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Front cover caption shows a Leica camera incorporating Ferranti u.l.a. (see page 52) on a background formed by tracks on an integrated circuit. Photograph by Paul Brierley.

IN OUR NEXT ISSUE

Can we distinguish 'amplifier sound'? **This article first discusses the subjective aspects of listening tests then describes objective laboratory experiments to verify listeners' reports.**

Microprocessor interfacing. **First of a series on methods for connecting microprocessors/microcomputers to other equipment. Part one on a "universal" interface for 6502-based microcomputers.**

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SEPTEMBER 1981 Vol 87 No 1548

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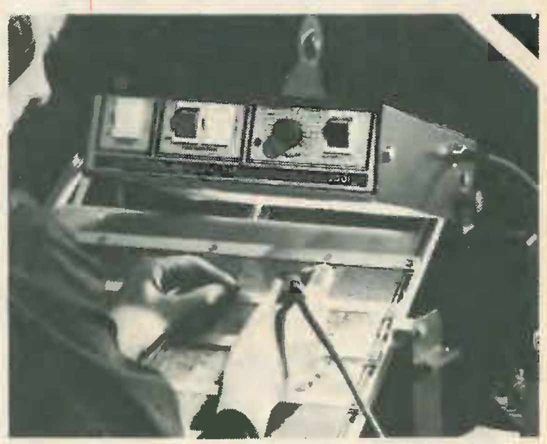

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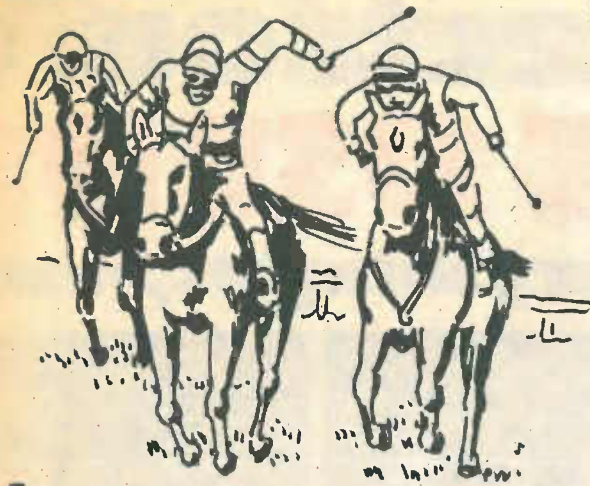

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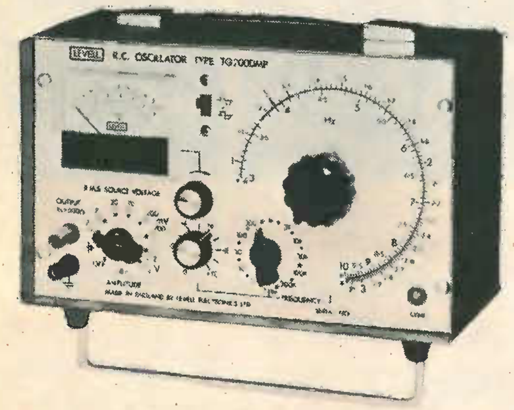
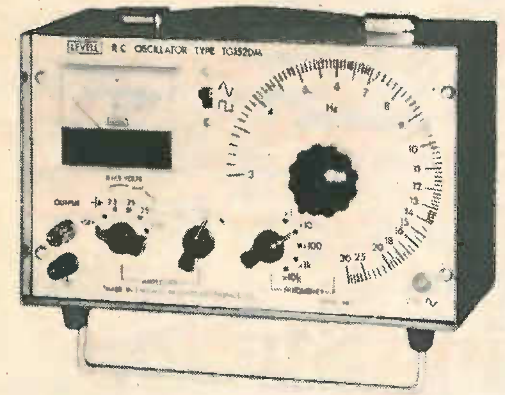


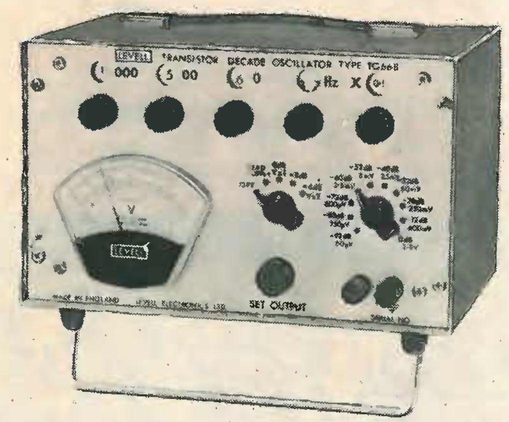
FREQUENCY	1Hz to 1MHz in 12 ranges. 0 to 1% fine control on TG200DMP
ACCURACY	±1.5% ±0.01Hz up to 100kHz. ±2% up to 1MHz.
SINE OUTPUT	7V r.m.s. down to <200μV with Rs = 600Ω.
DISTORTION	<0.05% from 50Hz to 15kHz, <0.1% from 10Hz to 50kHz, <0.2% from 5Hz to 150kHz, <1% at 1Hz and 1MHz.
SQUARE OUTPUT	TG200D, DM & DMP only, 7V peak down to <200μV. Rise time <150nS.
SYNC OUTPUT	<1V r.m.s. sine in phase with output
SYNC INPUT	±1% freq. lock range per volt r.m.s.
METER SCALES	TG200M, DM & DMP only. 0/2V 0/7V & −14/+6dBm.
SIZE & WEIGHT	260 × 130 × 180mm. 4.3kg with batteries.

TG200	TG200D	TG200M	TG200DM	TG200DMP
£99	£108	£125	£130	£135



FREQUENCY	3Hz to 300kHz in 5 decade ranges.
ACCURACY	±2% ±0.1Hz to 100kHz. Increasing to ±3% at 300kHz.
SINE OUTPUT	2.5V r.m.s. down to <200μV
DISTORTION	<0.2% from 50Hz to 50kHz. <1% from 10Hz to 200kHz.
SQUARE OUTPUT	2.5V peak down to <200μV.
SYNC. OUTPUT	2.5V r.m.s. sine.
METER SCALES	0/2.5V & −10/+10dB on TG152DM.
SIZE & WEIGHT	260 × 130 × 180mm. 3.4kg with batteries.

TG152D Without meter **£80** | **TG152DM** With meter **£99**



FREQUENCY	0.2Hz to 1.22MHz on four decade controls.
ACCURACY	±0.02Hz below 6Hz. ±0.3% from 6Hz to 100kHz. ±1% from 100kHz to 300kHz. ±3% above, 300kHz.
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METER SCALES	2 Expanded voltage and −2/+4dBm
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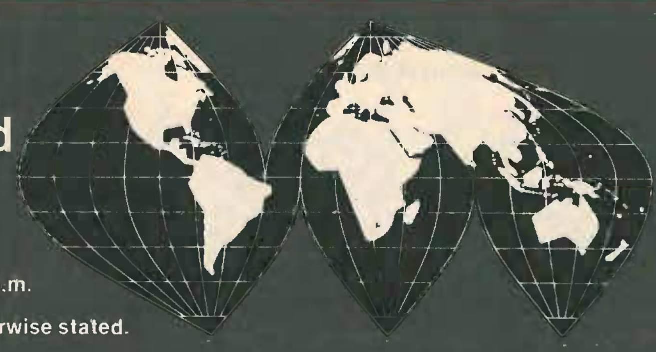

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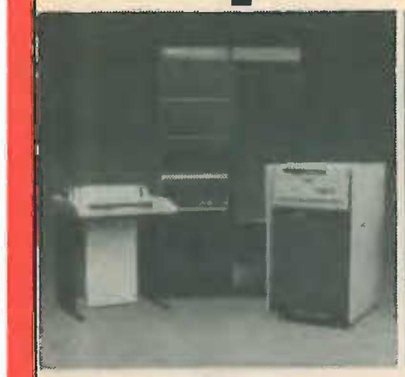

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PDP11 SYSTEMS

PDP11/34A 128KB MOS, KY11-LB Programmers Panel, DL11W Interface, 2 x RL01 Disk Drives and Controller, 6ft. Cabinet, VT100 Console . **£11,500.00**

PDP11/34A 128 KB MOS, KY11-LB Programmers Panel, DL11-W Interface, RK05J and RK05F Disk Drives and Controller, 6ft. Cabinet, DECwriter IV Console **£9,950.00**

PDP11/34A 256KB MOS, KY11-LB Programmers Panel, DL11W Interface, 2 x RL02 Disk Drives and Controller, 6ft. Cabinet, VT100 Console **£19,750.00**

PDP11/34A 128KB MOS, KY11-LB Programmers Panel, DL11W Interface, 2 x RK07 Disk Drives and Controller, 6ft. Cabinet, VT100 Console . . **£12,750.00**

PDP11/60 System with 2 RK07 Disk Drives and Controller, choice of Console . . . . **P.O.A.**

PDP11 C.P.U.s

DEC.

PDP11/03-SD Processor in 3½" chassis complete with 16KW MOS memory and EIS option.
BRAND NEW — ONLY **£1,495.00**

PDP11/04 Processor in 10½" chassis complete with 16KW MOS memory and DL11W Interface.
BRAND NEW (can be enhanced to 28KW) **£3,950.00**

PDP11/34A Processor, 5¼in. Chassis, 128Kb MOS, KY11-LB Programmers Panel, DL11W Interface **£4,950.00**

PDP11/34A Processor, 10½in. chassis 128KB MOS, KY11-LB Programmers Panel, DL11W Interface **£6,250.00**

PDP11 MEMORY

DEC.

KK11A 11/34A Cache Memory option	£2,000.00
MF11L 8KW core memory c/w 9-slot system unit	£975.00
MK11CB 512Kb 11/70 expansion MOS memory including frame	£14,500.00
MM11L 8KW core memory	£795.00
MM11LP 8KW parity core memory	£750.00
MM11DP 16KW core (ex DEC-maintained 11/34 systems). BARGAIN OFFER — ONLY	£395.00
MM11UP 16KW Parity core memory complete with 9-slot system unit	£1,500.00
MM11UP 16KW parity core memory (pre-requisite MF11UP)	£1250.00
MS11JP 16KW MOS memory	£395.00
MS11-LB 128KB MOS	£1,995.00
MS11-LD 256KB MOS	£3,500.00
MSV11C 16KW MOS memory (LSI 11)	£495.00
MJ11-BE 64KW 11/70 memory	£4,500.00
MK11-BE 64KW MOS memory for 11/70	£3,950.00
MS11-MB 256KB ECC MOS memory for 11/44 (NEW)	£3,942.00

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DEC.

RK05J add-on disk drive 2½ meg. Exchangeable cartridge type. From.	£1,500.00
RK06-ED Add-on 14 Meg disk drive	£2,750.00
RK611-ED Unibus Controller + 1 RK06 drive	£4,500.00
RK07-ED Add-on 28 Meg disk drive	£4,750.00
RK711-ED Unibus Controller + 1 RK07 disk drive	£6,500.00
RL01-AK Add-on 5 Meg disk drive	£1,975.00
RL02-AK Add-on 10 Meg Disk Drive	£2,500.00
RM03-Add-on 67 Meg disk drive	£7,500.00
RP04-AB Add-on 88 Meg Disk Drive	£4,950.00
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Controllers usually available for above drives.

MAGNETIC TAPE

DEC.
Available from time to time — TU10, TU45, TE16 TS03 etc.

PDP11 OPTIONS

DEC.

AA11D VT01 Controller with 4-slot System Unit	£125.00
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M792 ROM Diode Matrix	£195.00
M9301-YB Bootstrap	£325.00

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DEC.
H720 Power supply for BA11 Expander Box, BRAND NEW SURPLUS. **£175.00**

PDP8A C.P.U.

DEC.
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PDP8A MEMORY

DEC.

MM8AA 8KW Core	£750.00
MM8AB 16KW Core	£995.00

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DEC.

DP8EB Communications Adaptor	£395.00
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Heavy Duty Matrix printer with 64 ASCII upper case character set. 165 cps operation. 132 print positions with adjustable tractor feed. Parallel input. ONLY. **£495.00**

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Daisy-Wheel KSR (keyboard-send-receive) model with standard RS232 interface 45 cps print speed, 110/150/300 baud, switch-selectable parity, top-of-form selector, Graphics capability under software control . **£1,275.00**

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BRAND NEW — LOW COST MATRIX PRINTER IDEAL FOR MICROPROCESSOR USERS SUCH AS HOBBYISTS & EDUCATIONALISTS OR ANY LOW-BUDGET APPLICATION

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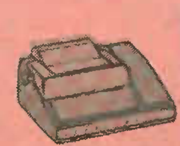
Reconditioned ASR33 Teletype Terminals with paper tape punch and reader, even parity keyboard and RS232 interface.
SPECIAL OFFER — SEVEN DAY WARRANTY —CASH AND CARRY ONLY **£295.00**



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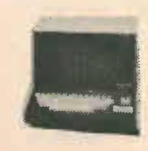
Hazeltine.



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H2000 Superb spec. including full XY cursor addressing and edit facility, 27 x 74 display; upper case ASCII, RS232 interface, switch-selectable baud rates **£299.00**

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Modular One. Now with upper/lower case, XY cursor addressing, 24 x 80 line display, dual intensity detachable keyboard, choice of 8 transmission rates up to 9600 baud. . . **£399.00**

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4010-1 Graphics Terminal with high-resolution graphics mode, standard alphanumeric mode, printer port, integral stand **£1,750.00**
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Electronic Brokers
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Dual Trace. DC to 20MHz. 8 x 10cm display. Risetime 17.5nS. Sensitivity 5mV/cm-20V/cm. Timebase 0.5µs-0.2s. X5 magnifier. X-Y operation. Auto or variable trigger. Channel 1, Channel 2. line and external. Coupling AC. or TV low pass filter. Weighs only 6Kg. Size (m.m.) H. 145, W. 285, D. 380.
Unbeatable value at £220.00

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HM 412-5 OSCILLOSCOPE

Dual Trace. DC to 20MHz. 8 x 10cm rectangular display with internal graticule. Risetime 17.5nS. Sensitivity 5mV/cm-20V/cm. Timebase 0.5µS-0.2S. X5 magnifier. X-Y operation. Z modulation. Auto (peak value) or variable trigger. Channel 1 or 2, altern. Ch. I/II. line ext. Sweep delay. Variable hold-off time. Weight 7.5Kg.
Still at only £350.00

HM 512-8 OSCILLOSCOPE

Dual trace. DC - 50MHz. Risetime 7nS. 5mV/cm-20V/cm. Timebase 100nS/cm-2S/cm. X5 magnifier. X-Y operation. Z modulation. Sweep delay and delay line permits viewing of leading edge.
THE BEST PRICED 50MHz SCOPE ON THE MARKET AT **£580.00**

All the above scopes are available with P7 long persistence C R.T's (except HM 307) prices on application

The above prices do not include carriage or VAT (15%). Please send for Technical Literature.

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Fluke

FLUKE 8050A (ILLUSTRATED)

4½ Digit LCD DMM with true RMS on AC volts and current DC volts 200mV-1KV, 10µV resolution AC volts. 200mV-750V, 10µV resolution. DC/AC current 200µA-2A, 0.01µA resolution. Resistance 200Ω-20MΩ. 0.01Ω resolution. Also reads dB direct referenced to 16 stored impedances. Conductance ranges 2mS and 200nS. **£245** mains model **£285** mains battery.

FLUKE 8012A

3½ Digit LCD DMM with true RMS on AC volts and current. DC volts 200mV-1KV, 100µV resolution. AC volts 200mV-750V. 100µV resolution. DC/AC current 200µA-2A, 0.1µA resolution. Resistance 200Ω-20MΩ, 0.1Ω resolution Low resistance 2Ω and 20Ω, 1mΩ resolution Conductance ranges 2mS-20µS-200nS **£218.00** mains model **£244.00** mains battery.

FLUKE 8010A

3½ Digit LCD DMM Same spec as 8012A plus a 10Amp AC/DC current range, but not low resistance range. **£167.00** mains model **£193.00** mains battery.

FLUKE 8024A

3½ Digit hand held LCD DMM with peak hold level Detector and continuity tester. DC volts 200mV-1KV, 100µV resolution. AC volts 200mV-750V, 100µV resolution. DC/AC current 2mA-2A, 1µA resolution. Resistance 200Ω-20MΩ, 0.1Ω resolution. Conductance 200nS. Peakhold of AC or DC volts and current. Level detector operates around +0.8V reference. Audio tone on level and continuity, **£155.00,** carrying case **£8.00** extra.

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Also available a range of accessories including current shunts, EHT probe, rf probe, Temperature probe and touch and hold probe. Full details on request.

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£24.50

680R HIGH ACCURACY MULTIMETER 80 RANGES

DC volts: 100mV-2-10-50-200-500-1000V AC volts: 2-10-50-250-1000-2500V DC current: 50-500µA-5-50-500mA-5A AC current: 250µA-2;5-25-250mA-2.5A X2 switch on all voltage and current ranges except 2500V AC setting. Resistance: Ω x 1-Ω x 10-Ω x 100-Ω x 1000 and LowΩ, full range 1Ω-10MΩ, up to 100MΩ can be measured using ext. AC supply. dB scale —10 to +22dB. 0dB = 1mW into 600Ω Sensitivity DC 20KΩ/V, AC 4KΩ/V. Accuracy DC 1%, AC 2%. Battery Eveready No. 3. Overload capability 1000:1 on resistance ranges. Protected by internal 3Ω fuse. Size with case 13.7 x 10.4 x 5.4cm. Meter size 12cm. Supplied with leads and carrying case.

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£16.60

Please add £1.50 carriage per meter plus 15% VAT on total meter and carriage price. Send for Literature.

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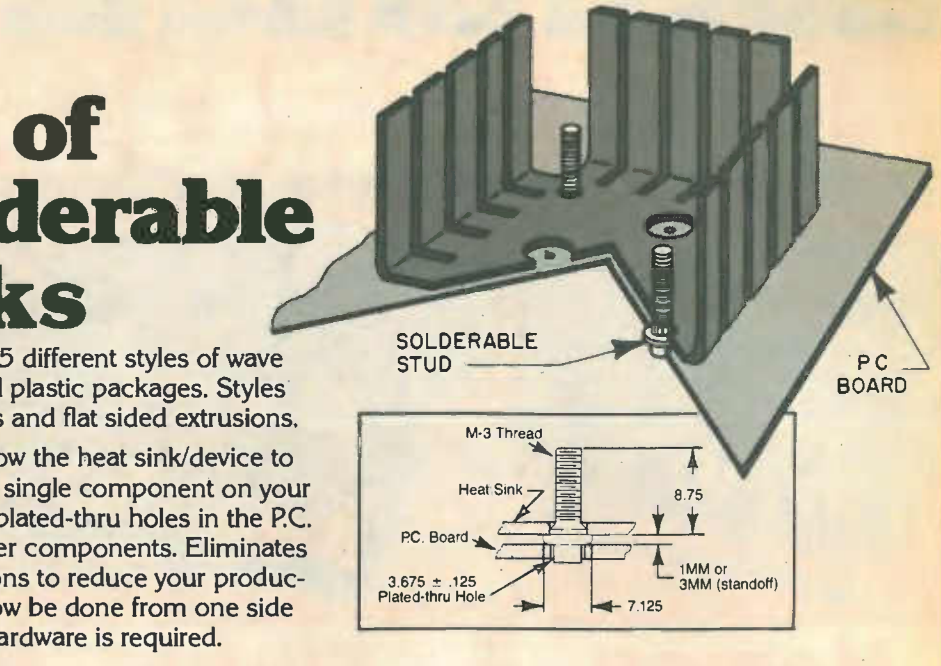
New Line of Wave Solderable Heat Sinks



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- ★ XY Facility: Matched XY inputs.
- ★ Trigger: Level control, ± Slope selection.
- ★ Auto, Normal, TV Triggering.
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- ★ Z-Modulation.
- ★ CAL output 1v 1kHz.
- ★ Graticule blue ruled 8x10 div. (4in. CRT).
- ★ Size: H215mm, W165mm, D280mm.
- ★ Weight: 4kg.

PROBE (~~XI-REF-X10~~) £10.50

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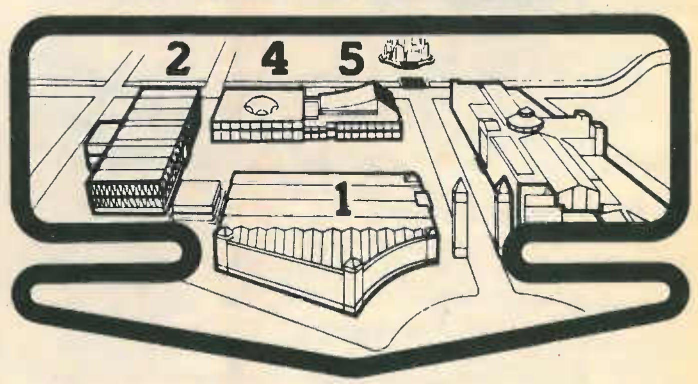

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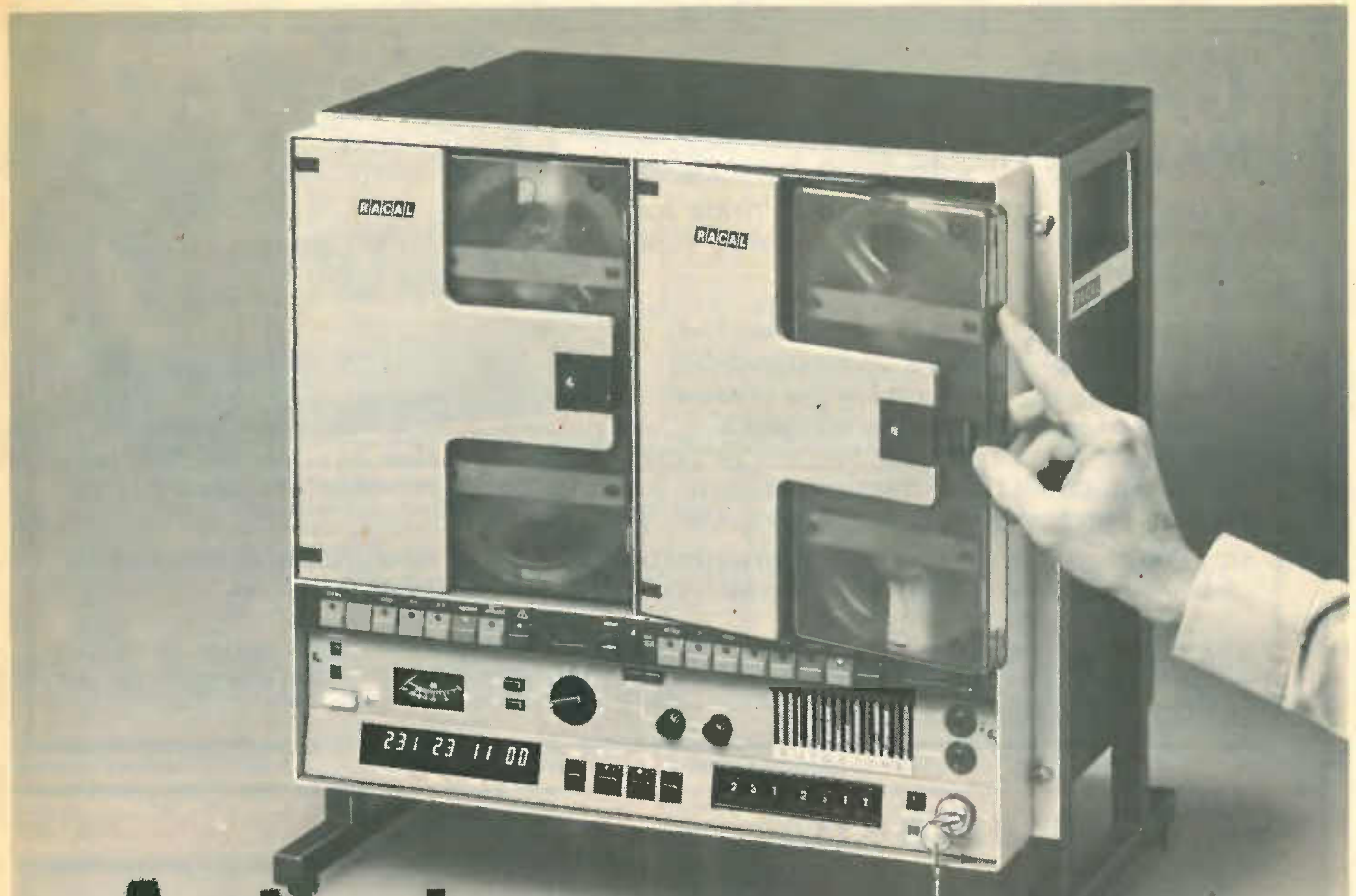

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Colour printout is quickly assimilated, makes graphics more understandable and is an ideal medium for the presentation of complex data or concepts.

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The CX80 is a product of our own design and development laboratories. It represents a British breakthrough in colour printer technology. Colour brochure on request. OEM pricing available.

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The **first ever** kit specially produced by Integrex for this British NRDC backed surround sound system which is the result of 7 years' research by the Ambisonic team. W.W. July, Aug., '77.
The unit is designed to decode not only UHJ but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC HJ. 10 input selections.
The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 or 2 input signals and 4 or 6 output signals are provided in this most versatile unit
Complete with mains power supply, wooden cabinet, panel, knobs, etc.

Complete kit, including licence fee **£57.70** + VAT or ready built and tested **£76.95** + VAT

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With Home Office Type approval

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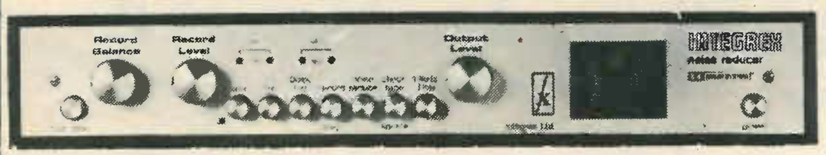
Wireless World Dolby noise reducer

Trademark of Dolby Laboratories Inc.



Typical performance
Noise reduction better than 9dB weighted.
Clipping level 16.5dB above Dolby level (measured at 1% third harmonic content)

Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%

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Dynamic range >90dB

30mV sensitivity

Complete Kit **PRICE: £49.95** + VAT (3 head model available)
Also available ready built and tested .... Price £67.50 + VAT
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- 4424 Noise Dosemeter — 375

CASTLE ASSOCIATES
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- 7D01F Logic Analyser 16ch 50 MHz P/in — 2650
- 832 Datacomm Test V24/RS232/I loop — 1150

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COLE
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BONTOON
- 71AR LC Bridge — 150

E.S.I.
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GENERAL RESISTANCE
- DAS56 DC V and I Calib 1μV-10V 30mA — 600

HEWLETT PACKARD
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- 4342 QLC Meter 22 KHz-70 MHz — 1100

MARCONI
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- TF1245 Q Meter 1 KHz-300 MHz — 350
- TF1313 Universal LCR Bridge — 350

WAYNE KERR
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STC
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TEKTRONIX
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- 1911 250 MHz 7 Digit Counter — 298
- 1912 520 MHz 7 Digit Counter — 375
- 1912A01 As 1912A but inc. re-charging batteries — 430
- 1920A 520 MHz 9 Digit Counter inc. Brst. mode — 575
- 1920A14 1250 MHz otherwise as 1920A — 750

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- 5305B 1300 MHz Counter for 5300 — 325
- 5308A 75 MHz Counter Timer for 5300B — 112
- 5345 500 MHz 11 digit Counter Timer — 1350
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RACAL
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- 9025 1 GHz 8 digit Counter — 450

SYSTRON DONNER
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- 8414A Polar Display for 8410 N.W.A. — 700

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- OS3300B 50 MHz 1mV 2 Trace 2T base — 675

HEWLETT PACKARD
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- 1825A Dual Timebase Plug-in — 500
- 1805A 100 MHz 5mV 2 Trace Plug-in — 625

PHILIPS
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- PM3212 25 MHz 2mV 2 Trace TV trig — 550
- PM3233 10 MHz 2mV 2 Beam Ch sig delay — 450
- PM3250 50 MHz 2mV 2 Trace 2T base — 400
- PM3260 120 MHz 5mV 2 Trace 2T base — 1450
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- 326 10 MHz 1mV 2 Trace weight 13lb c/w re-chg batts. For harsh environment — 540
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- 475 200 MHz 2mV 2 Trace 2T base — 1750
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- 661/4S3/5T1A 1 GHz Sampling scope — 775
- 7A19 500 MHz 10mV 1 Trace Plug-in — 950
- 7904 500 MHz CRT r/out 4 slot M/Frame — 3900
- P6013A X1000 12KV Probe — 95
- P6201 FET Probe DC-900 MHz — 300

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- D83/V4/S2A 50 MHz 1mV 2 Trace 2T Big CRT — 750
- D1015 15 MHz 5mV 2 Trace TV trig — 295
- D1016 15 MHz 1mV 2 Trace TV trig — 340

- 603 Bistable Storage Monitor XYZ amps — 750
- T912 10 MHz 2mV 2 Tr 1TB 250cm/ms — 650

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HEWLETT PACKARD
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- 478A Type N Coax sensor for 432A — 90

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- TF893A 10 Hz-20 KHz Powermeter — 135

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- L30B 0-30V variable 1A Metered — 65

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ITT
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MARCONI
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EH RESEARCH
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- TF2330 Wave Analyser 20 Hz-50 KHz — 425
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RADFORD
- DMS2 Distortion meter 20 Hz-20 KHz — 200
- *Note: see also "Spectrum Analysers"*

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GENERAL RADIO
- 1362 Generator 220-920 MHz — 375

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- 614 Generator 0.8-2.1 GHz — 825

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- TF2012 Generator 400-520 MHz FM — 550

PHILIPS
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- VS60 Sweeper 5-1000 MHz — 890
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- 3580A 5 Hz-50 KHz with digi store disp — 2450
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- 411A 0.5-500 MHz 10mV-10V DC O/P — 175
- 427A AC/DC/Ω AC-1 MHz — 195
- 3400A TRMS 10 Hz-10 MHz 1mV-300V DC O/P — 390
- 7562A DC-100 KHz Log V/meter — 250

MARCONI
- TF2603 50 KHz-1.5 GHz 300μV-3V — 300
- TF2604 20 Hz-1.5 GHz 300mV-300V — 425

PHILIPS
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RACAL
- 9301 RMS 10 KHz-1.5 GHz 100μV-300V — 550

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- 33B-2 1mV-1V Electrometer — 200

VOLT/MULTI-METER (DIGITAL)
ADVANCE
- DMM7A 1999FSD AC/DC/V/I/Ω — 100

BOONTON
- 92AD 1999FSD 10 KHz-1.2 GHz 10μV res — 525

FLUKE
- 8010A 2000 FSD TRMS AC/DC/VIΩ — 140
- 8010A01 As 8010A + re-charging batteries — 159
- 8020A 2000 FSD Handheld AC/DC/VIΩ + cond. — 99
- 8022A 2000 FSD Handheld AC/DC/VIΩ — 75
- 8030A-1 2000 FSD AC/DC/VIΩ Batt + AC — 165
- 8050A 20000 FSD AC/DC/VIΩ dB TRMS — 215

HEWLETT PACKARD
- 3490A 100000FSD AC/DC/V/Ω — 625

SOLARTRON
- A200 19999FSD DC only 1μV-1 KV — 85
- A203 19999FSD AC/DC/V/Ω — 175
- A205 19999FSD TRMS AC/DC/V/Ω — 195

Carston Electronics Ltd
01-267 5311
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Full details and specification of equipment listed, available. Because of long copy dates this list is not comprehensive – ring for inventory update or tell us your SPECIFIC NEEDS. Hours Monday to Friday 9.00 am-5.30 pm (4.30 pm Fridays). **Prices exclude delivery and VAT.** We take Access or Barclaycard.

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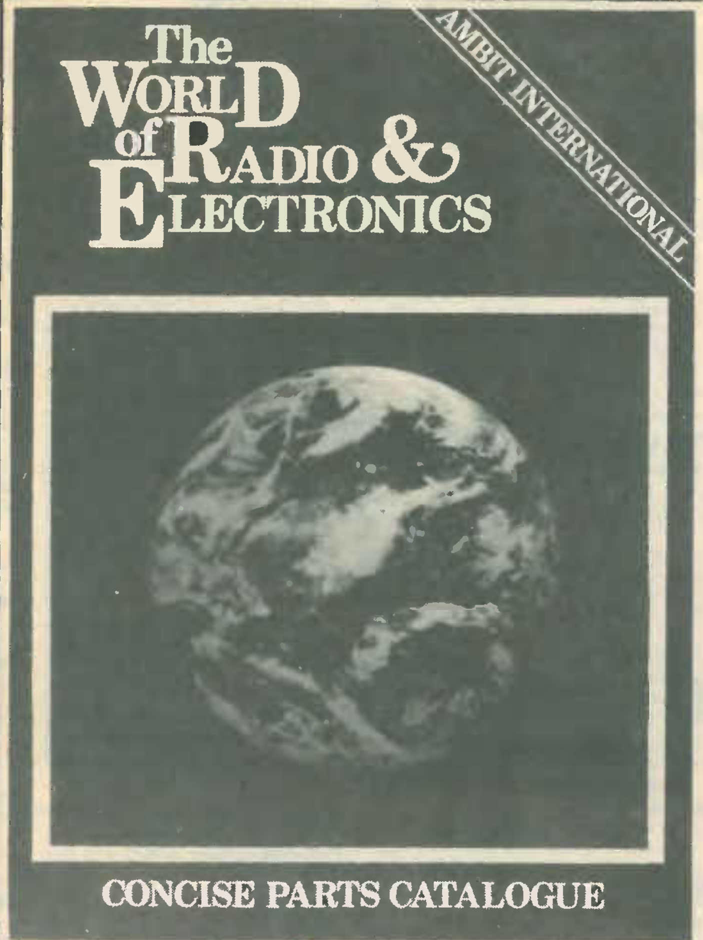

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In an attempt to collate and organize our burgeoning ranges of 'stock' components (now over 7000 line items), we have at last produced a 'concise' 80 page parts catalogue to supplement the popular 'Tecknowledgey' series of 'wordy' applications catalogues, which now lists a wide range of basic components - as well as our unique RF and Communications components. The *World of Radio and Electronics* contains everything the informed electronics user needs, at prices which we guarantee will match the lowest on the market for equivalent product.

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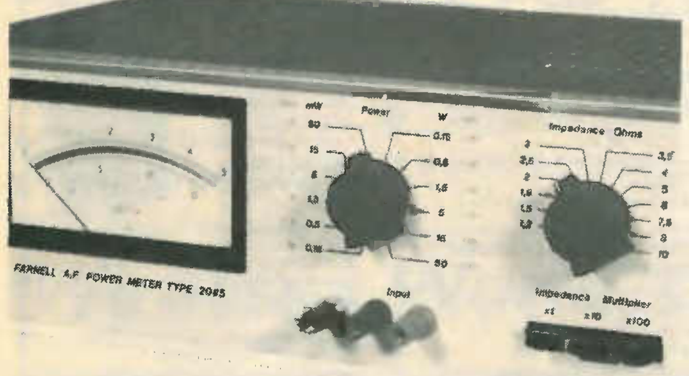

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Reader inquiry number 220

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PM 2517 digital multimeter
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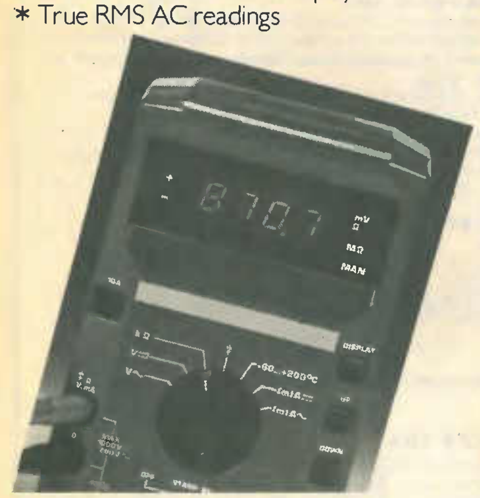

* Autoranging with manual override
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Reader inquiry number 222

PM 3207 dual trace oscilloscope
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* Triggering from either channel or external input
* Auto TV triggering
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Reader inquiry number 223

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Readers inquiry number 224

PHILIPS Test & Measuring Instruments

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Send for your free copy by circling **reader inquiry number 225.**

WHERE TO BUY YOUR PHILIPS AUDIO AND VIDEO SERVICE EQUIPMENT

The entire range is available from the Philips Electronic Instruments Department (see address below) or from Philips Service Centres ('phone 01-686 0505 for the address of your nearest branch). In addition, the PM 2517 and PM 3207 are available from Wessex Electronics Ltd, 114-116 North Street, Downend, Bristol BS16 5SE. Tel (0272) 571404.

INPUT
FROM PHILIPS TEST & MEASURING INSTRUMENTS

Use the inquiry service to obtain information about the products which interest you. Alternatively, 'phone Cambridge (0223) 358866 and speak to our Commercial Office on extension 145 or 148.

	Inquiry No
PM 5519 CTV pattern generator	**220**
PM 5326 RF signal generator	**221**
PM 2517 digital multimeter	**222**
PM 3207 15 MHz oscilloscope	**223**
PM 6667/6668 frequency counters	**224**
1981 Test & Measuring catalogue	**225**

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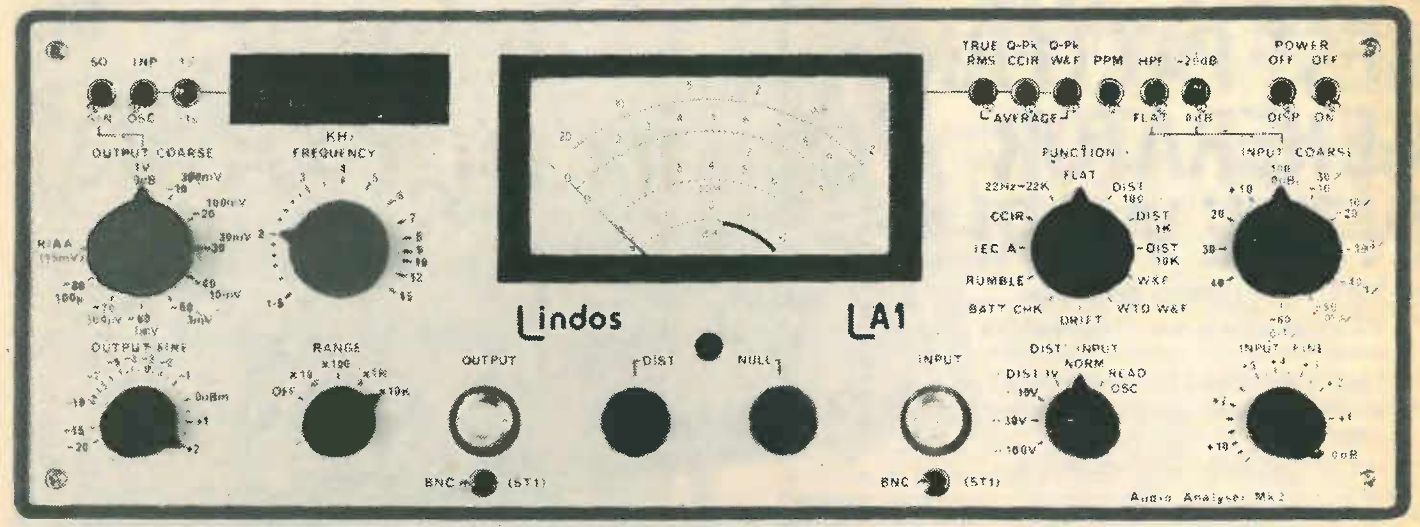

This is the LA1 analyser from LINDOS. Not much bigger than a transistor radio – it measures frequency, distortion, level, noise and wow and flutter. It is very accurate and easier to use than most 'complete test sets.' Options are available that transform it to meet almost any requirement.

THE BASIC LA1 ANALYSER COSTS £450 + V.A.T.

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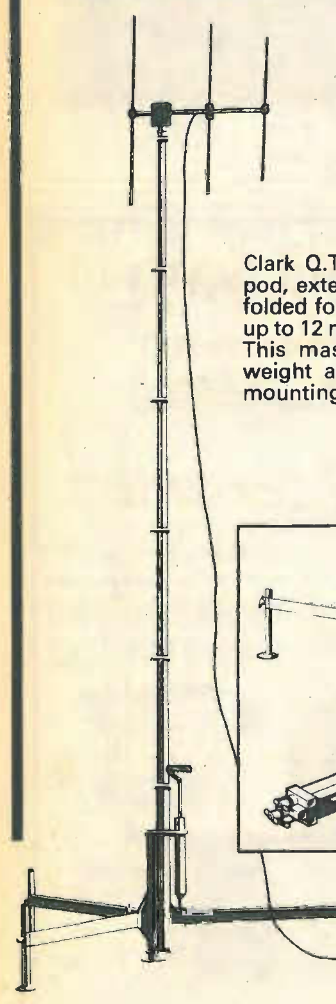
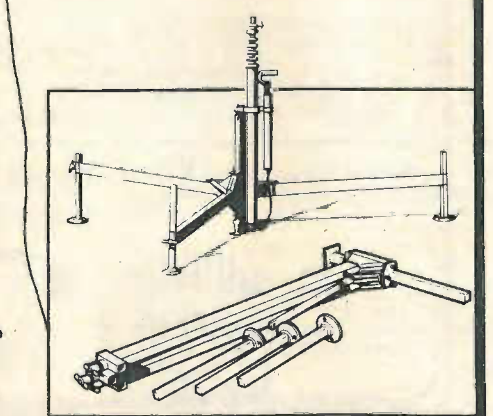


Clark Q.T.4M/HP mast shown on tripod, extended to 4 metres and tripod folded for transit. Available in heights up to 12 metres.
This mast is ideal for raising lightweight antennas for field or vehicle mounting.



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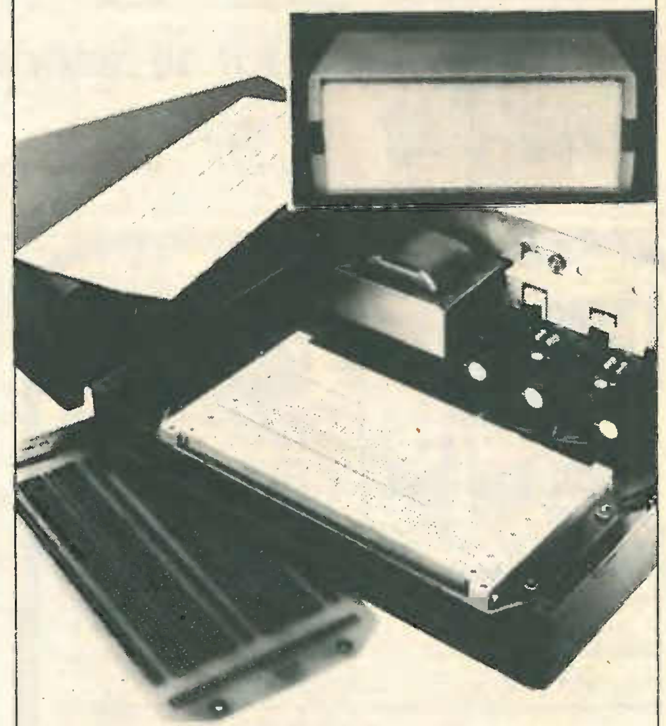

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A Siemens tester for all standards

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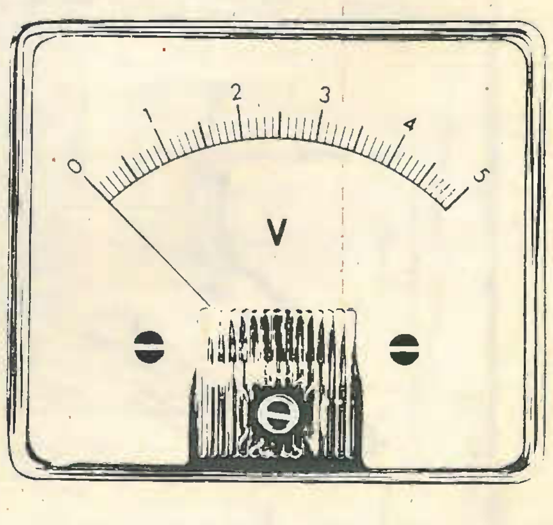
METER PROBLEMS?



