a choice of V, dBV and dBm units. For p.c.b. manufacturers, they were offering an **automatic testing station** which could point out faults in tracks or components and highlight the faults on a v.d.u. display of the p.c.b. while retaining a full history of each board in the computer memory. **WW324**

In our next issue

Community radio has no fixed frequency allocations as yet but could be accommodated by low-power transmitters sharing frequencies on a grid system similar to that for cellular radio telephones, according to a study by Norman McLeod.

In a subject that can provoke heated argument, often from deep-seated prejudice, M. B. Butler argues for representation by mixed logic and the abandonment of the fixed convention of positive and negative logic.

Growth in home computing underlines the need for a reliable low-cost means of transmitting data by telephone. Des Richards describes a 300 baud full-duplex modem that can be used in auto-answer mode.

On sale 15 June

RANDOM ECHOES

By Chirp

CONVERSATION

One of the criticisms frequently aimed at television, and even at old fashioned steam radio, is that potted entertainment in the home has killed the art of conversation. If this art implies some specially intellectual type of discourse, I can only say I'm glad it's dead but I doubt if television killed it.

But, if the "art of conversation" just means talking to each other, I wonder what kind of families these critics belong to. Take almost any family group not watching telly. Are they chatting away? No, they've run out of something to say; so Mum is knitting, Dad's puzzling over the *Sunday Telegraph* crossword and everyone else has found something to do. Then Dad remembers that "Last of the Summer Wine" is on BBC1 and switches on the telly. Mum then remembers that variety show on ITV, and we immediately have a lively discussion about which programme to watch.

Even when this is over there will be regular comment about the programme as it progresses, usually timed to kill the punch line of a tv comic's joke, to mask some vital dialogue in the play you are watching or cause any distraction from any serious programme that may be showing.

If you should be watching television in company and a particularly talented singer or instrumentalist appears in the programme, a casual remark that you appreciate the talent can ruin the whole enjoyment. Everyone agrees with you and collectively gives you a complete account of the life of the artiste – marriages, illnesses, sons and daughters, accounts of performances – until the performance is over. And you wish you had kept your big mouth shut. I expect I'm one of the worst offenders.

I see no sign that television is killing conversation. On the contrary, it is conversation that is killing television – unless, of course, the programme material is so poor that it is not worth mentioning, and then everyone keeps quiet.

ANYBODY SEEN MY VIDEO?

Eddy Spinks says that most of his customers have videos at home; so he's going to make a video about his firm's revolutionary microprocessor-controlled chip frying machine for them to show on their tellies. He was also telling me about his company's splendid security system, whereby the security guard can keep an eye on any location in the plant by simply watching it on the video.

He's a bit of a "Clever Dick", Eddy Spinks. He knows how to use modern technology. He's not too particular about the use of technical terms, and there are thousands like him; but what do they think a video is? . . . the programme, the v.c.r. or the c.c.t.v. system?

Mind you, "video" is a word that was being misused by people who should have known better long before the likes of Eddy Spinks ever heard it. I used to think it was an adjective, applied to a signal carrying visual information. We referred to a video signal to distinguish it, for example, from an audio signal. By inference, we then referred to "video frequency" on the basis that the video signal occupied a significantly wider bandwidth than the audio signal.

And then the word was used very carelessly even in technical circles. Any old wideband amplifier would be described as a video amplifier whether it was used in a visual display application or not. One famous manufacturer even produced a "video oscillator", and an electronic counter by another manufacturer was equipped with a "video amplifier" that was really a pulse regenerator and not an amplifier at all.

Perhaps, then, we shouldn't be too hard on Eddy Spinks; even though the word "video" is not a noun. I'm not going to bother what a video is. I've just illicitly recorded the Peer Gynt suite on my audio, and I'm going to listen to it.

PICTURE LANGUAGE

There I was standing in the radio and television department of the John Lewis department store, quietly watching the snooker on about a dozen television screens, when I was suddenly accosted by an elderly woman who demanded to know, "Which is the volume control?" It was a mistake to ask me. The John Lewis radio and television department is staffed by exceedingly well-mannered well-dressed Asian gentlemen, who would have been pleased to answer her question. I, on the other hand, am a boorish, scruffy European, and I did not take kindly to being asked in a somewhat impatient manner what I considered to be a damn silly question.

However, as I pointed out the volume control on one of the receivers to the lady, I realised that the question was not quite so silly as it seemed at first. On our old valve colour telly – and I daresay on her old valve colour telly – the names of the controls were spelled out in plain English. The volume control was marked "volume", and the fact that it also included the on/off switch caused no confusion to anybody. The picture controls marked "contrast" and "brilliance" were also quite familiar. I must admit that controls marked "chroma" and "hue" were a bit confusing – chroma controlled the colour saturation and I never did discover what the hue control did. Then, of course, there were the channel selector push buttons, and the only confusion there arose from the discrepancy between the number of buttons and the number of available stations; this is even worse on a modern set.

The controls on the modern all-solid-state colour television receivers in the John Lewis radio and television department are not nearly so simple. There seems to be a conviction among designers of all commodities that ordinary members of the public can no longer read and write. Plain words are being abandoned and little symbolic pictures are used instead. Even the easy ones are not always so clear. One is sometimes unsure of that picture of a little gent unless there is a picture of a little lady to compare it with. So what chances does the designer have in drawing pictures of abstract concepts such as the meaning of television receiver controls?

Apart from lots of channel selector buttons, most modern television receivers seem to have only four controls. There is a control identified by a picture of a paddlewheel and another with a picture of a partial eclipse of the moon. These are, of course, the brilliance and contrast controls, although you cannot be sure which is which. Then there is a control with a picture of three vertical sausages. This is actually the colour saturation control – we have to use this picture because ordinary people would not understand the meaning of a technical term like chroma. Finally there is the volume control that our lady in the shop was looking for; this is denoted by a picture of a wedge of cheese.

On reflection, the surprising thing is the way in which most of us fully accept and understand these funny little symbols, which bear very little relation to the concept that they are intended to describe. The old adage that a picture is worth a thousand words doesn't seem to apply to the pictures on the control panel of an average tv.

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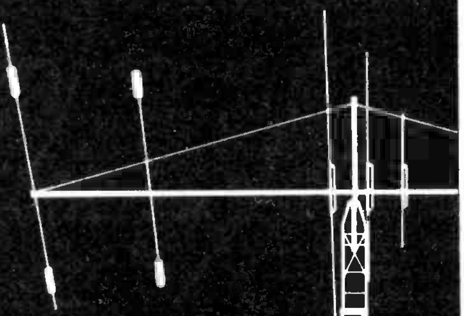

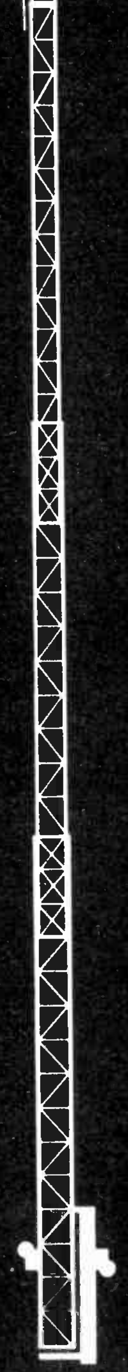

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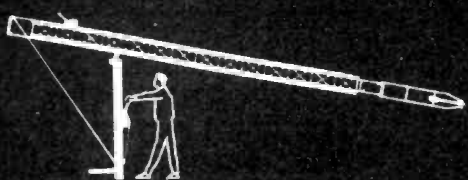

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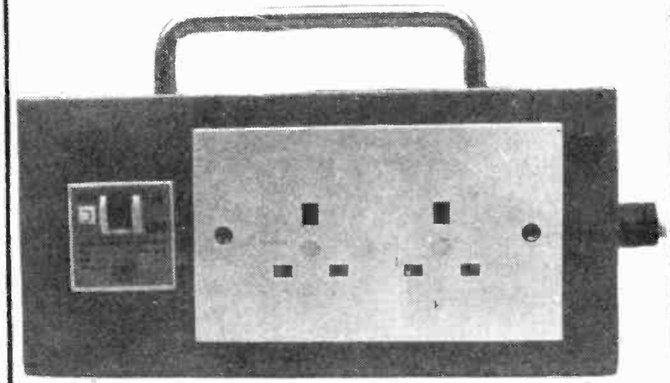

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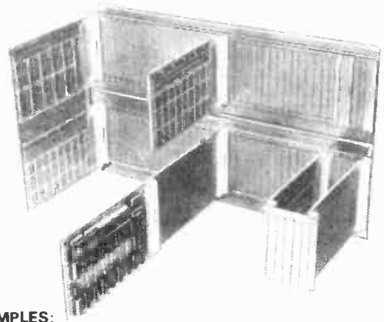

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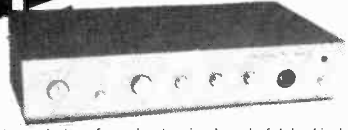
LINSLEY-HOOD 300 SERIES AMPLIFIERS



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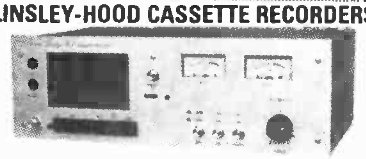
LINSLEY-HOOD CASSETTE RECORDERS



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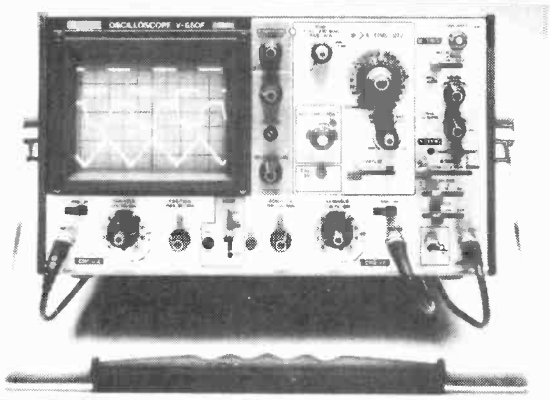

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Pri 6000 or 8000Ω or CT Sec 3.75 or 15Ω Ser/Par for EL84x2 12.5W **£4.50.** Pri 5000 for EL84 3W Sec **£3.75** or 15Ω Ser/Par **£2.50.** Pri 30-45-60-90 to 1 also 90TOI for push/pull Sec 3.75Ω **£2.** All prices include postage and VAT.

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8 MFD 1000V DC WKG. **£3.** P&P £1. 8 MFD 350V DC WKG. **£1.** P&P 50p. 6 MFD 350V DC WKG. **£75p.** P&P 25p. 6 MFD 300V AC WKG. **£1.50.** P&P 50p. 4 MFD 350V DC WKG. **50p.** P&P 25p. 2 MFD 350V DC WKG. **40p.** P&P 20p. 1 MFD 1000V DC WKG. **50p.** P&P 20p.

H.T. TRANSFORMERS

All are Parmeko potted style. All prices include VAT & carr.
No. 1, PRI 110V 220V 240V SEC. 350-325-0-325-350V 120 M/A **£6.75**
No. 2, PRI 110V 220V 240V. SEC. 400-0-400V 180M/A **£8.75.**
No. 3, PRI 110V 220V 240V SEC. 408-201-0-201-408V 500 M/A **£7.25.**
No. 4, PRI 110V 220V 240V SEC 400-0-400V 150M/A and 150-0-150V 20M/A **£6.50.**
No. 5, PRI 110V 220V 240V SEC. 250V 35M/A 375V 10 M/A 10-0-10V 4A 10V 1A 15V 100M/A x2 6.3V .3A 6.3V .15 AMP **£7.50**

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LARGE SELECTION OF CVTs BY FAMOUS MAKER

190-260V in 6V 15W out **£15**
190-260V in 12V 15W out **£20**
190-260V in 115V 50W out **£25**
190-260V in 115V 100W out **£35**
90-135V in 240V 200W out **£40**
All prices include VAT and carr.

ISOLATION TRANSFORMERS

Pri tapped 220-240V sec 240V 500 watts. Open frame type, top panel connections. Ex-equipment, but in perfect condition, **£15,** carr £3, VAT £2.70.

DC WKG BLOCK CAPACITORS

8 MFD 1000V DC WKG. **£3,** P&P £1, VAT 60p. 8 MFD 350V DC WKG **£1.25,** P&P 50p, VAT 26p. 6 MFD 350V DC WKG **£1,** P&P 50p, VAT 22p. 4 MFD 500V DC WKG. **£1,** P&P 50p, VAT 22p. 2 MFD 600V WKG. **60p,** P&P 20p, VAT 12p. 1 MFD 1000V DC WKG **60p,** P&P 20p, VAT 12p. 1 MFD 600V DC WKG **5 for £1.50,** P&P 50p, VAT 30p. 0.25 MFD 500V DC WKG. **5 for £1.25,** P&P 30p, VAT 16p. 0.1 MFD 1500V DC WKG. **5 for £1.25,** P&P 50p, VAT 16p. 2 MFD 100V DC WKG. **10 for £1.50,** P&P 75p, VAT 33p. Tubular metallised paper caps 20 MFD 350V DC WKG. with clip **£3,** P&P 50p, VAT 52p.

PARMEKO HT CHOKES

10H 250m/a	**£5.95**	20H 75m/a	**£3.50**
5H 250m/a	**£5.50**	10H 75m/a	**£2.95**
5H 180m/a	**£4.75**	7.5H 60m/a	**£2.50**
2.5H 500m/a	**£5.95**	15H 120m/a	**£3.95**
2.5H 250m/a	**£5.50**	50H 10m/a	**£2.50**
20H 120m/a	**£4.75**	25H 60m/a	**£2.75**

All prices include postage and VAT

LOW CURRENT LT TRANSFORMERS

Open frame clamped type, split bobbin. All primaries 240V No. 1 sec tapped 12-15-20-24-30V 750 M/A **£4.** No. 2 sec 9-0-9V 1A and 6.3V 200 M/A **£2.50.** No. 3 15-0-15V 600 M/A and 6.3V 200 M/A. No. 4 sec 12-0-12V 750 M/A and 6.3V 200 M/A **£4.** No. 5 sec 13V ½A **£1.50.** No. 6 sec 8V ½A 6.3V 600 M/A, 6.3V 300 M/A, 50V 40 M/A **£2.50.** No. 7 sec 17V ½A (DC) **£1.75.** No. 8 sec. No. 9 sec 18V 2A **£4.** No. 10 sec 24V 2A **£4.50.** No. 11 sec 15V 2A **£3.50.** All prices include postage and VAT

HIGH GRADE LT TRANSFORMERS

ALL PRIMARIES 240v
OPEN FRAME TOP PANEL CONNECTIONS

No 1 tapped 2-3-4-5-6-7-8-9-10-11-12-13-14-15v 8A **£10.** No 2 12v 8A **£7.50.** No 3 tapped 13-12-10-8v 8½A **£9.** No 4 Sec 6.3v 2A 6.3v 2A and 32-0-32v 280 m/a **£4.75.** No 5 Sec 37v 1.5A, 15v ½A, 9v 50 m/a **£3.95.** No 6 Sec 14v 2A **£3.95.** No 7 Sec 27.5-0-27.5v 1.2A and 7-0-7v 750 m/a **£3.50.** All prices include postage and VAT.

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Stylish aluminium case in dark blue finish with integral carrying handles and movable front legs for tilt facility. Fitted with IEC mains socket and 20mm fuse carrier. Comes complete with mains lead with 13 amp plug and IEC plug. Size: 20x28x33cm. **£15** inc. VAT and carr.

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Low voltage resettable counters, 52 ohms 6-12v DC 6 digit. Compact size. Only **£3.25** inc VAT and carr.

PARMEKO LT TRANSFORMERS

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No. 1 Sec tapped 12-18-32v 2A (dc) and 12-18-32v ½A (dc). No. 2 Sec tapped 12-18-32v 1A (dc) and 12-18-32 ¼A (dc) **£5.50.** No. 3 Sec tapped 12-18-32v ½A and 12-18-32v 100 m/a (dc) **£4.** No. 4 Sec tapped 12-18-32v ¼A (dc) and 12-18-32v 50m/a (dc) **£2.75.** No. 5 Sec 32v 100 m/a (dc) and 32v 25 m/a (dc) **£2.75.** No. 6 Sec tapped 24v 2A (dc) **£2.75.** No. 7 Sec 17v 1A (dc) **£2.** All prices include postage and VAT.

PARMEKO HT TRANSFORMERS

Pri 220-240v Sec 500-0-500v 120 m/A 6.3v 5A, 6.3v 3A, 5V 3A potted type **£8.50** inc. postage and VAT

KEYBOARDS

Full ASCII Keyboard with cursor control plus numeric pad, originally made for Viewdata editing. A very high-grade unit housed in an attractive off-white case, fitted with 25-way D-Type socket. Price **£56** inc. carr. and VAT.