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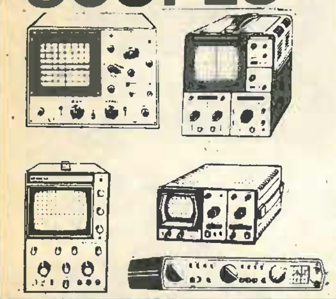

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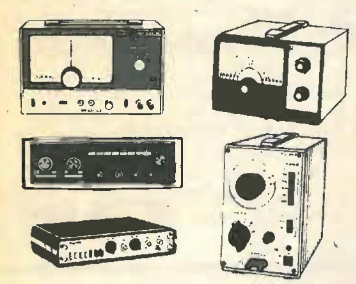

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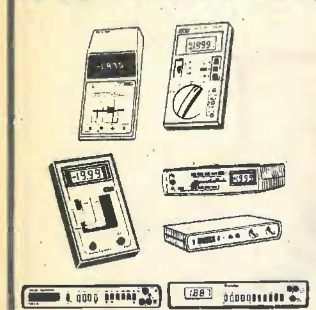

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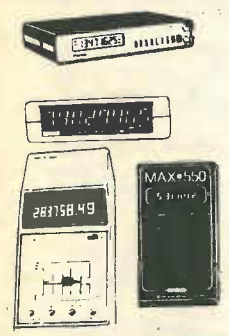

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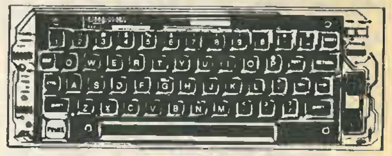

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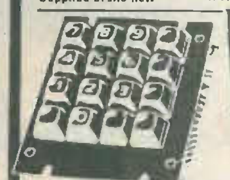

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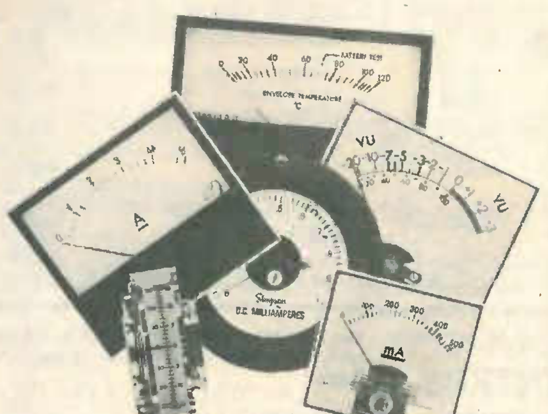

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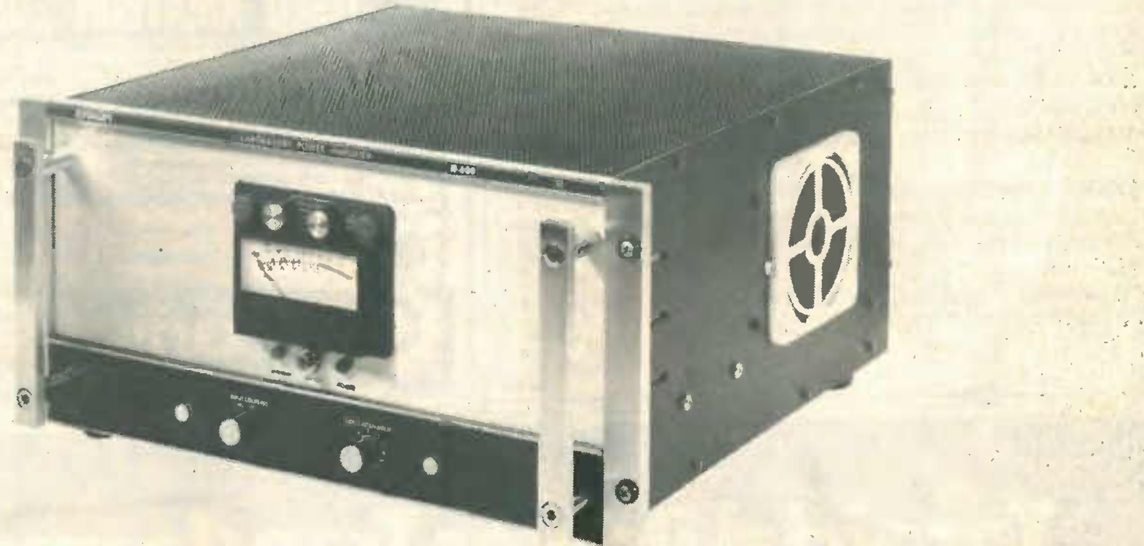

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C1003	30	15+15	1.00	70mm	30mm	0.45	
C1004	30	18+18	0.83	70mm	30mm	0.45	
C1005	30	22+22	0.68	70mm	30mm	0.45	
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C1016	60	30+30	1.00	87mm	33mm	0.75	
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C1033	160	30+30	2.67	108mm	42mm	1.5	
C1034	160	35+35	2.29	108mm	42mm	1.5	
C1035	160	110	1.46	108mm	42mm	1.5	
C1036	160	220	0.73	108mm	42mm	1.5	
C1037	160	240	0.67	108mm	42mm	1.5	
C1040	230	25+25	4.60	115mm	50mm	2.2	£10.20 (+ £1.73 p.p. + £1.79 VAT)
C1041	230	30+30	3.83	115mm	50mm	2.2	
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C1044	230	110	2.09	115mm	50mm	2.2	
C1045	230	220	1.05	115mm	50mm	2.2	
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C1065	530	110	4.82	145mm	60mm	3.8	
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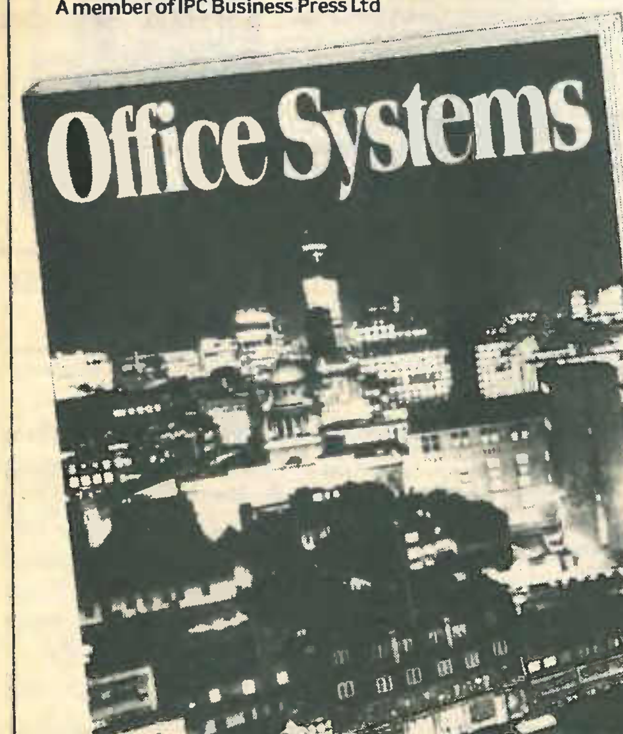

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74LS21	0.15
74LS22	0.15
74LS26	0.19
74LS27	0.15
74LS28	0.17
74LS30	0.14
74LS32	0.14
74LS33	0.17
74LS37	0.17
74LS38	0.17
74LS40	0.14
74LS42	0.40
74LS47	0.42
74LS48	0.70
74LS49	0.62
74LS51	0.14
74LS54	0.15
74LS55	0.15
74LS73	0.22
74LS74	0.18
74LS75	0.30
74LS76	0.22
74LS78	0.25
74LS83	0.54
74LS85	0.77
74LS86	0.18
74LS90	0.36
74LS91	0.81
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74LS113	0.26
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74LS379	0.56
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4009	0.31
4010	0.37
4011	0.13
4012	0.19
4013	0.34
4014	0.62
4015	0.64
4016	0.28
4017	0.54
4018	0.59
4019	0.36
4020	0.66
4021	0.70
4022	0.68
4023	0.19
4024	0.39
4025	0.15
4026	1.12
4027	0.36
4028	0.64
4031	1.55
4033	1.30
4034	1.60
4035	0.85
4036	2.25
4039	2.45
4040	0.67
4041	0.70
4042	0.56
4043	0.62
4044	0.62
4045	1.30
4046	0.75
4047	0.78
4048	0.44
4049	0.28
4050	0.27
4051	0.62
4052	0.62
4053	0.62
4054	1.02
4055	1.00
4060	0.88
4063	0.94
4066	0.38
4067	0.22
4068	0.21
4069	0.15
4070	0.23
4071	0.20
4072	0.20
4073	0.20
4075	0.20
4076	0.67
4077	0.23
4078	0.20
4081	0.20
4082	0.20
4085	0.45
4086	0.56
4093	0.43
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4511	0.51
4512	0.63
4514	1.53
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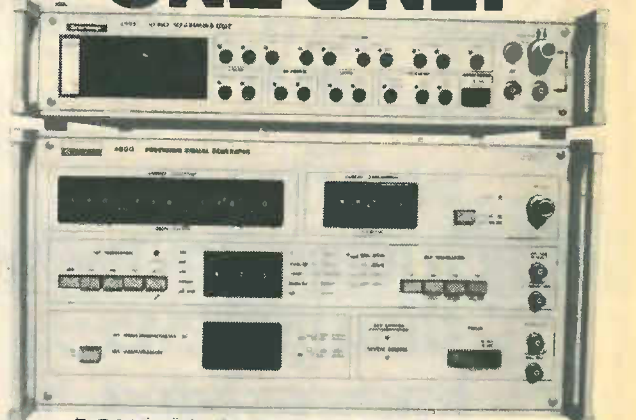

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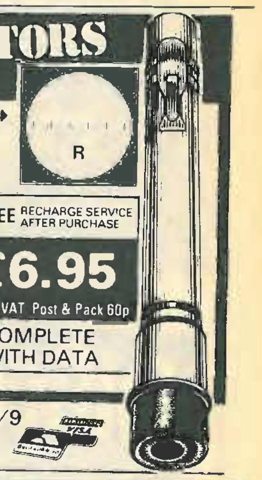

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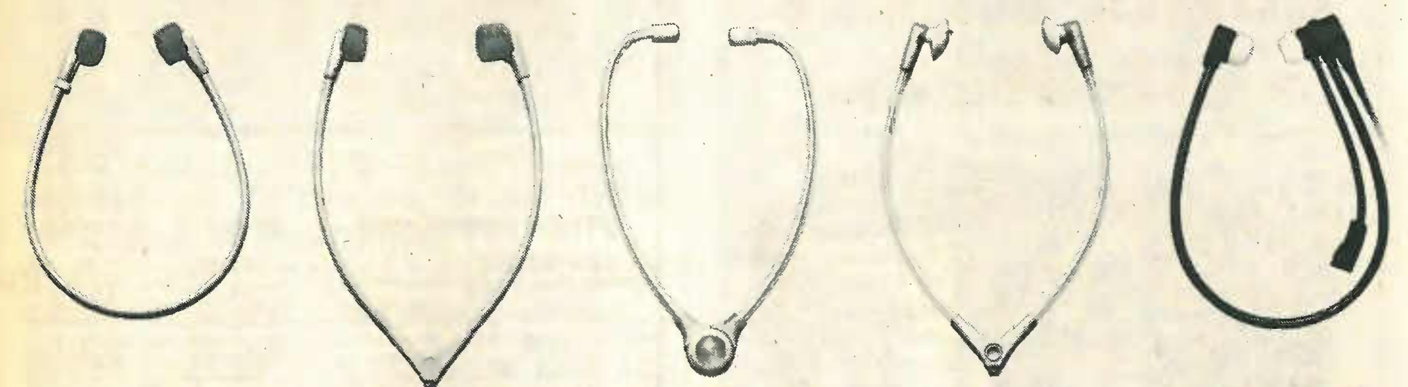

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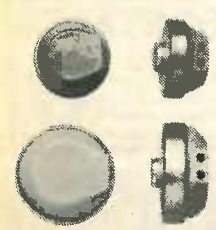

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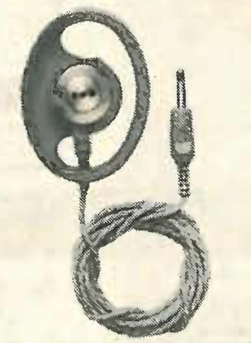

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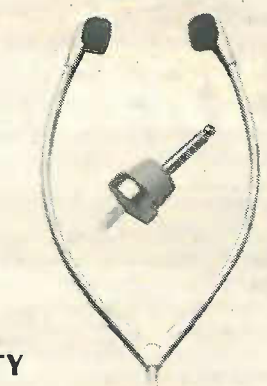

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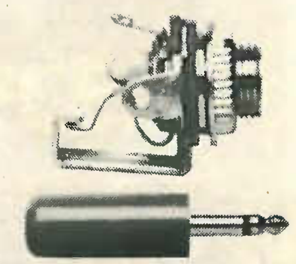

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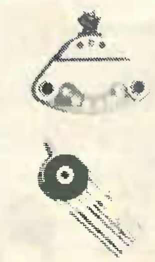

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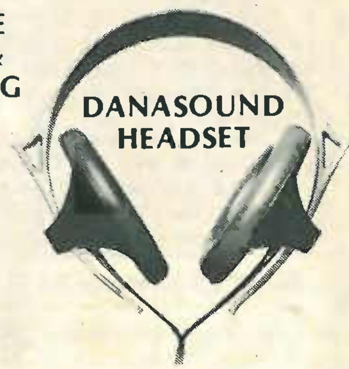

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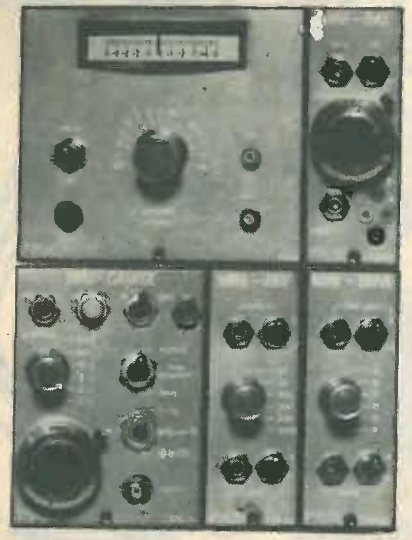

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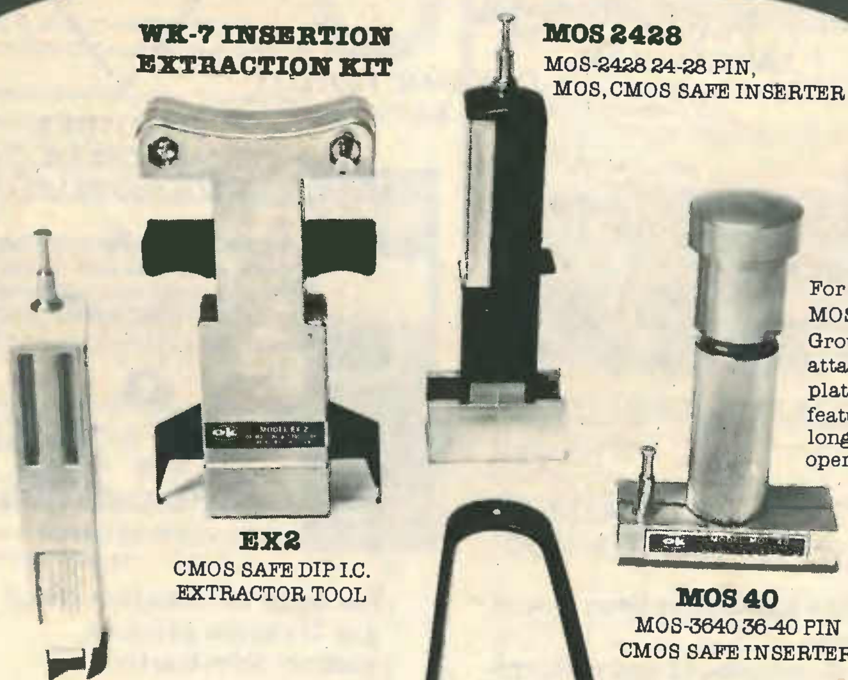

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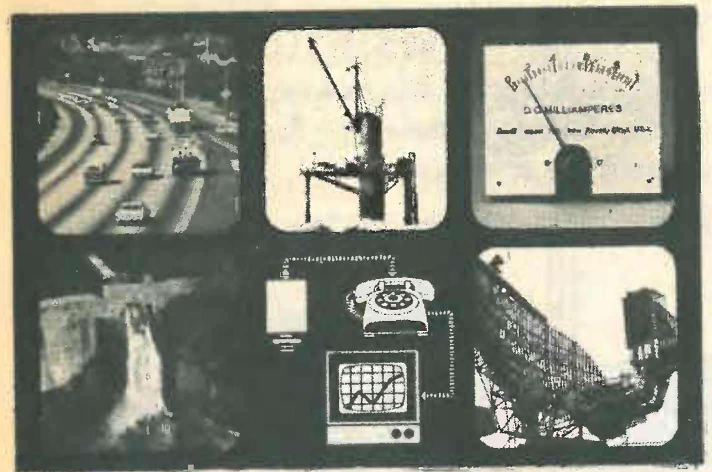

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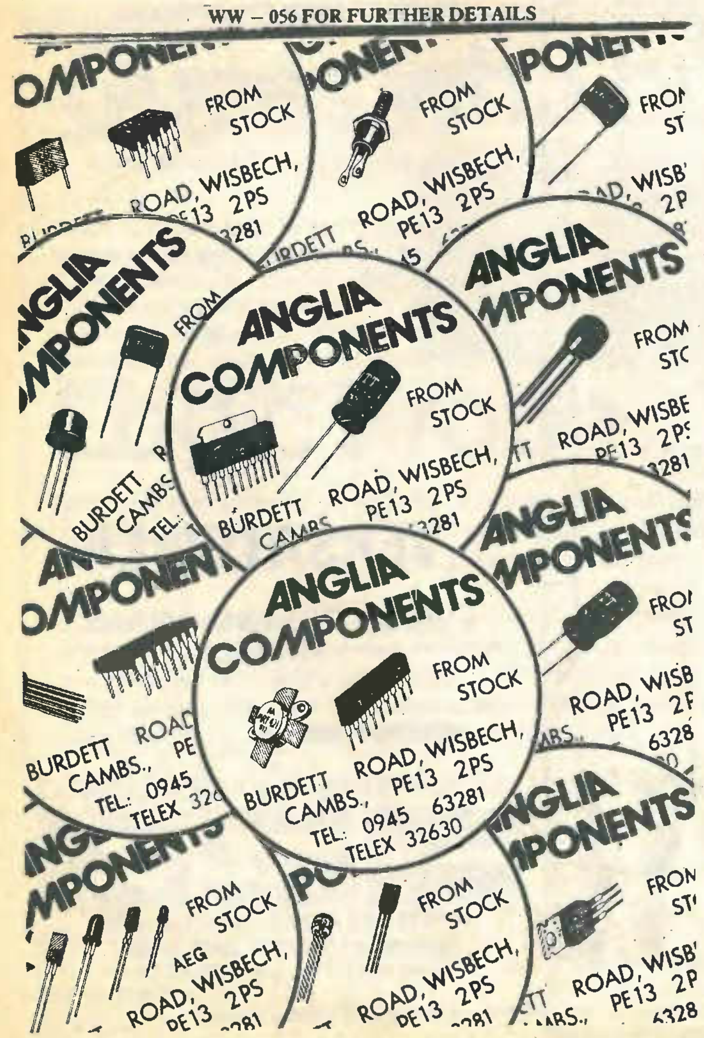

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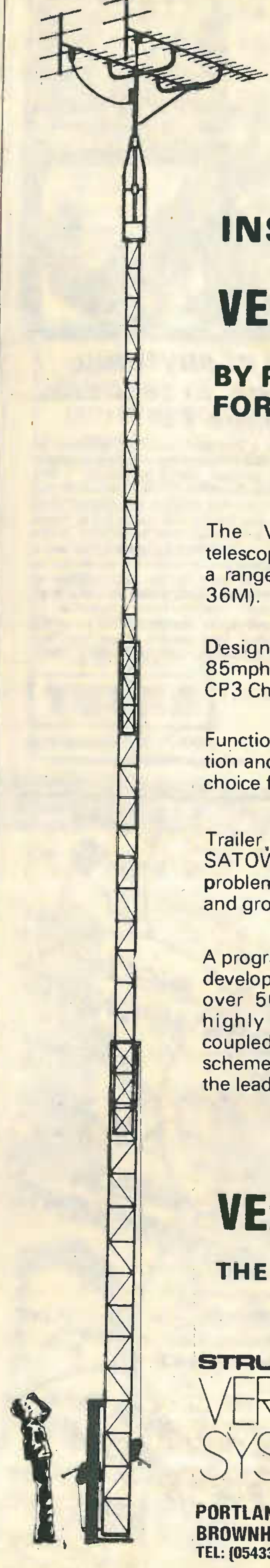

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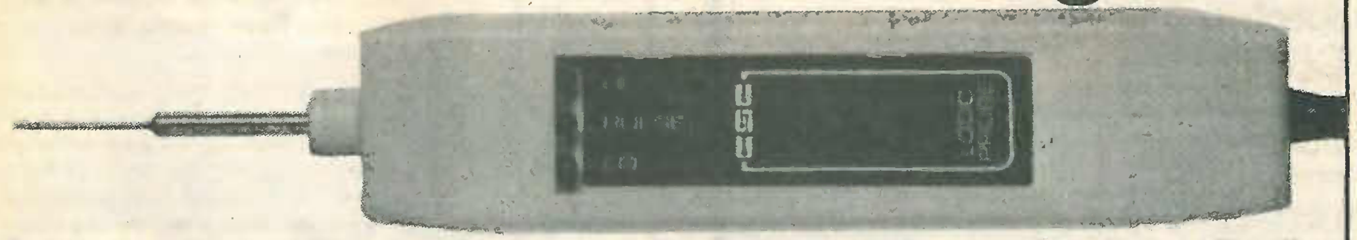

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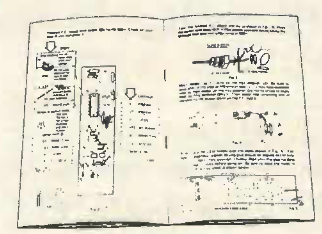

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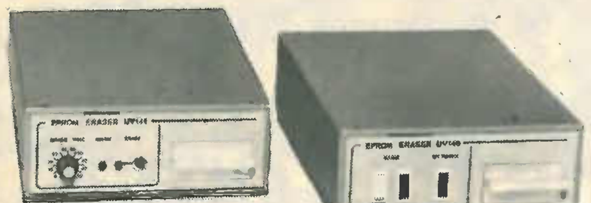

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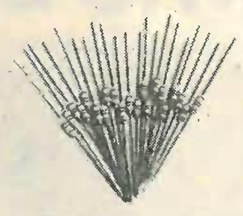

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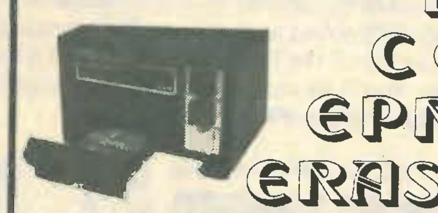

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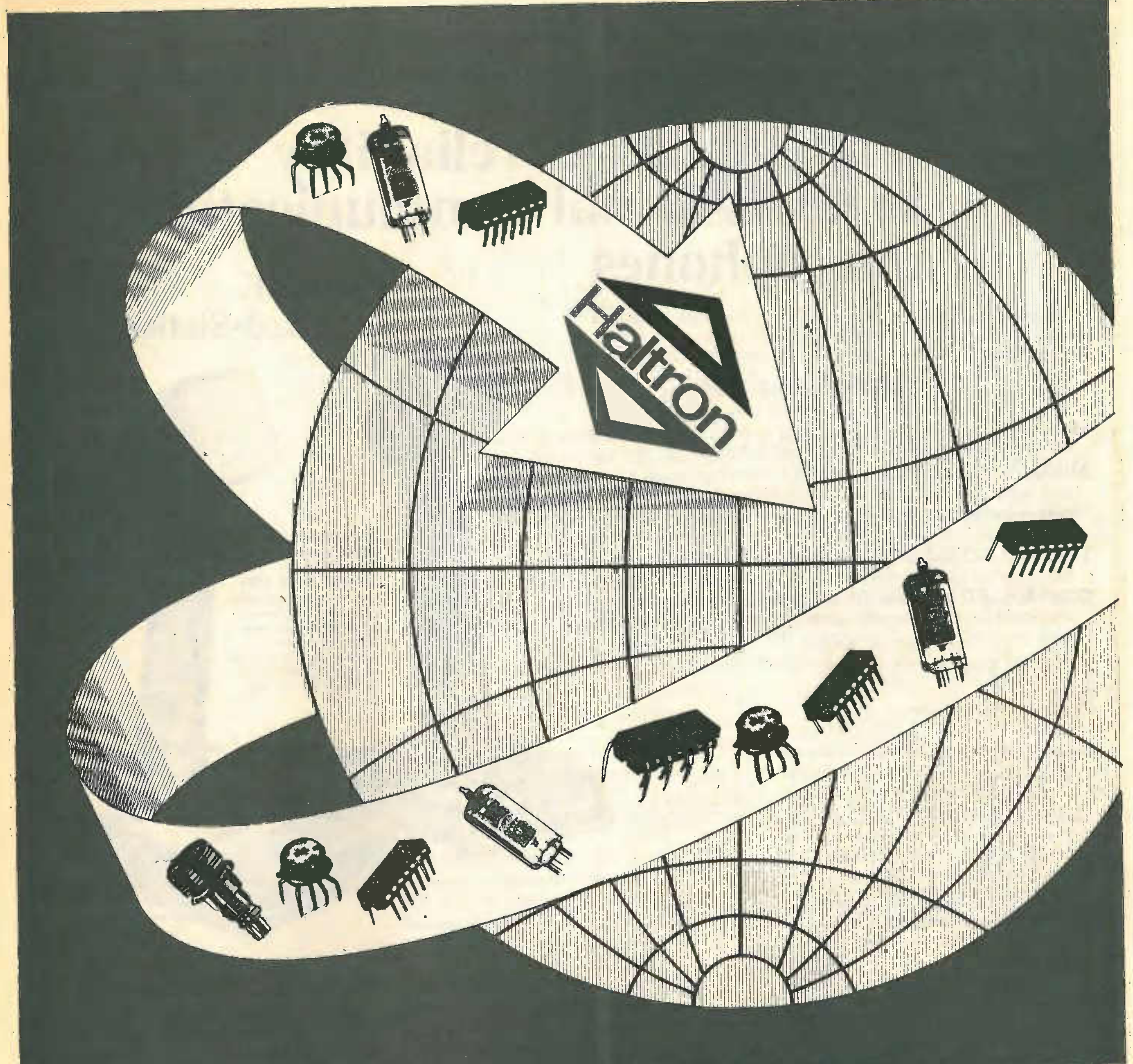

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View from the footprint

In giving his approval for an early start to satellite broadcasting in the UK, the Home Secretary has opened a hive of questions which are now buzzing out in all directions demanding attention: who will provide the satellites, the earth stations, the domestic equipment, the programmes, the finance; who will administer the service, what kind of programmes will it offer, how will the public respond . . . . ? and so on. Many of these questions are in fact being attended to with apparent urgency, and already at least two companies have been formed specifically to provide and operate satellite systems.

One source of pressure behind this urgency is the British aerospace and electronics companies. They, understandably, are keen to exploit the new technology which this type of broadcasting will make necessary throughout the world. An early start for a British service would given them a good domestic base from which to launch themselves into the world market. The existing broadcasters, BBC and commercial, are also keen to go ahead. Although the commercial programme contractors are now preoccupied with financial problems in their terrestrial broadcasting and have the prospect of supporting the fourth tv channel to face, they are of course completely alive to the potential of satellites as a new medium for advertising.

But in all these projections has anyone really stopped to consider the man in the footprint, the prospective customer for these new transmissions?

So far, it seems, the public has not been consulted in any effective way on what it thinks about the whole scheme. The Home Office has certainly published a report through HMSO (News, July issue), but after spending a year or more preparing it they allowed only two months after publication (on May 19) for anyone to comment on it. Such a time limit is plainly ridiculous. It is no more than a token gesture towards public consultation – another instance of the contempt with which governments treat electorates once they have used them to get into power (cf. last month's editorial). Of course, those who are directly interested – the specialized organizations, firms, pressure groups, well-informed individuals and so on – will have responded smartly enough. It will have been another "carve-up" among the elites, while the majority remains almost unaware of what is going on.

A project of this magnitude – essentially national because the transmissions provide immediate coverage of the whole country – justifies public consultation on a large scale. At least a year should have been allowed. Several months would be needed to ensure that people were properly informed about the proposed service and the remaining months to give them time to think, discuss and make considered replies. It would require all this time because the options available are not straightforward. For one thing, they depend on engineering options that are not simple to explain. For example, because, as mentioned above, a satellite transmitter provides national coverage without any difficulty, it is a more efficient way of broadcasting a national service than terrestrial transmitters, which could be reserved for local and regional services. Then there is the question of how the available bandwidth might be distributed between sound and television transmissions, with the possibility of including such newer developments as high-definition television, periphonic sound and text information retrieval.

The fact that satellite broadcasting is now possible gives us a fresh viewpoint for looking at our broadcasting as a whole. It would be folly to throw away this opportunity because of indecent haste to exploit what some people see merely as a new commercial gimmick. After all, the idea of satellite broadcasting has been established long enough (since Arthur C. Clarke's article in *Wireless World* of October 1945). Let us give it the chance it deserves for its potentialities to be used to the greatest advantage.

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Acceleration feedback loudspeaker

Feedback from speaker cone reduces distortion and improves frequency response

by D. De Greef and J. Vandewege. Laboratorium voor Elektromagnetisme en Acustica, Gent, Belgium.

An economical and easily built acceleration-feedback loudspeaker is described. It consists of a two-way, passive-crossover speaker system housed in a compact 44 litre box, and a preamplifier to process the woofer cone-movement feedback signal. Any good power amplifier with a maximum output power lower than 120W r.m.s. can drive this system; no critical adjustments are required. Acceleration feedback is shown to improve considerably the system response below 200Hz. In this region distortion is reduced by a factor 2 to 5, and the power handling capability of the box is increased by 50 percent. In spite of the simplicity of the design, a 20Hz to 20kHz response, flat to within ±3dB, was easily obtained.

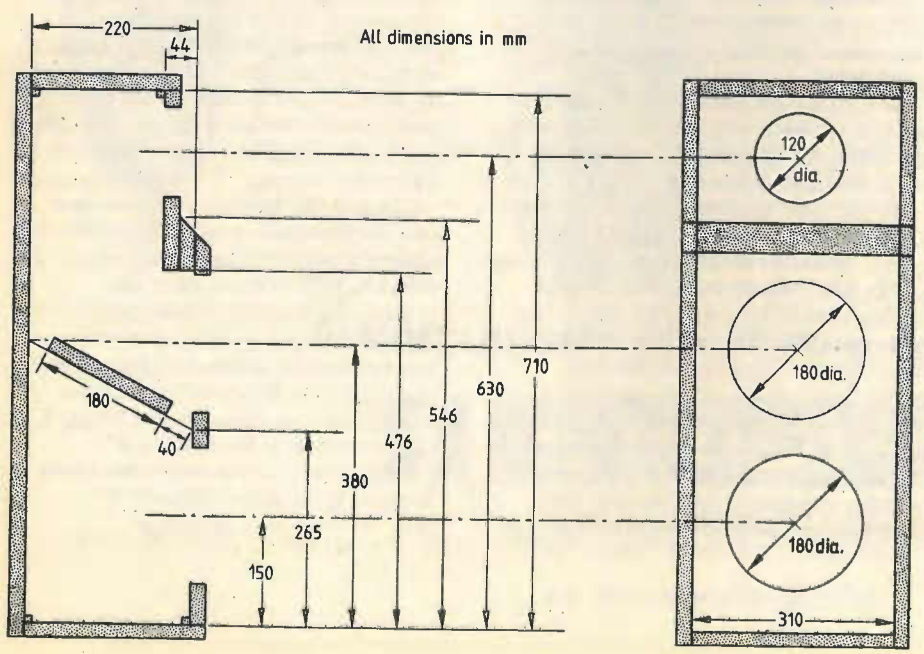
A pair of 20cm diameter Philips AD8067/WMFB4 woofers was chosen for our purpose. These speakers have a built-in piezoelectric transducer, and can handle 40W r.m.s. each. Electrically connected in series, and acoustically coupled, they displace the same volume of air as a single 25cm woofer. However, they are mechanically stronger, and cone break-up occurs at much higher frequency (1250Hz for the AD8067/WMFB4 instead of 200 to 400Hz for a 25cm woofer).

The coupling between the woofers forces them to behave as a system, showing a single fundamental resonance. The 22mm chipboard box shown in Fig. 1 has an effective volume of 44 litres. Its inside dimensions approach the 1.6: 1.25: 1 ratio required for a good distribution of the box resonance frequencies. The oblique partition successfully eliminates the lowest lengthwise resonance of the box at around 260 Hz without deteriorating the acoustical coupling between both woofers. Figure 2 shows the woofer frequency response measured in an anechoic room at 1m on axis, after filling the box competely with polyether foam, which produced a 60Hz woofer resonance with a 0.7 quality factor.

Each woofer cone carries a small printed-circuit board (Fig. 3) on which a piezoelectric acceleration transducer and f.e.t. amplifier are mounted[1,2]. As Reference 3 shows, cone acceleration is proportional to the low-frequency, far-field acoustic pressure generated.

The transducer output was recorded while driving the f.e.t. by a grounded-base n-p-n BC549 to form a cascode stage. Figs 4 and 5 show the results: the 30 to 120Hz speaker response is very well reproduced. Further measurements showed the transducer output below 30Hz to be decreasing, probably because of the finite f.e.t. input impedance. Above 120Hz, the transducer output falls because cone movements are increasingly damped by the surrounding air. Above 1kHz, cone break up and transducer resonances dominate. In the region of interest, the difference between speaker response and transducer signal can easily be modelled as a first-order, 300Hz highpass filter.

The enclosure in an anechoic room: front view showing the soft-dome midrange and both woofers.



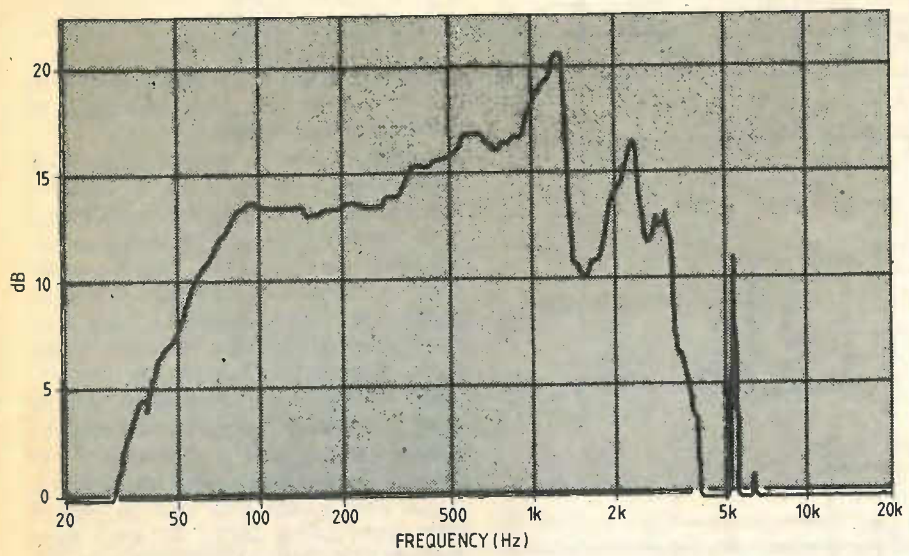
portant dimensions of chipboard nclosure.

Feedback system

A source of inspiration was the Philips MFB speaker system 22RH532[1,2]. It has separated power amplifiers for low (40W) and medium to high frequencies (20W), which are incorporated in the box together with a number of filter stages. Woofer feedback is active (loop gain <1) in the 15 to 400 Hz frequency range.

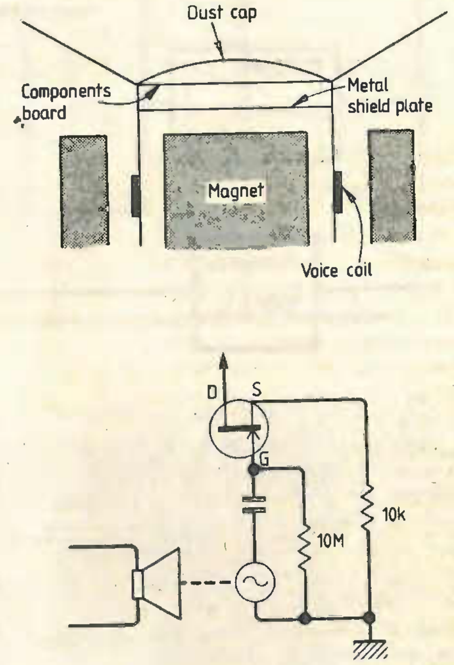
We succeeded in using a single good-quality power amplifier for the entire audio range, by carefully redesigning the feedback system as in Fig. 7. Any good power amplifier can be used, provided its passband reaches as low as 5Hz (for loop stability's sake), and its power output doesn't exceed 120W r.m.s. Loop gain has to be adjusted, once and for all, to 12dB at 100Hz, a 20 per cent fault being hardly noticeable.

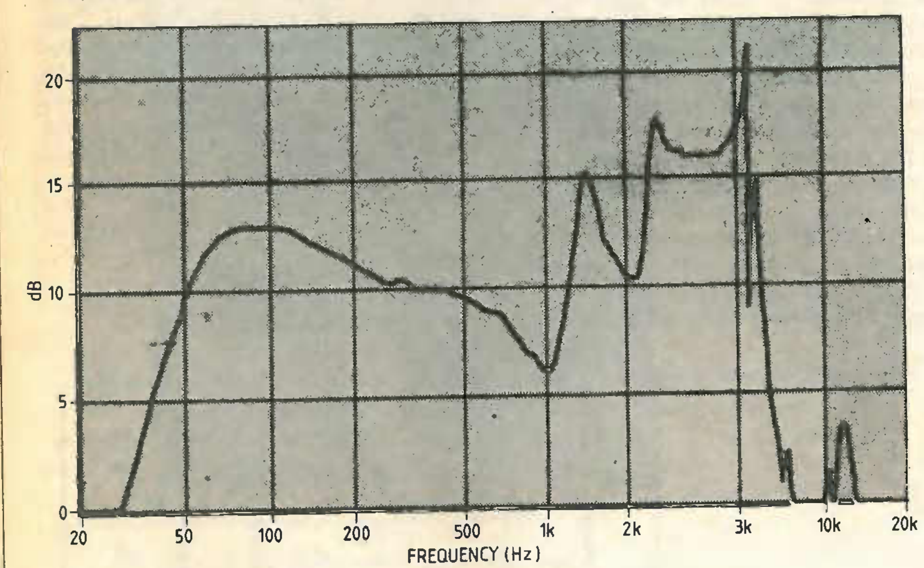
A crucial point in our configuration is the 44 Hz low-pass filter in the feedback signal path. It eliminates distortion components of the piezo transducer in the medium range, where transducer distor-



◀ *Fig. 2. Frequency response of the woofers, mounted in the foam-filled enclosure.*

Fig. 3. Woofer construction with built-in acceleration transducer and f.e.t. stage.





◀ *Fig. 4. Acceleration transducer response with constant speaker voltage applied.*

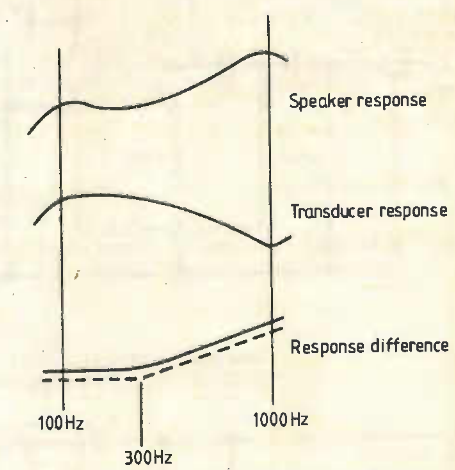
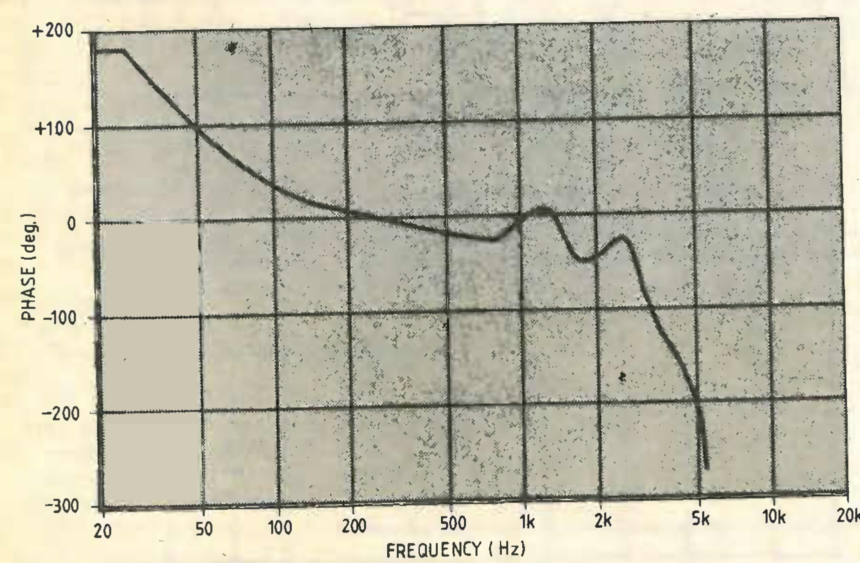


Fig. 6. Modelling the woofer-transducer response difference.