LT CHOKES BY FAMOUS MAKERS

8m/h 15A 'C' core type **£6.95.** 4.8m/h 10A open frame type **£5.50.** 2+2m/h 12A open **£5.95.** 100m/h 2A frame type potted type **£5.95.** 130m/h 1.15A **£2.75.**
All prices include postage and VAT

ELECTROLYTIC CAPACITORS

3600MFD 150v DC WKG **£2.50,** 6800 MFD 100v DC WKG **£2.50,** 12000 MFD 50v DC WKG **£2,** 5000 MFD 75v DC WKG **£1.50,** 6500 MFD 60v DC WKG **£1.50,** 100000 MFD 10v DC WKG **£2,** 3300 MFD 40v DC WKG, three for **£3,** 22000 MFD 10v DC, five for **£2.50,** 2200 MFD 63v DC WKG, five for **£2.50,** HT types 32+32 MFD 450v DC WKG **£1.25,** 32+32 MFD 350v DC WKG **£1.** All prices include postage and VAT.

AC WKG CAPACITORS

MFD	AC wkg	Price	MFD	AC wkg	Price
0.25	1500v	**£1.50**	5	360v	**£1.75**
0.75	440v	**£1.00**	5	440v	**£2.00**
1	400v	**£1.50**	4	600v	**£2.00**
2.5	360v	**£1.50**	6	300v	**£2.00**
2.7	700v	**£1.75**	8.4	250v	**£1.50**

All prices include postage and VAT

WW – 057 FOR FURTHER DETAILS

Pye Europa MF5FM high-band sets, complete but less mike and cradle. **£90 each plus £2 p.p. plus VAT.**
Pye M294 high-band FM sets, complete but less mike, speaker and cradle. **£150 each plus £2 p.p. plus VAT.**
Pye Reporter MF6 AM high-band sets, complete but less speaker and cradle. **£90 each plus £2 p.p. plus VAT.**
Pye Olympic M201 AM high-band sets, complete but less mike, speaker and cradle. **£90 each plus £2 p.p. plus VAT.**
Pye Westminster W15 FM G band 42-54 MHz sets, unused and like new, but less mike, speaker and cradle. **£65 each plus £2 p.p. plus VAT.**
Pye Westminster W15 AMD mid-band multi-channel sets, no mikes, speakers or cradles. **£45 each plus £2 p.p. plus VAT.**
Pye Westminster W15 AMD mid-band crystalled and converted to 129.9 MHz, 130.1 MHz, 130.4 MHz. Very good condition. **£120 each plus £2 p.p. plus VAT.**
Pye Westminster W15 AMD high-band and low-band sets available. Sets complete but less mikes, speakers and cradles. **£70 each plus £2 p.p. plus VAT.**
Pye Westminster W30 AM low-band sets only, no control gear. Sets complete and in good condition. **£45 each plus £2 p.p. plus VAT.**
Pye base station F30 AM, low band and high band available, remote and local control. **Prices from £220 plus VAT.**
Pye base station F401 high-band AM, local control, fully solid state, complete but less mike. **£275 each plus £15 p.p. plus VAT.**
Pye base station receiver R402 high-band FM 148-174MHz, single channel, 12'5 KHz channel spacing. **£95 each plus £5 p.p. plus VAT.**
Pye base station F9U, remotely controlled, 5 Watt output, UHF (440-470 MHz), single channel. **£90 each plus £5 p.p. plus VAT.**
Pye base station F412 UHF (440-470 MHz), 25KHz channel spacing, single channel, local control. **£250 each plus £15 p.p. plus VAT.**
Pye Beaver M254 high-band FM sets, 15 Watt, robust mobile radiotelephones for industrial use, sets complete but less crystals, as new condition. **£120 each plus £2 p.p. plus V.A.T.**
Pye base station receiver F27 AM, crystalled on 116.46 MHz, can be recrystalled on air band. Unused condition. **£15 each plus £5 p.p. plus VAT.**
Pye AC200 mains power unit for Olympic or Reporter, automatic standby power facility with trickle charging and built-in quartz digital clock. **£95 each plus £5 p.p. plus VAT.**
Pye PC1 radiotelephone controller, good condition, two only at **£50 each plus £2 p.p. plus VAT.**
Pye Tulip microphone as used on most base stations and PC1, 2400 ohm with ptt switch. **£15 plus £1 p.p. plus VAT.**
Pye PF1 UHF FM Pocketfone receivers, 440-470 MHz, single channel, int. speaker and aerial. Supplied complete with rechargeable battery and service manual. **£6 each plus £1 p.p. plus VAT.**
Ni-Cad Batteries for Pye PF1, used but good condition, Rx (Yellow) £2 each Tx (Red). **£3 each plus £1 p.p. plus VAT.**
Pye Pocketfone PF1 Battery Chargers, type BC14, 12 way with meter. **£10 each plus £1 p.p. plus VAT.**
Pye Pocketfone PF1 Battery Chargers, type BC5 single charger, brand new. **£20 each plus £1 p.p. plus VAT.**
Pye single sideband HF Mobile Radiotelephone, type SSB130M, 100 W P.E.P. output, 6-channel, 2-15 MHz. Complete and new condition but less power unit. **£250 plus £10 p.p. plus VAT.**
Pye fixed station transmitter, type T100 FM, 'G' band 38.6-50 MHz, 100 W output. 25 KHz channel spacing. New condition. **£100 each plus £10 p.p. plus VAT.**
Pye Pocketfone 70 type PF2UB, UHF Portables, complete with battery, aerial & mike, good condition. **£80 plus VAT. Sets only £50 plus VAT.**
Pye Pocketfone 70 type PF2FM, low band, FM portables, sets complete but less battery, aerial & mikes, good condition. **£50 plus VAT.**
Pye Pocketfone 70 type PF5, UHF portables, complete with batteries, good condition. **£45 plus VAT.**
Pye Pocketfone 70 battery chargers type BC11A, automatic charger, will accept up to 8 batteries/units, good condition. **£35 plus VAT.**
Pye Base Station type F9AM, remotely controlled, 5 watt output, high band & low band available. **£90 each plus VAT.**
Pye 'Lynx' closed circuit TV camera, 625 lines, video or RF output, VHF channels 2, 3, 4, good condition, complete with lens. **£45 each plus VAT.**

MAINS TRANSFORMERS

Mains isolating transformer, 500VA 240V input, 240V C.T. output, housed in metal box. **£15 each plus £6 p.p. plus VAT.**
Mains isolating transformer, 240V tapped input, 240V 3 amp, plus 12V 0.5 amp output. **£20 each plus £6 p.p. plus VAT.**
Advance Volstat transformers, type CVN200/5, input 24 or 28V DC via inverter, output 220 or 240V RMS 150 watt, 50Hz. **£10 each plus £4 p.p. plus VAT.**
Marconi signal generator type TF1064B/5, AM/FM covering three ranges 68-108, 118-185 and 450-470 MHz, good condition with service manual. **£125 plus VAT.**
Marconi signal generator type TF2002AS, MF/HF AM/FM, solid state 10 kHz-72 MHz in 8 ranges, good condition with service manual. **£400 each plus VAT.**
Cossor oscilloscope type CDU150 twin beam, solid state, 35MHz, good condition. **£195 each plus VAT.**
Marconi AM/FM signal generator, type TF995A/3/S (CT402), 1.5-220 MHz, good condition with copy of service manual. **£95 each plus £15 p.p. plus VAT.**
Airmec millivolt meter, Type 301. **£50 plus £2 p.p. plus VAT.**
Advance signal generator Type C2. **£25 plus £5 p.p. plus VAT.**
Airmec modulation meter, Type 210. **£75 plus £5 p.p. plus VAT.**
Marconi HF Spectrum analyser, Type OA1094A/S 0-30 MHz. **£100 plus VAT (buyer collects).**
Servomex AC voltage stabiliser, type AC2, 240V @ 9 amp. **£45 each plus £15 p.p. plus VAT.**
Servomex AC voltage stabiliser, type AC7, 240V @ 20 amp. **£75 each plus £15 p.p. plus VAT.**
Rhode & Schwarz power signal generator 0.1 to 30 MHz, Type BN41001. **£50 plus £10 p.p. plus VAT.**
Meguro signal generator, type MSG-230E, 16 KHz-50 MHz. **£130 plus £10 p.p. plus VAT.**
Rhode & Schwarz Polyskop Type SWOB BN4244, 0.5 MHz to 400 MHz. **£150 plus £15 p.p. plus VAT.**
Computer-grade electrolytic capacitors, screw terminals, 25,000mfd., 33 volts, brand new. **£1 each plus 50p p.p. plus VAT.**
60 amp alternator and general noise filters for use in vehicles. **£1 each plus 50p p.p. plus VAT.**
Modern telephones, type 746, with dials, colour grey, used but good condition. **£8 plus £1 p.p. plus VAT.**
Cigar lighter plug with lead. **£1 each plus 30p p.p. plus VAT.**
IC test clips, 28-way and 40-way, goldplated. **£2 each plus 30p p.p. plus VAT.**
Equipment wire, size 7/0.2mm, colour yellow, 500-metre reels. **£4 plus £1 p.p. plus VAT.**
Hartley Oscilloscope Type CT436, valved, DC to 6 MHz bandwidth. **£50 plus VAT.**
Power units, 70 volt @ 8 amp, 20 volt @ 3 amp. Brand new but no details. **£20 each plus £8 p.p. plus VAT.**
Beryllium block mounts for CCS1 valves, etc. **£10 each plus £1 p.p. plus VAT.**

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Siemens 1.6MHz Level Osc. Rel 3W231/233/234 as new	250.00
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Siemens Level Difference Meter D2003	300.00
Siemens 100MHz Return Loss Bridge R273	700.00
Siemens Pegamat System 1.6MHz sweep/lock facility	1,000.00
Siemens Pegamat Separate Units e.g D2010/S2010/B2004 and others	No reasonable offer refused
Hatfield Level Meter 1001 30Hz-30KHz	120.00
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STC 0.16KHz Selective Level Meter	100.00
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STC Sweep Set + Recorder	150.00
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Advance J2	40.00
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Marconi Valve Voltmeter TF2600	70.00
Sullivan Inductance Bridge	40.00
Anritsu Attenuator 500MHz	300.00
W & G EPM1 Milliwatt Test Set 300MHz	600.00
W & G 1350KHz Osc/Det	100.00
W & G 14MHz Osc/Det	100.00
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The ideal way to learn machine language and become acquainted with the new "single chip" control oriented microprocessors. 1.8K of EPROM, 20 I/O lines, 112 bytes of RAM and a timer all in a single 28-pin I.C. As featured in this, and subsequent issues of WW.

COMPLETE KIT **£39.87**
68705 DATA **£1.95**

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COMPLETE KIT **£9.39**
16 WAY LEAD **£2.35** extra

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Complet kit for this efficient C.D. system featured in March '82 WW. Includes: Case, improved PCB, ferrite transformer core, winding wire, all components, hardware and instructions.

£14.92 P&P 45p

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WW-072 FOR FURTHER DETAILS

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Despatch by return

OVER 150 TYPES OF TRANSFORMER STOCKED

MAINS ISOLATORS

Pri 0-120; 0-100-120V. Sec 0-CT-115V×2

Ref.	VA (Watts)	£	P&P
07★	20	**5.82**	1.60
149	60	**9.49**	1.80
150	100	**11.08**	2.00
151	200	**15.69**	2.25
152	250	**18.97**	2.64
153	350	**23.47**	2.70
154	500	**29.23**	2.95
155	750	**41.28**	3.70
156	1000	**53.00**	4.00
157	1500	**68.37**	4.70
158	2000	**82.27**	5.10
159	3000	**115.35**	OA
161	6000	**203.65**	OA

★115 or 240v sec only. State volts required. Pri 0-220-240V.

30 VOLT RANGE 2×15V sec

Sec volts available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 15V-0-15V

Ref.	30v	15v	£	P&P
112	0.5	1	**3.19**	1.20
79	1	2	**4.32**	1.40
3	2	4	**6.99**	1.60
20	3 A	6	**8.10**	1.85
21	4 M	8	**9.67**	1.90
51	5 P	10	**11.95**	2.00
117	6	12	**13.52**	2.02
88	8 S	16	**18.10**	2.26
89	10	20	**20.88**	2.24
90	12	24	**23.20**	OA
91	15	30	**26.60**	3.00
92	20	40	**35.64**	4.83

SCREENED MINIATURES Pri 240V

Ref.	mA	Sec Volts	£	P&P
238	200	3-0-3	**3.11**	.90
212	1A, 1A	0-6, 0-6	**3.45**	1.20
13	100	9-0-9	**2.59**	.80
235	330, 330	0-9, 0-9	**2.41**	.90
207	500, 500	0-8-9, 0-8-9	**3.36**	1.20
208	1A, 1A	0-8-9, 0-8-9	**4.27**	1.40
236	200, 200	0-15, 0-15	**2.41**	.90
239	50MA	12-0-12	**3.11**	.90
214	300, 300	0-20, 0-20	**3.39**	1.20
221	700 (DC)	20-12-0-12-20	**4.13**	1.20
206	1A, 1A	0-15-20, 0-15-20	**5.60**	1.60
203	500, 500	0-15-27, 0-15-27	**4.83**	1.50
204	1A, 1A	0-15-27, 0-15-27	**7.30**	1.60

12 or 24-VOLT RANGE

2×12V windings Pri 220-240V

Ref.	12v	24v	£	P&P
242	0.3	150mA	**2.41**	.90
213	1	0.5	**3.19**	1.20
71	2	1.0	**4.25**	1.20
18	4 A	2.0	**4.91**	1.60
85	5 M	2.5	**6.78**	1.50
70	6 P	3.0	**7.69**	1.40
108	8	4.0	**8.98**	1.64
72	10 S	5.0	**9.82**	1.80
116	12	6.0	**10.89**	1.90
17	16	8.0	**12.97**	2.12
115	20	10.0	**17.46**	2.44
187	30	15.0	**21.69**	2.64
226	60	30.0	**44.45**	OA

60 VOLT RANGE

Pri 0-120V×2

2×30V tapped secs volts available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V, or 24V-0-24V or 30V-0-30V

Ref.	60v	30v	£	P&P
124	0.5	1	**4.70**	1.50
126	1	2	**7.15**	1.50
127	2 A	4	**9.20**	1.90
125	3	6	**13.31**	2.02
123	4 M	8	**15.15**	2.26
40	5 P	10	**19.16**	2.24
120	6 S	12	**21.86**	2.64
121	8	16	**30.72**	OA
122	10	20	**35.76**	OA
189	12	24	**41.22**	OA

AUTO TRANSFORMERS

Voltages available 105, 115, 190, 200, 210, 220, 230, 240. For step up or step down.

Ref.	VA (Watts)	Taps	£	P&P
113	15	0-10-115-210-240V	**2.39**	1.20
64	80	0-10-115-210-240V	**4.84**	1.40
4	150	0-10-115-200-220-240V	**6.48**	1.60
67	500	0-10-115-200-220-240V	**13.30**	2.24
84	1000	0-10-115-200-220-240V	**22.70**	2.80
93	1500	0-10-115-200-220-240V	**28.17**	OA
95	2000	0-10-115-200-220-240V	**42.14**	OA
73	3000	0-10-115-200-220-240V	**71.64**	OA
80	4000	0-10-115-200-220-240V	**93.01**	OA
57	5000	0-10-115-200-220-240V	**108.30**	OA

50 VOLT RANGE 2×25V

tapped secs. Volts available 5, 7, 8, 10, 13, 15, 17, 20, 25, 30, 33, 40 or 20V-0-20V or 25V-0-25V

Ref.	50v	25v	£	P&P
102	0.5	1	**4.13**	1.40
103	1	2 A	**5.03**	1.40
104	2	4	**8.69**	1.84
105	3	6 M	**10.36**	1.90
106	4	8 P	**14.10**	2.12
107	6	12 S	**18.01**	1.84
118	8	16	**24.52**	2.70
119	10	20	**30.23**	OA
109	12	24	**36.18**	OA

CASED AUTOS

240V cable input USA 115V outlets

VA	Price	P&P	Ref
20	**£7.21**	1.25	56W
80	**£9.35**	1.50	64W
150	**£12.10**	1.84	4W
250	**£14.73**	1.60	69W
500	**£22.14**	2.24	67W
1000	**£33.74**	2.80	84W
2000	**£60.47**	OA	95W

400/440V ISOLATORS

400/440 to 200/240V

VA	Ref.	£	P&P
60	243	**9.50**	1.80
100	244	**11.08**	2.00
200	245	**15.68**	2.25
250	246	**18.97**	2.40
350	247	**23.47**	2.70
500	248	**29.23**	2.95
1000	250	**52.98**	4.00
2000	252	**82.27**	5.00
3000	253	**115.37**	OA
6000	254	**228.75**	OA

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250VA £157.36 2kVA 594.50
500VA £219.91 5kVA £1587.00
+ carriage + VAT

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1kW **£240.40** (24V input)
Continuous rating
+ carriage at cost + V.A.T. 15%

EDUCATIONAL METERS. 75×78mm free-standing finger screw connection. i) 0-10A; ii) 0-30V; iii) 0-2A 75×78mm **£4.50**+66p p&p+VAT 15%

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100v	25A+	**£2.10**	400v	6A	**£1.40**
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73 Portable Size)	**£68.90**
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DA212 LCD Digital	**£81.90**
DA116 LCD Digital	**£131.30**
DA117 Autorange LCD	**£157.00**
Megger 70143 500V	**£101.50**
Megger Battery BM7	**£11.60**

P&P £1.60 + VAT 15%

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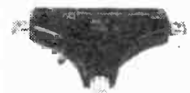

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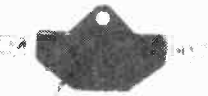

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THEFT!