◀ *Fig. 5. Acceleration-transducer phase response.*

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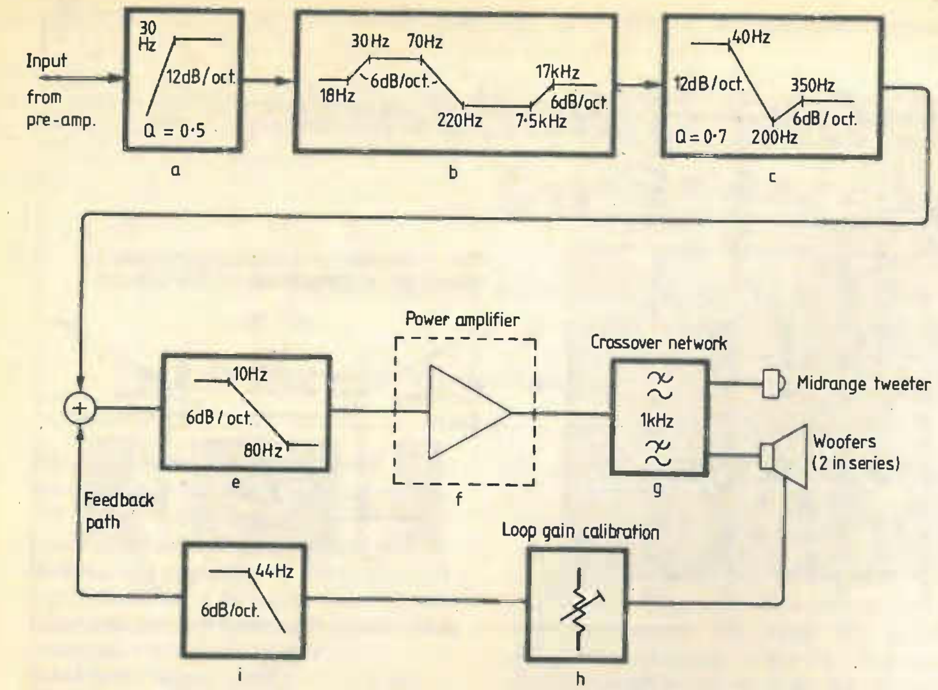

Fig. 7. Block diagram of the acceleration feedback system.

tion (0.5 to 1 %) exceeds the distortion of the woofers (<0.5% around 350 Hz). The 44 Hz cutoff frequency is optimized for a maximum allowable loop gain. Although the system remains stable for a loop gain as high as 22dB, one should not exceed 12dB: excess input signal would provoke too high a drive signal for the power amplifier, causing severe distortion, long settling times and possible destruction of the power stage or the speakers.

The filter stages a, b and c in Fig. 7 form a feedforward compensation of the servo-loop transfer characteristic. Only first-order and low-Q (<0.8) second-order filters were employed to avoid any ringing or overshoot in the system response. The circuitry shown in Fig. 8 is incorporated between the preamplifier and power stage of an existing audio amplifier, and contains all the signal-handling stages required. Except for the connexion of one LM381 input amplifier as part of the transducer f.e.t. cascode stage, its design is very conventional. The 12dB loop gain adjustment R should be set at about 22kΩ for a 34dB power amplifier gain. The whole is fed by a single 24V power supply, shown in Fig. 9. A relay shorts the power amplifier input for ten seconds after switch on, to avoid switching transients.

As Fig. 10 shows, the power-amplifier input signal, generated by a constant servo-system input level, is a complement of the woofer frequency response, as determined by the servo loop. Because audio programme material seldom contains strong very low frequencies, this bass boost does not require excessive power levels. However, the box must be carefully sealed and filled with polyether foam in order not to reduce the woofer's low-frequency power-handling capabilities. As the servo loop is operative as low as 12Hz, a high-pass rumble filter may be needed when reproducing discs: the filter time constants, however, produce an increasing feedback level for those very low frequencies. Subsonic cone movements are strongly damped, obliging the voice coil to stay in the linear region of the magnet system even for higher drive levels. This raises the processable power level, for typical audio programme material, from 80 to about 120W r.m.s. Figure 11 shows woofer distortion when a 25W sinusoidal signal is applied to the box: closing the feedback loop dramatically decreases low frequency distortion.

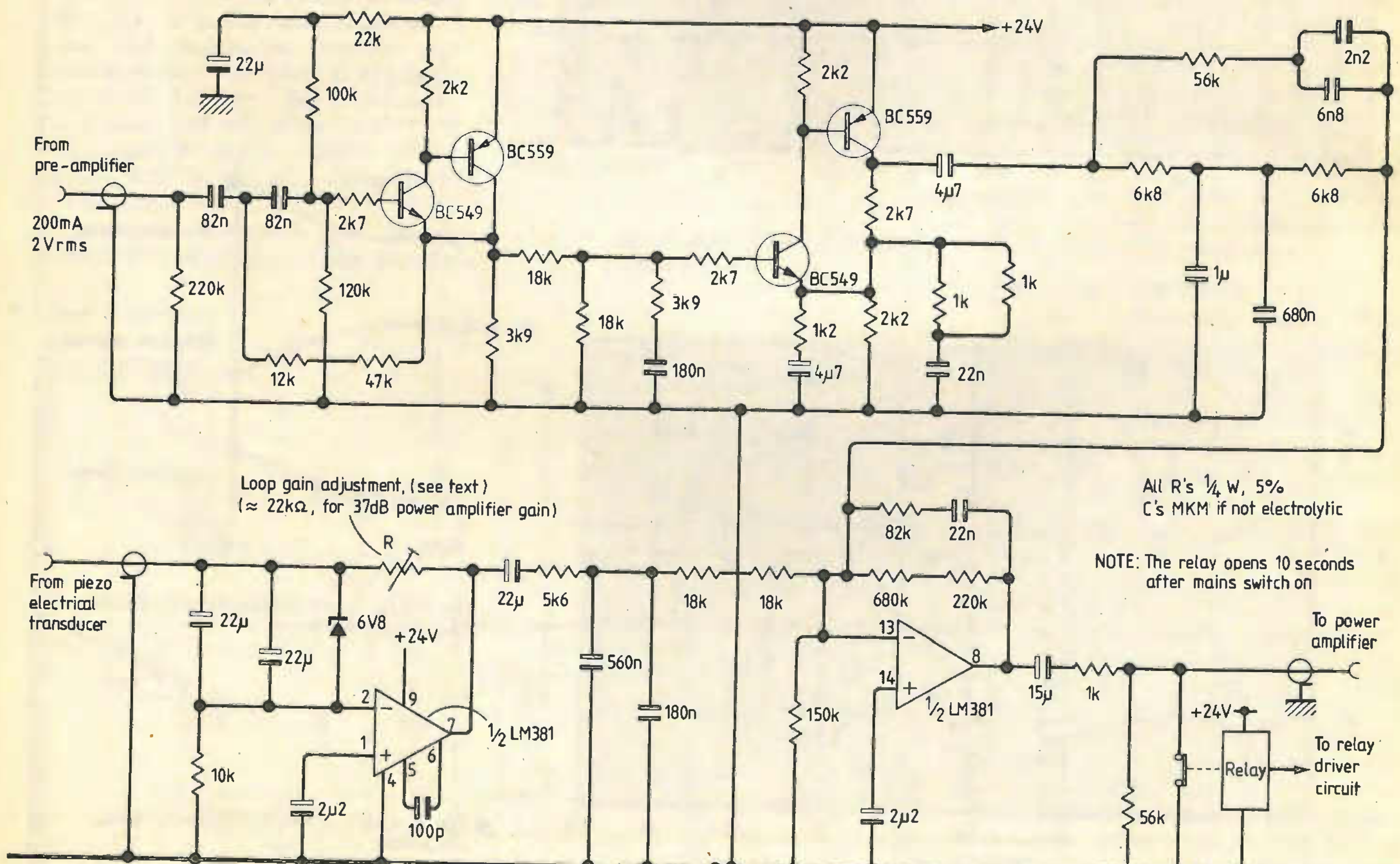

Fig. 8. Filter and feedback stages.

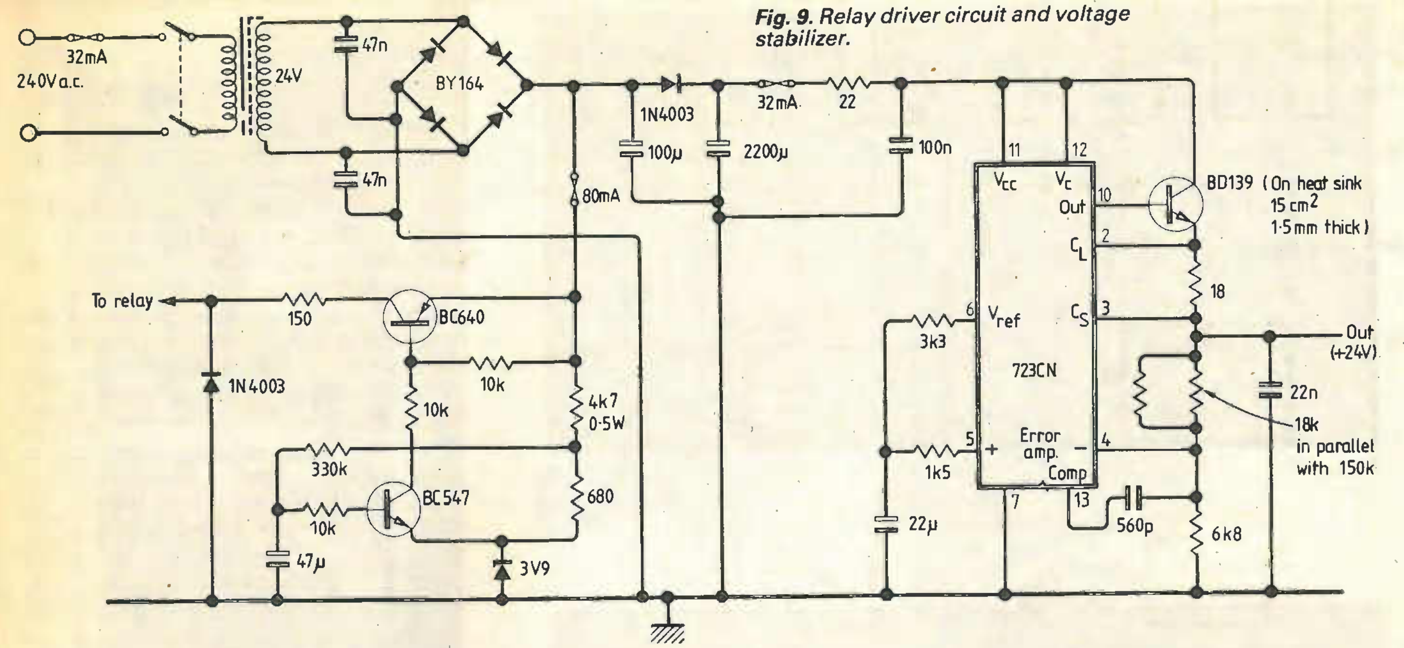

Fig. 9. Relay driver circuit and voltage stabilizer.

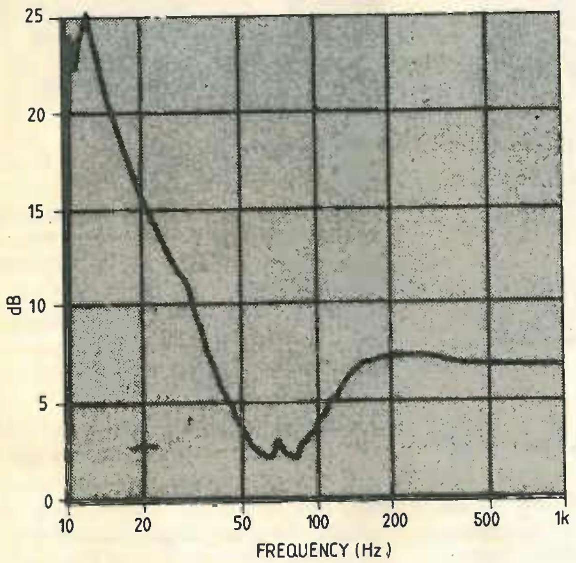

Fig. 10. Power-amplifier drive signal with constant servo-system input voltage.

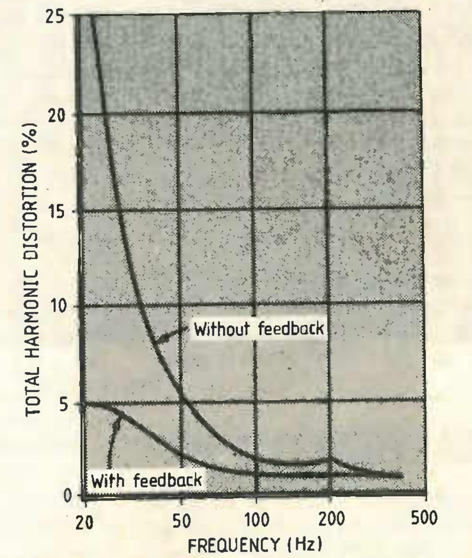

Fig. 11. Total harmonic distortion of the speaker system with and without feedback, for 25W sinusoidal drive.

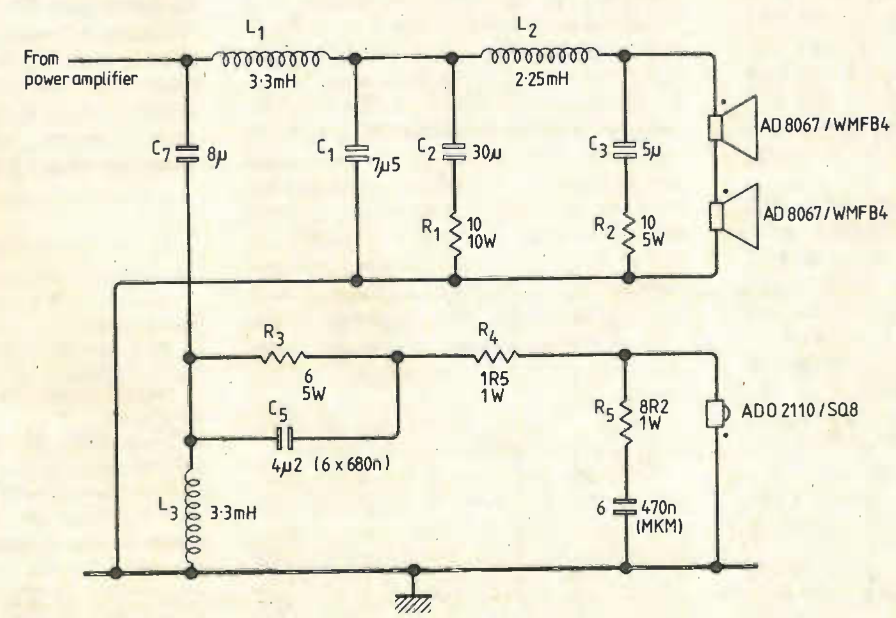

Fig. 12. Passive crossover network.

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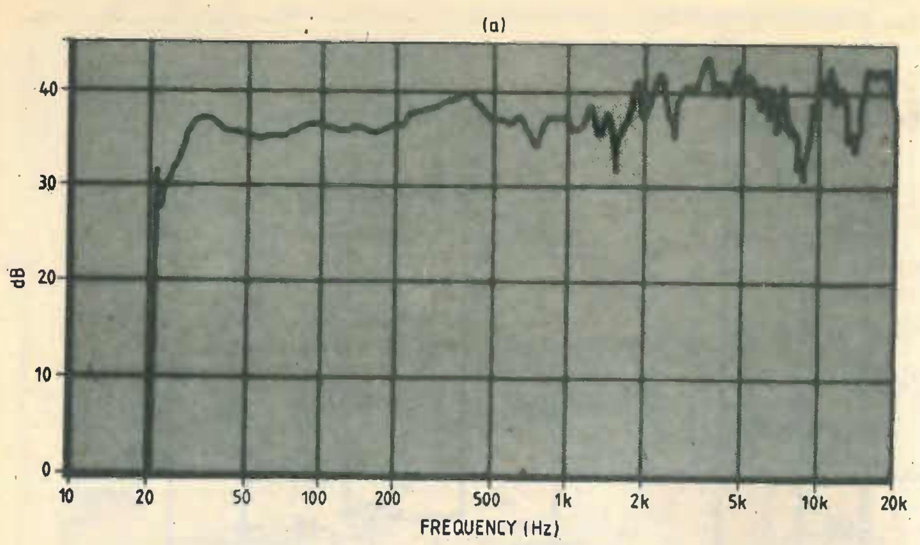


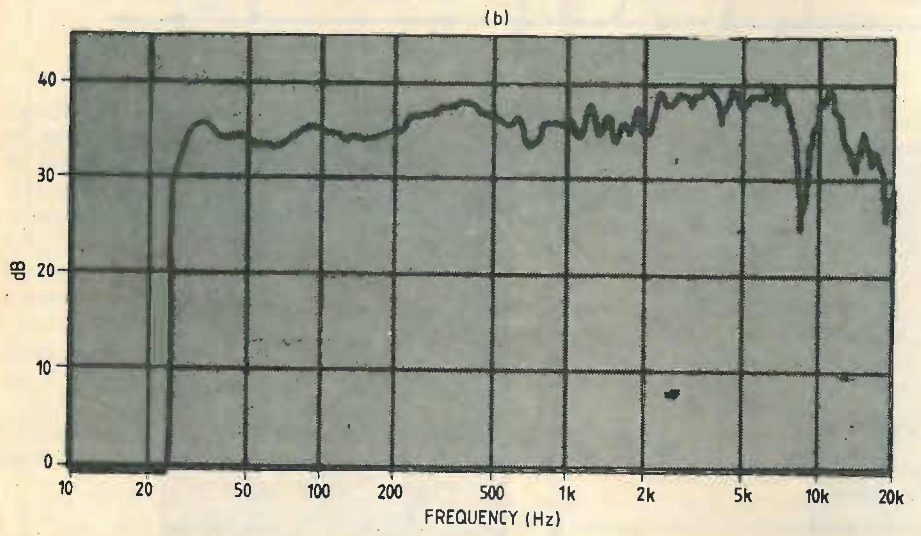
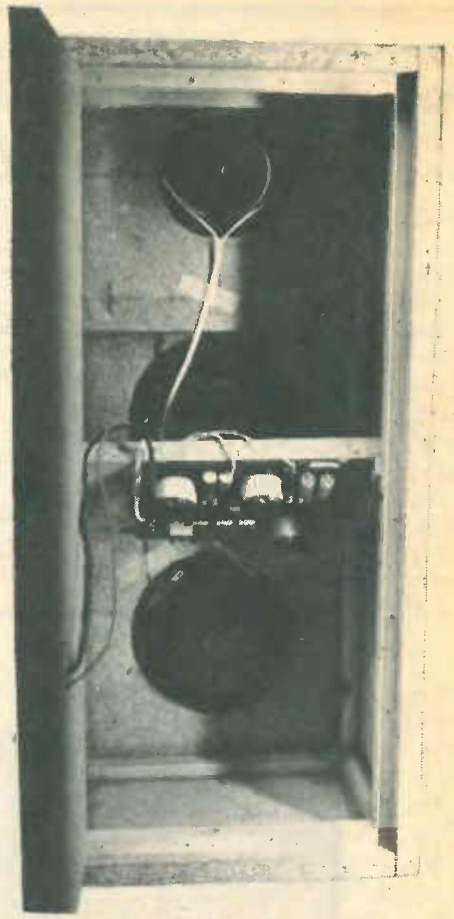


***Fig. 13.** Overall system frequency response in anechoic room, at 1m distance. a) on axis. b) 30 degrees off axis (horizontal plane).*



Inside view of the enclosure showing the crossover network suspended on the oblique partition. Box must be completely filled with foam.

Crossover

With constructional simplicity in mind, we searched for a good amplitude and transient waveform response[4]. Ordinary constant-resistance filters showed excessive ringing (squarewave response), and only combinations of first-order and low-Q second-order filters proved to be acceptable acoustically.

Different three-way combinations were built, in which or a Motorola piezo tweeter, or a 2.5cm Philips dome tweeter, AD0141T8, was used with a 4kHz second crossover frequency. Main problems were tweeter resonances in the 1 to 4kHz region, causing poor squarewave response. Moreover, thermal modulation of the tweeter sensitivity was observed at higher drive levels: due to the short thermal time constants (around two seconds for a 2.5cm dome tweeter), voice coil resistance can change appreciably with the rhythm of strong transients[5].

A much better result was obtained with a 5cm Philips soft dome midrange, type AD02110 SQ8, in a two-way configuration with 900 Hz crossover frequency. This speakers has a 20 seconds thermal time constant. Its high-frequency response is equalized electronically from 8 to 20kHz in filter stage c of Fig. 7, and from 4 to 8 kHz (approximately a first-order pole at 4 kHz) in the crossover network of Fig. 12. The coils are wound on Siemens ferrite drum cores, thus avoiding excessive wire length and resistance. The high-pass section contains no electrolytic capacitors, as these were inaccurate and often inductive at higher frequencies, and parallel combinations of foil capacitors (Siemens MKM series) were used, each capacitor being able to handle 400mA of current. Low inductance resistors are also to be preferred.

Finally, Fig. 13 shows the anechoic room amplitude response of the system.

Although these curves can stand comparison with much more complicated (and expensive) setups, the most impressive result cannot be written down: a very sharp-cut transient response even at high levels, and a completely uncoloured reproduction of the human voice.

Editorial note

The drive units are obtainable from **Philips Spares Division**, 604 Purley Way, Waddon, Croydon CR94DR, at £34.22, £22.70 and £17.25 for the woofer, 2in dome and tweeter respectively. Siemens MKM capacitors are stocked by A. Marshall (London) Ltd, Kingsgate House, Kingsgate Place, London NW6 4TA.

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2. Philips sonant, *Electuur*, 1973 September, pp.926-931.
3. Jason Christophorou, Low frequency loudspeaker measurements with an accelerometer, 62-64th Convention AES, preprints.
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5. P. Skritek, H. Pichler Extended application of TIM test procedures, 64th Convention AES, preprints.

Consumer video records

There is still no agreement on a single standard for video disc systems

Lack of agreement on a single standard for consumer video discs has been no barrier to the completion of many other agreements, but none so obviously in the consumers' interests as a single standard. Almost every interested company has an agreement to produce more than one kind of video disc system.

The first of the video disc systems to be demonstrated was the laser optical disc originated by Philips a decade and £75million ago, and put on the market in the USA 2½ years back. Then came RCA's grooved capacitance disc, the product of 15 years research and development costing between $50 and $200million, put on sale six months ago. And third there is Matsushita in the form of JVC looking to repeat its VHS video cassette recorder success with a grooveless capacitance disc, to go on sale next month in Japan, and in 1982 for the USA and UK. Other systems, such as the optical transmissive of Thomson-CSF, are not destined for the domestic consumer market. So what are we going to be faced with?

Philips may have been first to publicly show their disc and player but they certainly haven't made most noise. That honour goes to RCA who, ever since the "go" decision for the launch of Selectavision was taken in 1979, have inundated the press with announcements of their licensing deals, some hardware, most software.

First news was that RCA had concluded a licensing arrangement with CBS to make and distribute Selectavision "capacitance electronic discs" (CED). CBS was a natural choice: it had pressing plant that could be converted, falling audio record sales, a record distribution system, and wanted to get into video discs with the least risk. Next RCA needed equipment licencees.

North American marketers say that the chances of selling a particular brand to a household are much better if a commitment already been shown to that brand, especially to the extent of owning a colour tv set. And the owners of a product are likely to listen to what its makers recommend. So with the biggest share of the colour tv market (21%), RCA thus hopes for the biggest share of the video disc market. So naturally their first target for licensing their technology was the next biggest tv brand – Zenith (20%). News of an agreement with Zenith came three months after the CBS deal and covered the factor of players and discs and an exchange of patent rights.

The third largest US tv set maker is GE, who are committed to the JVC disc technology. The next largest sections of that market are retailers' own brands and the Japanese makers. All three "own-brand" names, Sears, Ward, Penney, agreed to sell CED, representing over 11% of the colour market. Japanese makers Hitachi, Sharp, Sanyo and Toshiba agreed to CED in the USA (but VHD in Japan and maybe also optical players), whose share comes to over 6%. Remainder of the US makers are either in the optical group (Magnavox, GTE's Sylvania and Philco, acquired by Philips, with 12%), or committed to VHD (JVC, Quasar, Panasonic, about 8%). A total of nearly 60% for CED.

There have been no agreements announced to market CED in Japan. Which suggests this was the price of getting all the non-Matsushita Japanese manufacturers that sell in the US to adopt CED rather than VHD.

But such licence agreements do not always mean very much. As an RCA spokesman admitted: "licences only become meaningful when manufacturing starts". As an example, out of 20 CED licensees in Japan, one is Pioneer, who are heavily committed to the optical system, and another is Sony, who already have an exchange agreement with Philips and declare no interest in consumer discs. However, considering the momentum that CED is achieving there is every reason for supposing that manufacturing has begun with a vengeance.

Five weeks after launch RCA were saying that CED had achieved "the most successful introduction of any major electronic product", selling 26,000 players and 200,000 discs. To meet a stronger than expected demand RCA say they are increasing the number of presses and raising this year's production target for discs from two to three million, and expect to stamp 10million by 1982. Annual sales of video discs and players could be about $7.5billion by 1990 they say.

Mock-up or the real thing? Photograph claims to show Matsushita laser disc recorder that can playback one of 15,000 images in under half a second.

But the bulk of the RCA announcements were about licensing deals for programmes, and involved separate deals with films and tv companies. They have so far acquired rights to 85 Paramount films, 20 Rank, 24 Disney, 100 United Artists, 12 Chaplin, 7 Presley, and 11 Bond films; Charlie Brown programmes, music and show productions, NBS "specials", football games, boxing matches . . . all of which will doubtless impress the "average family", because it was designed for precisely that market. The opening catalogue had 100 titles, half priced at under $20, the rest at between $15 and $28. This summer 26 new titles were added, a further 25 due this autumn. From next year 120 new titles a year will be added, say RCA "to maintain excitement and interest".

Will success in the programme catalogue decide which is the successful disc format? The answer may in part depend on how

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many of the agreements being reached are exclusive. What seems to be happening is that the vast majority of agreements are non-exclusive – RCA named only two items as exclusive. Nevertheless, in a situation as competitive as this one must expect features to be sought on an exclusive basis and used for promotional purposes. Negotiating rights to overseas material is an area where video disc companies are very active. RCA have formed joint companies in various countries; those announced are with Beta/Taurus in Germany, Precision Tapes in the UK, Gaumont in France, as well as a joint company with Columbia Pictures to trade in overseas rights.

In proclaiming its 26,000 sales RCA could be said to be gloating when they compared this with an estimated 30,000 sales for the optical system over two years.

Optical system protagonists argue that optical player sales had been held back as a result of difficulties in supplying discs. Philips contest the estimated figure, quoting sales of 40,000 at the end of 1980.

But a CED player does not directly compare with a laser player; limitations of mono sound, no freeze-frame facility, limited stylus and record life go with this unashamedly mass-market machine. And price differential is substantial: $750 for the optical player and $499 for CED.

The optical disc system, now called Laservision and sold by both Magnavox and Pioneer, is set for UK launch later this year* with a promotions budget of £1.5m and selling "marginally cheaper" than a VCR (£499?). Details are largely as previously reported (see Berlin show reports, especially 1973 and 1975), the major extension in recent years being adoption of constant linear velocity to extend playing time. This is achieved by cramming more than two fields per revolution as the track radius increases and motor speed decreases proportionately. The constant angular velocity mode, with its facility for reversing, speeding up, slowing down and freezing motion by track jumping, gives only half an hour playing time a side, and is now distinguished from the long-play version by the name "active play". And though the players will accept both kinds of record, not everyone is clear that with Laservision you don't get both at the same time.

In addition to the Blackburn and Eindhoven pressing plants of Philips, three German companies are to make Laservision discs—Sonopress, Bertlesmann, and Bavaria. In the USA discs are made by 3M and Discovision Associates (MCA and IBM), while in Japan Universal-Pioneer will make discs for the consumer market and Sony for the industrial market.

The VHD (video, high density) grooveless capacitance disc group may be more willing to exploit interactive instructional programmes than RCA. Matsushita's chief revenue earner is now the video cassette recorder and to protect that position they say VHD should offer something the cassette recorder can't. According to a recent report in *TV Digest*, Matsushita have enough films for January's US launch (from United Artists, MCA, EMI) reportedly 55% of their first 76 items, with the remainder classed as special interest, i.e. music productions and as many as 30 interactive instructional discs. Average price will be $25.

In the UK Thorn-EMI is spending £5m on two disc production sites. A recently-acquired factory at Swindon will produce stampers for pressing at Swindon and at EMI Electrola, Köln. The new factory will be operational by January, in full production by April with 100 employees and so ready for the UK selling in June. Thorn say combined output will be three million discs, and that could be doubled by 1983.

The process appears to differ from RCA mastering in at least one respect – a laser cutting head scribes 0.3μm deep pits into a coated glass blank. This makes the process vibration-sensitive and Thorn-EMI say choosing a site sufficiently free of vibration has been a problem. Sequential electroforming leads to a metal master from which metal stampers are made.

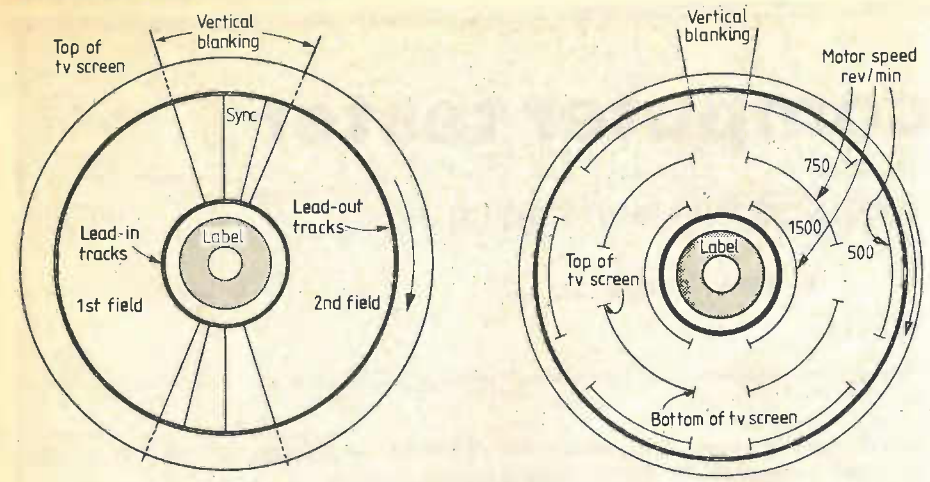
At least thirteen companies have declared their support for VHD in Japan: Akai, General, Hitachi, Mitsubishi, NEC, Sansui, Sanyo, Sharp, Toshiba, Trio, Yamaha, in addition to the two Matsushita companies. Many of these will produce players for more than one system, and others are almost certain to have licences.

But a large part of the strength of the UK operation lies in the JVC participation with Thorn-EMI. They are both counting on Thorn's rental outlets – nearly 1600 of them – that have been instrumental in the undoubted success in bringing VHS to the UK.

*At the time of going to press launch date was "autumn."

First model of RCA video record player features rapid access at 150 x normal speed with muting, visual search at 16 x normal speed by groove jumping and is priced at $499. 150 programmes, aimed at "average family", sell at $15 to $28 each. CBS as well as RCA are expected to sell records in the UK, but a PAL version of the player has yet to be demonstrated.

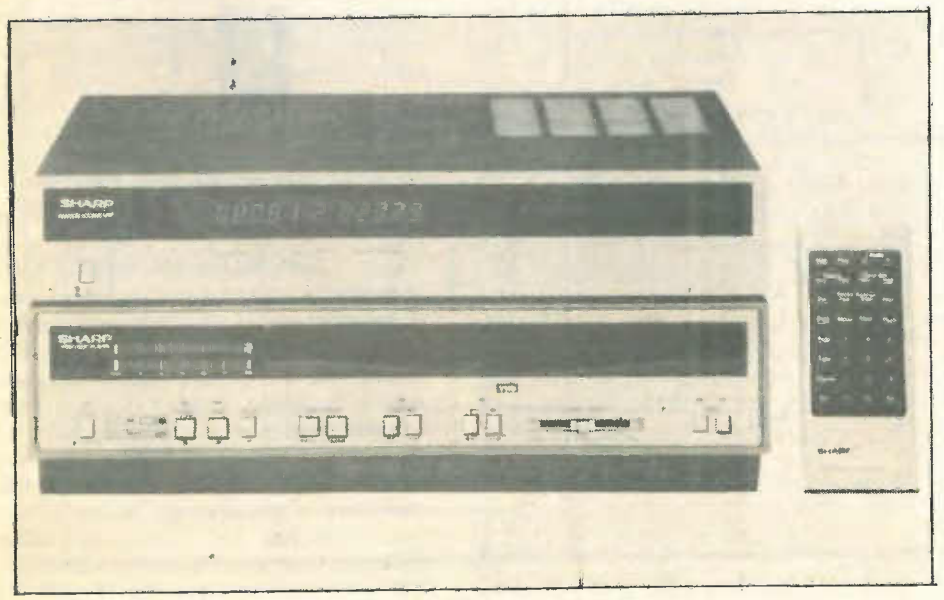
Costing almost as much as a video cassette recorder, optical players will accept two kinds of disc; "long play" for one-hour per side programmes with no "trick" modes and "active play" for half-hour programmes with fast, slow and still modes. Average price of discs will be £15, players under £500. More compact players with solid-state lasers are in development.



Field arrangement on two kinds of optically tracked disc. "Active play" half-hour type has constant motor speed and variable track length to allow track jumping (left). Penalty for increased playing time of long-play version is the loss of slow, fast and still-frame options (right).

Optical video discs carrying education programmes could be used for interactive teaching programmes tailored to individual needs by linking record player to microcomputer (both beneath tv set) with cassette program and separate text display. But teaching and training programmes – for which the features of slow motion, freeze-frame and reverse play are ideally suited – will not be available initially.

Available for sale in the U.S. early next year, Sharps' VHD-format video record player includes "video search," enabling speeded up viewing by either 9 or 120 times normal speed; frame-stop; frame-by-frame advance in either forward or reverse; variable speed control from 1/8 to five times normal speed in either forward or reverse; and pause control. In the UK players may turn out to be dearer than the £350 currently being quoted.



Secret of capacitance discs

To make a video c.e.d., signals with identification codes inserted in the vertical blanking intervals feed a half-speed cutter made of a diamond stylus and driven by a piezo element (optical and electron beam mastering methods have been dropped). This cuts a v-shaped groove into a thin layer of copper coated on a heavy aluminium disc. Electroplating with nickel and peeling off the coating a few times provides a number of nickel masters (negative moulds). They are returned to the electroplating bath to generate multiple positive nickel moulds which are themselves electroplated to produce hundreds of stampers for disc pressing. Two stampers mounted on a press – one for each side – then press a hot mass or "puck" of p.v.c. compound into a disc. on cooling the discs are washed, rinsed and dried and a 20mm coat of lubricant is sprayed on to prolong stylus and disc life.

Experiments conducted a decade ago at RCA showed that the resistivity of a p.v.c./p.v.a. copolymer as used in audio records was too high for a conductive record, at 500Ωcm. Lower resistivity could then only be obtained with polythene-based compounds but they were too soft and scratched under a sliding stylus. So coatings of metal, styrene and oil had to be applied to give the disc its conductance. But when problems with conductive coatings (adhesion, environmental exposure, complex equipment) began to mount the search for a new compound was renewed. Chief result was discovery of a low-resistivity carbon black made by Akzo Chemie, Netherlands together with a suitable p.v.c. copolymer. The carbon loading level was the tricky thing to get right, affecting not only resistivity but also melt viscosity, physical characteristics – especially brittleness and resistance to scratching, warping – and surface quality.

Electron tunneling theory suggests it is the average width between particles or agglomerates that determines conductivity of the carbon-resin composite (tunneling current is an exponential function of gap width). Detailed investigations showed resistivity to be a steep function of carbon content which hadn't levelled off at resistivities as low as 2-5Ωcm, where loading level becomes impractical (20%) due to high sheer stress from particle-to-particle contact.

Detailed analysis of the properties of filled polymer composites with a loading level of 15% showed its suitability – except in respect of brittleness. But RCA say "proprietary" additives can modify this to enable the discs to withstand normal handling and drop tests.

In any case, the specification for disc warp i.e. a maximum peak-peak warp of 0.5mm after 48h at 55°C cannot be met by audio-type p.v.c./p.v.a. systems; but is easily met by carbon-filled resin systems of propylene-vinyl chloride copolymer or p.v.c. homopolymers. It is the success of this conductive disc that gives CED perhaps its biggest selling point against optical pressings – that records can be made on existing presses. But as the filled resin is much stiffer it is more difficult to form by injection moulding; therefore compression moulding has to be used.

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Microcomputer tester

A simple but versatile fault-finding aid

by Tony Cassera

More and more service and repair departments are finding themselves dealing with the repair of microprocessor oriented equipment. Larger departments can usually afford dedicated analysers to aid fault finding but the majority, mainly for cost reasons, have to rely on manufacturers' test routines, logic probes and the 'plug-a-new-one-in-and-see' method used since the advent of the thermionic diode. The author presents here a low-cost design, for both amateurs and technicians, for testing 8080 based microcomputer circuits and, rather than concentrating on constructional details, he has described the unit so that it can be adapted for testing any microprocessor based system.

Over the past few years, this test unit has been used successfully for fault finding in 8080-based microcomputer peripheral circuit boards and features of its design will be of interest to others faced with the problems of repairing similar boards. As anyone who has ever tried to measure voltages at i.c. pins using standard probes will understand, connection of the test unit to the circuit under test is difficult and the chances of damaging the unit through misconnection are great. With this in mind, the test unit was designed as cheaply and as simply as possible so it can easily be repaired or replaced. The tester can be used to

– read data from memory
– write data into memory
– check i/o operation
– single step through a program
– run a program and stop it at preset breakpoints

When used in conjunction with an oscilloscope, circuit diagrams and program listings the unit can be used to diagnose most faults.

Microcomputers have strong similarities in general architecture but differ in details so, rather than give full constructional details, I shall describe each function of the tester so that it can be tailored to suit the application of the reader. Any details given apply to an 8080 based system. The system for which the tester was originally designed consisted of an 8080A microprocessor, 8224 clock, 8228 bus controller and, of course, r.a.m., r.o.m. and various other components.

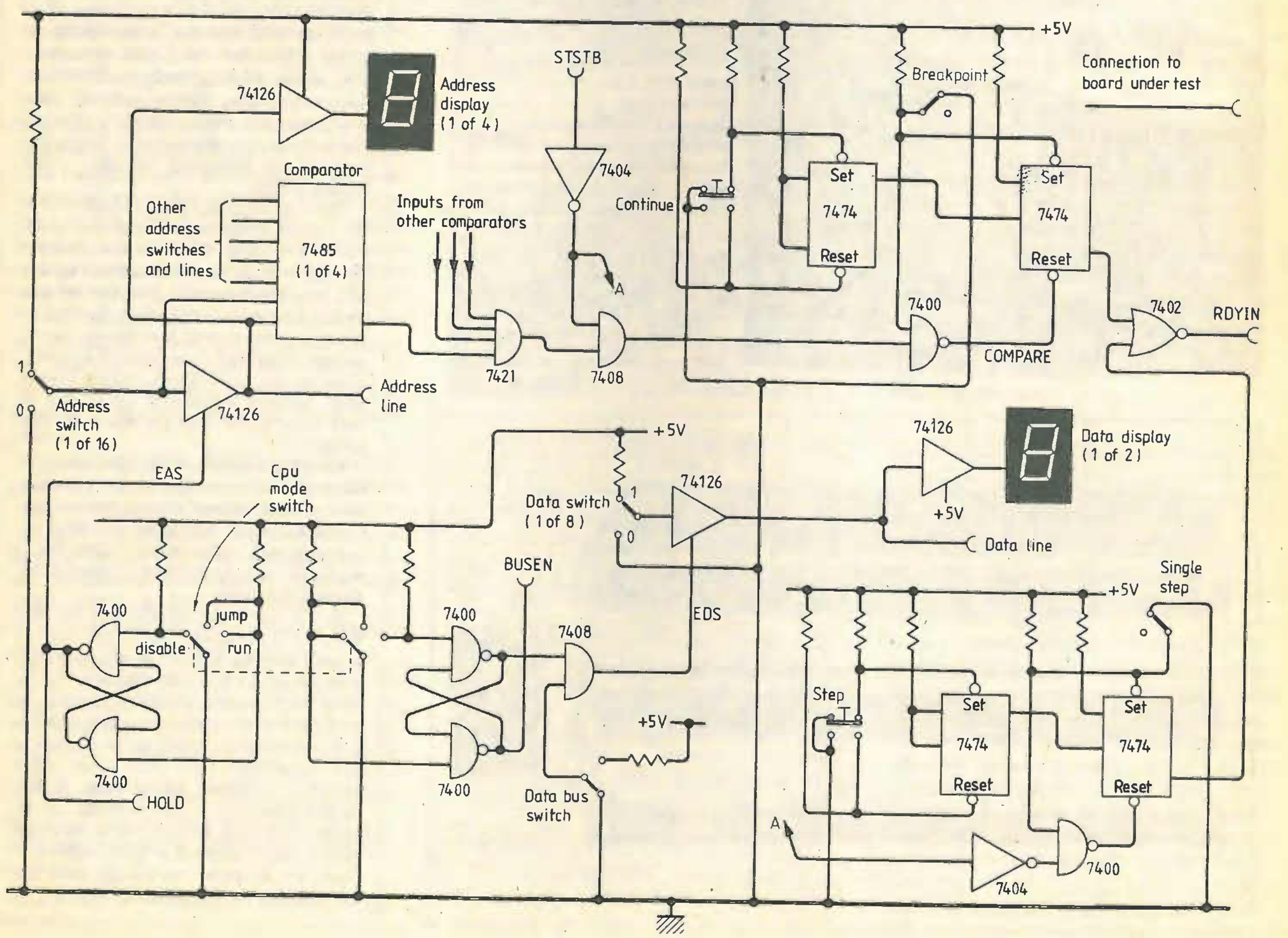

Fig. 1. Outline of the c.p.u. mode, address, data, data bus, breakpoint and single step functions of the microprocessor tester. All resistors shown here are 1kΩ.

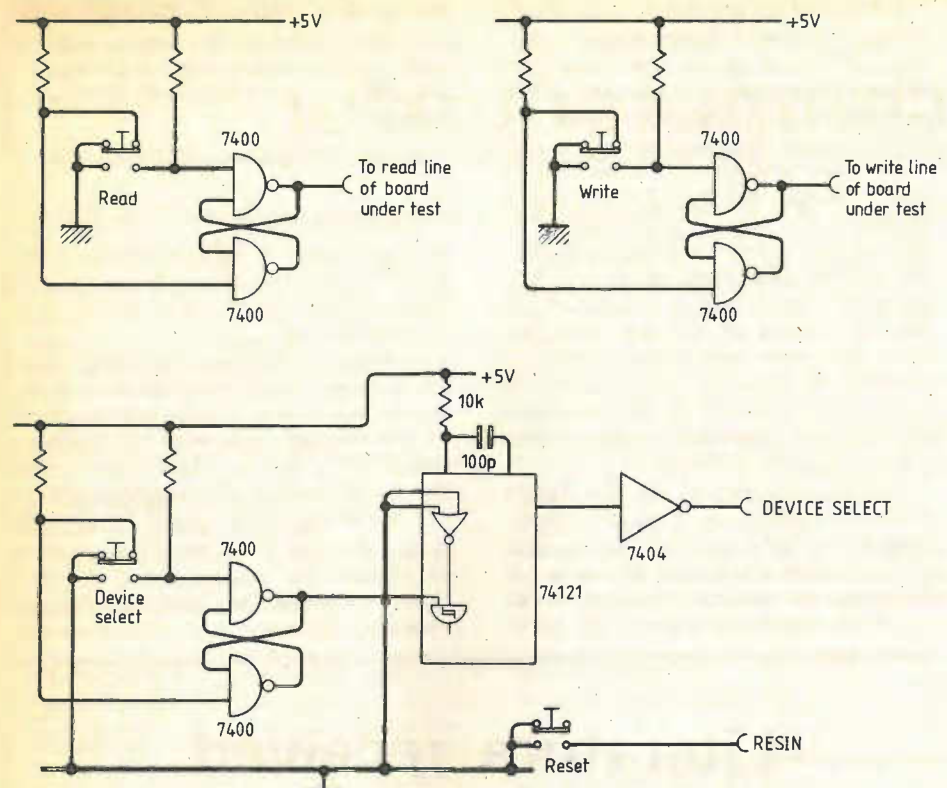

Fig. 2. Circuits of the tester used to produce signals for read, write, select and reset functions. The NAND gates connected as flip-flops are used to debounce the push switch contacts. RESIN is debounced within the 8224 clock i.c. of the board under test. Apart from the timing resistor of the monostable, all resistors are 1kΩ.