During the period of the recent All Electronics Show, a car owned by Vic Saunders of Tecnicad Ltd, 20/22 Poole Hill, Bournemouth BH2 5PS was broken into and several personal items were stolen.

Vic reported the incident to the Metropolitan Police at King's Cross, N1, for amongst many items stolen was his briefcase containing all the enquiries made at the show. Disaster!

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TBA395	1.50
TBA396	0.75
TBA440N	2.55
TBA480Q	1.25
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TBA510Q	2.50
TBA520	1.10
TBA520Q	1.10
TBA530	1.10
TBA530Q	1.10
TBA540	1.25
TBA540Q	1.35
TBA550Q	1.45
TBA560C	1.45
TBA560CQ	1.45
TBA570	1.00
TBA641A12	2.50

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TBA950	2.35
TBA950/2X	2.35
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TBA990Q	1.49
TBA1441	2.15
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TDA2532	1.95
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AC176K	0.31
AC187	0.25
AC187K	0.28
AC188	0.25
AC188K	0.37
AD142	0.90
AD143	0.82
AD149	0.70
AD161	0.39
AD162	0.39
AD161/2	0.90
AF115	0.75
AF124	0.34
AF125	0.35
AF126	0.32
AF127	0.32
AF139	0.40
AF150	0.42
AF239	0.42
AU106	2.00
AU107	1.75
AU110	2.00
AU113	2.95
BC107	0.10
BC107A	0.11
BC107B	0.11
BC108	0.10
BC108A	0.11
BC108B	0.12
BC109	0.10
BC109B	0.12
BC109C	0.12
BC114	0.11
BC116A	0.15
BC117	0.19
BC119	0.24
BC125	0.25
BC140	0.31
BC141	0.25
BC142	0.21
BC143	0.24
BC147	0.09
BC147B	0.09
BC148A	0.09
BC148B	0.09
BC149	0.09
BC157	0.12
BC158	0.09
BC159	0.09
BC160	0.28
BC161	0.28
BC170B	0.15
BC171	0.09
BC171A	0.10
BC171B	0.10
BC172	0.10
BC172B	0.10
BC172C	0.10

BC173B	0.10
BC174	0.09
BC174A	0.09
BC177	0.15
BC178	0.15
BC182	0.10
BC1B2LB	0.10
BC183	0.10
BC183L	0.09
BC184LB	0.09
BC204	0.10
BC207B	0.13
BC208B	0.13
BC212	0.09
BC212L	0.09
BC212LA	0.09
BC213	0.09
BC213L	0.09
BC214	0.09
BC214C	0.09
BC214L	0.09
BC237	0.10
BC237A	0.09
BC237B	0.09
BC238	0.09
BC239	0.12
BC251A	0.12
BC252A	0.15
BC258	0.25
BC258A	0.39
BC284	0.30
BC300	0.30
BC301	0.30
BC303	0.26
BC307	0.09
BC307A	0.09
BC307B	0.09
BC327	0.10
BC328	0.10
BC337	0.10
BC338	0.09
BC347A	0.13
BC461	0.35
BC478	0.20
BC527	0.20
BC547	0.10
BC548	0.10
BC549A	0.08
BC550	0.08
BC557	0.08
BC557A	0.08
BC557B	0.08
BC558	0.10
BCY33A	1.60
BD115	0.30
BD116	0.60
BD124P	0.59
BD131	0.32
BD132	0.35
BD133	0.40
BD135	0.30
BD136	0.30
BD137	0.32
BD138	0.30
BD139	0.32
BD140	0.30
BD144	1.10

BD159	0.66
BD166	0.55
BD179	0.72
BD182	0.70
BD201	0.83
BD202	0.65
BD203	0.78
BD204	0.70
BD222	0.46
BD223	0.48
BD225	0.48
BC232	0.35
BD233	0.35
BD234	0.35
BD236	0.45
BD237	0.40
BD238	0.40
BD241	0.40
BD242	0.50
BD246	0.60
BD376	0.32
BD410	0.55
BD434	0.55
BD437	0.50
BD438	0.60
BD506	0.50
BD508	0.40
BD520	0.65
BD538	0.65
BD597	0.75
BD697	1.10
BD698	1.10
BD707	0.80
BDX32	1.50
BF115	0.36
BF127	0.24
BF154	0.12
BF158	0.22
BF160	0.27
BF167	0.24
BF173	0.22
BF177	0.38
BF178	0.26
BF179	0.34
BF180	0.29
BF181	0.29
BF182	0.29
BF183	0.29
BF184	0.28
BF185	0.28
BF194	0.11
BF195	0.11
BF196	0.11
BF197	0.11
BF198	0.16
BF199	0.14
BF200	0.40
BF241	0.16
BF245	0.30
BF246	0.28
BF256/LC	0.28
BF257	0.28
BF258	0.28
BF259	0.28
BF271	0.26
BF273	0.13
BF336	0.34
BF337	0.29
BF338	0.32
BF355	0.37

BF362	0.38
BF363	0.38
BF371	0.20
BF394	0.19
BF422	0.32
BF457	0.32
BF458	0.28
BF459	0.36
BF595	0.23
BF597	0.25
BFR39	0.23
BFR40	0.23
BFR41	0.28
BFR88	0.30
BFR90	1.50
BFR91	1.75
BFT42	0.28
BFT43	0.28
BFW92	0.86
BFX29	0.30
BFX84	0.26
BFX85	0.32
BFX86	0.30
BFX88	0.25
BFY50	0.21
BFY51	0.21
BFY52	0.25
BFY90	0.77
BR100	0.26
BR101	0.30
BRC4443	0.86
BT106	1.22
BT108	1.22
BT116	1.20
BT119	1.66
BT120	1.66
BU105	1.22
BU108	1.69
BU124	1.25
BU125	£1.25
BU126	1.60
BU204	1.55
BU205	1.30
BU208	1.39
BU208A	1.52
BU326	1.20
BU326A	1.42
BU326S	1.90
BU407	1.24
BU500	2.25
BU526	1.90
BUY69B	1.70
MJ3000	1.98
MJE340	0.40
MJE520	0.48
MPSA12	0.20
MPSA13	0.20
MPSA92	0.30
MRF450A	11.50
MRF453	13.50
MRF454	17.50
MRF475	2.50
MRF477	10.00
OC23	1.50
OC42	0.55
OC44	0.55
OC45	0.55
OC70	0.45
OC71	0.40
OC81	0.50

R2008B	1.70
R2010B	1.70
R2322	0.58
R2323	0.66
R2540	2.48
RCA16334	0.90
RCA16335	0.80
SKE5F	1.45
TIP29	0.40
TIP29C	0.42
TIP30C	0.43
TIP31C	0.42
TIP32C	0.42
TIP33B	0.75
TIP34B	0.75
TIP41A	0.45
TIP41C	0.45
TIP42C	0.47
TIP47	0.65
TIP120	0.60
TIP125	0.65
TIP142	1.75
TIP146	1.75
TIP161	2.95
TIP2955	0.80
TIP3055	0.55
TIS91	0.20
TV106/2	1.50
2N2219	0.28
2N2905	0.40
2N3053	0.40
2N3054	0.59
2N3055	0.52
2N3702	0.12
2N3703	0.12
2N3704	0.12
2N3705	0.12
2N3706	0.12
2N3708	0.12
2N3773	1.75
2N3792	1.35
2N4427	1.50
2N4444	1.15
2N5294	0.42
2N5296	0.48
2N5298	0.60
2N5496	0.65
2SA715	0.60
2SC495	0.80
2SC496	0.80
2SC1096	0.80
2SC1172Y	2.20
2SC1173	1.16
2SC1306	1.00
2SC1307	1.50
2SC1449	0.80
2SC1678	1.25
2SC1945	2.10
2SC1953	0.95
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2SC1969	1.95
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2SC2029	1.95
2SC2078	1.45
2SC2091	0.85
2SC2166	1.95
2SC2314	0.80
2SD234	0.50
3N211	1.50

DIODES

AA119	0.08
BA102	0.17
BA115	0.13
BA145	0.16
BA148	0.17
BA154	0.06
BA155	0.13
BA156	0.15
BA157	0.30
BAX13	0.04
BAX16	0.06
BB105B	0.30
BT151	0.79
BY126	0.10
BY127	0.11
BY133	0.15
BY164	0.45
BY176	1.20
BY179	0.63
BY184	0.35

BY199	0.40
BY206	0.14
BY208-800	0.33
BY210-800	0.33
BY223	0.90
BY298-400	0.22
BY299-800	0.22
BYX10	0.20
BYX36-150R	0.20
BYX38-600R	0.60
BYX55-600	0.30
BYX71-600	0.60
BZY95C30	0.35
OA47	0.09
OA90	0.05
OA91	0.06
OA95	0.06
OA202	0.10
IN914	0.04
IN4001	0.04
IN4002	0.04

IN4003	0.04
IN4004	0.06
IN4005	0.05
IN4006	0.06
IN4007	0.06
IN4148	0.02
IN4448	0.10
IN5401	0.12
IN5402	0.14
IN5403	0.12
IN5404	0.12
IN5405	0.13
IN5406	0.13
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ECC83 Mullard	1.35
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ECC85	0.60
ECC86	1.46
ECC88	0.85
ECC91	2.00
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ECC189	0.78
ECC801S	3.50
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ECF86	1.70
ECF200	1.85
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ECH83	0.78
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ECL80	0.60
ECL82	0.65
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ECL85	0.69
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EF94	0.55
EF95	1.00
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EF183	0.85

EF184	0.65
EF731	1.80
EF732	1.80
EF800	11.00
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EL33	4.00
EL34	1.95
EL34 Mullard	3.50
EL36	1.50
EL37	9.00
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EL42	2.00
EL81	3.95
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M8098	3.20
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M8100	2.85
M8136	7.00
M8137	5.50
M8161	5.50
M8162	5.50
M8163	3.85
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M8196	3.25
M8204	2.00
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P41	2.50
PABC80	0.50
PC86	0.75
PC88	0.75
PC92	1.20
PC97	1.10
PC800	1.10
PC900	0.75
PCC84	0.40
PCC85	0.54
PCC88	0.70
PCC89	0.70
PCC189	0.70
PCC805	0.70
PCC806	0.80
PCE82	0.80
PCF80	0.65
PCF82	0.60
PCF84	0.65
PCF86	1.20
PCF87	0.40
PCF200	1.80
PCF201	1.80
PCF800	0.40
PCF801	1.35
PCF802	0.60
PCF805	1.25
PCF806	1.00

PCF808	1.25
PCH200	1.10
PCL82	0.80
PCL83	2.50
PCL84	0.85
PCL85	0.80
PCL86	0.85
PCL200	1.60
PCL800	0.80
PCL805	0.80
PD500	3.50
PD510	3.65
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PEN25	2.00
PEN4ODD	2.50
PEN45	3.00
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PL21	2.50
PL33	1.25
PL36	0.95
PL38	1.50
PL81	0.72
PL81A	0.72
PL82	0.60
PL83	0.52
PL84	0.65
PL88	1.00
PL95	1.20
PL302	1.00
PL345	12.50
PL500	0.95
PL504	0.95
PL508	1.95
PL509	4.85
PL519	4.95
PL802	4.50
PL820	2.95
PY32	0.80
PY33	0.50
PY81	0.70
PY82	0.70
PY83	0.70
PY88	0.52
PY500A	1.79
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Q13-110BA	47.50
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QQVO3-20A	11.00
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QS150/30	1.15
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QS1203	4.15
QS1205	3.95
QS1206	1.05
QS1207	0.90
QS1208	0.90
QS1209	2.00
QS1210	1.50
QS1211	1.50
QS1212	3.20
QS1213	5.30
QS1215	2.10
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U50	2.00
U54	4.50
U82	3.00
U191	0.70
U192	1.00
U193	0.65
U251	1.00
U291	0.60
U301	0.55
U801	0.75
UABC80	0.65
UAF42	1.00
UBF80	0.60
UBC41	1.75
UBC81	1.50
UBF89	0.60
UBL21	1.75
UC92	1.20
UCC84	0.70
UCC85	0.60
UCF80	1.00
UCH21	1.20
UCH41	1.20
UCH42	1.35
UCH81	0.65
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UF42	1.15
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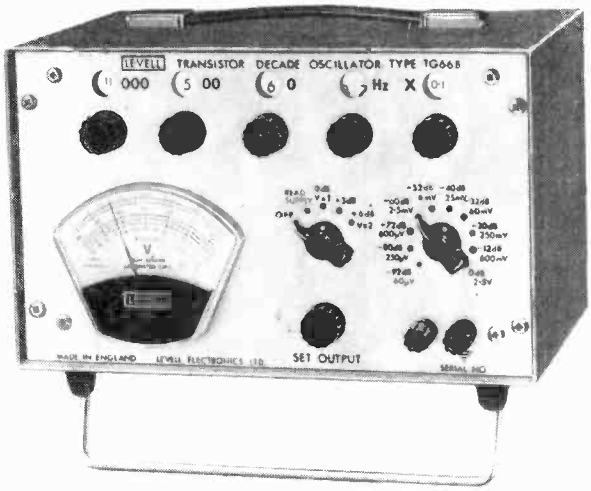

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WIRELESS WORLD Wireless World, June 1983 WW 8366

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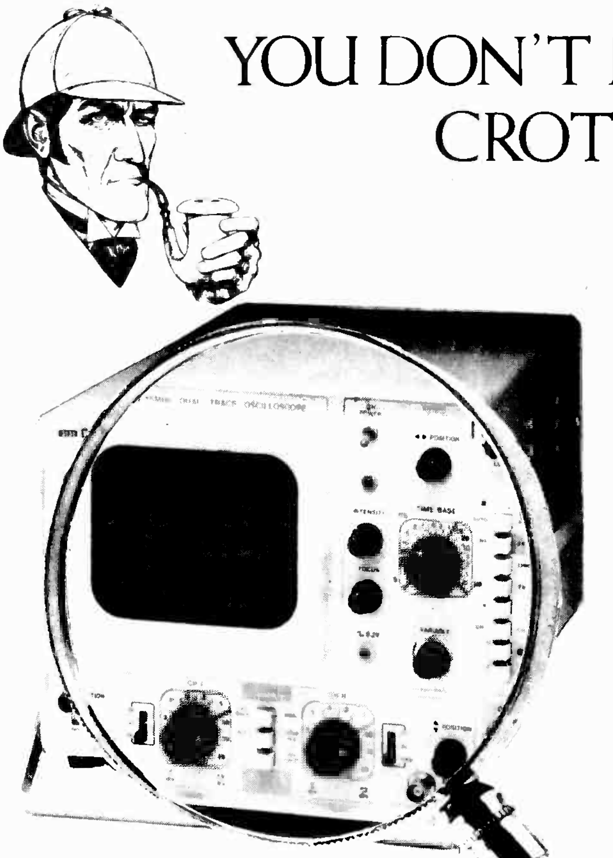

YOU DON'T NEED ME TO DETECT CROTECH'S VALUE

It's elementary. Just look at the **3030** at £154 and the **3131** at £250, both are 15MHz scopes with 5mV/Div maximum deflection coefficient. And the Dual Trace 3131 has matched X–Y, Algebraic Add and Subtract, and TV Trigger, all selected on easy to use clearly marked push buttons.

But that's not all, both incorporate a Component Tester, yes, even the Single Trace 3030, for the in or out of circuit testing of semiconductor and passive devices. With the resultant characteristic being displayed directly on the CRT.

There's only one thing left to say . . .

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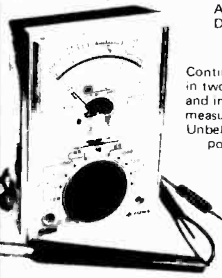
WW – 039 FOR FURTHER DETAILS

MINI-MULTI TESTER
Deluxe pocket size precision moving coil instrument, Jewelled bearings - 2000 o.p.v. mirrored scale.

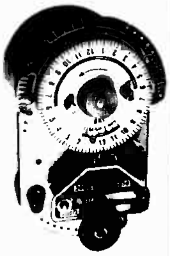
11 instant range measures: DC volts 10, 50, 250, 1000.
AC volts 10, 50, 250, 1000.
DC amps 0 – 100 mA.



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

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

VENNER TIME SWITCH



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

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

50 THINGS YOU CAN MAKE
or do and still have hundreds of parts for future jobs. **LEARN** the practical way with our 10 kilo parcel of useful parts. Minimum 1,000 items includes panel meters, timers, thermal trips, relays, switches, motors, drills, taps and dies, tools, thermostats, coils, condensers, resistors, etc. etc. Parcel with data on 50 projects.

YOURS FOR ONLY £11.50 plus £3.00 post.

3 CHANNEL SOUND TO LIGHT KIT

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

MULTI-CHANNEL or ROBOT CONTROLLER
This is two kits. The 8 channel transmitter kit and the 8 channel receiver kit. Each kit comes with diagrams and notes, but no circuit boards, the component layout being left to you. The data shows how to drive, reverse and steer two or more motors. With spare channels to perform other functions. Price **£9.50 for both kits.**

'BIG EAR'
As in December Hobby Electronics. Designed originally for listening to wildlife this could also be used to listen through walls or from long distances. Complete kit including the case at £9.50.