Signals

To aid the explanation, signal names have been used. The active state of each signal is indicated by suffix H or L, for active high and low respectively, the first time the signal name is mentioned. The following seven signals used by the tester are standard for an 8080-based system; other signals peculiar to the tester will be described as they crop up. HOLD H, applied to the 8080, stops the processor and puts its data and address buses into the high-impedance state. RESIN L, applied to the clock i.c., lets the clock generate the RESET H signal which in turn sets the processor program counter to zero. When RESIN is removed, the program starts from zero. STSTB L is a status strobe generated by the clock i.c. at the start of each machine cycle. RDYIN H is synchronized with the clock to give READY H to the processor. BUSEN L enables the tri-state output buffers of the 8228. When this signal is high, the output buffers are in their high-impedance state.

Functional description

C.p.u. mode. A three position switch with settings marked disable, jump and run is connected to the HOLD and BUSEN signals of the system, see Fig.1. In the disable mode a HOLD signal is applied to the microprocessor and two enable signals, EAS H and EDS H, to the address and data switch buffers respectively. The tester has control of the address bus in this mode.

When the switch is in the jump position the HOLD signal is not applied to the microprocessor but the data bus is held in its high-impedance state by the BUSEN signal. After resetting the microprocessor runs and advances the program counter. Each clock cycle should result in data in the form of 00 from the bus controller. As 00 is the no-op code the microprocessor does not act and the program counter goes on incrementing until the address switch setting and the bit pattern on the address bus are the same. At this point the RDYIN signal goes low and the microprocessor clock stops at the selected address.

In the run position the BUSEN signal is low, i.e., active, and other conditions are the same as those in the jump position. The processor is now in charge and executes whatever it finds in the program.

Address bus. Sixteen single-pole switches are used to write data onto the address bus through tri-state buffers. The enable line to these buffers, EAS, is controlled by the c.p.u. mode switch so that the address switches are only active when the c.p.u. switch is in the disable position. Four hexadecimal-input seven-segment display units are used to monitor the bit pattern on the sixteen address lines. The address lines to the display may need buffering to prevent excessive loading.

In disable mode correct functioning of the address and data buses can be checked by reading out known data from r.o.m., see Fig.2. To check the r.o.m. select decoders one or two words can be read from each memory i.c. used. Extensive r.a.m. checking is not possible but data can be written into and read back from r.a.m. locations to check the chip select function and the ability of the r.a.m. to retain data. In the write mode, see Fig.2, data can be written into memory for use when the program is run.

The address switches are also connected to four comparators which are used in jump mode and to find breakpoints.

Data bus. A set of eight single-pole switches is used to write onto the data bus through tri-state buffers. These buffers only pass the data on the switches to the bus when the c.p.u. switch is in the disable or jump positions and when the data bus switch, Fig.1, is in its enable position. The resulting signal controlling the buffers is called EDS H. Two hexadecimal-input displays are used to monitor the data lines and as with the address displays their inputs are buffered.

Comparator. The sixteen-bit pattern on the address lines is compared with the settings of the sixteen address switches by a thirty-two input comparator made up of four eight-input comparator i.cs. and a four input AND gate. The output of the comparator is fed into an AND gate along with the STSTB signal from the 8224 clock of the board under test. The resulting signal is fed into a NAND gate along with an enable signal from the breakpoint switch to form a signal called COMPARE L. One of the four sections of the comparator is shown in Fig. 1.

Breakpoint. A breakpoint is an address at which the processor will stop. Using a sensible choice of breakpoints, it is possible to reconstruct the path of the program under execution. When a breakpoint is set on the address switches, the c.p.u. mode switch set to run and the breakpoint switch to enable the program should run and stop at the breakpoint set. The address display will read the data on the address bus. Further breakpoints are sought by resetting the address switches and pressing the continue switch.

The breakpoint function is outlined in Fig. 1. When the breakpoint switch is in the enable position the set signal is removed from the control flip-flop but the device remains set. RDYIN is high so the processor runs. When a comparison between the address data and address switch settings is found the COMPARE signal resets the flip-flop and RDYIN goes low to stop the processor. Pressing the continue button sets the control flip-flop again and the processor continues to the next breakpoint.

Single step. When used in conjunction with a program listing the single step mode can often reveal the obscurest of system faults. Single cycle stepping is used as opposed to instruction stepping. The address bus is constantly displayed so that when calls are executed the successive outputs of the stack pointer can be monitored. Execution of the instruction code on the display takes place when the step switch is pressed. Although single step mode is useful it is also slow so as much use as possible

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should be made of the jump and breakpoint functions.

Operation of the single step section of the tester is similar to that of the breakpoint section. When the single step switch is enabled the set signal is removed from the control flip-flop but the i.c. remains in its set state. RDYIN is high so the processor runs. After one cycle STSTB is returned from the board under test and the flip-flop is reset resulting in a change in state of the RDYIN signal so the processor stops. Depressing the step button initiates the next step.

Read. When the read button is pressed, Fig. 2, data on the address switches is read and shown on the display. The c.p.u. mode switch must be in the disabled position and the data switches off. In the read circuit of Fig. 2 a flip-flop is used to debounce the switch contact. The output of the flip-flop goes directly to the board under test and is connected into the read line of the processor using an OR gate.

Write. Provided that the data bus switch is in its enable position the bit pattern on the data switches is written into r.a.m. at the address set on the address switches. The write signal is produced in the same way as the read signal described in the preceding paragraph, see also Fig. 2.

Select. In the system for which the tester was made the i/o ports were each selected by a DEVICE SELECT signal. This signal was generated by a decoded address bus signal along with the i/o pulse generated by the 8080 when executing an IN or OUT instruction. The tester simulates the i/o pulse from the processor, Fig. 2, using a flip-flop to debounce the switch contacts and a monostable multivibrator to produce a pulse of around one microsecond. This pulse is fed into the microcomputer i/o line again using an OR gate.

The address switches determine the device selected. Remember that sometimes the decoder reads the port number in the high byte, i.e., device number 3 may need to be addressed as 0303. When the select button is pressed the data on the data switches is clocked into selected output ports. It is not possible to verify data read from input ports but this feature could be added by incorporating an eight-bit latch on the data bus of the tester.

Reset. On pressing the reset button, Fig. 2, the RESIN input of the 8224 clock i.c. goes low. Debouncing of this signal takes place within the 8224 so a simple switch will suffice in this case, Fig. 2.

Connection

Some forty connections have to be made between the tester and the microcomputer system. In the system previously described, the c.p.u. board had a built-in test connector but not all boards will be so provided. The simplest way to make the connections is to connect single test clips to the legs of the i.c. packages, picking up the signals one by one. This method is, however, tedious and errors can easily be made. Multi-way test clips with test leads soldered in position are much more convenient.

If the processor is mounted in a socket a 'test jig' can be made from a second socket. This test jig has the necessary test leads soldered to its pins and is mounted pick-a-back fashion in the processor socket. The microprocessor then plugs into the test jig.

Care must be taken when connecting the signals HOLD and RDYIN (or similar signals) to the tester. On the boards for which the tester was made there were spare OR gates in these lines which were held high with external pull-up resistors. Open collector outputs in the tester supplied these gates with satisfactory signals. If there are no spare OR gates available on the board to be tested, an alternative is to wire OR the functions if suitable open collector lines can be found.

To stop clamping of the test signals where i.c. sockets are used, the appropriate leg of the i.c. may be bent outwards so that it does not fit into the socket. If sockets are not used, either the pin of the i.c. or the associated track on the p.c.b. can be cut and rejoined after the fault has been found. The sixteen address line and eight data line connections don't create a problem as they are connected via tri-state buffers.

Modifications

A single pulse is difficult to see on an oscilloscope so I added a 1kHz oscillator to the device select circuit as an alternative to the push button.

A small r.a.m. was considered into which simple test loops could be written. An extra circuit for directing the program to the starting address of the memory would be required. Data entry using switches is tedious so a hexadecimal keypad was envisaged for loading data. At this point I felt that these modifications were too complex and decided that if such features were needed an entirely new design would be required.

Literature received

Applications manual on analogue-to-digital and d-to-a **converters** is published by Pascal Electronics. It is mainly a discussion of specification terms and error sources, with additional information on sample-and-hold amplifiers and circuit layout. Copies from Pascall Electronics Ltd, Hawke House, Green Street, Sunbury-on-Thames, Middx. TW16 6RA. WW401

Two brochures from Spectra-Physics present general information and more specific product details of ring dye **lasers** and high-power ion lasers. They can be obtained from Spectra-Physics Ltd at 17 Brick Knoll Park, St Albans, Herts. AL1 5UF. WW402

Should anyone wish to make a cardboard model of the Z-LAB 8000 **development system**, Zilog's new brochure on the equipment provides the means of doing so, together with a short description of the system itself. Modelmakers should write to Zilog (UK) Ltd, Babbage House, King Street, Maidenhead, Berks. SL6 1DU. WW403

Advice on the range of Arklone flux removal **solvents** and **cleaning plant** is presented in a brochure, available from ICI Mond Division, Dept P, PO Box 13, Runcorn, Cheshire. WW404

3M have produced a brochure on the Scotchflex range of **ribbon connectors** and the jacketed and shielded **flat cable**, recently introduced. Copies can be had from Marketing Supervisor, Electronic Products Group, 3M United Kingdom Ltd, 3M House, PO Box 1, Bracknell, Berks. RG12 1JU. WW405

Small tools to assist in the assembly of components onto printed-circuit boards are described in a booklet from Vero Systems (Electronic) Limited, 362A Spring Road, Southampton, SO9 5QJ. WW406

Application note from Norsem describes the use of s.c.rs, diacs and triacs in the **switching of inductive loads.** Copies can be obtained from Norsem Power Products Division, Level 1, The Civic Centre, Hartlepool, Cleveland. WW407

Brochure from Burndept describes a new **u.h.f. f.m. transceiver** for 420-470 links, to Home Office spec. W645T. Leaflet can be had on application to Burndept Electronics Ltd, St Fidelis Road, Erith, Kent DA8 1AU. WW408

Catalogue of **components**, tools and **hardware** can be obtained from HB Electronics Ltd, Lever Street, Bolton, Lancs BL3 6BJ. WW409

Specifications and application data for the range of ERG wirewound **power resistors** (0.3 ohms to 100 kilohms) is available from ERG Components, Luton Road, Dunstable, Beds. LU 5 4LJ. W410

Short catalogue from Bourns gives brief details of a range of **precision potentiometers** and turns-counting dials, together with a number of resistor networks, attenuators, microtransformers and microinductors. Catalogue from Bourns Electronics Ltd, Hodford House, 17/27 High Street, Hounslow, Middx. TW3 1TE. W411

Voltage-controlled filter

In the article by A. A. Thomas in our June issue "Filter design with voltage-controlled sources" a correction is needed to Fig. 5 on page 81. The negative plate of capacitor C_7 should be connected to the common rail and not to the −15V supply as shown. Also, equation (10) defines ω_0 and not ω as shown. Finally, in the Appendix, the equations for cut-off frequency, low-pass and high-pass, have a round -left-hand-bracket omitted directly before the first occurrence of the identity α^2, reading from left to right. (See also comments in a letter to the editor, this issue.)

Morse decoding program

The sudden-interference handling capability of this program described in the February issue was affected by a small error in line 0C50 of the machine code. Instruction 8C (ADC A,H) should have been 84 (ADD A,H). This error does not affect normal operation of the program but increases susceptibility to errors in decoding due to interference.

LETTERS TO THE EDITOR

AMERICAN CB NOT HOUSE TRAINED

I could not help but note the item "House trained c.b." in Sidebands of your May issue. I assume that your "house trained" means the same as our "house broken" and generally consists of training a pet dog, cat, or other animal to stay clean in a house and to use the great outdoors as a bathroom. I hope for your sake that you can establish a c.b. system that will not offend your ears in the same way that a dirty pet will offend your nose. We have failed to "house break" our American c.b. system.

"Mixer" jokes about American c.b. slang. I doubt if he's heard much. It's not funny; it's filthy, rotten, degrading and totally uncalled for. He says that slang should evolve naturally. I agree, but our evolution was more of a gradual degradation. If this is what happens naturally, I suggest that you take steps to prevent it. Maybe if you learn from our mistakes, we might be able to adopt your methods to clean up American c.b. In the meantime, I won't have c.b. in my vehicles or my house. Thank God, I'm a ham!

Martin L. Shapiro, W1YSA
Needham
Mass., USA

INVENTION OF STEREO RECORDING

Reg Williamson of Norwich brought up the subject of the invention of the 45/45 stereo disc recording system in June letters. He makes mention of the issue of some recordings by Bell Telephone Labs of experimental work done between 1931 and 1932 which includes stereo disc recordings made at that time.

Some of the history of the 45/45 stereo system has been given in my paper published in the April issue of the *Journal Audio Eng. Soc.* and in giving this talk at several meetings the Blumlein question always come up. My answers to these questions are as follows:

1. My first exposure to the Blumlein matter was by the IRE paper in the October 1958 issue written by Frayne & Davis.
2. My patent (USA Patent No. 2,114,471) was applied for in 1936 and issued in 1938. Actually our best single groove stereo records were made in 1934 and one of these was lent to the BBC in 1964. Notebook and other written records show binaural recordings made in 1928.
3. The reasons for the delay in filing were primarily due to the financial depression of the 1929 period and the lack of interest by Victor, Columbia and other Bell System licensees in promoting a system which "required two loudspeakers when people could not afford to buy one loudspeaker." This lack of interest seems to have been reflected in the delayed action by the Bell Labs Patent Department. In any case we did not publish the single groove stereo system at that time. But neither did we publish our long playing record of 1929 which was a 10in record to replace the 16in Vitaphone Talking Picture record. Other unpublished work was on gold sputtering, electronic heating of plastics, the air advance hall, etc. The essential telephone was given preference during the shortened work week.
4. Binaural or stereo records was very much on my mind, particularly single groove systems such as the multiplex system applied for in 1929 and issued in 1933 as USA Patent No. 1,910,254. This speaks of two or more channels in one groove. This patent application also mentions the moving coil pickup, now also being "reinvented," applied for in 1929 and issued in 1934 as USA Patent No. 1,981,793.
5. The work in developing a single groove stereo recorder was time consuming and difficult in getting sufficient separation between the two channels. My recollection is that the two-channel recorder by linking two rubber line recorders started about 1928 and it took several years to be considered adequate.
6. In any case, by the time that Frayne "reinvented" the 45/45 system our USA Patent expired. Frayne should be given credit for the success of the 45/45 system which we were not able to "sell" in the early 1930s.

A. C. Keller
Bell Laboratories
Murray Hill, New Jersey, USA

WAFER-SCALE INTEGRATION

The novel computer architecture described by I. Catt in your July issue has some interesting implications for experimental psychology and neurology.

It is tacitly assumed by the general public, most engineers and some psychologists that there is an analogy between computers and the human brain, so that when we finally produce a 'powerful' enough computer, a suitable program will enable it to 'think' like a man. I suspect that this analogy often affects the way that psychologists frame and interpret their experiments.

The unsatisfactory nature of this supposition can be demonstrated by comparing the facility with which brains and computers perform particular tasks. The conventional computer can answer questions requiring mathematical manipulation and iterative procedures ("What is the thirteenth root of pi") orders of magnitude more rapidly than a human. For questions involving associative memory ("Where have I noticed that smell before?"), however, the man may win by a factor nearly as great.

Mr Catt's architecture may produce machines with a performance more similar to the human brain. By enquiring further, it is possible to find more points of likeness. One feature of the brain which has aroused comment in both popular and learned journals is that it has never been possible to find (physical) areas of the brain corresponding to particular memories; excision of one piece of grey matter will not lead to loss of memory for all events which happened on June 21st or all recipes using eggs. Instead, a more general degradation of function and memory occurs. The brain has been likened in this respect to a hologram, but it may be more useful to compare it with Mr Catt's distributed processing and content addressable memory. The gradual and partial restitution of function which occurs as neural paths re-form after brain damage would then be equivalent to the reformation of a 'spiral' at switch-on.

From an engineering point of view, the construction of computers more analogous to the brain offers some attractive, if rather remote, possibilities. Much scientific and programming effort is directed towards programming machines to perform tasks which humans perform with relative ease; this endeavour might be rewarded with more success. Finally, it might perhaps prove possible to make machines which 'learn' in the way that we do, and so realise the 'thinking' computer.

Tim Thorpe
Cheltenham
Glos.

TELEVISION FOR NO-SIGNAL AREAS

I read with interest the excellent article in your May issue by J. M. Osborne on active deflectors for tv in "no go" areas. The system is very similar to one I installed for a friend in Scotland two years ago. I think there are a few points Mr Osborne failed to mention which I think might help others and these are as follows:

1. Larger aerials on the re-transmit and bottom-of-hill receiving station would give approx 6-9 dB extra received signal for extreme range cases. They would also have a narrower beam width, so minimising interference with other houses, which may be receiving a direct signal.
2. It is best to feed a.c. up the supply cable at about 24 volts and use a Radiospares or similar regulator at the top. This eliminates voltage drop adjustments at the bottom end, prevents electrolytic action on the wire should it become slightly damaged and makes joining of the wires – if they ever become cut accidentally – simple.
3. It might be easier to use standard outdoor inductive splitters instead of 50-ohm quarter-wave matching sections.

It is always useful when considering what amplifiers to use on the complete system to know what level of signal you are receiving from the main aerial. Without a field-strength meter, this can be done by gradually reducing the signal into the portable test set until the picture just shows noise i.e. just snowy. This level on most portables is about 200μV. One has then only to count the dBs of attenuators at the rear of the set, increase the 200μV by this amount and you have got your approximate signal level.

Mr Osborne shows only one pre-amp driving the 1V amplifier but in our case we had to have two: one standard 20dB masthead amplifier into one 20dB 500mV output amplifier and then into the 1-volt amplifier.

Considering there could be three amplifiers in cascade, all their inputs will have to be de-rated to stop cross modulation. The easiest way to achieve this is with a Wolsey helical constant impedance attenuator inserted between the first amplifier and the aerial. Mr Osborne's excellent semaphore signalling system can then be used to adjust for optimum results.

On our Scottish job we were unable to run a supply cable to the aerial site so we used two 12 volt car batteries which were kept charged by a 24V yacht wind charger.

I can, by the way, supply all the amplification equipment made by a leading German manufacturer at very competitive prices (e.g. £45.00 for the 1-volt launch amplifier) or my company can install any systems anywhere in the UK.

The maximum usable line-of-sight range we have obtained is 1½ miles.

M. J. Rutty, G3UPV
Frome Relay Company
Westbury, Wilts

www.americanradiohistory.com

VOLTAGE CONTROLLED FILTER

The following comments on the article by A. A. Thomas in your June issue (pp. 79-81) may be helpful.

Filters of the form shown in Fig. 2, and their low-pass counterparts, are known as Sallen-and-Key filters.

Whilst it is quite all right to use the factor alpha ($=1/Q$) as in the article, it is not the damping factor as usually defined, but twice that factor. Damping factor is unity at critical damping ($Q=\frac{1}{2}$).

The virtual repetition of a rather lengthy algebraic expression could have been avoided by writing.

phase shift (high-pass)=
phase shift (low-pass)+180°

(Name and address supplied)

MICROCHIPS AND MEGADEATHS

Not one of the five contratulatory letters in your January issue (on your leader in the November 1980 issue) answers the fundamental dilemma posed in my December letter. All seem to suppose that if *we* (UK, plus NATO) heeded your words the danger of world cataclysm through nuclear armaments would be removed or at least greatly reduced. Do they really suppose that the USSR would also heed them and reduce or stop their enormous and increasing pile-up of armaments of every kind? And do they suppose that the resulting still further increase in Soviet superiority would *reduce* their manifestly aggressive policies of which Afghanistan is only one example?

If others would do the same, no one would be more keen than I to turn over our entire armaments industry to better things. But failing evidence to the contrary one is bound to conclude that your supporters in the January issue (though I note that none appears to go so far as to back your call to actual rebellion), by favouring unilateral disarmament, are in favour, intentionally or not, of Soviet world domination. The enormous over-kill in Soviet armaments still being built up, together with the steady Soviet policy of annexation by direct or indirect invasion, leaves no alternative. So to talk of usually voting Conservative, "the concept of free enterprise being attractive", in conjunction with being in favour of reducing our arms, is short-sighted. There would be no free enterprise under Soviet rule.

M. G. Scroggie
Bexhill
Sussex.

I have followed with interest the correspondence arising out of your excellent editorial "Microchips and megadeaths" in the November 1980 issue. Mr Linfoot in the April issue suggests that members of my profession who are worried about the arms race should cease work and become a burden on society to avoid (a) risking inventing anything of a military nature and (b) contributing financially to the arms budget.

I trust Mr Linfoot was simply trying to highlight the dilemma that some expenses such as defence are forced upon us whether or not we want them, but just in case he was serious I should like to offer an alternative: all cuts in spending on the health service, education, the arts, etc. should be fully restored, and a programme of expansion commenced. Defence spending should at once be cut to the bone and all the foreign targets that litter our countryside should be sent packing to the USA or NATO or whoever foisted them on us. Then those who are so paranoid about our resultant vulnerability can take up where thousands of ordinary folk in PTAs, friends of the arts or hospital societies have left off. Instead of running bring-and-buy sales and raffles to give their kids a decent education, they can run them to buy ICBMs and cruise and Trident.

I wonder how much support they would get?

Nigel E. Bacon
Leicester.

WIEN BRIDGE OSCILLATOR

I was interested to read Mr Linsley Hood's article on Wien-bridge oscillators in the May issue. My colleague Tom Nash and I have also used opto-isolator feedback to control the gain of a Wien-bridge oscillator [1]. In our circuit, which admittedly had a different function from that of Linsley Hood, we found that the opto-isolator could readily be replaced by a field-effect transistor [2]. We also found that the system functioned well with little or no smoothing at the d.c. feedback stage. Amplitude control was thus achieved without sacrificing speed of response.

Christopher Derrett
London E17

References

1. Nash T. and Derrett C. J. *J. Physics E: Scientific Instruments*, 1977, Vol. 10, pp.599-600.
2. Nash T. *Transducer Technology*, March 1979, Vol. 1, pp.28-32.

Now that the unfortunate drawing errors in the Wien-bridge oscillator article by Mr Linsley Hood in the May issue have been clarified (see correction, p.78, June issue), I feel I should point out that the preferred "new configuration" is in fact that covered in my patent application no. 44213/59 of 1959.

An oscillator using this configuration was marketed by Solartron (Type C01008) in agreement with NRDC, in whose name the design was registered. The original version, which I designed at RRE (now RSRE), gave an output of 1Vr.m.s. with a total harmonic distortion at 1000Hz of about 0.02% – not by any means up to the standards Mr Linsley Hood is now achieving, but the complete oscillator used only four germanium transistors type 0C44! It was shown at the 1960 Physical Society Exhibition.

Peter J. Baxandall
Great Malvern
Worcs

The author replies:

I have a great admiration for Mr Baxandall's resourcefulness and ingenuity in the field of electronics. I am, therefore, neither surprised nor dismayed to discover, when I set off on some journey of adventure or exploration in this field, that I am merely walking along a path trodden many years previously by Peter Baxandall.

I am, however, surprised, in view of the very considerable advantages inherent in the use of a Wien-bridge configuration, in which the CR parallel arm is taken across a simple inverting amplifier, and the CR series arm is taken from the output of a further inverting amplifier having a gain of two, that this arrangement should have been known for as many years as Mr Baxandall's letter implies and yet not be the standard circuit in use in Wien-bridge oscillators. I can only conclude that the rest of the world is as unobservant as I am myself.

J. L. Linsley Hood
Taunton
Somerset

MEDICAL TECHNICIANS' TRAINING

I was surprised to read in "Medical technicians get a new deal" in your May issue News of the Month, that it was felt that examinations, and hence an improved career structure, should come from outside medical physics, for we in the Trent Region have been in the forefront of training in this field, having run the ONC/TEC course in Medical Physics and Physiological Measurement for seven years. Furthermore, we have encouraged students to go on to HNC level courses in medical physics, run by various colleges, or one of the specialised subjects such as electronics. However, it is very difficult to provide acceptable courses for all the disciplines and, in addition, there are two types of medical physics technician.

First, there is the technician who belongs to a recognised medical physics department, structured in accordance with Whitley Council definitions; and secondly there is the ad-hoc technician, working alone or in a small group, responsible to any department wanting technical support – for any department needing a technician is within its rights to employ whoever it wishes, pay him/her on MPT scales and actually call him/her a Medical Physics Technician.

Not surprisingly this situation has caused a certain amount of resentment among genuine physics department staffs, who have long been campaigning for improved professional standing; and, while recognising the contribution made to the NHS by these other technical staffs, we feel that the title "Medical Physics Technician" should in future only be given to a suitably trained persons employed in a recognised medical physics department.

For these reasons and in the belief that the MPT has not yet been offered adequate professional representation by existing organisations, we in the Trent Region have recently established the Institute of Medical Physics Technicians (IMPT) to represent the interests of MPTs working in recognised medical physics departments. Its aims are the organisation and standardisation of training and the establishing of communication channels between other representative bodies. The initial response would seem to indicate a significant agreement with these aims.

In conclusion, if medical physics technicians are to be recognised as professional people, then the organisation must come from within and be seen to be professional, and I would appreciate any comments or ideas from other regions.

Donald J. Turner (Chairman)
Institute of Medical Physics Technicians
Royal Hallamshire Hospital
Sheffield

ACORN MONITOR BUG

Mr J. L. Gordon's program for an Acorn microcomputer (May issue) reminds me of the existence of a murky and sometimes infinitely deep pot-hole which awaits the unwary programmer. The Acorn monitor p.r.o.m. allocates the same memory location (001A) as temporary storage space in three of the monitor sub-routines (Scan, Hex. to display and Wait). If an interrupt occurs when a main program is executing one of these sub-routines and if subsequently the interrupt program uses any one of these sub-routines, then data is lost from 001A and the program may (and can!) crash. Disaster can be prevented by saving, and later restoring, the data in 001A; alternatively the monitor can be avoided and an amended sub-routine written

into the user's program.

Although Mr Gordon's listing includes all three of the sub-routines which use location 001A, I think that, at worst, he can suffer no more than a display jolt on return from interrupt, this safety skirting the rim of the unfathomable abyss into which one of my programs once vanished.

D. J. Jeffers
Cheadle Hulme
Cheshire

CB "MENACE" TO AMATEUR RADIO

May I first compliment you on your journal's ethical approach to the problem of illegal c.b. or "open channel" operators. Many other so-called professional publications would do well to note your approach as a model of propriety. I believe there is a need for c.b. I do believe, however, that when the citizens' band is legalized, and the law – and, one hopes, the penalties – made more realistic, licensed amateurs and professional users of the v.h.f. spectrum will take a more active part in stamping out the illegal "buddies" with their "burners" and high-gain antennae operating on a.m. and s.s.b. The amateurs have tended to be ambivalent to date, envying the low cost of c.b. rigs. They will now experience the full consequential benefit of their attitude. For instance, many s.s.b. c.b. sets have a high band. This starts at 28.5MHz and, by channel 40, has reached 28.940MHz. On the way it covers neatly several well used beacons and satellite channels. Add to this the often quoted 200-watt burner, place it at a distance of a few kilometres and there goes your DX or s.s.tv project under the QRM.

It is important that we stand up and fight off this illegal menace before it is allowed to become commonplace and 28MHz is useless and another, probably non-DX band is substituted as in the case of the legitimate 27MHz aero-modellers now forced to move to 35MHz.

(Name and address supplied)

MAINS-BORNE SIGNALLING

Arising from an item in your April 1981 issue I applied to the Electricity Council for a copy of their Engineering Recommendation on mains wiring to conduct signals. I enclose the resulting document, for which I was charged £1. It will, I feel sure, be of interest to you.

As the document is headed 'Chief Engineer's Conference' one wonders just how many man-hours of deliberation were expended to achieve the result. The document seems to me to add nothing to the subject which is not already evident to any person interested enough to apply for a copy, and at 50p per page it also appears to be rather dubious salesmanship. If the Council has nothing more useful to say on the subject then they really should keep silent.

Peter J. Reen
Thyreko Ltd
London NW2

The Electricity Council replies:

Your correspondent Peter Reen seems to have expected a full technical treatise on the subject of mains-borne signalling rather than the supply industry's policy statement and background as is set down in Engineering Recommendation G22/1. I am sorry that he was disappointed in that respect.

As I am sure your readers will know there is currently available a proliferation of ideas on how to utilise electricity mains and electrical installations for the purposes of signalling. In some countries this apparently cheap facility is being exploited without due respect for safety or of the detrimental effects on the performance of other equipments. From the large number of enquiries we are receiving it is obvious there is a need to explain to potential manufacturers of such devices these wider applications as well as the present statutory position in the UK. By so doing it is hoped to avoid placing electricity consumers in a position of conflict between manufacturers, the electricity boards and other consumers.

The electricity supply industry will continue to study current developments in the field of mains-borne signalling both from the point of view of its potential benefits to consumers as well as the avoidance of the detrimental effects of "mains pollution". No doubt future editions of Engingeering Recommendation G22/1 will reflect the findings of those studies.

In conclusion may I reassure Mr Reen that it is not the policy of the electricity supply industry to participate in "dubious salesmanship" in respect of its technical documents, which are produced primarily for internal purposes and not for profit.

D.V. Ford
London SW1

ACCURATE SINE WAVE OSCILLATOR

In the June issue N. Darwood suggests generating sine and cosine waves in real time by an iterative method. Relying upon a knowledge of these values at any time, their value one step later in time can be derived by four-function arithmetic. The first iteration considered is

$$s(n+1) = s(n) + \omega c(n)$$
$$c(n+1) = c(n) - \omega s(n)$$

Initially $s(0) = 0$ and $c(0) = 100$, while ω was fixed at ½.

Recurrence relations of this sort are not difficult to solve, and yield a function that will give $s(100)$, say, without going through 100 iterations. The above relations do in fact yield sinusoids, except that at each iteration the amplitude is multiplied by a constant. Since indefinite forward iteration is proposed, this would be a disaster.

Fortunately, therefore, for reasons connected with hardware the author decided to write $s(n+1)$ instead of $s(n)$ in the second equation above. The solution does now yield sinusoids of constant amplitude, as indeed appears from the careful plot in the article.

However, there is still a difficulty. For any angle the sum of the squares of sine and cosine must be unity. Yet after only one iteration the figures given in the article appear to yield 0.81 instead!

The matter is cleared up by studying the solutions. For the plot given it can be shown that after n iterations

$$s(n) = 103.280\sin(n\theta)$$
$$c(n) = 103.280\cos((n+\tfrac{1}{2})\theta)$$

where θ is just larger than the $\omega = \frac{1}{2}$ chosen. Actually $\sin(\theta/2) = \omega/2$.

Most of this is clear from the plot. The amplitude is over 103, and the cosine function indeed leads its proper position. It clearly crosses the axis half a step before sine reaches its peaks.

Thus the author's essential point has been fully established: his iteration does indeed produce pure sinusoids lasting for ever.

Calling a sinusoid a cosine, however, is only a way of saying that it is 90° out of phase, when compared to a reference sinusoid called sine. Thus although a second sinusoid has been produced, it cannot be used as a cosine, and the difficulty about sums of squares disappears.

Frequency also needs a little attention. From the above solutions it appears that the period of a full sinusoid is $2\pi/\theta$ times the iteration time, which is just under the $2\pi/\omega$ times suggested. The percentage error varies as the square of ω, and is only about 1% at $\omega = \frac{1}{2}$. But a crystal oscillator should show a noticeable difference.

It is recognised in the article that rounding errors will occur. By inspecting the general solution one can see that with the author's improved algorithm they cause no instability, but alter the phase and amplitude slightly. Owing to the irrational nature of π it is difficult to know whether such errors will accumulate. One may argue that they don't, at least on one's own system. A better approach might be to restart the iteration from scratch when an iteration occurs near the end of a cycle.

For example, if $\omega = \frac{1}{8}$ then in four cycles there are 200.93 iterations. So one might cancel the 201st iteration when it is called for, substituting instead the initial starting values. Careful selection of starting values will ensure that this occurs near a maximum, where there will be minimum discontinuity. Every fourth cycle would be stretched for a time of 0.07 iterations, which is 0.14% of a single cycle.

Certainly this procedure introduces a small error. But some error must exist in every system. For example, ideally nine of the twenty six results offered in Table 1 of the article need to be rounded up one in the last digit. Restarting the cycle as here proposed would indeed yield a known small error, but one would have the security that rounding and other errors cannot propagate, perhaps grow large, and then last for ever.

For many purposes, however, the simple implementation proposed will be very attractive.

M. McLoughlin
Haberdashers' Aske's School
Elstree

FLASHER PUZZLE

The era of semiconductors has produced an array of smaller handy devices, one of which is the bulb-flasher appearing in various forms.

Back in the 1950s, before this era had properly emerged, I purchased from an American electronics supplier a button-like object, plastic with a metal centre, which was inserted between an ordinary household bulb and the 110 volts mains supply socket. Behold, a 60-watt flashing bulb!

Perhaps readers might find it intriguing to speculate on the principle on which this little flasher works (at present in my 15-watt hall light working on 240 volts).

A. R. Purssglove
Sutton, Surrey

WE TAKE A DELIGHT*

In these days of gloomy news from the world in general and from our own country in particular, it is perhaps more than usually excusable to laugh when somebody slips on a banana skin, especially when the body is one of the mighty. I expect, therefore, that I am not the only reader to have felt a little satisfaction on reading an advertisement in the *Radio Times* and in some of the colour supplements for a National-Panasonic television receiver under the slogan "as sophisticated in the bedroom as it was in the drawing room."

As well as the usual blurb about "innovative" design etc., there is an exploded drawing of the works, in which three electron lenses are shown as convex glass lenses complete with reflections

*"... in having a french widow in all rooms, affording delightful prospects," – said to have been found in an advertisement by an hotel somewhere in the vicinity of the Aegean sea.

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of a four-pane window; and the text ends with the memorable statement, "which means that thanks to the efforts of our drawing room, it's easy to watch this TV in any room in the house."

Perhaps our own manufacturers should provide drawing rooms, elegantly furnished, quiet, and nicely removed from drawing office and laboratory, and encourage their draughtsmen and others to repair thither around 4 o'clock for best-quality tea (Rington's) served from Royal Worcester pots; cucumber sandwiches, and other things to match. But then I never have believed that inadequately washed earthenware mugs and lab tea are conducive to good work of any sort.

E. F. Good
Darlington, Co Durham

COMMERCIAL BROADCASTING

In the April 1981 issue a criticism of commercial broadcasting was launched by F. V. Bale, particularly, I think, with regard to the advertising it carries. My immediate reaction (and perhaps therefore the most reliable one) to this was one of complete sympathy with the mood of the letter, though he seemed prepared to exact a high penalty as the price of their success and excess.

However, later reflection brought to mind chapter 25 of "The New Industrial State" by J. K. Galbraith, where the point is made that "organised public bamboozlement" is a necessary and acceptable part of society – any society – from witch doctor through ivory tower to think tank. The rigid democracy he mentions would surely be the more so if only one organisation was allowed the monopoly of a particular medium, although scepticism about the immediate benefit to the quality of life to be gained by a proliferation of channels is understandable. It might increase the probability that among the infinity of re-runs of older films there would be just one showing of "A face in the crowd".

D. Brooks
Blackburn, Lancs

JAMES CLERK MAXWELL

Mr Wellard (March and May issues) attributes the change from the classical physics of Clerk Maxwell's time to the interpretation of three experiments – Michelson and Morley's measurement of the velocity of light, Thomson's experiments with cathode-ray tubes and Planck's measurement of the frequency distribution of black body radiation.

However, while Planck developed quantum theory to explain the frequency distribution of black body radiation it soon proved to have many other applications. It explained the dependence of the photo-electric effect on the frequency of the incident radiation, it explained Balmer's formula for the lines of the hydrogen spectrum and other similar formulae, it helped to explain the chemical properties of different elements, and it has continued to explain many other phenomena, such as the behaviour of tunnel diodes and of liquid helium.

Soon after Thomson's experiments, Millikan measured the charge of an electron in an experiment that showed that charge changed in discrete units, and the view that electricity is carried by the movement of charged particles has explained a huge range of other phenomena, for instance shot effect noise and transit time effects in vacuum tubes.

Michelson and Morley did not assume that the sun was the centre of the universe but only that the earth was not stationary in absolute space, both because of its motion round the sun, which was a known velocity, and also because the sun was moving with respect to other stars. Also, movement through a fixed ether would produce not only changes in frequency from the Doppler effect but also differences in the measured velocity of light according to whether the velocity was measured along the direction of movement or at right angles to it. And the Michelson Morley experiment tried to measure these differences in velocity.

Thus, Mr Wellard grossly underestimates the amount of evidence supporting quantum theory and the carriage of electricity by charged particles and completely misrepresents the Michelson Morley experiment.

Lindsay of Birker
Chevy Chase
Maryland, USA

The author replies:

Lindsay of Birker provides much food for thought. The sun was assumed to be at the centre of the universe until the Mount Wilson telescope was commissioned in the 1920s. Michelson and Morley's interferometer could not measure the velocities of light waves. Hertz noticed during his series of experiments that the efficiency of his spark gap was improved when the gap was irradiated by ultra violet light. This increase in efficiency was later found to affect only the negative pole of a spark gap. There is a connection between this phenomenon and the action of a radio valve or a cathode-ray tube – energy is radiated only from the cathode or negative pole. The sun or any other active star is continually radiating electrical energy, and can be compared with a negative pole or cathode. The sun is a volume in space occupied by a quantity of active electrical energy, and that active energy will one day be totally dispersed throughout space. As a negative quantity of electricity cannot possible exist, the idea that negative quantities of electricity are carried within the volume of space occupied by a particle, the electron, is illogical.

Maxwell's mathematical interpretation of his theory was that the energy of the electromagnetic field was "in two forms, which may be described without hypothesis as magnetic polarization and electric polarization." We should not confuse the mathematical positives and negatives of polarization with positive and negative quantities. I cannot agree with Einstein's theory that Planck's packets containing constant quantities of electricity are accelerated from a state of rest to the velocity of light in zero time. A force is the product of a mass and an acceleration and acceleration takes time. An infinite acceleration produces an infinite force and therefore an infinite amount of energy. The equation is absurd.

THE DEATH OF ELECTRIC CURRENT

I was pleased to note that Ivor Catt, in his reply to my letter (March issue), gave yet another example of the truth of its principal assertion. Before dealing with this latest example of nit-picking, it would seem advisable to tackle the question of reality. I think that most readers of this journal would agree with the physical reality of the phenomenon whereby energy converted at one location can be transferred, with or without the aid of an intervening medium, to a distant location. If you wish to call that electromagnetism, then, certainly, electromagnetism exists. However, to explain the phenomenon we have developed, over the years, a complicated model which includes such concepts or constructs as E, H, ρ and J. Since they are part of the model, these constructs no more have reality than a ventriloquist's dummy has life. As a further consequence, any model that shows that electric current does not exist shows nothing more than that electric current is not needed in that model.

The credibility of a model, or its implications, can be a stumbling block. Kepler's problem was that the central construct of his model could be refuted by the observations of any normally-sighted layman on a fine day! Clearly, the attitudes of electrons to the implications of the electric current model are beyond conjecture. Whether we see the detail seized on by Mr Catt as a problem depends on how we model electrons themselves; if we see tham as diminutive billiard-balls, then Mr Catt's problem may be real, but if we use a probabilistic model things may not look so bad. In any case, credibility may be affected by extraneous factors, such as religious beliefs (Kepler again) so that other means are used to test the viability of a model.

We require first that the model be mathematically rigorous (and I have been led to believe that Heaviside tended to be lax in this respect) and then test the model in the light of its agreement with observations. Hence, Kepler's model survived because it fitted stellar and planetary observations better than its rivals. Similarly, electric current theory gives results that agree well with observations –

$$i=I_0e^{-\frac{t}{CR}}$$

gives a close fit to the observable effects when a capacitor discharges through a resistor. The finer the detail of the agreement, the better the model, although it never becomes reality.

Now physicists realise that models can be refined, or replaced by better ones, so that the other test concerns the predictions of the model. What new facts or relationships does the model offer, and can they be tested by observation? Note that a model is not refined simply by making its structural details more credible to the user, because of the subjective nature of that assessment. If Mr Catt has, indeed, a better model could he not tell us either where it gives better agreement with known results or what testable predictions it makes? Until then, I suspect that most of us will continue to muddle through with the current version.

To end on a personal note, I would like to assure Mr Catt that there is no truth in the rumour that it was I who applied the torch to Bruno's pyre.

R. T. Lamb
Post Office Telecommunications Headquarters
Milton Keynes
Bucks

CB DISTRESS CHANNEL

In your news article "C.b. specification published" in the June issue, I notice that it is stated there will be 40 channels. As an ex radio officer of the merchant service, and remembering that in the maritime and port operations v.h.f. service there is a distress, emergency and safety channel, i.e. channel 16, I would like to suggest that a channel be designated, in this new c.b. band, for the purpose of catering for distress, emergency and safety. Such a channel would be used for no other purpose. Additionally, there should be a guard band on either side of the distress channel, with the same restrictions.

J. Courtenay-Kirkpatrick
Wigan, Greater Manchester

From the day the UK citizens' band service starts, Channel 9 will be the official distress channel and will be monitored 24 hours a day. An organisation similar to REACT in the USA will come into operation to deal with the distress calls. – Ed.

Microprocessors in the gas industry

Digital experiments at British Gas

Digital electronics are playing an increasingly important role throughout industry. Here we take a look at some of the applications that are being researched by British Gas at their Engineering Research Station, Killingworth, near Newcastle upon Tyne. As they are responsible for digging so many holes in the roads, it is not surprising that many of the projects will help them to locate the best place to dig, by locating the pipes or the leaks. Radio communication within a limited bandwidth and a novel way to measure the contents of a gasholder are two other experiments which will lead to improved efficiency in the operation of the gas industry.