TANGENTIAL BLOW HEATER

2.5 Kw quiet, efficient instant heating from 230/240 volt mains. Kit consists of blower as illustrated, 2.5 Kw element, control switch and data all for **£4.95**. post £1.50

CAR STARTER AND CHARGER KIT
In an emergency you can start car off mains or bring your battery up to full charge in a couple of hours. The kit comprises 250 watt mains transformer, 40 amp bridge rectifier, start/charge switch and full instructions. You can assemble this in the evening, box it up or leave it on the shelf in the garage, whichever suits you best. **Price £12.50 + £3.00 post.**

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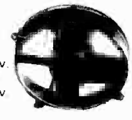

Mains operated – ex-computer

5" Woods extractor **£5.75**, Post £1.25.
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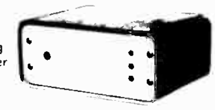
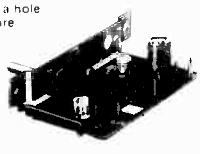
4" x 4" Muffin 115v. **£4.50. Post 75p.**
4" x 4" Muffin 230v **£5.75. Post 75p.**

PROJECT CASE



All metal construction. Tubular body, Size approx 7 x 3 x 5" long with removable ends, blue hammer paint finish. £1.75 each + 60p for postage.

MINI MONO AMP
on p.c.b., size 4" x 2" approx. Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amplifier. Brand new, perfect condition, offered at the very low price of **£1.15 each, or 10 for £10.00.**



COMPUTER PRINTER, ONLY £4.95 YOUR LAST CHANCE
Japanese made Epson 310 – has a self starting brushless drive motor. Complete with electronics – uses plain paper. Brand new with data. ONLY £4.95 plus £1.25 Post.

8 POWERFUL BATTERY MOTORS
(all different)

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

12v MOTOR BY SMITHS

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

Ditto, but double ended **£4.25.**

Ditto, but permanent magnet, **£3.75.**

EXTRA POWERFUL 12v MOTOR
Made to work battery lawnmower, this probably develops up to ¼ h.p., so it could be used to power a go-kart or to drive a compressor, etc. etc. **£6.90 + £1.50 post.**
(This is easily reversible with our reversing switch - **Price £1.15**).

GO KART MOTOR
24 Volt operated easily vary speed and reverse – terrific power. Price £9.50 + £1.50 post.

WW – 073 FOR FURTHER DETAILS

A COMPETITION OPEN TO ALL WIRELESS WORLD READERS WITH £8000 IN CASH PRIZES

Design an Electronic Device to help the Disabled

Could you design a piece of equipment to help a disabled person? If so, you would — in addition to undertaking this worthy task — be eligible to win a substantial cash prize.

Our competition is open to individuals or groups resident in the UK. You register your entry using the form below, sending it to the Editor to arrive at his office not later than June 30th 1983. The designs themselves must be submitted to his office by 1st October 1983.

Entries, which will be judged by a group of eminent engineers and doctors, must consist of the following:- a statement of the design objectives; an overall description of the device; detailed circuit descriptions and diagrams; a model of the device or a model of a unique aspect of the design sufficient to demonstrate its feasibility.

The finalists will be invited to London to talk over their entries with the judges and be awarded their prizes. The prizes are:

1st prize £2,500
2nd prize £1,500

and the 4 runners up will be awarded prizes each of £1,000

To make sure you have the maximum time to undertake your design, return your entry form now!

"DESIGN AN ELECTRONIC DEVICE TO HELP THE DISABLED"
LIST OF RULES

1. The competition is open to U.K. residents only.
2. Entrants can be individuals or groups.
3. All participants must register their interest in entering the competition on the form provided which must be returned to the Wireless World Editorial Department by the 30th June 1983.
4. All entrants agree to give Wireless World first serial publication rights to an article describing the entry.
5. All entrants indemnify Wireless World from any liability in respect of injury to people or damage to property arising from the use of the design.
6. All submitted designs must be the original work of the entrant or entrants and must not infringe the rights of third parties in anyway.
7. All submissions should consist of:
   a) **A statement of design objectives**
   b) **An overall description of the device**
   c) **Detailed circuit descriptions and diagrams**
   d) **A model of the device or the unique aspect of the design sufficient to demonstrate its feasibility.**
8. The design will be judged on:
   a) **Originality and benefit to the handicapped**
   b) **Potential for production**
   c) **Elegance of engineering design**
   d) **Electronics content**
   e) **Design reliability**
   f) **Simplicity of operation**
   g) **Freedom from excessive maintenance**
   h) **Safety.**
9. Software only solutions are not accepted.
10. The judges' decision is final.
11. All designs must be submitted to the Wireless World Editor by the 1st October 1983.
12. Shortlisted entrants must be prepared to travel to a venue in London sometime during November and December 1983 to demonstrate their design. All costs will be paid by the journal.
13. Employees of Business Press International are not allowed to enter this competition.

wireless world

COMPETITION ENTRY FORM

"Design an electronic device to help the disabled"

Name of competitor ____________________

Address ____________________

____

Telephone (home) ____________________

(business) ____________________

I intend to enter the competition and to abide by the rules as laid down in the May 1983 issue of Wireless World.

I understand that, in order to qualify, my entry must be in the hands of the judges by 1st October, 1983

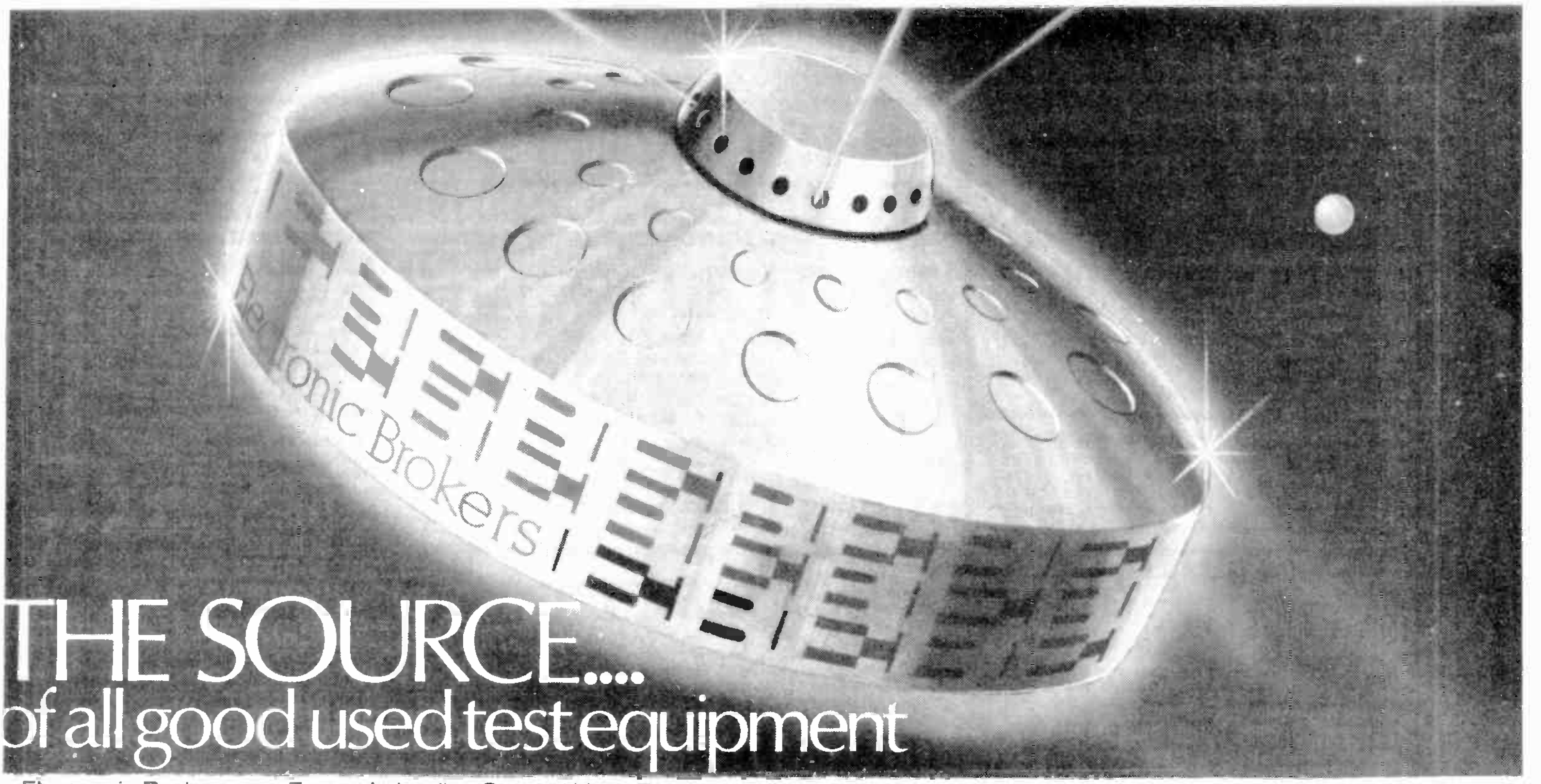
Signature ____________________

Date ____________________

Please send this form, as soon as possible, to:

The Editor, WIRELESS WORLD
Room L302, Quadrant House, The Quadrant
Sutton, Surrey SM2 5AS.