The pipeline system operated by British Gas would stretch around the world six times and it is being extended or replaced at the rate of 300 miles every day. In addition half a million holes were dug by British Gas last year – and each cost about £250. Not surprisingly, British Gas moved 40 million tons of earth last year. There will always be a need to dig holes in the road, to replace old pipes or repair damaged ones. But it is obvious that improved accuracy in detecting the position of a pipe would save the industry millions of pounds a year. It would also help excavation gangs to avoid damaging pipes or cables laid by other utilities.

Commercial pipe locators exist but the operators need special training and regular practice, and the equipment cannot be used successfully in congested area such as town centres.

Ideally, each excavation gang would be provided with compact, hand-held, inexpensive equipment that would locate all buried plant with both accuracy and good resolution. While it is possible to approach this ideal in terms of the location of metallic plant, it is not possible to detect plastic or non-metallic plant with simple hand-held equipment. Equipment currently available is unsatisfactory in terms of resolution and simplicity of operation and is incapable of detecting non-metallic plant.

Following the failure of commercial organisations to respond to the gas industry's needs, the Engineering Research Station (ERS) of British Gas started to develop two parallel and complementary types of location equipment. Although both use electromagnetic field techniques the compact equipment employs a low frequency induction or magnetic field to achieve detection of metallic plant, whereas the more sophisticated equipment for non-metallic plant uses the radiated field in the lower microwave frequency region.

ERS has developed an experimental instrument called GASCOPACT, acronym for GAS COrporation Pipe And Cable Tracer, which uses magnetic field detection. GASCOPACT is a considerable advance on currently available commercial equipment. The instrument has two parts, a transmitter to induce eddy currents in the ground and a receiver to detect the induced current that will flow in buried pipes or cables. The receiver uses an array of sensors to accurately locate the position of the pipe or cable. This array is the basis of an automated receiver which gives a digital readout of pipe or cable plan position. All the functions of sensitivity, tuning, etc, which make the operation of conventional instruments awkward have been eliminated by automatic control circuits. The receiver l.c.d. display provides an 'X' indication when the receiver is right over the pipe and an 'O' indication when near the pipe. The receiver monitors correct operating conditions, indicating when out of range by displaying 'L' for low field and 'H' for high field when too close to the transmitter. If the receiver batteries are exhausted the circuitry monitors that condition and displays 'F' for flat.

Careful use of the transmitter can resolve very closely spaced pipes to a much higher level than conventional equipment. The instrument is now undergoing limited field trials and has been shown to possess a tracing range of about ±70m about the transmitter, but under favourable conditions can be three to four times this distance. It can locate pipes and cables at depths up to 2.5m.

Once the trials are successfully completed it is planned that a manufacturing contract be placed for production models. Thus an effective, simple-to-use pipe and cable locator may become available to British Gas excavation gangs, easing their work and improving operation and hence – one hopes – giving better service to the customer.

Ground probing radar

The first polyethylene gas main in the UK was laid in 1968. Usage has grown to the point where 80 per cent of the 4,200km of gas mains laid each year for new supplies or as replacements to the existing system, and 90 per cent of the 65,000 services, are in this material. However, new technology such as this requires new instruments and one problem is the accurate location of the new pipe underground.

Conventional low frequency pipe locating instruments which operate by detecting the magnetic fields associated with electric currents deliberately induced in pipes cannot sense the presence in non-metallic objects such as plastic and earthenware pipes and ducts. An instrument capable of reliably locating all types of underground services would assist in improving the efficiency of excavation activities by allowing the use of mechancial digging equipment.

Radar techniques have been successfully used in the past to detect objects or geological features under the earth's surface. Examples of this are radars used to determine the thickness of ice in polar regions; to detect the presence of tunnels (used in Vietnam); to locate explosive mines buried just under the surface; and to measure the thickness of coal seams in mines. These past developments have led to the marketing of several radar systems, mainly by US companies, intended for the purpose of locating buried plant and services. However, none possesses the level of performance necessary to operate successfully in the congested streets of Britain's towns and cities.

High frequency energy

Ground probing radars are similar to conventional radars in that bursts of very high frequency electromagnetic energy are radiated from an antenna. The reflections from distant objects are then collected, usually, but not always, by the same antenna, amplified, detected and displayed so that an operator may obtain information not available by any other means. Normally, conventional radars operate over very large ranges (usually several hundreds of kilometres) and the transmission medium (free space) does not absorb energy. Ground probing radars on the other hand must operate over extremely short ranges (several tens of centimetres), and the transmission medium (the ground) is an extremely effective absorber of energy at the frequencies (approximately 1.0GHz) which must be used to obtain adequate resolution. In addition, the antenna of a ground probing radar leaks energy into free space which is also re-

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flected from objects and will be detected by the radar. These signals are usually much larger than those received from targets buried in the highly absorptive ground and tend to obscure them. Such unwanted but interfering signals, of 'clutter', are a very severe problem in ground probing radars.

Possible methods

Within the broad description of ground probing radars, there are several possible methods of implementing a system: –

- Microwave imaging. This is a continuous wave or unmodulated radar where an image similar to an optical image is mathematically constructed for systematic measurements taken in a plane horizontal to the ground.
- Passive microwave imaging. Similar to the above technique but the instrument does not transmit any energy but detects the natural emissions from objects within the beamwidth of the antenna.
- Short pulse radar. Pulses of energy lasting 10^{-9} seconds are transmitted using special antennae. Most conventional radars use this technique but with pulses lasting 10^{-6} seconds.
- Frequency modulated continuous wave (f.m.c.w.) radar. Conventional radar altimeters use this technique to accurately determine altitude.

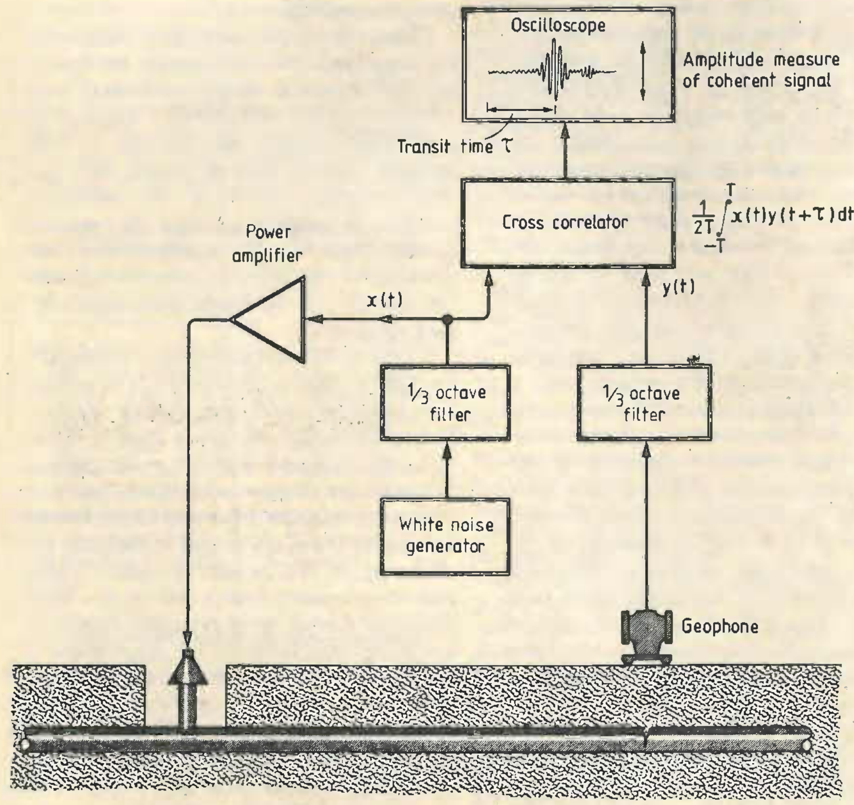
Of these four techniques, ERS is actively working on short pulse and f.m.c.w. techniques as being the approaches most likely to offer solutions. Progress in the other techniques will be monitored as part of the development programme.

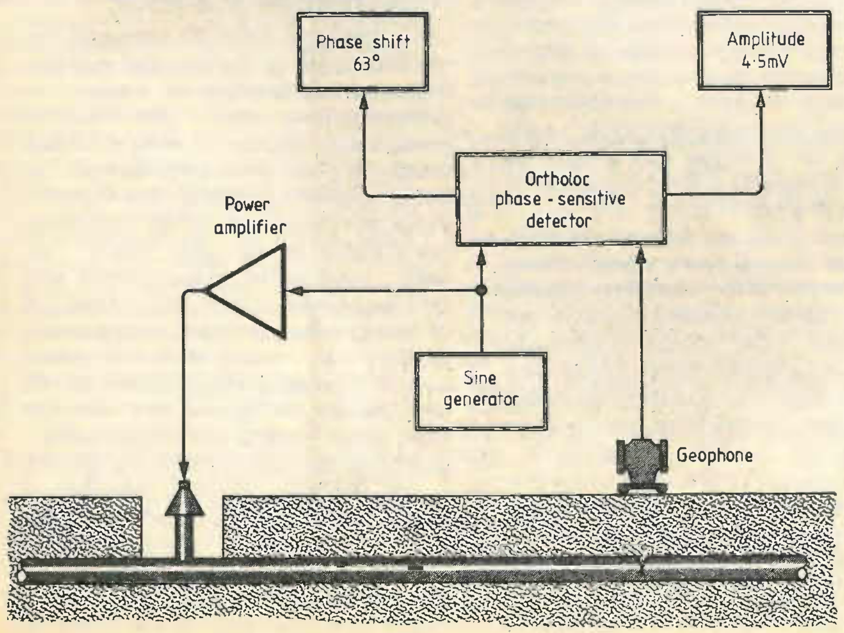
British Gas has sponsored a study into f.m.c.w. radars which was carried out by Queen Mary College, Univerity of London. As a result, a prototype radar system has recently undergone small scale field trials, the results of which have improved our knowledge of the operational characteristics of ground probing radars.

In summary, therefore, various solutions to the problem of detecting underground services using radar techniques are possible. ERS is pursuing two such approaches. The work so far has indicated that the most significant problems are the highly absorptive nature of ground and the large extraneous signals caused by unwanted targets to which, perhaps, insufficient attention has been paid in the past. A systematic study into the feasibility of radar techniques is being carried out and careful microwave design and sophisticated signal processing and pattern recognition will have to be developed to implement a unique development.

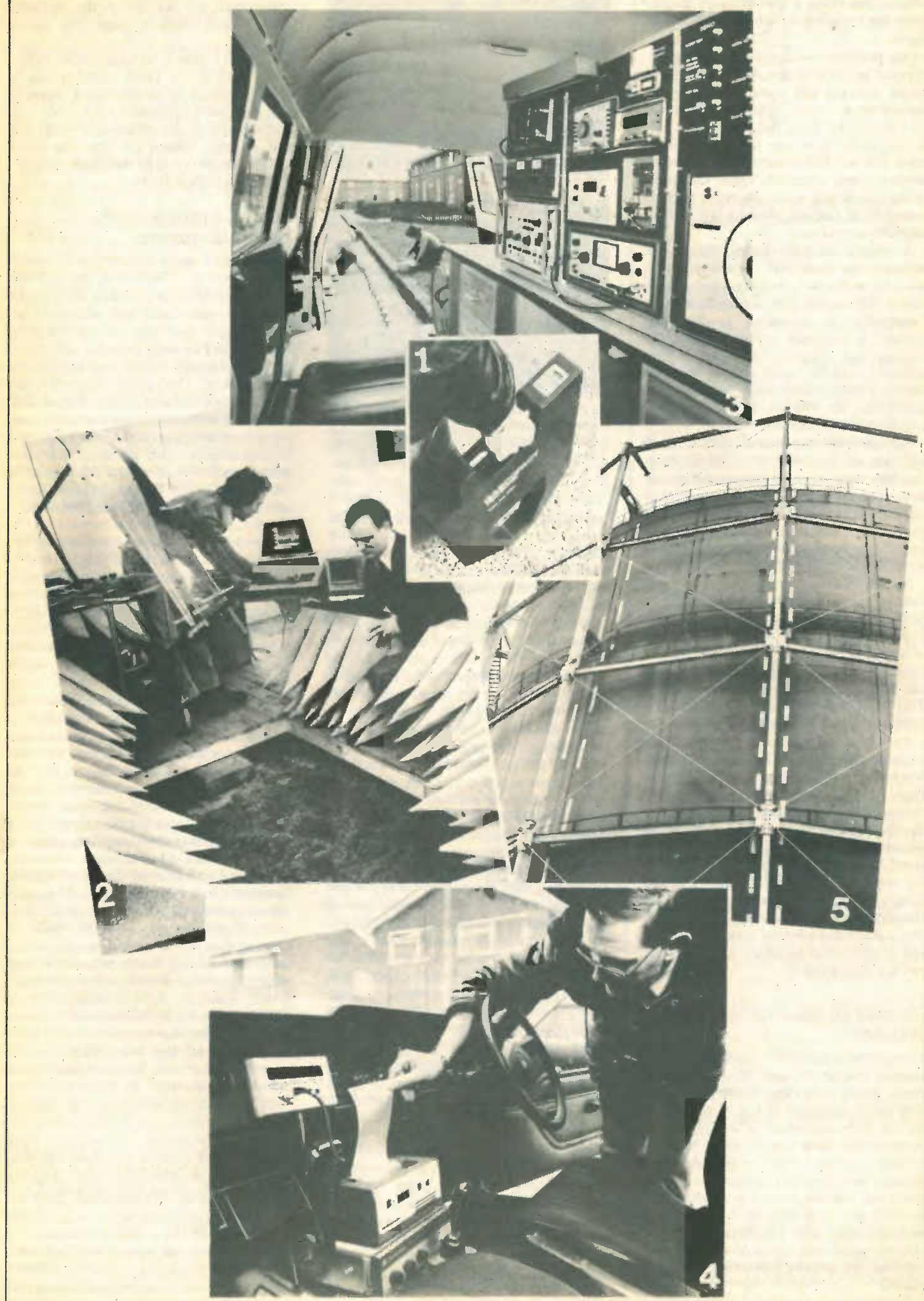
Acoustic leak location

It is important that the position of any gas leak is determined within one metre to avoid unnecessary digging. This position is normally deduced from concentration of gas in the soil above the suspect pipe; the leaks generally lying beneath the points of highest concentration. Samples of the gas and air mixture are obtained by probing through the road surface into the soil below. This technique is usually successful, but sometimes confusing results are ob-





Two methods of detecting leaks with sound waves



1. The 'X' displayed by the Gascopact locator indicates the position of the pipe. 'O' would be near the pipe, 'L' that the signal is too low, 'H' that the signal is too strong, and 'F' that the internal power supply is low – flat battery. A microswitch in the handle switches the instrument on automatically when it is lifted.

2. An experiment to locate pipes using microwave radar. The portable anechoic chamber surrounding the test site would not be necessary in practice.

3. Placing geophones to pick up the sound emanating from a gas leak, and the vanload of electronics used to locate the leak. This is at an experimental stage and it is thought that the equipment would be more compact when a practical system had evolved.

4. A service fitter returns to his van to find a print-out waiting for him with details of his next job. He can acknowledge the call or send a number of standard messages by pushing the appropriate button on his set. Speech contact is also possible if needed.

5. The Gray scale reflective strips on the side of this gasholder can be used to measure, very accurately, the contents of the holder.

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tained. A method free of ambiguity and able to determine a leak position directly from the surface will have obvious advantages.

One possible new approach is being developed at ERS. Sound waves are introduced into the gas using a loudspeaker excited by a known signal. These waves are transmitted along the pipe by the gas. At the point of escape the sound waves drive the soil into sympathetic vibration where gas and soil meet. These vibrations in the soil radiate outwards, with part arriving at the surface, where it may be detected by geophones.

A vehicle-mounted system using this principle has been built for experimental use. On arrival at a reported leak site, a line of the suspect pipe is traced, and the loudspeaker is connected to the pipe through a standpipe within 50m of the probably leak position. The system is then activated, and the surface above the pipe surveyed progressively using an array of 16 geophones set 300mm apart, to detect acoustic radiation from the leak.

Signals from other sources such as buses and cars are generally 30 to 40dB above any leak signals, thus preventing simple detection of leaks. Cross-correlation methods have therefore been used to reject the incoherent external signals, and receive the signals from leaks which are coherent with the loudspeaker drive.

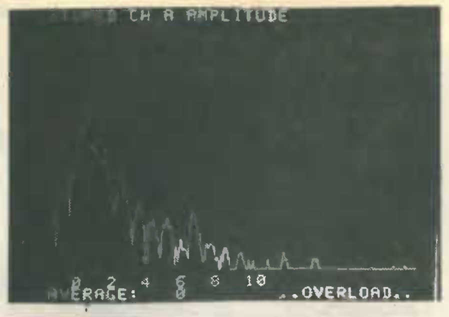
Measurements at experimental and real leak sites show a potential ability to locate both pipe breaks and weeping joints. Three artificial breaks were located, while at nine real sites, six leaks were located correctly, one was correctly judged to contain no leak and two gave false indications. This work will continue to validate the method as a leak locating tool.

Further development of the equipment is proceeding to improve the ability to detect low level leak signals and reduce the time to locate a leak. In particular a multichannel digital correlator is being built to handle signals from many geophones simultaneously, this will have the additional benefit of increased signal recovering power. The ultimate objective of this development is a practical instrument suitable for use by non-scientific staff wherever a leak from a buried pipe is suspected and conventional techniques are not fast enough to pinpoint it.

Control of gas holder stations

Low pressure gas holders still play an important role in the gas distribution network. Being very close to the customer, they allow variations in the local demand for gas to be smoothed to that the trunk transmission lines can be sized to meet average, rather than peak, demand. Holders are, however, extremely costly to build and suitable sites close to centres of demand are very difficult to find. It is therefore important to make maximum use of existing holders, and to do this an extremely reliable height measuring system is needed.

Conventional methods of measuring



By taking a radar picture of the ground and then subtracting that from the composite picture of the ground with pipes, it is possible to leave a picture of the pipes.

holder height all involve moving parts and, because of this, occasionally fail. Typically, a 15 per cent margin has to be allowed. This 15 per cent of wasted capacity represents substantial investment and it is clearly worth considering possible methods for reducing it. In the ERS system, an arrangement of coded strips on the side of the holder is read either by infra-red sensors detecting the presence of reflective strips or by microwave sensors where the code consists of small corrugated sheets and the microwaves are dispersed by the presence of a sheet. In this way the gas holder is in effect made into a linear digital transducer system. No moving parts are needed and hence the inherent reliability of the system is high.

Reliability should be further enhanced by using a microprocessor software programme employing an error correction technique. Here the microprocessor is programmed to accept only a height reading that changes by one unit at a time. If it sees an apparent height change greater than this, it will recognise that an error has occurred, deduce the nature of the error, correct for it and send a signal to headquarters indicating the presence of a fault. Several more faults can be allowed to develop before repairs become necessary; thus maintenance can be carried out at the most convenient time.

In addition to the error correction function the microprocessor can also be used to determine which gas holder at a holder station containing a number of holders is used in accordance with a programmed sequence depending on plant operating conditions. By introducing transducers to measure solar heating effects, it will also be possible to adjust operating limits to cater for gas expansion or to control gas input-/output conditions if the holder is full. Should the telemetering link to central grid control fail then the microprocessor will take over in accordance with a stored programme and perform all the necessary local control functions until the link is restored.

The ERS hope to develop the microprocessor unit to the point where it can be used to control all the governors, boosters and associated equipment on a holder station site. With an integrated system like this, accurate control will mean the holder station can be run at its optimum capacity, safely and economically.

Digital mobile radio communication

British Gas is an extensive user of mobile radio systems for the efficient management of field staff. The number of vehicles equipped with radio has recently been growing and they claim this is evidenced by improved customer service and ability to respond rapidly to customer requests for attendance. Currently some 15,000 vehicles are fitted with mobile radios. This increase in numbers means that more messages have to be passed over the air, which of course uses more air time. With the present radio spectrum available to mobile radio users in the UK, an increase in the number of messages could lead to congestion and delay.

Against this background other significant developments are beginning to emerge from within the user departments in the application of computers for job scheduling and the organisation of records. If vehicle users could be given access to these systems while in the field a further increase in operational efficiency would result.

There is clearly a need to reduce call durations if the congestion problem is to be relieved. By making use of data transmission techniques to reduce the time taken to contact the mobile and pass the message it would be a relatively simple step to interface the mobile radio system with the new work scheduling computer arrangement and provide direct access to them from the field vehicles.

An analysis of British Gas mobile traffic revealed that it takes more than 40 seconds to issue job details to customer service field staff. Replacing this voice dictation by transmission of the text in digital form to a printer or display in the vehicle will provide a significant reduction in transmission time. Even at modest data rates of 300bits/second a four-fold speed improvement can be expected.

This pay-off has been recognised for some time but over the past five years a number of attempts to apply traditional data transmission techniques (as used in telephone circuits) to mobile radios have met with little success. Work done at ERS, however, has pointed to a data transmission technique which can cope with the imperfections of a mobile radio channel.

The system

Characters are transmitted using seven-bit ASCII and to each character an eight-bit protection code is added to form a data sub-block. Data messages are transmitted

using long blocks of 48 characters. Status functions and acknowledgements use a short block of eight characters. Both types of block have their bits interleaved on transmission and de-interleaved on reception. This technique ensures that long error bursts that occur during fades will be distributed over the block lengths as small groups of one or two errors per character which is within the power of the error correcting code. The error correcting code used will correct up to two errors in any sub-block with certainty and if more than two errors are detected an asterisk is printed in place of the character.

In addition to the normal error correction, further protection is given to numerical characters transmitted in the long data block. When numerical characters are contained in a message the blocks are formed as normal, but in addition the numerical characters are incorporated twice within the 48-character block. On reception the numerical characters are checked for a match with the corresponding repeated one. If they do not match the data block they will be rejected and a re-transmission will be requested. This technique almost eliminates the possibility of a number being printed in error.

Both long and short data messages are always acknowledged by a short data block to indicate that messages have been received. The acknowlegement will contain information on whether the message has been received correctly or with uncorrectable errors. If no acknowledgement is received or the acknowledgement indicates that more than the predetermined number of errors were received the data message block will be re-transmitted. The present protocol allows a message block to be re-transmitted three times before it is aborted and the operator informed of the action. The acknowledgement strategy is arranged so that the mobile always makes the last reply allowing the control to know that mobiles have received data before moving on to the next message.

Each data block is preceded by a 16-bit preamble and a 32-bit synchronisation word. The synchronisation word is in a special code which is unlikely to be found in a data block and has a very low probability of being generated by random noise.

The system transmits and receives data at 300 bits/second and the data waveform causes the output signal to the radio to be frequency shifted (f.s.k.) between 980Hz and 1180Hz. The 300Hz clock information amplitude modulates the f.s.k. waveform to enable an accurate clock to be recovered at the receiver end.

System hardware

A prototype field evaluation package has been constructed. At the mobile radio control point, a desk-top computer is used to control the system. Data messages are fed from the computer via an RS232 interface to a "data preparation module". this module consists of microprocessor controlled hardware; this adds the error correction and interleaves the data stream for the transmit direction and de-interleaves the data and does the error correction for the receive direction. It also contains the 300 baud f.s.k. model which is connected to the radio system. The interfaces to the radio control unit are normally made at the microphone input circuit and at the audio output circuit before the loudspeaker volume control.

At the mobile end the audio output is again taken so it is independent of volume control settings and the data input being interfaced at the microphone connection point. The mobile data unit which is connected to the radio contains microprocessor controlled hardware to encode and decode the error correction process as well as drive the mobile printer. Status conditions are entered via a simple keypad.

System functions

The mobile installation is able to receive both long and short messages which allow the functions listed below to be performed. Mobiles will receive all data messages, but only decode messages containing their own callsign code. Callsigns consist of one letter and two digits.

- Receive and print typical work issue messages which normally consist of two long data blocks. The system will, however, allow up to six blocks to be transmitted to build up a longer printed message.
- Receive a short message containing selective call data and light the indication lamp when a valid code is decoded.
- Allow normal speech operation, but the press-to-talk function is inhibited while the mobile is transmitting or receiving data.
- Transmit acknowledgement to all data messages received.
- Transmit up to six status conditions which can be identified as required.

The software at the control end allows the following operations to be performed via the data link.

- Selectively call any mobile.
- Display the queue of waiting mobiles.
- Send one of three standard messages held in the store.
- Send user messages entered via the keyboard.
- Highlight the emergency status on the screen when received from a mobile.

The future

A multi-base station system for operational use is at present being studied which will be based on the principles of the simple single base station system described above.

We would like to thank Dr Mike Sporton, the manager of the Electronics and Instrumentation division of the British Gas Engineering Research Station, and his colleagues for their help in compiling these notes.

IN OUR NEXT ISSUE

Distinguishing 'amplifier sound'

Some audio enthusiasts claim to be able to distinguish the 'sound' of an amplifier from that of other equipment in a reproducing chain. This article first discusses the subjective aspects of the experience then describes objective laboratory experiments to verify whether this claim is justified.

Microprocessor interfacing

First of a short series on methods for connecting microprocessors or microcomputers to other equipment, e.g. for measurement or control applications. Part one describes a "universal" interface board with a-d, d-a and other functions suitable for use with any of the popular 6502-based microcomputers.

Multichannel digital recorder

Using an ordinary stereo cassette recorder and some digital electronics to construct a 12-channel instrumentation type recorder with zero wow and flutter. Number of channels can be reduced to two, improving bandwidth from 70Hz to 420Hz. S/n ratio of played-back analogue signal is 60dB.

On sale 16 September

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Improved custom-designed l.s.i.

Faster, more dense uncommitted logic arrays

Advertisements for Sinclair's ZX81 personal computer mention its British custom-designed "master chip" but do not go into the details that this is a Ferranti device designed from an uncommitted logic array (u.l.a., an array of standardized logic cells on a chip subsequently interconnected by a metallization layer to form the required system). This is a good example of the use of u.l.a. custom design to reduce the number of i.cs required – and hence the cost of manufacture – in a consumer product. So is the Leica camera on our front cover this month, which includes a Ferranti u.l.a. chip as the main processing unit of its light measurement and exposure control system for automatically determining shutter speeds. There has, in fact, been a wide variety of applications for this firm's u.l.a. process, in both consumer and professional products, ranging from a Black & Decker drill speed control system to British Telecom electronic telephone exchanges.

The majority of u.l.a. custom designed i.cs are made by bipolar processes. Ferranti in particular have developed the Bell Telephone Laboratories collector diffusions isolation (c.d.i.) bipolar process for this purpose.* This so far, throughout the 1970s, has allowed the manufacture of u.l.a. chips containing from 100 to 2000 logic gates. But recent demand for greater chip complexity and higher performance, as we move further into the era of l.s.i. and v.l.s.i., has caused this firm to develop a more advanced type of u.l.a. for custom-designed circuits. The aim has been to produce devices with up to 10,000 gates on a chip, propagation delays characteristic of emitter-coupled logic, e.g. down to less than a nanosecond, and gate power dissipation levels comparable with c.m.o.s.

This has been done, claims the company, with a new bipolar process which is similar to c.d.i. in being simple and therefore requiring only a small number of masks – a desideratum for economic yields in manufacture – but which in fact uses six masks instead of the five required for c.d.i. A cross-section of a bipolar n-p-n transistor made in the new process is shown on the right, alongside a corresponding transistor in c.d.i. It will be seen immediately that it is smaller. In fact the minimum "feature size" is now 3μm and with a smaller emitter structure the improvement in packing density of devices on a chip is claimed to be about 2:1. The extra, sixth, mask is used to remove the non-selected p+ diffusion away from the isolation diffusion in c.d.i. (see footnotes). This reduces the capacitance at the critical collector/base junction and results in an improved speed-power performance, higher voltage capability and the availability of a p-channel junction f.e.t. by further masking of the p+ region under the transistor emitter. Capacitance is also reduced as a result of the smaller emitter structure mentioned above.

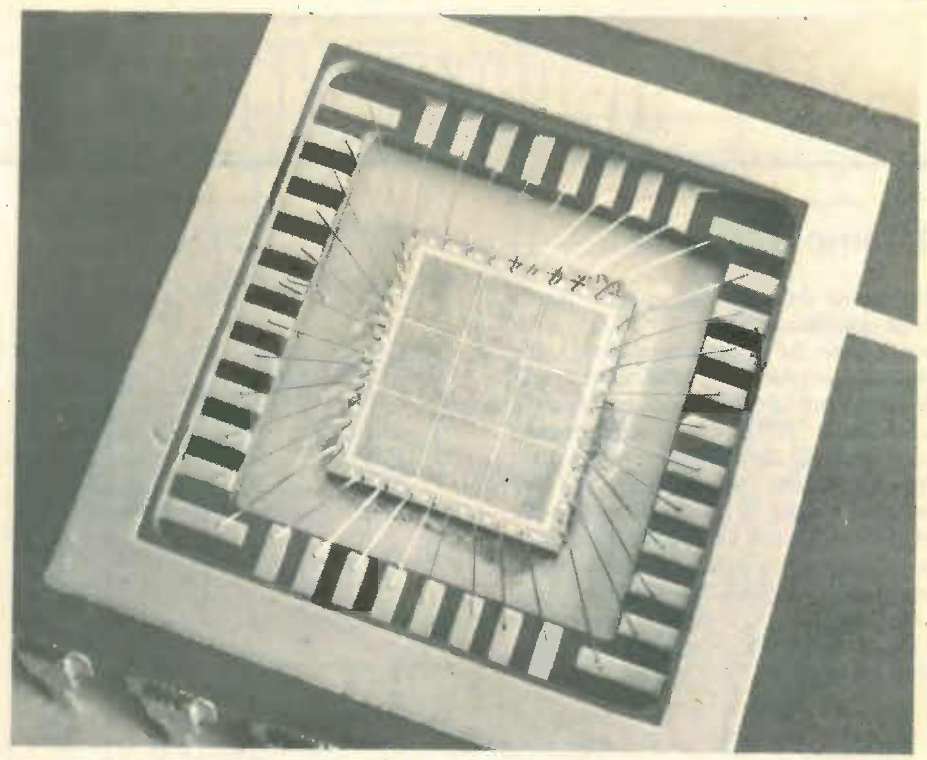
A recent camera, the Minox GT, using u.l.a. chip as part of its exposure automatic control system.

The new uncommitted logic arrays for custom design arising out of this new process offer chip complexities varying from 500 to 10,000 logic gates and gate delays varying from 15ns down to 0.5ns. One group, in the l.s.i. bracket, includes five arrays of 500, 900, 1,200,1,600 and 2,000 gate complexities. Each array has three gate delay/gate power categories, 2.5ns, 300μW; 7.5ns, 60μW; and 15ns, 30μW. These arrays are available for design work now. A second group, of v.s.l.i. devices, comprises two arrays of 4,000 and 10,000 gate complexities. In each case the gate delay is 2.5ns and the gate power 300μW. Engineering samples of these will be available by the end of 1981 and customers' designs will be accepted during 1982. Finally, a third group, described as "sub-nanosecond" u.l.as, provides 1,000, 2,000 and 4,000 gate arrays with gate delays of 0.5ns, 1ns and 1ns respectively. These will be available during 1982.

New gate circuit

Apart from the manufacturing process itself, the new u.l.a. devices also incorporate an innovation in the circuit design of the basic logic gate. The gate circuit has similarities to e.c.l. but is said to consume less power. It consists of a non-saturating current-sourced logic gate with emitter follower buffered outputs (see diagram). Minimum propagation delay can be as low as 0.5ns and, because of the emitter-follower buffer, the delay is independent of fan-out. Ferranti think this feature is unique in v.l.s.i. arrays, most manufacturers apparently preferring a simple gate circuit because of packing density limitations. A further advantage of the emitter-follower buffer is that it allows smaller logic signal swings than have been possible previously (since the critical collector node is buffered from the loading effects of the gates it drives) and this is a factor in reducing the power dissipation. For a V_{cc} of 5V, a gate with a 250mV voltage swing is claimed to dissipate only a quarter of the power of its advanced c.m.o.s. counterpart.

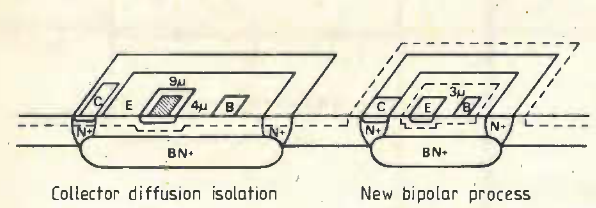
*Murphy, B.T., *et al.* "Collector diffusion isolation". *Proc. I.E.E.E.*, vol. 57, 1969, pp. 1523-7. See also "Breakthrough in integrated circuits", *Wireless World* November 1971, p. 526


An uncommitted logic array chip containing 2000 logic gates, in a 40-pin ceramic d.i.l. package with the lid off (type ULA9C000).

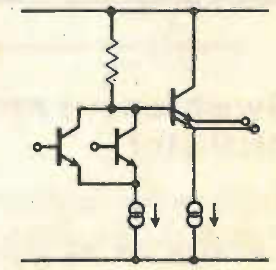
Cells on the chip

The chip organisation of the new 'R' series of devices, as they are called, remains the same as for the current u.l.as, that is, a regular matrix of identical cells occupying the centre of the chip, each cell containing a number of uncommitted transistors and resistors whose main function is to satisfy the logic hierarchy of an l.s.i system. Peripheral cells, also containing a number of uncommitted components, are located around the matrix cells and these are provided to allow interfacing and linear functions. Each matrix cell uses the new buffered logic circuit and provides two 2-input NOR gates.

We understand that the Department of Industry may be promoting a scheme to combine Ferranti u.l.as with ICL's Multiboard four-layer printed circuit boards (New Products July issue, p.84) to provide a very flexible method for constructing electronic equipment.



Comparing the structure of a transistor fabricated in the new bipolar process (right) with the structure in the c.d.i. process.


Basic gate circuit used in new u.l.a. devices has emitter-follower buffered outputs.

. . . . . . and 150 years earlier

The firm of Ferranti, which makes the above devices, owes its existence to the 19th century pioneering work of its founder, Sebastian de Ferranti, in building alternators for the public electricity supply. So, like many others, it would not have come into being but for the discovery of electromagnetic induction by Michael Faraday earlier in that century. August 29th this year is the sesquicentennial of Faraday's famous experiment with the iron ring and its copper coils – the first transformer – at the Royal Institution, London, in 1831. Within a matter of days he made the related discovery that an electric current could be generated in a conductor by moving it near the poles of a magnet. Sir Ambrose Fleming wrote (in his book "Fifty years of electricity"): "In ten days of experimental work in the autumn of 1831 Faraday explored so thoroughly, in the laboratories of the Royal Institution of Great Britain, the new phenomena he thus brought to light, that no one has since been able to add anything to his work in the discovery of the fundamental facts."

By coincidence, 1831 was also the year in which James Clerk Maxwell was born (see the appreciation in our March and May issues). The names of these two great scientists are of course forever linked in the history of electromagnetism. It was Faraday's concept of "lines of force" which stimulated Maxwell (he read a paper on it at the age of only twenty-three) and led to his later theoretical work on electric and magnetic fields and their interchangeability. Between them the two men produced a profound shift in the prevailing view of physical reality. Under the influence of Newtonian mechanics, a force had been seen as something belonging to a material body. Now it was replaced by a subtler concept, namely a *field* of force; something that was a reality in itself and could be considered in isolation from material bodies. But although it was left to Maxwell to predict formally that electromagnetic fields are propagated through space as waves, and that light is electromagnetic, some historians of science point out that Faraday might well have had an inkling of these concepts as early as the 1830s. Here is part of a sealed note, signed by Faraday on 12th March 1832, which had been deposited in a strong box at the Royal Society, London, and was not opened until 1938 (photographs of the note appear in "Magnetism and electricity in 1832" by G. R. M. Garratt, *Wireless World*, 5 May, 1938):

"Certain of the results of the investigations which are embodied in the two papers entitled *Experimental Researches in Electricity*, lately read to the Royal Society, and the views arising therefrom, in connexion with other views and experiments, lead me to believe that magnetic action is progressive, and requires time; i.e. that when a magnet acts upon a distant magnet or piece of iron, the influencing cause, (which I may for the moment call magnetism), proceeds gradually from the magnetic bodies, and requires time for its transmission which will probably be found to be very sensible.

"I think also, that I see reason for supposing that electric induction (of tension) is also performed in a similar progressive way.

"I am inclined to compare the diffusion of magnetic forces from a magnetic pole, to the vibrations upon the surface of disturbed water, or of those of air in the phenomena of sound, i.e., I am inclined to think the vibratory theory will apply to these phenomena, as it does to sound and most probably to light.

"By analogy I think it may possibly apply to the phenomena of induction of electricity of tension also."

In the above-mentioned *Wireless World* article the author makes this final comment: "To Faraday . . . must belong the honour of having put forward the first suggestion that time is required for the transmission of electro-magnetic forces." That he should have simultaneously suggested that their propagation is comparable with waves on the surface of disturbed water such a short time after his 1831 experiments is further proof of his genius.

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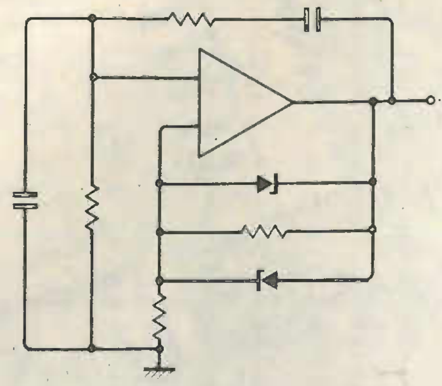
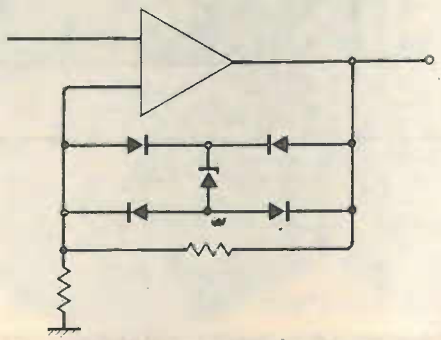
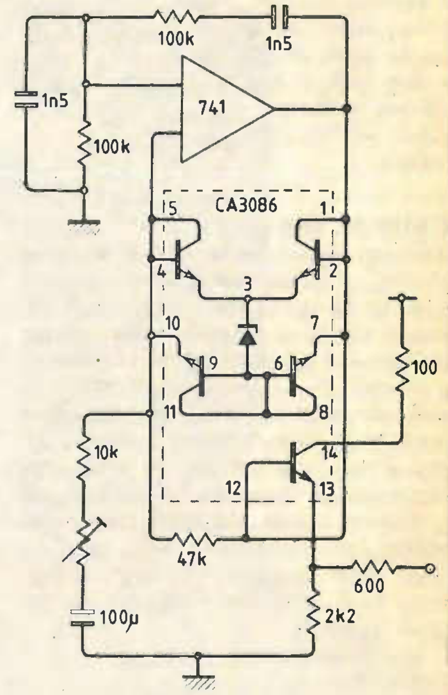
CIRCUIT IDEAS

Op-amp oscillator

During the design of an op-amp Wien-bridge oscillator, two Zener diodes were used to limit the amplitude. However, the distortion produced by this circuit was high due to a slight difference between the Zener diode voltages. An arrangement using a single Zener diode in a bridge rectifier reduced this problem, but the distortion caused by non-linearities in the bridge rectifier was still above 0.1%. The final circuit uses a transistor bridge which reduces the t.h.d. to 0.04% at 1kHz.
G. C. Gale
Guildford
Surrey

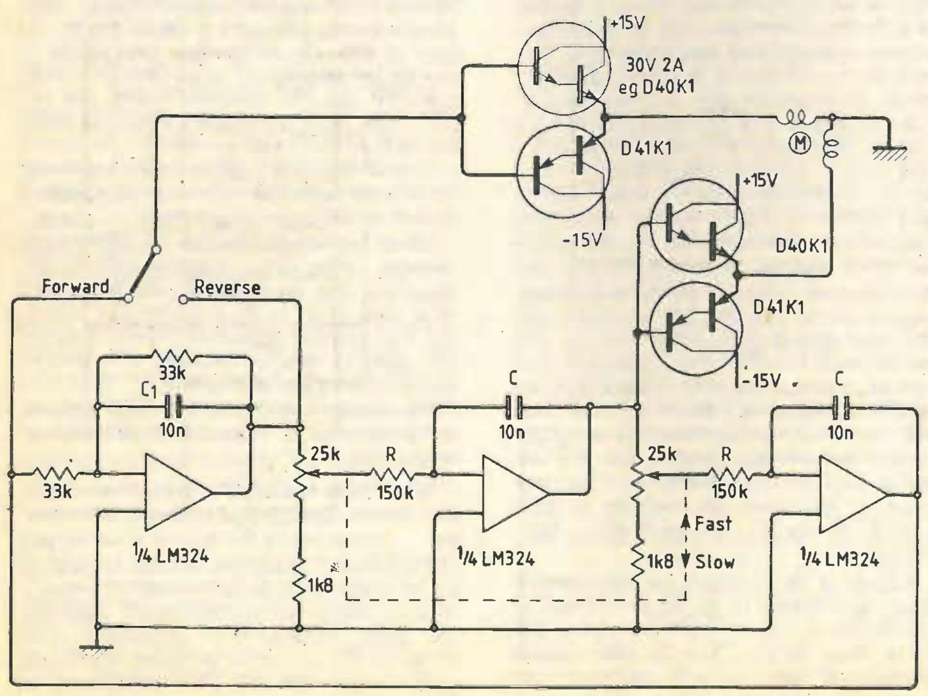






Synchronous motor oscillator

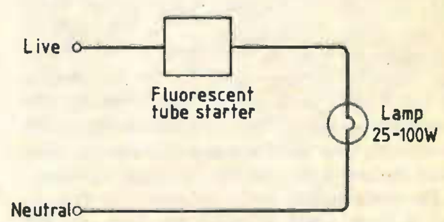
A small two-phase synchronous motor can be driven in either direction over a 10:1 speed range with this oscillator. The design is a two-integrator loop which forms a loss-free resonant circuit whose resonant frequency is 1/RC. Capacitor C_1 provides excess phase for starting and the frequency is controlled by varying R or, as shown, the drive voltage to R. If the drive voltage is varied, the frequency scale is linear except for the loading effect on the potentiometer, which can be eliminated with buffer amplifiers if necessary. With the component values shown, the frequency range is about 8 to 80 Hz.
M. W. Egerton
Owings Mills
USA



Theatre fire effect

For theatre use the circuit shown provides an alternative to the flickering-fire effect published in Jan. 1981. Although this method lacks the sophistication of the original, it is simple and cheap.

A fluorescent-tube starter is wired in series with the lamp, and the rate of flicker can be adjusted slightly by using different lamps from 25 to 100W. The fire effect can be improved if several lamp and starter circuits are used. Theatre dimmers can still be used to switch the fire on and off together with other stage lighting.
N. C. Moon
London

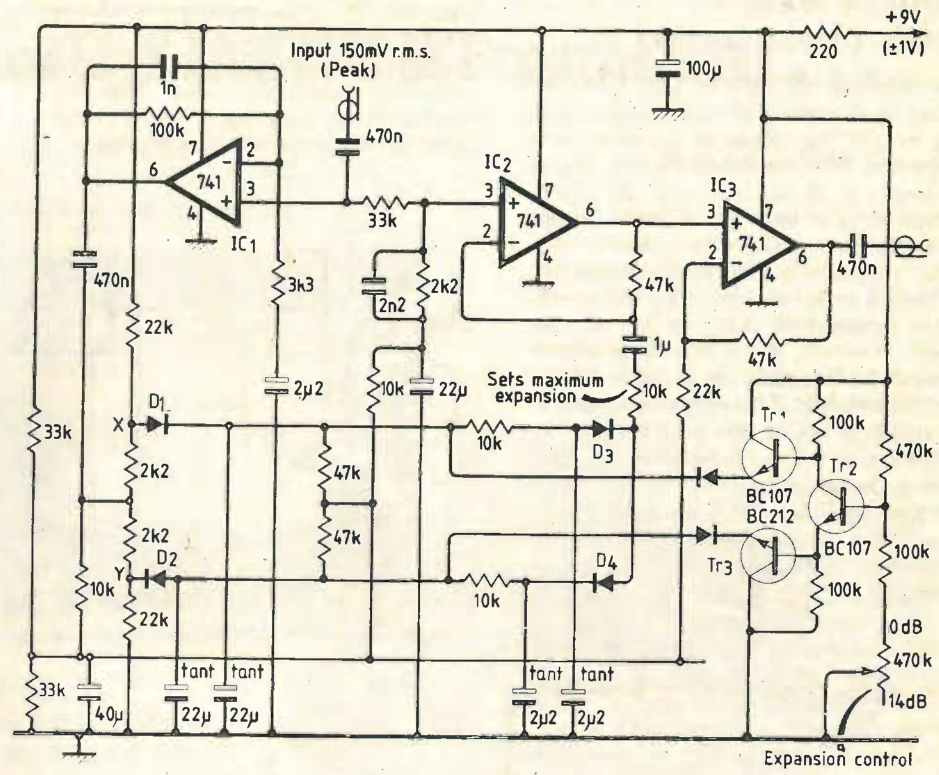


Variable expansion unit

Wideband expansion can successfully be achieved using current biased diodes as voltage controlled resistors. This design produces less than 0.5% t.h.d., below 1mV l.f. modulation, and d.c. surging below ±0.5mV.

The control section, Tr_1 to Tr_3, consists fo two voltage regulators back-to-back which provide smooth and noiseless control of expansion. One control section can drive up to 12 expanders over a 14dB range. If a greater range is required, the 10kΩ resistor can be reduced. IC_3 is provided to restore the original volume level and can be omitted. The 22μF tantalum capacitors should be matched as closely as possible. Because silicon diodes require 0.4V to conduct, the resistor network around D_1 and D_2 provides a bias voltage so that active rectifiers are not required at low levels. If a higher supply voltage is used, the resistors should be adjusted to provide 0.8V across points X and Y. To keep distortion below 1%, the voltage applied to v.c.r. diodes D_3 and D_4 does not exceed 7mV. Also, the 10kΩ resistors in series further reduces distortion.

It is not advisable to use a supply voltage below 9V because the 741s do not operate satisfactorily.
R. G. Young
Newhaven
Sussex



600 ohm floating source

Fig. 1 shows a unity-gain 300 ohm driver which uses voltage and current feedback to provide a high maximum output level from low supply rails. Driving two of these circuits in antiphase produces a 600 ohm balanced-line output as shown in Fig. 2. However, connecting an unbalanced load to this circuit causes a level drop of 3.5dB because one amplifier drives into 600 ohms and the other is shorted. Fig. 3 shows a current source driven from the current-feedback resistor of A_1. This provides an infinite common-mode output impedance, i.e. a floating load. By splitting the feedback to A_1 equally between the two output terminals as shown in Fig. 4, the output amplitude remains constant irrespective of whether the centre or either end of the load is connected to ground.
D. Austin
Birmingham

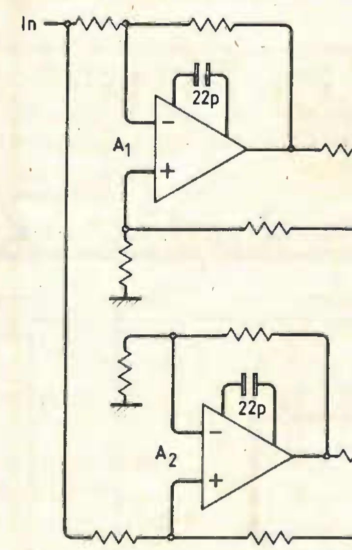


Fig. 2.

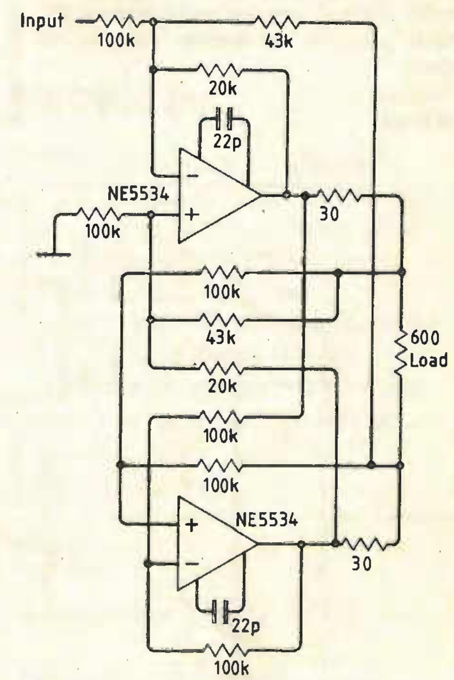


Fig. 4.

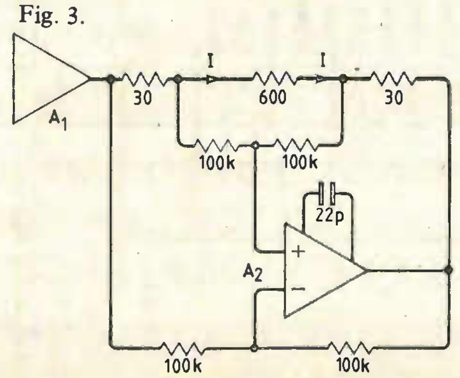


Fig. 3.

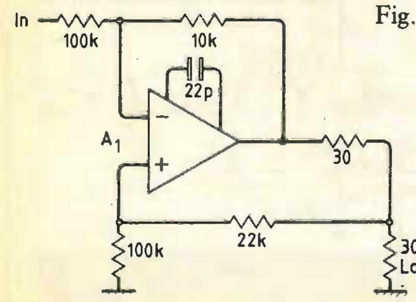


Fig. 1.

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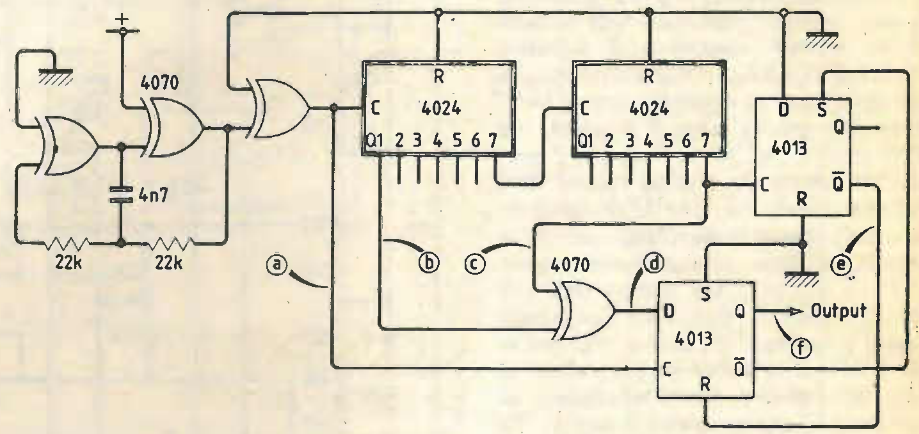
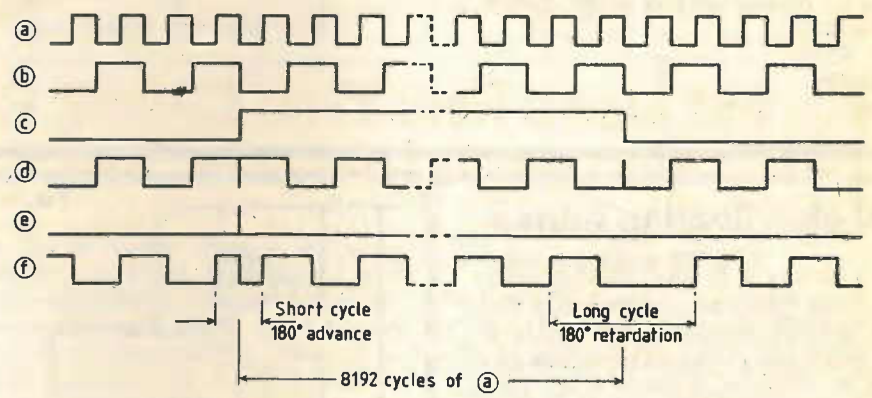
Generating square-waves with phase-jumps

The transient response of a p.l.l. can be tested by alternately advancing and retarding by 180° the phase of a square-wave generator. With the values shown, output frequency is about 2kHz and the phase-jumps occur at intervals of about 2s, but these figures can easily be altered to suit other applications. The output frequency is limited to below 1MHz by the ripple-carry propagation delay of the divider chain. However, if a synchronous divider is used, the frequency range can be significantly increased. If the output is applied to an auxiliary divider, the magnitude of the phase-jumps will be reduced in the same ratio as the frequency.

Three exclusive-OR gates form a conventional oscillator which drives the divider chain at about 4kHz. The fourth gate produces a 2kHz square-wave which is reversed every 4096 cycles. A spike produced at each reversal is eliminated by the output 4013 which triggers on opposite oscillator transitions to the divider. At alternate reversals, a second 4013 is triggered which resets the first, so the output 4013 completes one cycle during one oscillator cycle, which represents a phase-advance of 180°. At intervening reversals, the second 4013 is not triggered and the output 4013 remains in the reset state for two consecutive oscillator cycles. Therefore, three oscillator cycles are required to complete the sequence and this represents a retardation of 180°. The output waveform contains the same number of transitions as the first-stage output of the divider chain, and the positive-going transitions are directly timed by the oscillator.

E. L. Jones
Bucknell
Shropshire

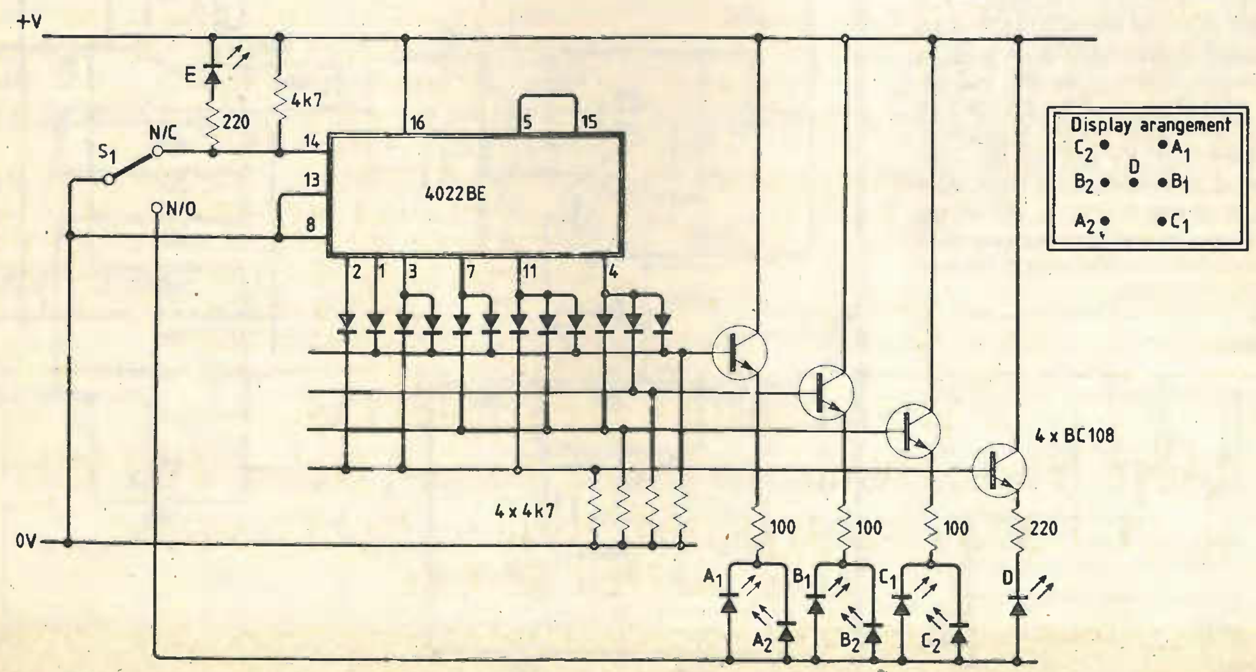




Random-number generator

A simple random-number generator, such as the electronic die circuit shown, can be constructed by using switch bounce to produce clock pulses. If the switch is biased l.e.d. E is normally on, so pressing the switch turns E off and enables the display. Each depression and release of the switch produces a random number of pulses.

J. Cameron
Bradford



WIRELESS WORLD SEPTEMBER 1981 57

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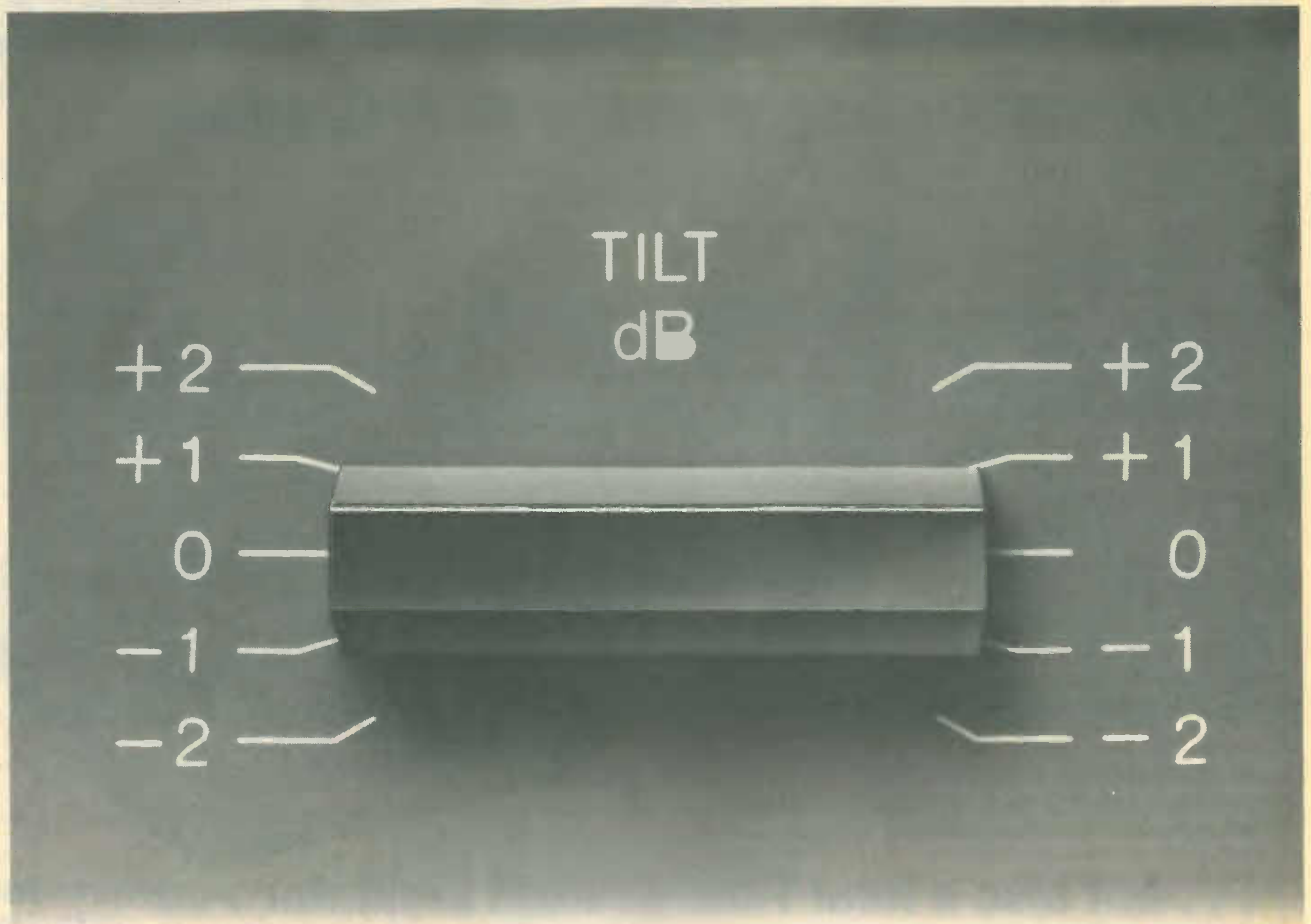


Tilt.

Nothing to do with pinball wizardry, has a great deal to do with programme balance.

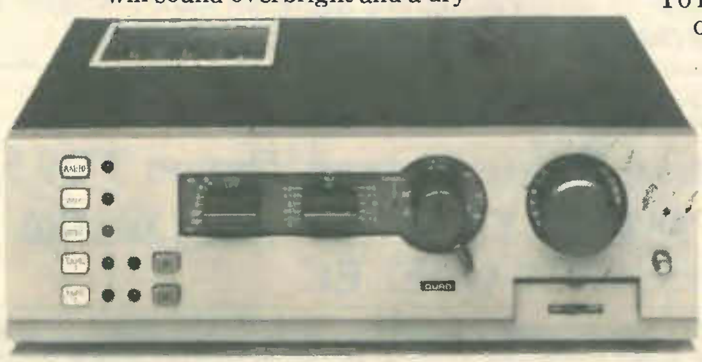
The recording or broadcast engineer attempts to capture the ambience of the studio or concert hall but what the listener perceives is the aggregate of this and the reverberation characteristics of his listening room.

If all listening rooms were equal the engineer could make due allowance, but since some listening rooms are more equal than others, the engineer has to assume some arbitrary norm, and the chances are that further correction and compensation will give improved results. Thus a reverberant recording reproduced in a 'live' listening room will sound overbright and a dry recording reproduced in an overdamped or 'dead' room will sound dull and bass heavy.

The tilt control on the Quad 44 cannot alter the reverberation characteristics of your room but by gently sloping the frequency response of your system about a centre point, chosen to maintain a constant overall subjective level, it can produce a more natural programme balance, without introducing unwanted colouration.

If you are in any doubt that the listening room characteristics have a fundamental effect upon the final results try listening to the same record played on the same equipment in two different rooms.

To learn all about the Quad 44 write or telephone for a leaflet.
The Acoustical Manufacturing Co. Ltd., Huntingdon PE18 7DB.
Telephone: (0480) 52561.



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Frequency synthesizer for c.b.

A circuit for the proposed UK bands

by **P. E. Chadwick,** Plessey Semiconductors Ltd.

So called 'single-chip' synthesizers now in existence require a considerable number of extra circuits as they are designed for use in mixer-type synthesizer applications. This article outlines a simple single-loop type synthesizer designed with the Home Office's proposed regulations for UK citizens' bands in mind (as far as transceiver specifications and frequency allocations are concerned). At the hub of the design are two i.cs from Plessey; the SP8793, 40/41 dual-modulus divider and the NJ8812 n.m.o.s. synthesizer controller.

The proposed frequency allocation for citizens' band (c.b.) radio in the UK is 27.60125 to 27.99125MHz. This band is divided into 10kHz channels numbered from 1 to 40. A simple low-cost frequency synthesizer capable of meeting the proposed UK c.b. specifications in terms of adjacent channel noise, spurious sidebands, etc. can be made using the NJ8812 and SP8793 i.cs from Plessey. Frequency modulation of the synthesizer is simple but the audio response is shaped to limit adjacent channel power.

An n.m.o.s. synthesizer controller, the NJ8812, controls the divider. This device comprises two programmable dividers, one in the signal path and one for the reference-frequency input to the phase detector. These dividers feed a digital phase detector, the outputs of which are used to drive the frequency of the v.c.o. higher or lower as required.

An address consisting of 3½ words, each 4-bits long, is used to program the controller. These words are multiplexed into the device under control of an internal data selector and result in two outputs called DS1 and DS2 which form part of the program for a r.o.m. or p.r.o.m.

The controller address may be provided in a number of ways from a simple circuit with two 74153 multiplexers to a microprocessor system. A 2716 p.r.o.m. is used here. The reference divider in the controller can be set to one of sixteen division ratios using pins 8 and 9 (FA and FB). In this case, FA and FB are wired to 5V and ground respectively.

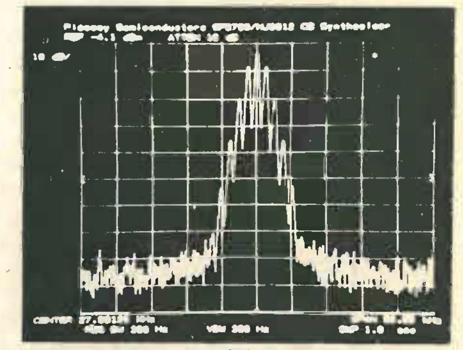
Circuit description

The circuit, Fig. 1, is a simple single-loop synthesizer with two-modulus prescaling. A low-power consumption 40/41 dual-modulus divider, the SP8793, does the prescaling. This high-sensitivity i.c. has a t.t.l. compatible control input and divider output, and an internal voltage regulator so that it can be used with a wide range of supply voltages.

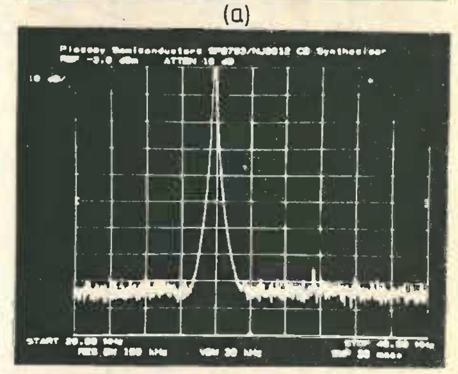
One gate of a CD4011, biased to operate in its linear region, is used for the 4.8MHz reference oscillator. A further gate of the same i.c. buffers the oscillator signal. The Ø/U (up) and Ø/D (down) outputs of the NJ8812 are combined in a charge pump circuit. The Ø/U output is inverted by a c.m.o.s. gate and fed through a diode into the loop filter so that when the Ø/U output decreases the control line voltage increases. At the same time the ØD output pulls the control voltage lower.

The loop filter, consisting of C_1, C_2 and R_2, integrates the pulses from the phase detector. Further filtering is provided by a low-pass filter with a −3dB point at 450Hz, C_3 and C_4. The reference frequency fed into the phase detector is 10.000444kHz. Because the loop locks so that the output frequency of the synthesizer is an integral multiplied by the reference frequency, exact 10kHz steps can only be produced on channels that are an exact multiple of 10kHz. For example, with a reference frequency of 10kHz and a divider ratio of 2780, the output frequency is changed to produce an output of 27801.25kHz. Thus, channel 1 will be 2760 times the reference frequency and channel 40, 2799 times. This results in small errors of +8.54Hz at channel 40 and −8.99Hz at channel 1.

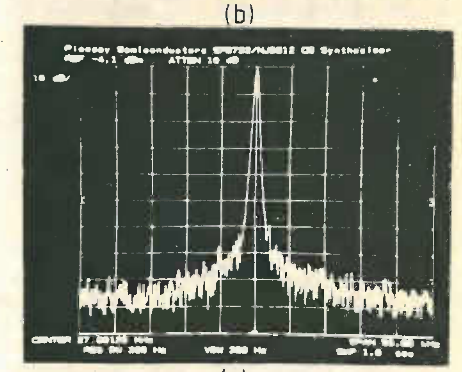
The reference frequency input to the NJ8812 is set by means of a crystal adjusted to 4800.215kHz. The specification requires that the transmitter frequency be controlled to within ±1.5kHz at all times. This means that an accuracy of ±50 p.p.m. is needed. Through not using exactly 10kHz as the reference frequency, an error of 0.33 p.p.m. is introduced. This error can thus be ignored. Because the required temperature is 50°C the temperature coefficient of the reference frequency crystal should not exceed 0.75 p.p.m./°C. This stability allows for some degradation of the other oscillator components.



(a)



(b)



(c)

Spectral purity of the synthesizer from a spectrum analyzer. (a) Shows response with 1kHz sine-wave modulation in a one-second sweep. The centre frequency is 27.00125MHz and each horizontal division is 5kHz. (b) Is a 20ms sweep without modulation starting at the left from a frequency of 20MHz. Each horizontal division represents 2MHz. (c) Is a one-second sweep, also unmodulated, with a centre frequency of 27.00125MHz and 5kHz/div. horizontally. In all three cases the vertical scale is 10dB/div.

Voltage controlled oscillator

The v.c.o. is the heart of any frequency synthesizer. It has to be carefully designed to ensure that phase noise is minimized, that the frequency/control voltage characteristic is monotonic and that the frequency range is no more than that required for the coverage so that noise modulation is minimized.

In this synthesizer the v.c.o. uses a junction f.e.t. in a Colpitts circuit. An f.e.t. was used because it does not produce l.f. noise and thus minimizes noise modulation

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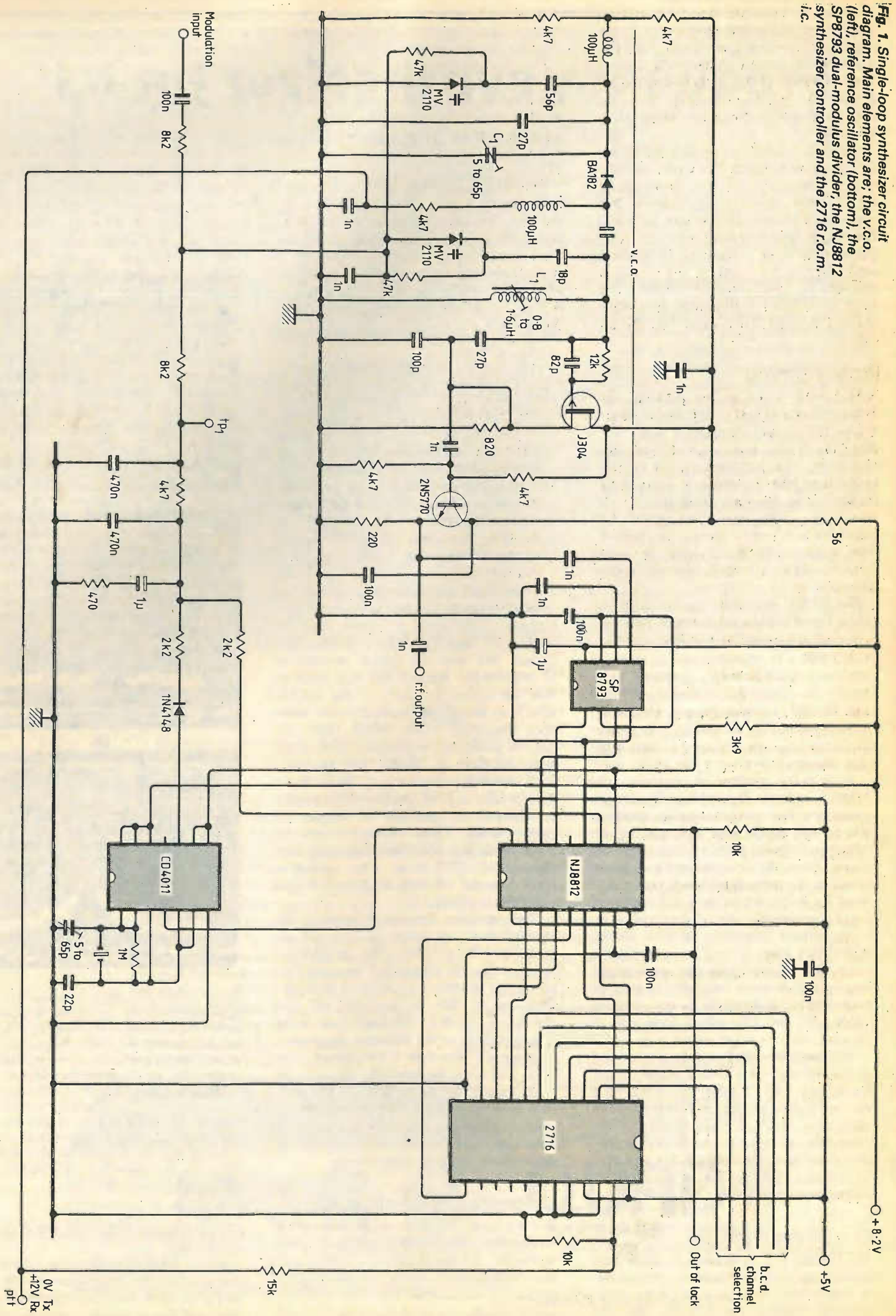


Fig. 1. *Single-loop synthesizer circuit diagram. Main elements are; the v.c.o. (left), reference oscillator (bottom), the SP8793 dual-modulus divider, the NJ8812 synthesizer controller and the 2716 r.o.m. i.c.*

of the signal. Tuning is done by a variable-capacitance diode and modulation is applied to the control line on transmit. For receiving, a second variable-capacitance diode is switched in parallel with the inductor. A parallel trimming capacitor allows the receive frequency range to be adjusted.

An emitter follower provides the necessary isolation between the v.c.o. and the external circuitry. In the prototype a 2N5770 was used for the follower but many other similar divices may be used. The output from this stage is at a low level and amplification is required in transmit mode. In the receive mode the output is adequate for most receiver mixers. The v.c.o. is buffered to minimize the chance of spurious modulation caused by the divider.

Programming

A 31/2 word×4–bit address programs the divisor in the NJ8812 and hence determines the output frequency from the controller/divider phase-locked loop configuration. The controller/divider combination used here is capable of dividing by integer values between 1600 and 11839. When the range input (pin 1) of the controller is at logic 0 the divisor range is from 6720 to 16959. Divisors between 1600 and 6720 are covered when the range input is at logic 1.

The 14 bits that make up the address can be found using a calculator as follows. First find the program number N using the formula,

$$N=\frac{(1000\times f)}{C}-R$$

where f is the v.c.o. frequency in MHz, C is the channel spacing in kHz and R is the devisor range number. When the controller range input is at logic 1, $R=1600$ and when at logic 0, $R=6720$.

The program number N may be converted to its decimal equivalent on a calculator using the following procedure:

- enter the number N
- divide by 640
- write down the number before the decimal point
- subtract the number before the decimal point
- multiply by 16
- write down the number before the decimal point
- subtract the number before the decimal point
- multiply by 40
- write down the nearest whole number to the one displayed.

For example, you will have an answer in the form 8, 11, 30. This result can now be converted to binary noting that the third decimal number gives the last six bits of binary as follows: 1000, 1011, 011110, or as four binary words, 1000, 1011, XX01, 1110.

The least significant word is first entered during the data read 1 time slot via the inputs D_3, D_2, D_1 and D_0 and the most significant last (data read 4 time slot). The second least significant word contains only two bits entered via the inputs D_1 and D_0. Data presented to the inputs D_2 and D_3 during the second time slot is ignored by the controller.

For example, with a v.c.o. frequency of 121.2MHz and channel spacing of 25kHz, $f=121.2$, $C=25$, $R=1600$ and $N=3248$.

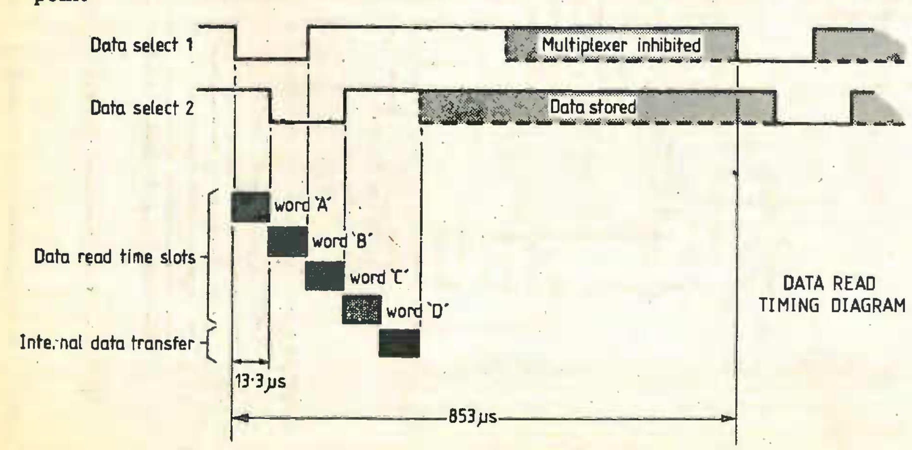
Conversion to a 14-bit binary number is performed as follows:

– Divide N by 640	5.0750
– Write down number before decimal place (word 'D')	5
– Subtract this number	0.0750
– Multiply by 16	1.2000
– Write down number before decimal place (word 'C')	1
– Subtract this number	0.2000
– Multiply by 40	8.000
– Write down nearest whole number (word 'A+B')	8

The decimal numbers obtained for words 'C' and 'D' may be directly converted to 4-bit binary words, while the decimal number for words 'A' and 'B' will convert to a 6-bit binary word. The least significant four bits of this word give word 'A' while the two most significant bits give the least significant bits of word 'B' (the two most significant bits of word 'B' having 'don't care' states). These are presented to the data inputs as follows:

DS1	DS2	D_3	D_2	D_1	D_0	
0	1	1	0	0	0	word 'A'
0	0	X	X	0	0	word 'B'
1	0	0	0	0	1	word 'C'
1	1	0	1	0	1	word 'D'

As mentioned above the NJ8812 is programmed for each channel by 31/2 words of 4 bits each. As a result 1120 bits are required to program a 40-channel synthesizer (i.e. 40 transmit and 40 receive). Because of the architecture of r.o.m.s/p.r.o.ms these channels can only be satisfactorily accommodated by a 512×4-bit memory. Such memories are available but they are expensive. This circuit uses the common 2716 p.r.o.m., which may be replaced by a 2316 r.o.m. if required.



Manufacturers of equipment covering European channels conforming to the FCC specification and/or the 934MHz UK allocation can use the spare capacity of the p.r.o.m. or r.o.m. to include the extra programming information. Selection of either UK or FCC channels can then be made by providing a link on the p.c.b. for the A10 input. For 934MHz, A10 is either grounded or tied to +5V depending on the system (as will be described later) and A11 is tied to +5V.

Where a 455kHz second i.f. is used in the receiver, a separate crystal is required to convert the nominal 10.7MHz first i.f. to 455kHz. This crystal varies between 10245.481kHz for UK channels and 10246.968kHz for FCC channels, and is best realised using a 10246.25kHz crystal in a circuit which allows adjustment to either frequency.

The r.o.m./p.r.o.m. used to program the NJ8812 is addressed from the channel selection mechanism of the equipment. Because the channels are numbered 1 to 40 rather than 0 to 39, additional circuitry is required to modify the display using, say, an 8-input NOR gate. The b.c.d. program input to the r.o.m./p.r.o.m. is arranged so that addresses 1 to 39 program channels 1 to 39, and address 0 programs and displays channel 40.

The NJ8812 has a "lock-detect" output which, when integrated in an RC network, provides a logic level 0 which can be used for inhibition. This flag can also be used to blank the l.e.d. display.

Setting up

Referring to the circuit diagram of Fig. 1, start by selecting channel 20 and connect point p.t.t., i.e. the point at the bottom right of Fig. 1, to 0V. Adjust the core of L_1 so that the voltage at tp_1 is 4V. Next, connect p.t.t. to +12V, i.e. in receive mode, and adjust C_1 until tp_1 is at 4V.

The specification requires that when the transmitter is modulated at 1250Hz with a modulation level 20dB greater than that required to produce 1500Hz deviation, the power in an 8.5kHz bandwidth centred 10kHz away from the carrier frequency should be less than 10µW. This corresponds to a power of −95dBc in a 1Hz bandwidth for carrier separations of 5.25kHz or greater.

The Home Office's publications describing performance specifications for c.b. radio equipment are MPT1320 for 27MHz and MPT1321 for 934MHz. They are available from Her Majesty's Stationery Office. Plessey Semiconductors Ltd's address is Kembrey Park, Swindon, Wilts SN2 6BA.

Double-sided glass fibre p.c.bs will be available for £6 inclusive v.a.t. and UK postage from M. Sagin, 23 Keyes Rd, London NW2.

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Electronics on the road – 2

Automatic control, instruments and display

by J. R. Watkinson, B.Sc., M.Sc.

The first part of this article, in the August issue, was concerned with ignition electronics and automatic gearboxes. Part 2 is on the use of electronics in controls for braking, suspension and throttle operation. Electric drive for vehicles is described and there is mention of recent work on instruments and computers.

One of the more important uses of electronics is in braking, particularly in heavy vehicles and in poor road conditions, where jack-knifing can happen.

Antilock braking. Under heavy braking (Fig. 8), weight transfer unloads the rear wheels of a vehicle to such an extent that the reaction from the road may not be enough to turn them against the resistance of the brakes. This results in a rear-wheel slide, which means that braking efficiency will be lost. More serious, however, is the fact that a vehicle with locked rear wheels is directionally unstable, and will spin unless it is travelling dead straight.

An electronic antilock system, as shown in Fig. 9, monitors the tangential velocity of the wheels, using pulse generators built into the hubs, or in some cases the speed of the propellor shaft. If the velocity changes at a rate much more than 1g then the wheel is sliding. The decision can be made by differentiating the velocity signal and comparing it with references. Having predicted imminent lockup, the system reduces pressure to the affected wheel(s) with the vacuum operated de-boost unit shown in Fig. 10. This device works by first isolating the brake line to the affected wheel with a ball valve, and then by increasing the volume of the fluid reservoir, until the wheel is observed to be turning again, when the de-boost unit re-applies line pressure. This cycle will repeat as necessary.

Modern tyres are made from hysteresis rubber which dissipates elastic energy as heat. When such a tyre slips in a controlled fashion over road irregularities work is done on the rubber, which implies that a force is acting over and above that due to simple friction. By setting up the antilock system to slip the tyres in this way, decelerations of considerably more than 1g are possible.

Antilock brakes have been particularly successful in preventing jack-knifing in articulated vehicles. For diesel vehicles, the de-boost unit is designed to run from the air brake system, as diesels have no inlet vacuum. Current systems cannot prevent power jack-knifing, where engine effort exceeds the available adhesion, although in principle this is possible.

Active suspension. When a vehicle corners, the force accelerating it toward the centre of the turn acts at ground level, but the centre of mass of a practical vehicle is some distance above. Weight transfer causes the vehicle to lean outwards on its springs, which usually results in an interaction with the steering and changes in the camber angles of the tyres. Energy is stored in the springs, which must be dissipated by the dampers as the vehicle leaves the corner. The moment of inertia of the vehicle about the roll axis and the roll stiffness govern the resonant frequency of the system. If the dampers are ineffective, or if the vehicle is high and heavy, roll resonance can turn it over. This is why goods vehicles are sometimes to be seen on their sides at the exit from a roundabout.

The principle of active suspension could eliminate the slow-roll-over phenomenon. As shown in Fig. 11, the suspension spring is carried on a hydraulic ram, and the wheel position is monitored with a transducer. If the wheel moves toward the vehicle, the movement is sensed by the transducer, causing the ram to extend until the wheel is back where it was, which compresses the spring. In the case of a vehicle cornering, as in Fig. 12, one spring will become compressed, and the other will extend, but the vehicle will not roll: by incorporating an accelerometer into the system, the vehicle can actually be made to lean into a corner. The bandwidth of the system has to be carefully restricted, since otherwise the suspension would appear infinitely stiff to road bumps. It will be evident that if a heavy load is placed in a vehicle having such a system, it will remain parallel to the ground however badly distributed that load may be. In addition, the fluid pressure in each ram is proportional to the reaction at the wheel, and could be used to accurately apportion braking effort between the wheels.

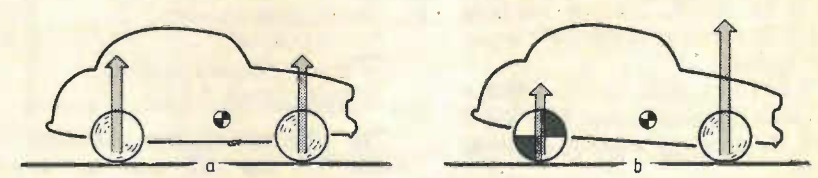

Fig. 8. At constant speed, weight is distributed evenly, while during braking, weight is transferred to front wheels. Reduction of weight at rear axle could cause rear wheels to lock

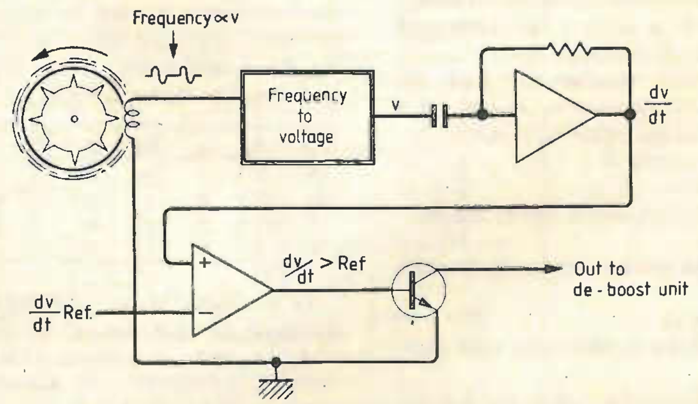

Fig. 9. If rate of change of wheel speed, v, exceeds reference, wheel is sliding and brake is released.

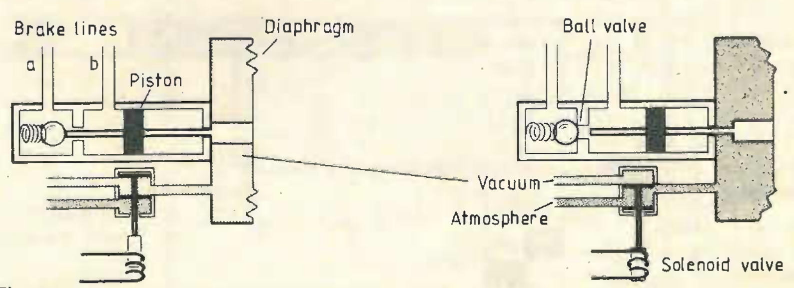

Fig. 10. Vacuum-operated deboost unit isolates wheel from brake line and reduces hydraulic pressure. Solenoid valve controls vacuum to diaphragm, which closes ball valve and retracts piston, reducing pressure in brake line. Other wheels are not affected.

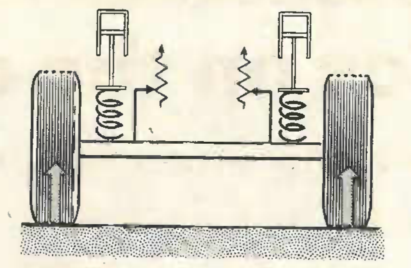
Fig. 11. Active suspension interposes rams between springs and body

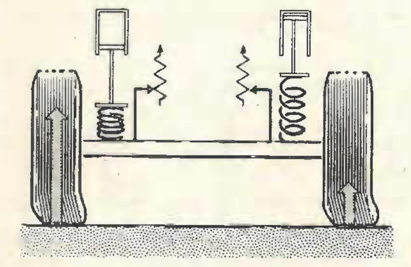
Fig. 12. When vehicle corners, rams counteract weight transfer

With the suspension under complete control, it is possible to insert an offset into the servo loop which is derived from roadspeed, such that at low speeds the ground clearance is high for traversing rough ground, and as the speed rises the ground clearance falls to reduce drag and improve stability. Active suspension systems can be implemented in a purely mechanical fashion[10], but as the complexity rises, electronic control has to be considered. A subset of active suspension is self-levelling suspension, which is designed to compensate only for load variation. In these systems the rams on each end of the axle are plumbed in parallel, and the bandwidth of the system is very small. Citroen have offered cars with full self levelling and load-sensitive brake proportioning for many years, although no electronics were employed as the system was launched in the 1950s.