Receipt of the form will be acknowledged.



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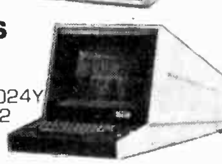

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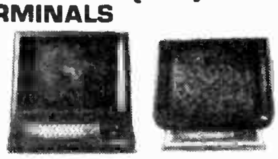

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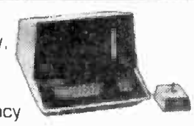

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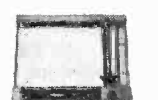

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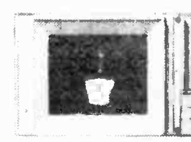

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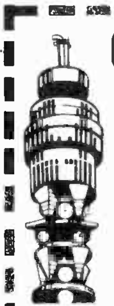

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Applications including a full curriculum vitae and the names of two referees should be sent to Dr J. F. Alder, Department of Instrumentation and Analytical Science, UMIST, PO Box 88, Manchester M60 1QD. Please quote reference IAS/S3/AU.

(2122)

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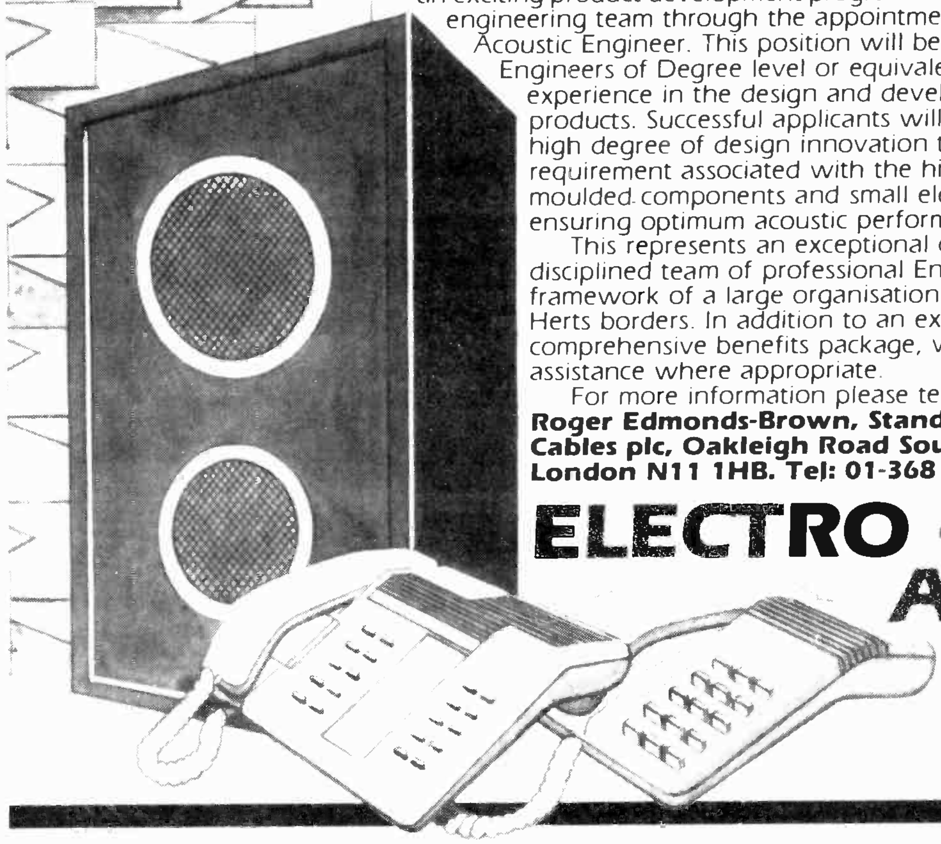

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The work will involve assisting in the detailed planning of administrative telecommunication systems; liaison with other Departmental groups; British Telecom, the Emergency Services and equipment suppliers, drafting of technical specifications, the preparation of detailed information for feasibility studies; arranging field trials and practical tests of new equipment; and technical administrative work concerned with radio frequency allocation, radio clearance and transmitter licensing.

Candidates must have either TEC or SCOTEC Higher Certificate in Electronics, Telecommunications or similar discipline or City and Guilds Full Technological Certificate (Technicians Certificates Parts I, II and III) in Telecommunications or Higher National Certificate in Electrical/Electronic Engineering *or* Council of Engineering Institution's requirement for registration as a Technician Engineer CEI (TEng CEI) *or* an equivalent or higher acceptable qualification.

In addition all candidates must have an aggregate of at least 10 years' recognised training and experience which may include up to three years' full-time study and should include at least four years' experience in communications engineering in one or both of the following fields: (a) Telephony and line communications including voice, data, teleprinter and facsimile systems, large and small PABX equipments and British Telecoms full range of facilities; (b) Radio communications including VHF and UHF radio schemes, radio links, radio paging systems, and mobile radio control systems.

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Scottish Office.

(2124)

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(2114)

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Sortex (2115)

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(2025)

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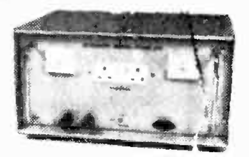

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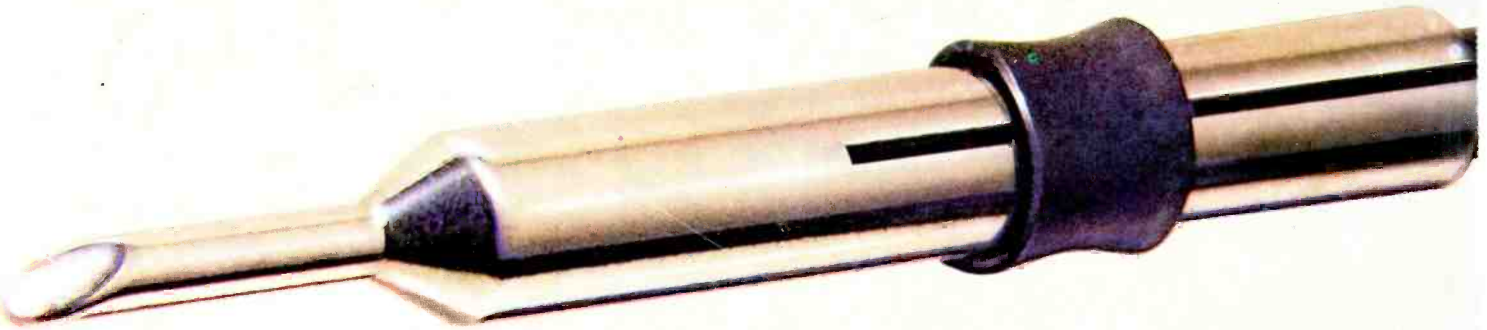

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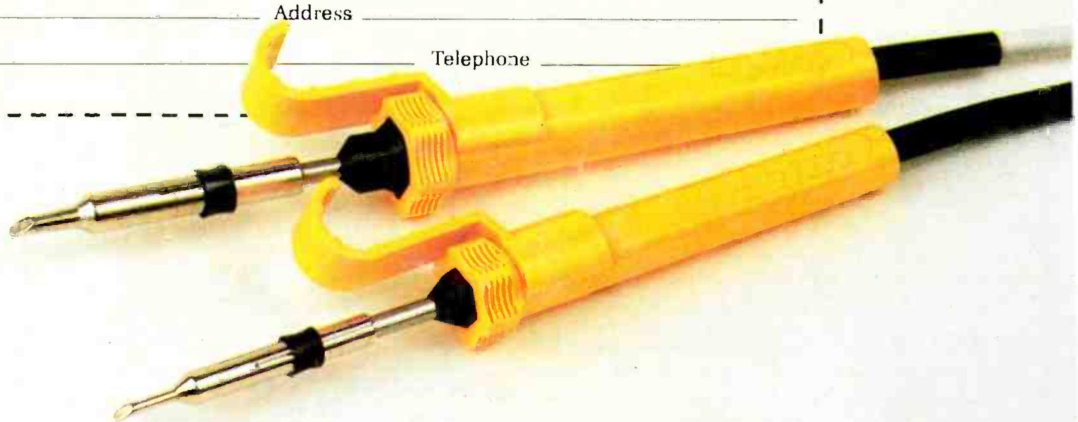
Name ________________ Address ________________

________________ Telephone ________________



WW–002 FOR FURTHER DETAILS