Cruise control. This application takes the form of a feedback loop which compares actual roadspeed with a preset reference, and operates the throttle to maintain constant speed. As shown in Fig. 13, roadspeed can be monitored by a pulse generator on the propellor shaft, as in the antilock brake system. The servo error drives an actuator on the throttle spindle, which can be electrically or vacuum operated. For safety reasons the system disengages if the brake pedal is pressed, and a switch is fitted to the clutch pedal to prevent the system blowing up the engine if the clutch is depressed. On most systems the driver can override the speed control to go faster just by pressing the throttle, the preset speed being resumed when the throttle is released. The desired speed is latched from the roadspeed at the moment that the system is engaged.

Having fitted the speed transducer, it is a simple matter to drive a long-scale, moving-coil speedometer dial, eliminating the usual drive cable. The odometer then counts pulses from the transducer. Fig. 14 shows such a device which is considerably more linear than the usual eddy current type mechanical speedometer.

Electric motor control. The technology of electric vehicles is well developed, mainly in the fields of rail traction, fork trucks and milk floats. The mass application of electric power to road vehicles awaits the development of lightweight batteries or fuel cells since, with current designs, range is very limited. The main attributes of electric power are that there is very little noise, the transmission is very simple, and dynamic braking can be used, which conserves energy. The oft-quoted virtue of reduced pollution is a pure fallacy, as the source of the pollution is simply shifted to the power station. A simple speed control and braking circuit is shown in Fig. 15(a).

The decision as to whether an electrical machine is a motor or a generator is made by comparing the supply voltage with the e.m.f. due to rotation. If the e.m.f. exceeds the applied voltage, the machine is a generator, and current will flow against the applied voltage because mechanical energy is being converted to electrical energy. Conversely, if the applied voltage exceeds the e.m.f. current will flow in to the machine, and it becomes a motor, converting electrical energy to mechanical energy. The current in or out of a machine can be predicted by Ohm's Law, stated as the difference between the applied voltage and the e.m.f. divided by the total circuit resistance. For a constant supply voltage, the machine will try to run at a constant and very nearly equal e.m.f. The e.m.f. of a conventional d.c. motor is proportional to the field current multiplied by the r.p.m. It follows that to increase the r.p.m., the field current has to be reduced, and to reduce the r.p.m., the field current has to be increased.

In Fig. 15(b), the motor is driving the vehicle. The field current is moderate, and the e.m.f. is just less than the applied voltage, causing current to flow into the motor. In Fig. 15(c), the driver has operated the brake pedal, and instead of dissipating the kinetic energy of the vehicle as heat, the field current is in-

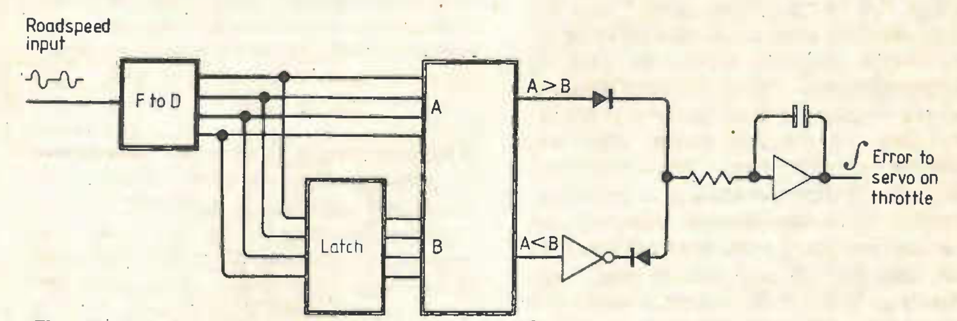

Fig. 13. Cruise control. Pulse rate represents road speed. current speed is latched and subsequent speeds compared. Error operates throttle.

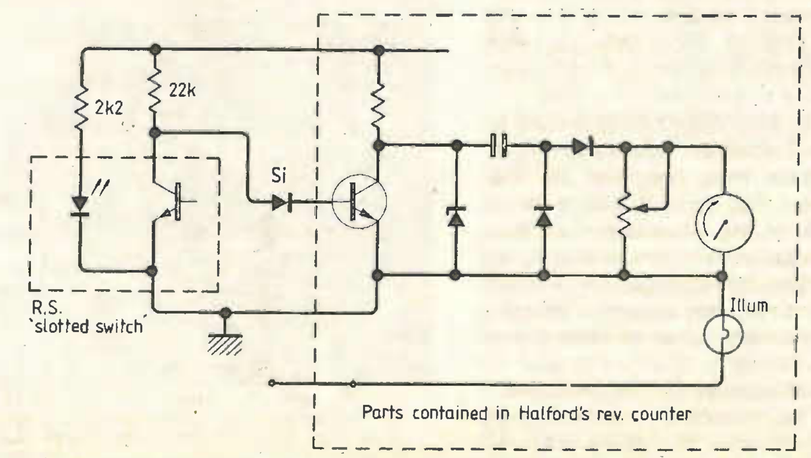

Fig 14. Linear speedometer eliminates mechanical drive. odometer is c.m.o.s. divider driving electromechanical counter

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creased, such that the e.m.f. now exceeds the applied voltage, and the motor acts as a generator, taking energy from the vehicle's movement and putting it back into the supply. In the interests of efficiency the field current is controlled by a switching regulator.

Dynamic braking is already in use in trams and railway trains, where true regeneration takes place. It also finds application in very heavy vehicles, such as those used in open-cast mining and civil engineering. Because of the enormous power of such vehicles, conventional clutches and brakes would burn up. To overcome this problem, the transmission from the diesel or gas turbine is by way of a generator driving electric motors. Control is then by field current as previously described. As it is not possible to regenerate with the main engine, the electrical energy developed during braking is dumped into huge resistor banks. With all dynamic braking systems it is not possible to brake to a complete halt, and therefore conventional brakes must be provided to finally stop, and for parking. On light vehicles with a single motor, these brakes would also be necessary in the case of a motor failure, but heavy vehicles use multiple motors with duplicated systems so that a motor failure would not interfere with safety requirements.

Monitoring and display

Instruments. A replacement for the cable-driven speedometer has already been described, and the application of electronics to other instruments could further reduce the clutter behind the dashboard. Much of the potential lies in the area of displays, which can be made very thin. There are still problems to be overcome, however, as l.e.d.-type displays cannot be read in bright sunlight, without elaborate arrangements to enhance contrast, and currently liquid-crystal displays do not appreciate temperature extremes. The widespread adoption of digital readout is to be discouraged, as psychophysical research has shown that it is quicker in all cases to read an analogue display than a digit, and therefore safer. The current mania to fit seven-segment indicators to everything from f.m. tuners to ballpoint pens will perhaps have given way to more ergonomically reasonable displays by the time that electronic displays are available in motor vehicles. Certainly the swing back to analogue readout wristwatches is an indication that people appreciate an ergonomic interface to electronic equipment. C.r.t. displays have been proposed for road vehicles, but this type of display would appear to have little advantage, since space behind the dashboard is at a premium, and a suitable size of tube would have considerable depth. Power requirements, warm-up time, contrast and safety are issues which must be considered, to say nothing of the considerable software overhead required to generate an ergonomic and pleasing display. Less attractive features of this kind of display have been anticipated[11].

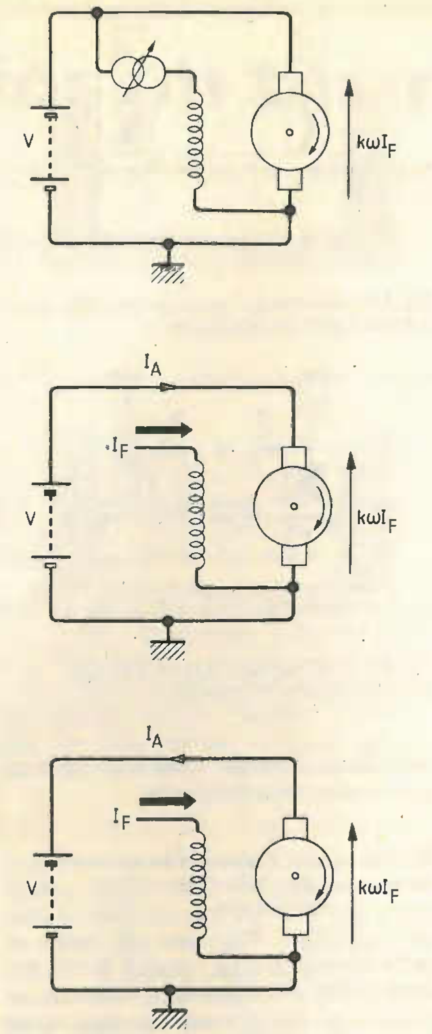
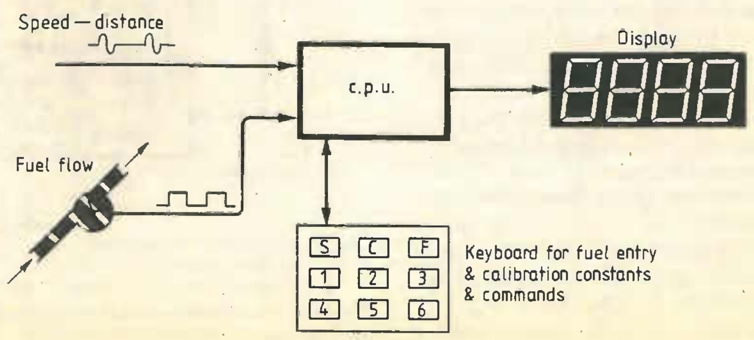


Fig. 15. Electric motor control. Armature e.m.f. in (a) is proportional to speed multiplied by field current. With moderate field current, as in (b), motor draws current and propels vehicle. Heavy field current in (c) causes armature e.m.f. to exceed battery voltage. Motor therefore acts as generator, reversing battery current

Trip computers. This is a relatively recent instrument as far as motor vehicles are concerned, although it is nothing new in aviation. Referring to Fig. 16, a pulse train representing roadspeed (pulse rate) and distance travelled (pulse count) from the usual sources, and a pulse train from a flowmeter in the fuel line feed the fuel

Fig. 16. Input pulses to represent speed, distance and fuel flow, with further information manually entered, allow c.p.u. to calculate various quantities.



computer. Constants such as tank capacity and calibration factors are entered with a keypad, as is the quantity of any fuel taken on. Commercial units have been available for about two years which incorporate microprocessors to perform certain useful and certain less useful calculations on the input data. One unit[12] offers the following outputs

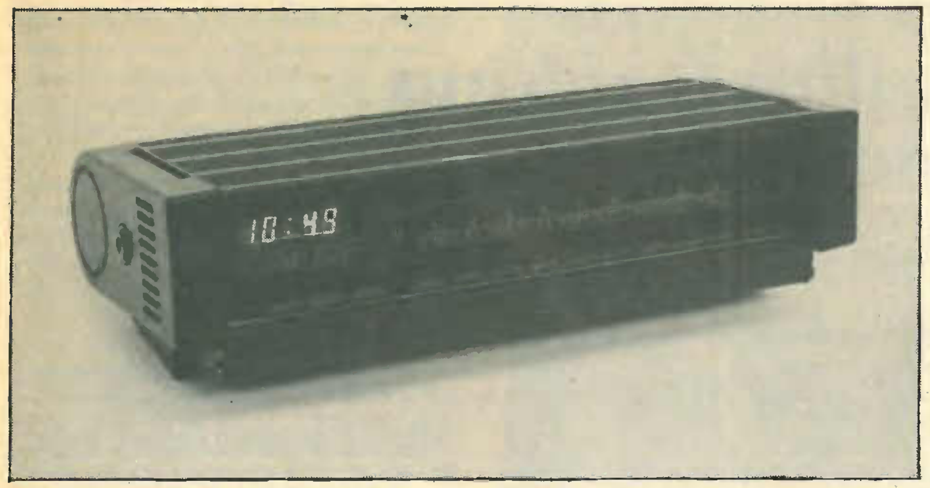
- instantaneous m.p.g.
- average m.p.g.
- fuel remaining
- average speed
- time to destination at current speed
- distance before fuel runs out

Collision avoidance. Many problems beset the introduction of collision-avoidance systems for road vehicles. Possibly the most likely system yet has been researched in the U.S.A. The most common collision in conditions of poor visibility is that of running into the preceding vehicle, and a radar-based system has been postulated to help prevent this. The main problem with on-vehicle radar is discrimination between the preceding vehicle and those going the other way, not to mention roadside objects. One solution is that the rear licence plate of all vehicles should incorporate a passive frequency doubler network, so that the radar of a following vehicle would only respond to echoes of twice the transmitted frequency[13]. In the U.S.A. one buys licence plates annually instead of tax discs, and as a result it would be possible to equip every vehicle with a transponder in about a year. The radar-equipped vehicle could then compute distance and closing speed, and actuate warning signals and ultimately the brakes if a transponder was being approached in the path of the vehicle. Input from the steering would probably be necessary in order to prevent false alarms from parked vehicles at the side of the road, particularly on bends.

Influences on automotive electronics

Engineering efficiency is only one of the constraints in the design and selection of automotive electronic devices.

Social forces. At the moment, most cars are sold to fleet owners who will keep them for two years before discarding them. There is thus little incentive to make cars which last much longer without requiring major replacements. To take just one example, the cost, countrywide, of replacing corroded exhausts can only be described as scandalous. Nevertheless, be-



TC-15 car computer by Smith's Industries, which the makers claim could save up to 20% of fuel.

cause it is socially acceptable, the nation continues to drive cars with mild steel exhausts which drop off every two years.

One of the major features of electronic devices is that moving parts are largely eliminated and that long-term performance is therefore good. In the peculiar logic of the motor industry longevity is not a virtue, and as a result no electronic device will be selected on this ground alone except by quality makers. The electronic device must actually be cheaper than the mechanism it replaces before the economists who really design mass-produced vehicles will consider it. The exception to this is if the device can be latched upon by the image makers of the advertising department. An example which happily fitted both categories was the alternator, which was actually cheaper to make than the dynamo, and whose advantages could be explained in nursery language by the Admen. The unfortunate regulator could not be expected to capture anyone's imagination, so for a long time mechanical regulators degraded alternators until electronics became cheaper.

Environment. The underbonnet area of a motor car is pretty hostile to electronic equipment, so good design and engineering practices have to be used to ensure that the device survives. If, however, the device does survive, it should do so for a long time.

One problem is the temperature range encountered. Vehicles are frequently parked in sub-zero conditions, and on starting the engine, parts of the engine compartment can go up to boiling point in a short time. An electronic device has to be carefully positioned to avoid temperature extremes. As electronic devices and water are mutually exclusive, positioning also has to reflect this. In the past, manufacturers have been peculiarly adept at positioning the electrics where most water will be sprayed. One famous small vehicle could not be driven in heavy rain because the distributor was mounted directly behind the grille!

The power supply in a motor vehicle leaves a lot to be desired from an electronic engineer's point of view. When cranking a freezing engine, the voltage can drop to as little as 6 volts, but with the engine running it can go up to about 14½ volts. Superimposed upon this are interference spikes from the ignition and from various electric motors and switching regulators. Filtering, decoupling and screening can all be used to combat the interference problem and careful circuit design has to be used to ensure operation at extremes of supply voltage.

Legislation. The form of modern vehicles is heavily controlled by legislation which, in turn, is usually only dictated by safety and emission requirements. In due course, the motor industry will probably be forced to employ more electronic devices to meet higher standards demanded by law. Certainly had it not been for emission and fuel economy legislation in the U.S.A., electronic ignition would not have become so widely used.

Maintenance. Before designing any device, the responsible designer must first establish the level of competence of those who are expected to maintain it. There is little point in designing a complex device for production if it is too difficult to repair. The motor trade already works extensively on an assembly exchange principle, whereby a unit is replaced whole rather than any attempt being made to repair it at component level. The exchanged assemblies are then either repaired by specialist centres or thrown away, depending on the economics of the individual assembly concerned.

Smith's TC-10 trip computer, designed for the Metro. Calculates distance to go and time of arrival, plus many other quantities.

With mechanical parts, the fault is usually pretty easy to locate to an assembly, but this is not necessarily the case with electronic systems. Before designing a complex electronic system for a vehicle, it will have to be assumed that the system will incorporate sufficient diagnostic ability to call out its own faulty parts. The latest generation of computers incorporate such features, so that the majority of faults can be fixed by relatively unskilled technicians, and it is expected that this technology will filter down to consumer equipment. Ultimately, of course, someone has to know how these devices actually work, in order to repair the small percentage of faults which the internal diagnostics fail to locate. Judging by stories of customer dissatisfaction with the motor trade, it would appear that it is in this support area that there is a need for a more effective structure.

The amateur. The home constructor has a great advantage over the mass producer in that he is not obliged to make a profit. Looked at in a cold light, no home-made electronic equipment results in a financial saving, but the potential for learning and self expression far exceeds that of purchasing ready-made goods. In the sphere of automotive electronics, there are certain constraints which are not normally applicable to the home constructor. If a home-made music centre packs up, no one is going to be too upset, but if, for the sake of argument, your home-made fuel-injection system passes away in the middle of Dartmoor you can look fairly silly. It cannot be emphasized enough that in automotive applications a circuit has to be engineered as well as designed, and some kind of soak testing has to be carried out before venturing far away. The effects of a failure should be predicted rather than discovered, and steps taken to ensure that it is still possible to get home in the event of a failure. Graceful degradation and redundancy should be designed in wherever possible. It has been observed that for putting one's money where one's mouth is, automotive electronics is at about the same point on the scale as radio-controlled model planes.

Finally, the safety aspect has to be mentioned. As with any application of electronics, some technical knowledge of the field of that application is needed in addition to electronic knowledge. Motor vehicles have no shortage of parts which can maim, burn and poison if handled unwisely, and yet which are handled in perfect safety by those with the right kind of knowledge.

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Satellite tracking by home computer – 2

Formulae and programs

by Neoklis Kyriazis, B.Sc.

Part one of this article on a tracking system for circular orbiting satellites described a computer interface for controlling aerial azimuth and elevation angles, and aerial rotators and their mountings. This section concludes the article, describing formulae and a Basic/machine-code program for the Wireless World scientific computer. The program uses the formulae to process satellite orbit parameters and converts resulting data for use with the interface.

The complete program consists of two parts; a BURP MkIII program to handle numerical computations and a machine-code program for rotator-motor control through the interface. All satellite tracking variables are processed in the BURP program so, thanks to the CALL instruction of the MkIII minitor, the machine-code program need not be changed when orbit parameters change. In the machine-code program some subroutines are used to carry out the main task of controlling the aerial rotators and others are used to check hardware. Both program explanations refer to the interface and rotators described in part one of this article. But before the program explanations, a few formulae relating to satellite orbit calculations need to be given.

Formulae

The following formulae, presented in a form which makes it easy to relate them to programming language, outline the procedure for finding azimuth and elevation angles for a satellite.

$$Fs = \arcsin(\sin a \sin(2\pi t/P))$$

where Fs is the sub-satellite latitude, a is the orbit inclination and t is the time elapsed after EQX (equatorial crossing) and

$$Gs = Gx + We + \arccos(\cos(2\pi t/P)/\cos Fs)$$

where Gs is the sub-satellite longitude, Gx is the EQX longitude and We is the rotational speed of the earth which is 15°/h. If the orbit inclincation is less than 90° then Gx should be negative.

Two intermediate angles given by

$$n = Gs - Gq$$

and

$$d = \arccos(\sin Fs \sin Fq + \cos Fs \cos Fq \cos n)$$

where Gq is the station longitude and Fq is the station latitude are required to give the final results;

$$A = \arccos((\sin Fs - \sin Fq \cos d)/(\cos Fs \sin d))$$

Table 1: This machine-code program uses data from the BURP program to control the aerial rotators through the interface.

1600	02 16 F5 E5	C5 ED 56 21	63 1F CD EC	06 CD C7 02
1610	03 06 00 37	39 3F FF 21	63 1F CD D5	06 ED 5E FB
1620	C1 E1 F1 C9	D9 ED 5E 3E	16 ED 47 FB	C3 56 16 D9
1630	ED 5E FB C3	56 16 D9 ED	5E FB DB 00	E6 04 20 03
1640	C3 56 16 21	43 1F 56 21	EF 1E 5E 7A	E6 3F 57 7B
1650	E6 3F 5F CD	5E 16 76 F3	ED 56 D9 C9	00 18 21 06
1660	00 ED 4B 5C	16 78 BA 28	18 CB DC 38	02 CB D4 CD
1670	E4 16 79 BB	28 10 CB CC	38 02 CB C4	CD E4 16 18
1680	05 79 BB 20	F1 C9 DB 00	E6 06 F5 CB	5C 28 1F CB
1690	57 28 1B CB	55 20 17 CB	54 78 28 04	D6 01 18 02
16A0	C6 01 27 47	BA 20 07 CB	9C CB 94 CD	E4 16 F1 CB
16B0	4C 28 27 CB	4F 28 1D CB	4D 20 19 CB	44 F5 79 28
16C0	04 D6 01 18	02 C6 01 27	4F BB 20 07	CB 8C CB 84
16D0	CD E4 16 F1	6F CD 80 17	18 AC CB 5C	20 F6 ED 43
16E0	5C 16 C9 00	7C C5 06 08	D3 A0 07 10	FB C1 C9 00
16F0	26 0C CD E4	16 0E 04 CD	19 17 26 03	CD E4 16 0E
1700	02 CD 19 17	01 00 00 ED	43 5C 16 11	09 18 CD 5E
1710	16 01 00 18	ED 43 5C 16	C7 06 00 DB	00 A1 28 F9
1720	CD 80 17 00	10 F5 26 00	CD E4 16 C9	00 00 00 00
1730	DB 00 E6 04	28 FA 11 08	81 CD 61 02	20 01 1A 09
1740	0D 15 14 08	20 3F 20 1D	CD 68 17 67	CD 61 02 20
1750	05 0C 05 16	01 14 09 0F	0E 20 3F 20	1D CD 68 17
1760	6F EB CD 5E	16 76 18 C8	76 07 07 07	07 E6 F0 47
1770	76 E6 0F B0	C9 76 06 08	D3 A0 07 10	FB C3 75 17
1780	C5 F5 01 FF	07 3E 00 0B	B8 20 FC F1	C1 C9 00 00

where A is the azimuth angle and finally,

$$E = \arctan((\cos d - R/(R+H))/\sin d)$$

where E is the elevation angle, R is earth's radius in km (6367km) and H is the height of the satellite above the earth. The sign of $\sin n$ is used as an indicator for the azimuth bearing; if $\sin n$ is used as positive A must be adjusted to $360-A$ for a western bearing.

Machine code

The complete machine-code program is given in Table 1. Once the rotator interface is completed it should be connected to the computer with the rotators disconnected and RUN 1775 typed into the computer to start a test routine that sends out a serial character from the keyboard to the interface. When the characters space, A, B, C, up to O are typed in all the on/off combinations of RLA to RLD should be obtained in binary. This routine tests the operation of the shift register and relay drivers.

When the above is satisfactory, connect the rotators and type in 16F0. The azimuth rotator should run in a counter-clockwise direction until it reaches its stop, when the elevation rotator should run counter-clockwise until it reaches its stop. Now both motors should run until the azimuth is 180° and the elevation is 0°. This routine is used to set the aerials in the refence position, chosen as due south in the horizontal position, and to set the locations 165C and 165D to 00 18. These locations hold the current position of the aerial and are used by the routines that control aerial rotation direction. This routine can be used when the aerials or program lose their synchronization when, say, the computer is reset while one rotator is running under the control of the program.

For manual rotation of the aerials the routine at 1730 is used which first checks if S_2 of the interface circuit is open and then requests azimuth and elevation angles from the operator. These angles must be given as two-digit numbers to the nearest 10°, e.g., 05 03 for 50° azimuth and 30° elevation. When the ready signal is obtained the space bar must be pressed to restart the program.

The interrupt service routine starts at 1602 entering the real-time variable T into the MM57109 and adding 1/360h to it, i.e., 10 seconds is incremented each time a pulse is received from the timer. A list of

these variables with their starting addresses is made by the interpreter in the memory reserved for variables after the list of line numbers at the end of the program. Each variable name is stored in two bytes with the second character first. For single character variables 3A is used as a dummy second character so T is listed as 3A 14 followed by 63 1F which is the reverse order address of the last (rightmost) of six bytes that contain the value of T. The first four bytes contain the mantissa in the reverse order while the fifth is a sign byte and the sixth the exponent.

To illustrate, pi is stored as 26 59 41 31 0B 01 and the decimal point is assumed to be between the two most significant digits in the fourth byte. The list of variables is made during a run so if changes in the BURP program are made the memory location of the variable may also change. After a dummy run of the program with S_2 closed, use FIND 3A 14 to find the address of T. If the address of T has changed, insert it at locations 1608, 1609 and 1618, 1619 in the reverse order.

The routine called at the end of line 12 of the BURP program, starting at location 1624, selects IM2, loads the interrupt register with HEX 16 and then jumps to location 1656 and waits for an interrupt to return. This routine is used only once to set up the interrupt register for mode-two interrupts.

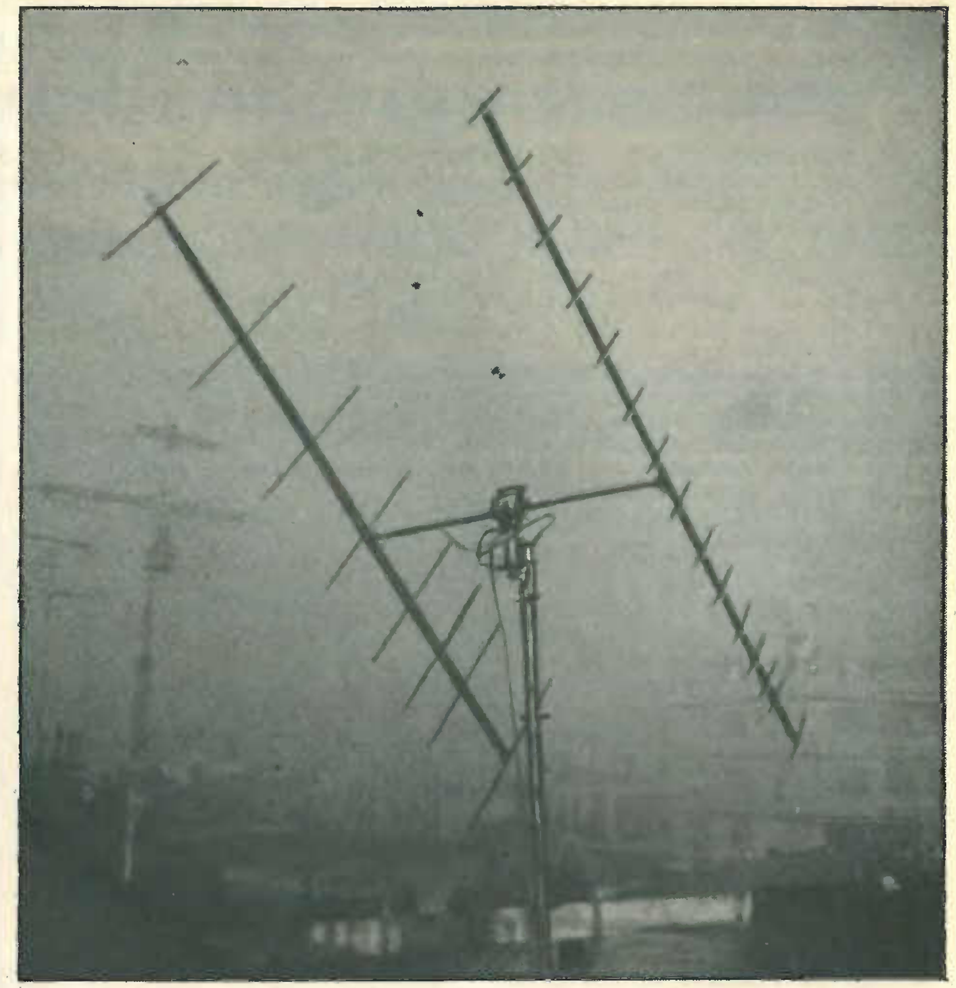
The routine at line 34 of the BURP program is called when the elevation angle is less than −5° and simply selects IM2 and waits for an interrupt by jumping to location 1656. This routine is used only for time-keeping.

Line 42 of the BURP program calls the routine at location 1636 when the elevation angle is greater than −5°. This routine is used when tracking is not required during a pass and when the programs are being tested. When called this routine checks whether switch S_2 is closed and if so jumps to 1656 then returns when an interrupt is received from the interface timer. If S_2 is open the bytes containing the two most significant digits of the azimuth and elevation angle variables (A and E in the BURP program) are loaded into the D and E registers of the Z80.

Unless the BURP program is altered, the above mentioned bytes will be in locations 1F43 and 1EEF; otherwise the bytes will change and should be entered in locations 1644, 1645 and 1648, 1649 in reverse order as follows. Use FIND 3A 01 and FIND 3A 05 to find the starting address of the memory string holding A and E then put the address of the bytes to the left of the sign byte in the locations as above. Remember that the starting address of A and E stored by the interpreter after 3A 01 and 3A 05 refers to the rightmost byte in the string, which holds the exponent.

After the D and E registers are loaded an AND 3F operation is carried out to limit their maximum values to 39. This operation is required as the number cruncher (MM57109) uses b.c.d. numbers.

When all the number juggling is finished the subroutine at 165E is called to activate the aerial rotators. The H register



This aerial system is used by the author for tracking Oscar satellites. The aerial to the left is for 145.9MHz and the one to the right for 435.1MHz. Both aerials are mounted on the same shaft supported in the middle by the elevation rotator which is mounted on the azimuth rotator.

holds the command word for the rotator controller and the L register stores the rotator cam switch conditions. Bits 0 and 1 of the H register control forward/reverse and start/stop functions of the elevation and bits 2 and 3 the same function for the azimuth rotator. The same subroutine loads the position of the aerial into the BC register while rotation is carried out.

If the position of the aerial corresponds with the requested position the subroutine returns without action. If the two positions do not correspond the forward/reverse and stop/start flags will be set or reset as necessary and the subroutine at 16E4 called to send the contents of the H register to the controller in serial form.

Next, the rotator cam switches are monitored at 20ms intervals via port 00 and their states compared with the settings previously stored in the L register. The subroutine at 1780 is used to generate the delay. If a switch setting has changed the corresponding shift register, B for azimuth or C for elevation, is incremented or decremented. To save time, azimuth and elevation angles are controlled independently. When both azimuth and elevation angles in the BC register are the same as those requested in DC register the subroutine stores the new position in 165C and 165D and returns to the BURP program when an interrupt is received.

The BURP program

Starting at line 2 of Table 2 the program requests the following data. ORBIT TYPE: If this request is answered with 1 the system tracks an ascending orbit. If 2 is entered a descending orbit is tracked. This information is used later in the program for calculating whether the satellite will pass north of the station. EQX LONGITUDE and EQX TIME: The first request is for the satellite's equator crossing longitude in degrees west and the second for the equator crossing time in hours and decimal parts of an hour to two places, e.g., 19.85 hours.

In line 4 the real time in hours and minutes is requested. Minutes are converted to decimal parts of an hour by the program in this case. Data from line 200 is read in line 6. This data is the station's longitude west, the station's latitude, the height of the satellite above the earth in km, the orbit period in minutes. For the Amsat Oscar 8 and my QTH in Limassol, Cyprus, line 200 of the program reads as follows:

200 DATA 326.75 34.72 877 99.99 103.2

This line is not included in Table 2. Any circular orbiting satellite can be tracked if the data as shown above is known.

Further in line 6 and then in line 8 the

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Table 2: The BURP program for satellite tracking calculations. Variables such as satellite height, orbit inclination and station position, are contained in line 200 described in the text.

```
002 INPUT "ORBIT TYPE" N "EQX LONGITUDE" L "EQX TIME" Z
004 INPUT "TIME NOW: HOURS" H "MINUTES" M !T=H M 60 / +
006 READ Q O H I P !A=O SIN I SIN / SIN- !IF N=2 A=180 A -
008 B=A P * 360 / !C=Q 0.25 B * - A COS O COS / COS- - L -
010 W=A COS C SIN * !B=O SIN !C=O COS !I=I SIN
012 H=H 6367 / 1 + REC !P=21600 P / !CALL 1602 !CALL 1624
014 T1=T Z - !D=P T1 * !F=D SIN !D=D COS !J=F I * !Y=J SIN-
016 M=Y COS !X=L 15 T1 * + D M / COS- + !S=X Q -
!N=CS SIN
018 S=S COS !U=B J * C M * S * + !G=U COS- !V=G SIN
020 E=U H - V / TAN- !A=J B U * - C V * / COS-
022 R=6367 V * E G + COS / !G=6367 G * PI * 180 /
024 IF X<0 X=X 360 +
026 IF X>360 X=X 360 -
028 TOP !D=T HMS !!F N>0 A=360 A -
030 PRINT "TIME:" D#4 !PRINT " AZIMUTH:" A#1, " ELEVATION:"
    E " SLANT RANGE:" R
032 PRINT " LONGITUDE:" X, " LATITUDE:" Y, " GROUND RANGE:" G
034 IF E<-5 CALL 162F !GO 14
036 IF W>0 A=180 + !E=180 E - !IF A>360 A=A 360 -
038 A=A 5 + 10 / INT !IF A<10 A=A 40 +
040 E=E 5 + 10 / INT !IF E<10 E=E 40 +
042 CALL 1636 !GO 14
```

program calculates two angles, A and C, which are used in line 10 to calculate a pointer called W. If W is positive the satellite will pass north of the ground station. When W is positive it is used later in the program so that the limit stops on the rotators are avoided as discussed in part one of the article. Later in line 10 and then in line 12 calculations relating to satellite tracking begin. Satellite height and orbit inclination and period (H, I and P) are redefined for further use in the program. The call of 1602 at the end of line 12 is needed to keep the correct time, and call 1624 to initialize the interrupt register.

Processing of the formulae mentioned earlier begins in line 14 with the calculation of the relationship between real time and EQX time and other auxiliary values. The formulae are broken down for the program to reduce computing time. Final variables of the program which may be useful are D which is converted real time (using the HMS statement), A the azimuth angle in degrees, E the elevation angle in degrees, R the slant range of the satellite, X and Y the sub-satellite longitude and latitude and G the ground range in relation to X and Y. These results are printed on the v.d.u. by lines 30 and 32.

If the elevation angle is less than −5° the 'non-active' time-keeping routine at 162F is called in line 34 and after an interrupt signal a jump to line 14 is made. The real-time variable T is incremented by 10 seconds by the interrupt service routine.

Where the satellite is to pass north of the earth station azimuth and elevation angles are adjusted in line 36 to avoid action of the azimuth-rotator limit stop. In lines 38 to 42 the azimuth and elevation angles are finally converted to the nearest integer representing them in steps of 10° and the tracking routine at 1636 is called. After aerial rotation the sequence is repeated from line 14.

Operating the system

After the aerial-control interface has been tested using the procedure described earlier the system is ready for final setting up. When the routine at 16F0 is run the rotators will be at 180° azimuth and 0° elevation so the aerials can be positioned on the rotator mountings but remember to leave slack in the cables to allow rotation to the limit stops.

To track a satellite enter the DATA statement at line 200 but before running the BURP program turn on the aerial-control interface and stop the timer by opening switch S_1 (see the circuit diagram in part 1 of this article). Type RUND @ 2 into the computer and then supply the data requested by the program. When real time is equal to the time requested in line 4 of the BURP program the timer of the interface should be started by closing switch S_1 of the rotator-control interface. The program will run 10 seconds later after a pulse from the timer on the interface is received.

Tracking will commence when the elevation angle is greater than −5° and S_2 of the interface is open. If S_2 is closed tracking will stop and if the azimuth rotator is running the program and rotator will no longer be synchronized. Problems with synchronization will also be encountered if the program is reset while either rotator is running. The routine at 16F0 can be used to solve synchronization problems.

After a satellite is out of range the interface timer can be stopped when the computer's ready light comes on and another satellite can be tracked with the same program but using new data. Accurate timing signals are available on the short-wave band at 5, 10 and 15MHz and on 60kHz MSF (Rugby).

BOOKS

Electrics and Electronics for Small Craft
by John French.
254pp., hardback.
Granada, £15.00.

Mr French is clearly a mariner with many years of bitter experience. He has been concerned with the design, installation and maintenance of marine equipment for thirty years, and the second edition of his book compels one to wonder at the temerity of electronic engineers in designing such equipment at all. Deterioration of hull fittings and even of the wooden or g.r.p. hull itself, the hard work of calibration, interference and the crippling cost of it all are such as to make landlubbers feel guilty at having such an easy life.

Nevertheless, his book is a model of lucid explanation of highly technical equipment in an accessible manner – its selection, installation and maintenance. Part 1 is on electrical matters – corrosion, interference suppression and batteries – and is followed by twelve chapters on every type of electronic installation to be found in small craft, from echosounders to radar and hyperbolic navigation systems. Mr French is extremely thorough and includes a great deal of detailed information, but nonetheless writes in a humorous and sympathetic style: not many authors would introduce a chapter on interference suppression with a quotation from "Paradise Lost."

The Alien, Numbereater and Other Programs for Personal Computers
by John Race.
86pp., paperback.
MacMillan,
£3.50.

Dr Race presents fourteen programs, mostly in Basic, which are intended as worked examples of techniques. The programs consist, in the main, of games, but one or two are mathematical or problem-solving, such as the one written by Tom Race for finding a set of non-primes, and a program for cyphering or decyphering messages. There is also an 80-column histogram plotter.

Each program has been selected to illustrate a number of techniques, which are listed at the start, such as recursion, machine-code programming, special graphics, heuristics, etc. Some of the programs described need a printer or a second cassette deck to work.

The programs are all on a cassette, which can be obtained from MacMillan.

Amateur Radio, by Gordon Stokes and Peter Bubb.
192pp., hardback.
Lutterworth Press, £8.95.

Mr Bubb is a lecturer and coach for the Radio Amateur Examination and Mr Stokes, also an amateur, is a professional writer. Between them, they have produced a book which, it is claimed, contains the relevant information to enable readers to pass the RAE.

The basics of electricity and electronics take up six chapters and are treated in such a way that no previous knowledge is needed – the text is extremely easy to read. Modulation, receivers and transmitters, aerials, propagation, measurements, operating procedure – all is dealt with in a manner that recognizes the varied background of candidates for the examination. There is no mathematical treatment and some of the description is so limited that there may be a danger of falling short of the exam. requirements. The book should, however, be a useful introduction to the subject for those lacking any electrical knowledge of any kind.

Designing with microprocessors

11 – Direct memory access systems

by **D. Zissos** assisted by **Glen Stone**, Department of Computer Science, University of Calgary, Canada

Direct memory access (d.m.a.) systems allow data to be transferred directly between a peripheral and the main memory in microprocessor-based systems. The procedures will be illustrated, as in previous articles, by means of problems and solutions.

In the methods we have discussed so far for moving data between a microprocessor and a peripheral (wait/go, test-and-skip and interrupt), the information moves through the microprocessor chip, as shown in Figure 1(a). These methods, the reader will recall, require several instructions to be executed for the transfer of each byte. For example, if we use the interrupt mode, we must 1. disable further interrupts, if not automatically disabled, 2. store the re-entry point, 3. identify source of interruption, 4. save working registers, 5. service the request, 6. clear the flag, 7. restore the re-entry point, 8. enable interrupts, and 9. return to the current program, as explained in the May issue.

Two problems are created in these situations. First, for large blocks of data this can involve excessive amounts of m.p.u. time. Second, the net transfer rate of data in and out of memory can be reduced to levels well below the minimum limits, as in the case of fast data links.

Clearly, the most straightforward method to solve both problems, namely the heavy software overheads and the speed limitation, is to bypass the microprocessor chip, by establishing a direct link between the 'peripheral' and memory, as shown in Figure 1(b). Most if not all, microprocessor chips have a facility which allows the designer to establish a direct link between the main memory and a peripheral. This facility is called **direct memory access**, or **d.m.a.** in abbreviated form.

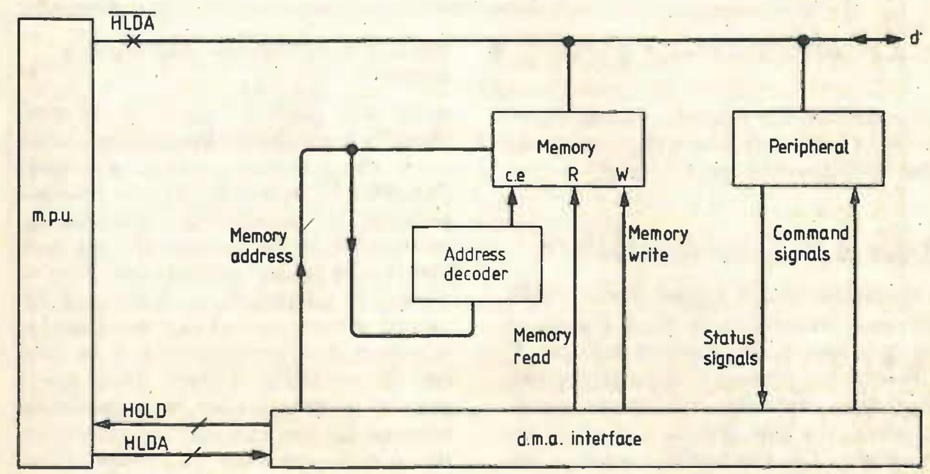

Fig. 2. Block diagram of a direct memory access system.

Contrary to common belief, the design and implementation of such system is uncomplicated, once a framework of reference is established. The d.m.a. hardware is straightforward. In its basic form it comprises an address decoder, a couple of counters, two flip-flops and half a dozen or so gates. Similarly, the d.m.a. software is minimal, consisting of less than a dozen instructions for a block transfer – see pages 164 and 165 of reference 1.

The d.m.a. concept

When direct access to the main memory is required by a peripheral, the microprocessor chip is requested to go on hold and cut itself off the address and data buses, as well as the control lines which carry the memory read and write signals. When the microprocessor chip responds to **the hold request** (HOLD), it generates **a hold acknowledge signal** (HLDA) to inform the requesting hardware, commonly referred to as a **d.m.a. interface**, that it can 'go ahead'. 'Going ahead,' in this case, consists of the d.m.a. interface generating the appropriate signals needed by the memory and the peripheral to move data between them as shown in Figure 2.

There exist two main methods of accessing directly main memory in microprocessor-based systems, **the block transfer method** and **the cycle-steal method**. In the first method the microprocessor chip is kept on hold until the complete block of data has been transferred, whereas in the second method the microprocessor chip is put on hold for one memory cycle each time a piece of information (typically a byte) can be transferred between memory and the peripheral.

At first sight, it would appear that the block transfer method would be easier to implement than cycle stealing. This is because conceptually the mechanism needed to put the microprocessor chip on hold once is simpler than having to do so many times. This, as will be shown in a later article, turns out not to be the case. Furthermore, the block transfer method suffers from a major operational disadvantage, namely, when the microprocessor chip is on hold it is not sensitive to its environment. Although this may be acceptable in computational environments, it cannot be tolerated in high-risk

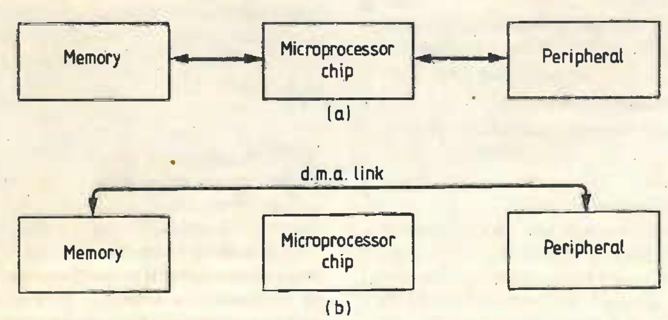

Fig. 1. (a) Indirect memory link; (b) direct memory link

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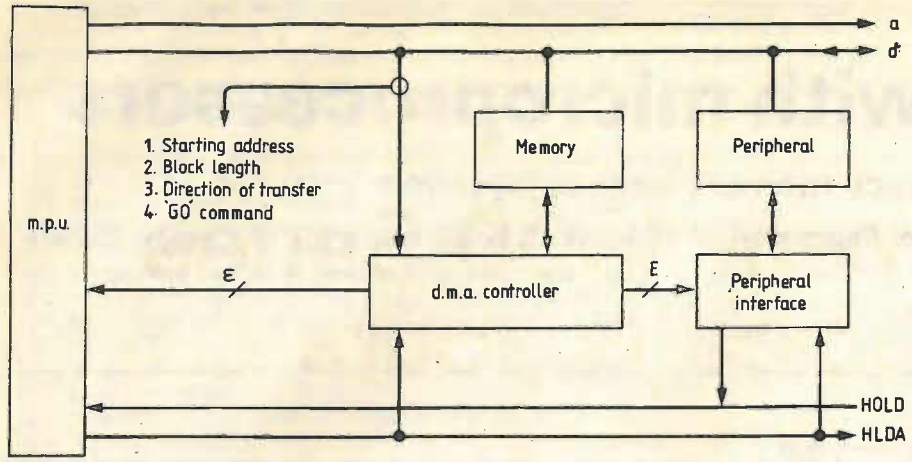

Fig. 3. Simplified form of a d.m.a. system. ▲

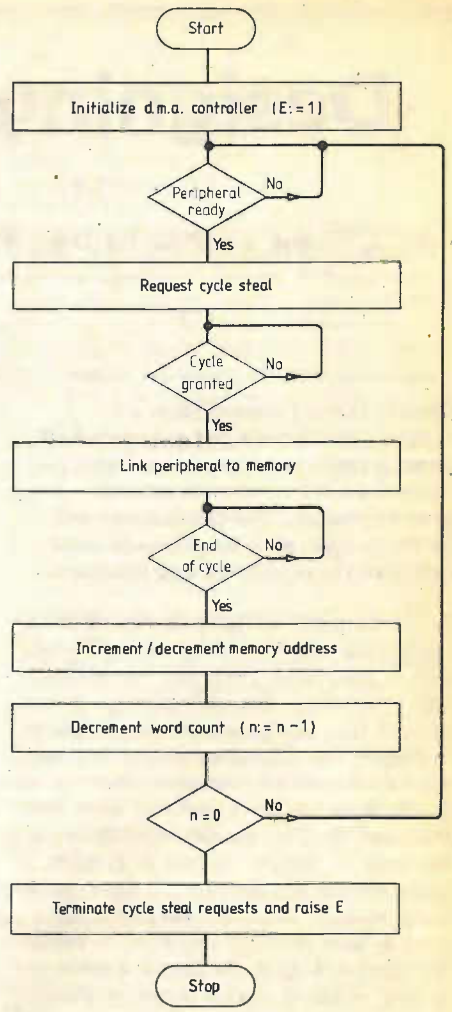

Fig. 4. Step-by-step operation of d.m.a. system. ▶

environments (for example, patient monitoring in hospitals), where high sensitivity and fast responses are essential.

Basic d.m.a. configuration

A simplified form of **a basic d.m.a. configuration**, using either the block transfer or the cycle steal mode, is shown in Figure 3. The interface consists of two components, **the d.m.a. controller and the peripheral interface**, the basic functions of which are as follows. The programmer sends to the d.m.a. controller (by means of i/o instructions) three items of information specifying (i) the starting address, (ii) the size of the block, and (iii) the direction of transfer, followed by a 'go' command. On receipt of the 'go' command, the d.m.a. controller activates the peripheral interface by pulling enable signal E in Figure 3 high (E:=1). In its activated state, the interface monitors the status signals of the peripheral, and requests the microprocessor to go on hold (HOLD:=1) when the peripheral is ready. No further action is taken until the microprocessor responds (HLDA:=1), at which time the interface generates the appropriate command signals needed by the memory and the peripheral. The process repeats itself. That is, a piece of information is transferred between memory and the peripheral whenever the microprocessor is on hold and the peripheral is ready. Each time a piece of information has been transferred between the memory and the peripheral, the d.m.a. controller increments/decrements the memory address and decrements the word count. When the word count becomes zero, the controller de-activates the peripheral interface (E:=0), and generates an **end-of-transfer signal**, denoted by ε in Figure 3. Signal ε, typically an interrupt flag, informs the programmer that the block transfer has been completed. The step-by-step operation is flowcharted in Figure 4.

Note that once the initial conditions have been set up, data transfers in d.m.a. systems take place autonomously, that is with no programmer intervention.

References

Zissos D. "System Design with Microprocessors," Academic Press, 1978.

BOOKS

Electronic Pocket Book, by Andrew Parr.
350pp., paperback.
Newnes Technical Books, £5.60.
This is a heroic attempt to cover, in 340 pages of largely non-mathematical text, the whole gamut of electronics. It starts with the atom and touches on circuitry, components and systems from transistor amplifiers to computers in industrial and domestic use.

The book is the fourth edition of a well-known title, completely rewritten since the last one in 1976. It is by no means a detailed textbook, but is rather an introductory view of the many topics covered: the writing is simple and direct and no background knowledge is assumed. Coverage of individual subjects is necessarily limited and fairly superficial, but the book will serve as a convenient lead-in for the newcomer, who can then follow up his particular interest in more exhaustive texts: a list of suggested further reading would have been useful to this end.

Dictionary of Telecommunications, by S. J. Aries.
329pp., hardback.
Butterworth, £15.
A companion volume to those by Roberts, Amos and Jackson on related electrical and electronic subjects, this work is concerned exclusively with those terms used in the broad field of communications, overlapping, to some extent, the others in the set in its coverage of radio, electronics and audio. Expressions used in the US are explained in terms of their UK equivalents, and a list of acronyms and abbreviations appears at the end of the book, some also being given in subsidiary positions in the main body of the text.

Mr Aries is a member of international committees working on units and terminology: the authority of the entries can therefore be relied on with a high degree of confidence.

Guide to Acoustic Practice, prepared by K. A. Rose.
95pp., paperback.
BBC, £10 (airmail plus £2.31)
Engineers and architects at the BBC have accumulated a great deal of experience over many years in the design of studios and control rooms, which has been distilled and prepared for publication in the form of a guide. Until recently, the guide has been in constant use inside the BBC, but demand from overseas has forced the Corporation to make it more generally available.

Insulation to reduce external noise and acoustic treatment for internally generated sounds are both covered thoroughly, a further section dealing with the effects of studio furniture and fittings on sound characteristics. There are two sections on noise borne by service ducts and generated by plumbing, lifts, electrical equipment and generators. Nearly half the book is devoted to drawings and tables relating to the text.

This is a remarkably concise and practical work and is highly relevant to other structures such as conference halls and music rooms where the sound quality is important. As is pointed out at the beginning, it is no use glueing a few acoustic tiles on the wall and expecting the noise to disappear.

Oscilloscopes
by Ian Hickman,
122pp., paperback.
Newnes Technical Books, £3.45.
This is addressed to school physics students and technicians, as well as to those with an interest in electronics as a hobby. It is a simple book, with no pretensions to depth, and provides an easily read guide to modern oscilloscopes and their use, which should help students approaching these instruments for the first time.

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Input attenuator tolerances are now specified at ±3% for all D1000 series oscilloscopes, a considerable improvement over the previous ±5%. But again, the user may well find the true figure closer to ±2%.
More Accurate Time Bases
The time bases, too, have been upgraded. All new D1000 instruments have been equipped with thermal compensation which tightens time measurement accuracy to ±3%, with improved stability as a bonus.
To match these improved time base specifications, trigger bandwidths and performance characteristics have been substantially enhanced.
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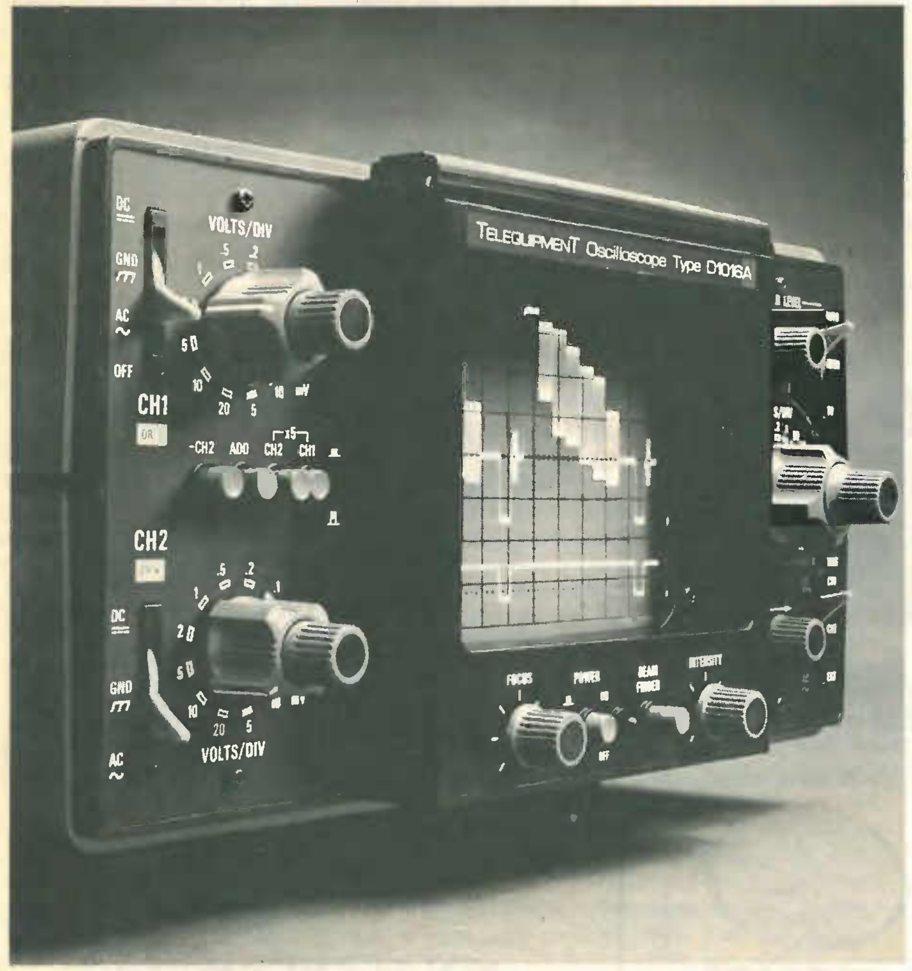

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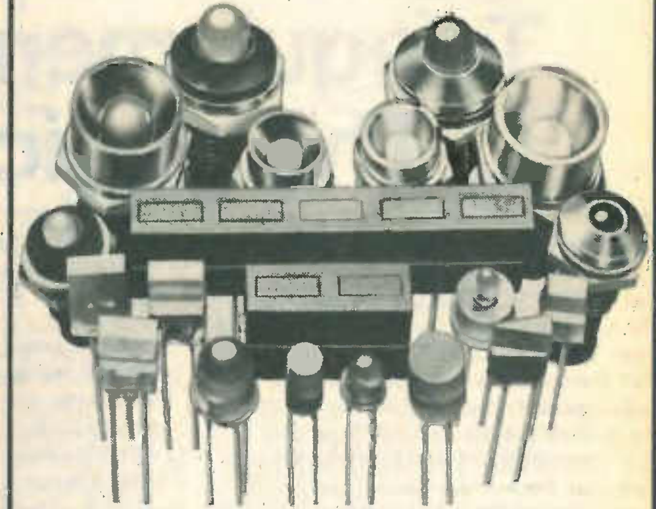

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CES, Chicago

Round up from the largest American consumer electronics show

by George Tillett

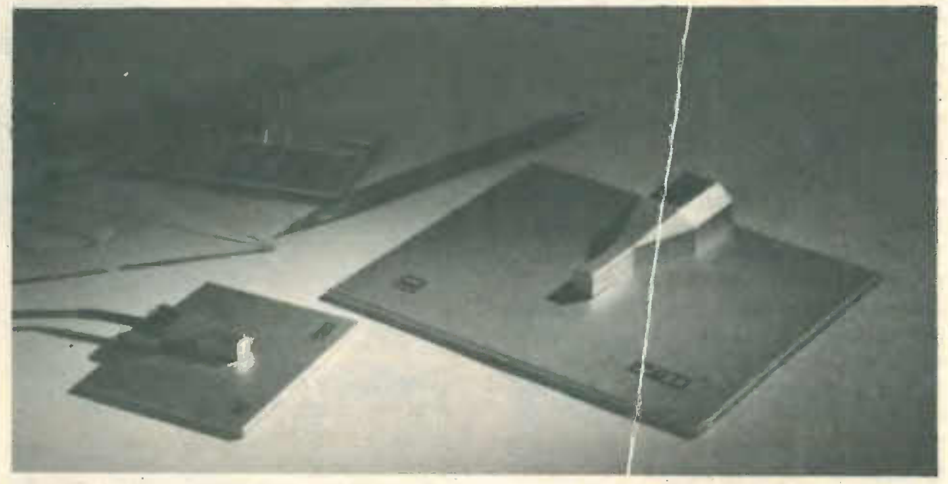
This year the Summer Consumer Electronics Show in Chicago was larger than ever with a record breaking attendance of well over 60,000. Almost 900 exhibitors were spread over 550,000 square feet of space and 300 demonstration rooms at adjacent hotels: As with recent shows, main interest centred on video, emphasized by the impressive space age array of giant satellite dishes outside the main entrance.

Video disc players were naturally attracting a lot of attention – in fact, you could hardly miss them, stacked as they were to make an eye-catching video wall. Although the new RCA Selectavision model has only one audio channel and lacks many of the features provided by its competitors, it has been popular, mainly because of its lower price. In terms of basic performance, it is comparable with the VHD and laser models in spite of its stylus-in-groove design. Critics described it as "a giant step backwards" but this hasn't deterred companies like Sanyo and Toshiba who have also opted for this system, now called CED. The VHD system developed by JVC also uses a stylus but it glides over the record surface, not in a groove. New models were shown by Sansui, Quasar and Sharp, the last-named deciding to go with VHD "because of the superb stereo sound". Sansui were also showing a CED model and at this point were undecided which kind to make.

Laser players are made by Pioneer and Magnavox and the former has signed agreements with Columbia Pictures, Covent Garden Productions and many Hollywood program sources. Further agreements are being made between the various film makers so the same movies will eventually be available in all three formats: CED, VHD and Laservision. So the situation is a little better than the quadraphonic fiasco when the competing manufacturers didn't even agree on the spelling of the name!

Turning to video cassette recorders, well, we have had to live with Beta and VHS recorders for some time but it seems that we'll have to contend with another standard or standards for portable models. Technicolor introduced a miniature camera-recorder last year which used ¼-inch tape in cassettes not much larger than

See also article on video discs elsewhere in this issue.



Pressure zone microphone claims flat amplitude response at all angles of incidence by virtue of tiny phase-cancelling gap.

those made for audio and weighing only two ounces. But now Japanese photographic equipment makers, faced with a disappearing home movie market, have turned their eyes to video so to speak. Funai and Canon have already introduced "Camcorders" and other manufacturers will release models soon. Sony retaliated with the Betapak described as the "world's lightest VCR" at just over 9lb. A great many Beta and VHS portable and domestic models were introduced at the Show, including entries from Kenwood (Trio) and Sansui.

Prices have come down to meet the video disc competition but the tape itself is expensive. One reason is the high cost of real-time duplication but the situation could change. Mitsubishi were showing a high-speed video tape duplicator which uses a process called "video anhysteric transfer printing" to copy a four-hour tape in four minutes. It's expensive but the quantities involved are high enough to justify the outlay for many cassette suppliers. There are rumours of a video disc system with recording capability but I can find no hard evidence. On the other hand, it is true that a company in New England has plans for a playback-only video cassette machine to cost about half the present models.

A great number of new cassette decks were to be seen: most of the top models boasting automatic bias, equalization and sensitivity circuits. Several provide Dolby C noise reduction while Marantz, Teac, Yamaha and Technics have plumped for dbx in some of their models. Competition between dbx and Dolby has increased recently with the Dolby Labs emphasizing the greater dynamic range plus noise reduction over the whole band. Dolby's answer was the HX circuit and Dolby C, plus the reminder that compatibility is most important as there are some 100 million Dolby decks out there!

The new CBS CX (compatible expansion) records were being demonstrated by Sound Concepts, MXR, Phase Linear and Audionics, all of whom make the decoders. At the moment, only four records are actually on the market but CBS say that all their records will soon be in this format. Furthermore, their goal is to make it the industry standard for recording. Warner are believed to go along with the idea but at the time of writing, nothing* has been heard from RCA or any other record company. In some respects the CX process is like the dbx system: it uses the same 1:2 expansion ratio in playback but it does not function over the whole dynamic range. No pre-emphasis is used in the encoder and CBS claim that these records will be "audibly acceptable" when played without a decoder. Amplitude response will be unchanged and noise level will be no worse. The decoder parts are relatively inexpensive so eventually, if the idea catches on, we will see this facility built-in to many record players, receivers and amplifiers.

Another noise reduction unit was being demonstrated by National Semiconductor. This is the DNR and it is in the form of a single i.c. with two channels. It works on the same principle as the Burwen-KLH

* RCA Records have since agreed to adopt the process.–Ed.

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system introduced some years ago. A dynamic filter keeps the bandwidth narrow with low-amplitude signals but opens it up when the signals are loud enough to mask any background noise. Attenuation commences above 800Hz and the attack time is less than 1ms of a second with a release time of 50ms. Effective noise reduction is claimed to be 10dB (CCIR weighted) but it doesn't require encoded material as it is single-ended.

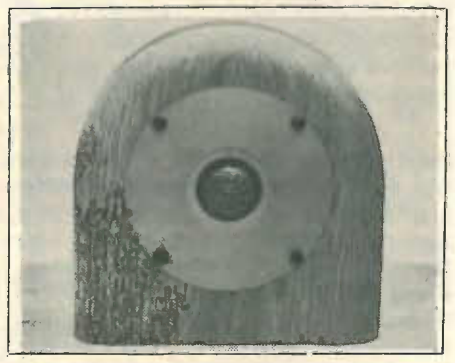
Crown's PZM microphone is now being used by many recording studios as well as for sound reinforcement at such places as the Hollywood Bowl and Wolftrap Performing Arts Center. It uses the principle of the pressure field where there is no direction of propagation. Within a few millimeters of a large surface, sound levels from a pair of equal signals add coherently because in close proximity to the surface, the particles are still in-phase as they accelerate after being brought to a stop by the boundary. So two engineers, Long and Wickersham, mounted a pressure microphone above a Formica surface with a tiny spacing between the diaphragm and the surface, hence the name "pressure zone microphony". It is claimed that no signals can arrive on axis but can only enter at the sides, so the amplitude response is flat at all angles of incidence. The standard model uses an electret capsule and it is mounted on a five-inch square plate. By using various shields, a wide range of directional characteristics can be obtained, without affecting amplitude response. PZM microphones have been particularly successful with recordings of the piano and large-scale choral works.

Loudspeakers

As usual, there was a tremendous variety of loudspeakers at the Show, ranging from tiny shoebox systems with giant four-inch bass drivers to huge behemoths costing a sizeable fortune. The Quad electrostatic attracted a lot of attention, so did the B&W 801S which uses a new midrange enclosure made from an acoustically dead plastics-cement mixture. The Sony Esprit APM-8 is a rather unusual floor-standing model using four drivers, all with flat diaphragms. The bass radiator measures 125 square inches and is driven by four speech coils and it is claimed that this multi-drive system extends the piston range by two octaves. RTR were demonstrating a new electrostatic panel consisting of two vertical arrays of twelve units. One section handles frequencies from 130Hz up to 2.2kHz while the other radiates from 2kHz up to beyond 20kHz. It is, of course, designed to match a subwoofer. Another RTR model uses a novel dome tweeter which has a plastic diaphragm reinforced by a geometrical arrangement of hard fibre threads. Ferrofluid is used in the magnetic gap and the low frequency limit is 750Hz while the first resonance occurs at 40kHz.

The Cosmostatic system uses eleven electrostatic panels in an umbrella-shaped array with four 6-inch bass drivers which fire upwards. Low frequencies are augmented by two 10-inch passive radiators.

Looking like any combined tv, radio and audio cassette player, this is actually a video cassette recorder and 20cm colour tv.



According to RTR Industries, Dupont's Kevlar fibre – five times stronger than steel – in a special pattern allows behaviour to be modelled by a computer.

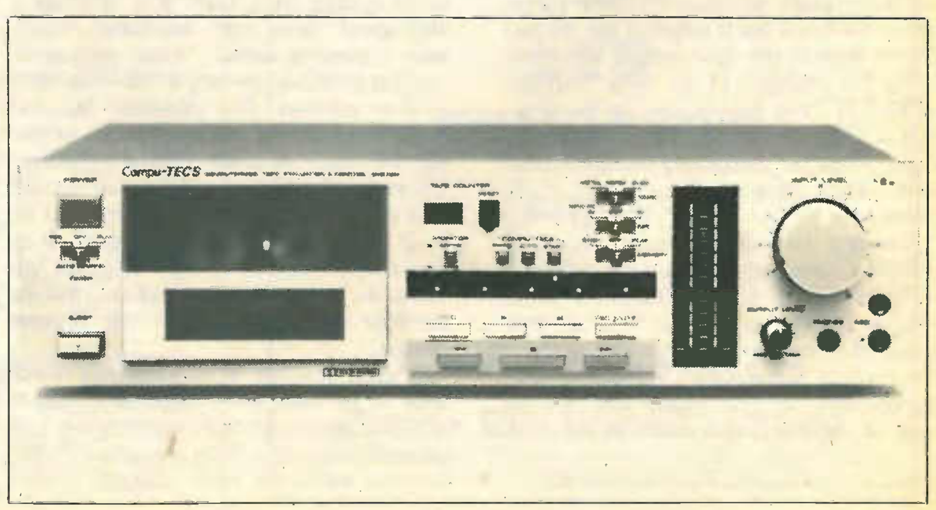
Most top models of cassette deck feature automatic bias, equalization and sensitivity circuits.

The built-in ESL matching amplifier is claimed to handle peaks up to 1200 watts.

In brief . . .

Yamaha's top receivers are provided with a "spatial expander control" which is claimed to widen the stereo image. It appears to work by delaying a portion of the signals from one channel and feeding them to the other . . . The Carver company were demonstrating a new f.m. tuner which, it is claimed, virtually eliminates multipath distortion. The detector circuit is called the "asymmetrical charge-coupled f.m. detector" but no other details were available. However, I can testify that it really works!

. . . Digital audio records were demonstrated by Sony, Fisher, Philips and Sanyo . . . Onkyo had a cassette deck which provided Dolby B & C and dbx noise reduction . . . Mitsubishi were showing a microwave oven which could be operated by voice commands. It makes announcements (your dinner will be ready in three minutes!) and it has a tv screen for menu displays or tv programs.



NEWS OF THE MONTH

BBC radio on v.h.f.

Once again the BBC has announced that it is to concentrate its efforts into improving the quality of its transmissions on the v.h.f. bands. This will become necessary when there is an increase in interference from European stations on the medium and long wavebands over the next ten years.

Aubrey Singer, managing director of BBC radio, has said that the first priority was to make the four national networks 'properly audible on v.h.f.' This involves re-engineering existing transmitters to include a vertically polarised signal in addition to and equal in strength to the horizontally polarised signal; in effect to give 'slant' polarisation. This would improve reception for receivers with vertical aerials, especially portable sets and car radios. There would also be a programme to build new transmitters to provide a v.h.f. service to those areas not provided for.

Another long term proposal is a campaign to get the fixed and mobile services, principally the police and fire services, shifted to a different wave band. This has already been proposed by the WARC in 1979 but the regulations allow some services to continue in Band II until 1995. There will be two European v.h.f. allocation conferences in 1982 and 1984 and the BBC are instituting their campaign now so that the British negotiators will have decided upon a plan well in advance of the conferences. If the full 88 to 108 MHz band became available for broadcasting, the BBC could go ahead with plans to have a new v.h.f. network for Radio 1, full UK coverage on v.h.f. for Radio 4 and possibly a separate network for educational broadcasts including schools and the Open University. Each network would occupy a similar position on the tuning scale regardless of the transmitter being used, and each sub-band would be 2.8MHz wide.

In addition the BBC proposes to increase the number of their local radio stations in England to 38 from the existing 22 at a rate of about three each year. There would also be some local stations in Scotland, Wales and Northern Ireland which could opt out of the national region stations and broadcast in Gaelic, Welsh or provide local news.

All this is going to cost some three to four millions each year.

Aubrey Singer also looked forward to improvements in receiver technology. Many listeners tend to stick to one or two radio stations because of the problems of finding and tuning into the other stations. If push buttons were provided as they are on tv sets, it is probable that more use would be made of the services. Another possibility is the use of programme labelling or 'radio data' (see photo) – additional modulation on the signal which would not affect the received signal but could activate a display included on the set and provide a time readout, the date, channel identification and possibly even some news headlines: a sort of Ceefax for radio. (See BBC reply to letter, October 1980 issue, p.49 and news report December 1978 issue, p.50.)

Assuming that The Archers *continues, the radio of the future may have a display similar to the one shown in this mock-up. The BBC have now announced officially that they have been making test transmissions with programme labelling subcarriers, or "radio-data" as they call it, for the past three years. If further tests are successful listeners with suitable microprocessor controlled receivers may be able to tune in by commanding a station, or even a programme, without having to bother about wavelengths. The final form of the service has not yet been determined in full but it is suggested that programme labelling data may include such information as music titles, sports scores and future programmes for display on the receiver's read-out. Among other countries experimenting with programme labelling are Sweden and France, who have systems similar to the BBC's, and talks are under way in conjunction with the EBU to agree a common European system. More details next month.*

EMP and thermionic valves

The electromagnetic pulse (EMP) produced by a nuclear explosion high above the Earth could wreck telecommunications across a continent, according to Anthony Tucker, writing in the *Guardian* of 2 July.

With the exception of several US Department of Defence reports issued in 1977, the Bell Laboratories' *EMP Engineering and Design Principles (1975)* and a recent three-part series in *Science* on the subject (May to June 1981), Anthony Tucker's book *The Electromagnetic Pulse in Civil Defence* is the first serious treatment.

Several monthly UK journals have carried material on the implications of EMP over the last three years, concentrating on the vulnerability of communications links which employ semiconductors rather than thermionic valves, but none has generated more than a fleeting response.

Any atmospheric explosion generates an electromagnetic pulse because of the interaction of the rapidly expanding ball of ionised gas with the Earth's magnetic field, but in the case of a nuclear weapon explosion two effects combine to produce a very powerful electrical pulse, resulting in peak signals of kV order (rather than the more normal μV order) appearing at receiver antennae, with devasting results on sensitive semiconductor r.f. stages. With much of NATO's military and business data (including strategic information) now spread by p.c.m. methods, in the event of attack this could mean a dangerous blackout of communications and other vital data services.

The principal effects in such an explosion are caused by the conversion of gamma ray energy into an atmospheric charge (well-known Compton Effect) and the disruption of the ionosphere – the latter could clearly have serious implications for general h.f. communications. In theory the optimum height for such an explosion, were it to be used tactically, would be 300 miles up, but no actual tests have been possible because of the Test Ban Treaty on atmospheric explosions.*

When a Russian MiG-25 fighter plane was flown into Japan by a defector in 1976, it was found that the body shell had been arranged to form a Faraday cage and, even though the turbine technology was very advanced, on-board radio communications equipment consisted of sub-miniature valve circuits, suggesting that Russian designers have EMP very much in mind.

Thermionic valve equipment, while not totally impervious to EMP, offers a greater margin of safety, although designers will have to balance the safety factor against the higher efficiency of semiconductor devices.

Communications satellites are therefore highly vulnerable to EMP but it seems unlikely that Russian design strategy will involve the use of a thermionic valve equivalent of l.s.i. – it would probably require the sending of bodies the size of the Albert Hall into Earth orbit.

* The last (observed) effect of EMP was in 1958 when a nuclear explosion 250 miles above Hawaii doused the street lights 800 miles away.

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Levy on blank tapes

Six of the main suppliers of blank tape have banded together to form the Tape Manufacturers' Group. The Group consists of BASF, 3M, Maxell, Memorex, Sony and TDK and has been brought together specifically to combat any levy on blank tapes reported to be recommended in the government Green Paper on copyright law, to be published soon (at time of writing).

Mr Bill Fulton, from Sony UK, acting as chairman for the Group, said that the levy plan proposed by the record industry was impractical and unworkable. "The problem of home taping has been grossly overstated. A levy would penalise, to an unfair degree, all tape users, whether they breach copyright or not," he said. "Consumer groups as well as organisations representing the professional interests of journalists, educationalists, businessmen, tape retailers and disc jockeys appear to agree with us, and a broadly based campaign of opposition is planned." He likened such a levy to a levy on blank paper which would be used to compensate writers and publishers in case copyrighted material were to be reproduced.

The British Phonographic Industry has been the main promoter of the levy. They claim to be losing £1m a day through breaches of copyright, and say that the levy, which would effectively double the cost of blank audio tape, would provide adequate compensation. Mr Fulton would not deny that some home copying from discs was carried out but challenged the reported extent of such breaches of copyright. "The fall in sales for which the record companies appear to blame home taping must be due to other factors within the industry. The development of low cost, high quality cassettes and home recording equipment has in fact helped the record industry by stimulating an interest in music."

A levy scheme would be fraught with problems, such as the proposed exemption for blind people and for other categories. Another problem in the administration of such a scheme would be how to apportion the income from the levy to the record companies and artistes. Counterfeiters, who are already selling inferior tape disguised as the more popular brands, could also forge the proposed levy stamp and get that money in addition. This could throw the whole market into confusion.

Used to correct the angle of view of photographs taken from the air, the Wild OR1 orthophoto system is a high-speed, computer-assisted differential rectifier. In producing plans from aerial photographs, the instrument takes into account the effect of slopes in the terrain. The illustration shows the transformation of an oblique photograph, of a mosaic floor in Delphi, into a true-to-scale reproduction.

Dialled radio-telephone

Those who are rich/important enough to have telephones in their cars can now dial direct to any number in the UK or to any of the phones connected to the international direct dialling network in some 100 countries. This has been made possible by the installation of equipment, supplied by Pye Telecommunications, in four regional centres.

The former manually operated exchange in London had reached full capacity with more than 3,000 customers. In order to allow more, British Telecom are increasing the number of Radiophone channels by reducing the bandwidth of each. Even so the capacity of the service is still limited and cannot expand further unless the Home Office allocates more radio bands.

Many of the existing customers are transferring to the new service, which leaves some vacancies on the manual exchange. But there is no need to rush to apply – there is a long waiting list of applicants.

News in brief

The autumn bunch of exhibitions and conventions includes the **Business and Light Aviation** Show at Cranfield Airfield, 3 to 5 September; the **Video Show**, West Centre Hotel, Fulham, London 16 to 18 October; **Viewdata** at the same venue, 4 to 6 November; The **Sound Broadcasting Equipment Show**, Albany Hotel, Birmingham, 29 September; **Electronic Displays '81**, The Kensington Exhibition Centre, London, 23 to 25 September; **The West of England Electronics Show**, Bristol Exhibition Centre, 15 to 17 September; **Emag '81**, Cavendish Laboratory, Cambridge, 7 to 10 September.

A **radio amateur course** is to be held at the Gosforth Adult Association, near Newcastle upon Tyne, starting in September. Further details may be obtained by telephoning Newcastle upon Tyne 668439.

The Sixth Annual Microprocessor Workshop on **Microprocessor Applications** will be held in the Computer Laboratory of the University of Liverpool on the 7th and 8th September. Within the two days there will be some 22 lectures on all aspects of microprocessor hardware and software systems with a special session on 'microism'. Details from Miss C. A. Bryson, Microprocessor Workshop, Computer Laboratory, University of Liverpool, PO Box 147, Liverpool L69 3BX.

Following our story last month of the collapse of the Rank empire, we have heard that the Mastercare service, owned by Currys, for after-sales repair and servicing of electric and electronic appliances is to take over the **guarantee liabilities of Rank** Radio International. The Rank distribution warehouse in Milton Keynes has gone to Binatone, and the Murphy trade mark to J. J. Silber, a subsidiary of Great Universal Stores.

NRDC merges with NEB

British electronic inventions like the Ambisonics surround-sound system which hitherto have been commercially developed by the National Research Development Corporation will now be taken up by a new, more vigorous organization called the British Technology Group. This is the result of a merger, recently announced by the Government, between the NRDC and the National Enterprise Board. The merger proposal has been on the cards for some time, but the Government, alarmed at reports of inadequacies in the existing system for exploiting British inventiveness, has now brought it forward.

The new BTG will be run much more like a private company, with an eye on profit, setting up joint ventures with other industrial firms and entering into partnerships with financial companies in the City of London. It will have about £300m of investments in over 90 companies and will be responsible for some 700 research and development projects. Its general mode of operation will be to provide money to develop inventions and new industral products and, when they have reached a sufficiently commercial stage, sell them off as investments to private industry.

Chief executive of the new organization is Bruce Willmott and his deputy is Dr Jim Cain.

TV subtitles for the deaf

There has been much correspondence in *Wireless World* about tv audio aids for the deaf; the provision of earphone sockets, for example. These are no good at all for the completely deaf but there have been some advances on their behalf in the form of Ceefax and Oracle subtitles. Television viewers saw some examples of the current art of subtitling during the recent Royal Wedding outside broadcasts. Some of the phonetic rendering were distinctly odd.

Now the Independent Broadcasting Authority, together with the Independent Television Companies Association and the University of Southampton has published *Guidelines for the subtitling of television programmes* by Robert G. Baker. Mr Baker is a psycholinguist who specialises in the needs of the deaf and the hard of hearing.

The 18-page publication includes detailed recommendations on the display, editing and preparation routines for subtitle captions. It emphasises both the action and the captions; the need to reduce frustration in the viewer by subtitling all obvious speech and relevant sound effects, and by placing subtitles accurately in time and in position on the screen.

While captioning should not try to reproduce the entire text of a programme, the *Guidelines* warns against excessive use of abbreviations and idiomatic speech forms. Bad language should not be bowdlerised, but could be reduced in frequency. Such idiomatic phrases as 'he gets my goat' are usually better presented as 'he annoys me'. [This could be very confusing to those who can lip-read – Ed.]

The *Guidelines* includes practical recommendations on the length of captions, on the use of punctuation and upper and lower case characters, on the creative use of colour and, for example, on the use of flashing characters to highlight repetitive sound effects, such as a ringing telephone.

Copies of the publication are available from the IBA Engineering information Services, Crawley Court, Winchester, Hants SO21 2QA, from ITCA, or from the author at the Department of Electronics, The University, Southampton.

Industry, education and riots

"The importance of computer games as a learning tool should not be underestimated" said Kenneth Baker, Minister of State for Industry and Information Technology at the English Speaking Union in Cambridge.

"This is one way of introducing young people to the potential of microelectronics, and I am all for it – so long as space invaders do not entirely take over the inventive energies of young people.

"We need more young people studying the skills industry needs; we produce around 500 electronics and 200 production engineers per year; the Japanese ten times this number. At 'O' level half a million students enter English Language, 300,000 Maths, only 10,500 Computer Studies. We must give this fourth 'R' the push it needs. About 1,700 students entered university to study Computer Science in 1980, it is not enough.

"50 per cent of our companies still do not use microelectronics. I recently announced Information Technology Year for 1982 to tackle this. There are huge markets open to us; £50 billion per year world-wide, expanding 10 per cent per annum in real terms. We need to achieve a large slice of this cake; currently we have about 6 per cent. The potential here is tremendous for wealth and job creation. The huge range of industries that make the products and provide the services under this generic term Information Technology, stretch from satellites to computer games. But let me emphasise as clearly as I can that if they are going to be the surest sources of economic growth in the coming decade and if we cannot make the most of this enormous opportunity then we will not be able to create in our society the wealth needed to underpin the huge social and educational expenditure which we need.

"An argument put to me against Information Technology is job loss. The long term solution to unemployment is more products, well designed, well produced, well marketed and produced on time, which meet the nation's needs. Many occupations such as chimney sweeps, corn chandlers, cart-builders and others have gone from the Department of Employment list and have been replaced by other emerging occupations, such as data processors and system analysts. As the Prime Minister said when opening the recent robotics exhibition, we damage job creation opportunities by refusing to adapt to change, and by not grasping the opportunities. As recently as 30 years ago a report estimated that the UK would only ever need about six or seven computers for information handling. You all know that things have turned out very differently; the important thing is to maintain flexibility of attitude and skill so that we can take advantage of new opportunities and markets which open up.

"Information Technology is one of the areas of greatest scope in moving along the path to economic prosperity."

● Shortly after the inner-city riots Mr Baker announced that up to 20 centres will be set up in the UK, by the Manpower Services Commission and the Department of Industry, to give unemployed young people training and work experience in microelectronics and computing skills. The centres will develop technical products and attention will be paid to the relevance of the training to the needs of local industry. Companies in "high technology" will be helping them. Likely locations for these "Information Technology Centres" at present are: Liverpool, Glasgow, Bristol, Manchester, Birmingham, Rhondda, Brixton, Southwark and Sunderland. Most of the centres should be operating by the middle of next year, according to the DoI.

The heuristical approach to flat panel displays

Inventor of a number of display systems including the Nixie tube, Mr Paul Kuchinsky, has started a company to explore and develop advances in flat panel displays.

Mr Kuchinsky assumes that most of the current work on displays, in gas plasma, liquid crystals, electrophoretic and others, all show promise and have specific advantages in different applications. He also believes that too many applications involve labour intensive manufacturing processes and not enough attention is paid to using advanced automated techniques, the availability of outside resources or the understanding of materials and processes.

His studies with the late John G. Bennett, a British humanitarian and educator, led Mr Kuchinsky to identify certain concepts which he describes as *quantum qualities:* "instruments of discovery and communication which unify an organisation and lead to creative achievements on a greatly reduced timescale." For this reason he has called the company Quantum Systems.

His official title of president and heuristician to the company indicates that he intends to use the heuristical method; a method of learning through self-discovery and trial and error. He says that the flexible approach to management that are implied in his methods "would triple the performance and profits of almost every organisation."

● Two flat screen electro-luminescent display panels, one intended mainly for messages and the other for general graphics, have been launched in the UK by Impectron Limited. The units, both manufactured by Sharp Corporation, are only 39 mm thick and of extremely lightweight construction.

The Message Display Unit, Model S-1050, provides a screen area of 186×50 mm, containing 65,536 pixels (picture elements). It is constructed using 512 lines of vertical transparent electrodes on a glass substrate, upon which a layer of luminescent material is sandwiched between two insulating layers. On top of these layers is a stratum of 128 lines of horizontal electrodes. When an appropriate drive voltage is applied to one vertical and one horizontal electrode, one pixel at the 'crossing point' emits a bright orange-yellow spot of light measuring approximately 100μm square. The Graphics Display Unit, Model S-1021A, operates on exactly the same principles, but has 320 lines of vertical electrodes with 240 lines of horizontal electrodes – providing a total of 76,800 pixels.

Both types of display incorporate logic and driver circuits which may be controlled from externally applied signals, and both types may be used to display moving or stationary graphic patterns, symbols or characters as required. Four input signal lines are required, i.e. data signals, data transfer clock, horizontal synchro signal and vertical synchro signal.

The desired display position of any image is specified by selecting the appropriate vertical and horizontal electrodes in an X-Y matrix. Because each pixel is generated at a fixed point, the image is sharp, stable and without either distortion or glare. The orange-yellow colouring and uniform distribution of luminous intensity also combine to minimize eye strain.

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WORLD OF AMATEUR RADIO

UOSAT prepares

AMSAT-UK report that the launch date for Britain's first amateur-radio satellite, UOSAT, built at the University of Surrey at a cost approaching £100,000, is unlikely to be before September 4 and probably not before September 15. The satellite is not expected to become fully operational until some four weeks after launch, although telemetry signals should be received on 145 and 435MHz. It is being stressed that this is a highly complex unit that will require considerable post-launch activity to assess the performance of the on-board experiments and service modules. The Science Research Council has approved a grant of £18,000 to cover work at the University of Surrey in the three months following the launch. There is still some uncertainty about the correct exposure settings for the special c.c.d. slow-scan television camera experiment.

The long-lived Oscar 7 satellite (launched November 1974) began to malfunction on June 12 with the transponders remaining mute, apparently due to battery problems in the deep shadow period. It is hoped that, by resting the transponders for a period, a further season of operational usage may prove possible, though clearly the satellite's operational future is in doubt. AMSAT-UK has recently contributed a further £1500 towards the cost of German work on a Phase 3 satellite.

Radio interference report

The latest "Radio Interference Report" from the Home Office's Directorate of Radio Technology, covering 1980, shows a sharp (10.74%) decrease in the total number of complaints (investigations completed) but rather more complainants. The reason for this paradox, the Home Office suggest, is that a sharp rise in complaints of interference due to illicit c.b. transmissions has necessitated concentration of investigating effort on this form of interference, to the detriment of normal interference cases. Some 2741 complaints of c.b. interference were received between September and December 1980 of which 1964 were to television; 646 to radio/hi-fi; and 131 to private mobile radio services. Rather speculatively, it is claimed that such complaints in 1981 may equal the number received for all other sources combined. The report concludes that the very rapid rise in these complaints "is the most significant factor in the interference field in recent years . . . this cause of interference may soon become the largest single source of complaints."

Only 127 cases of interference from 75 sources are attributed directly to amateur radio transmitters, although 3470 investigations attribute interference to inadequate receiver immunity, and presumably a number of these are related to amateur activity. After a steady annual rise throughout the 1970s the number of complaints of interference to sound radio from all sources (23,782 in 1979) shows a sharp downturn to 20,345 (13,980 l.f./m.f., 6365 v.h.f./f.m.). The report is concerned with the increase in recent years of harmful interference to aircraft communication channels, many in the form of broadcast music and speech. The Civil Aviation Authority and the Home Office are co-operating in an investigation aimed at determining the unidentified sources of interference. In general, contact devices (such as thermostats and switches) in both domestic and industrial equipment remain the largest source of interference, the 11,100 complaints representing 27% of all complaints. There was a total of 41,086 complaints from 35,790 complainants.

More n.b.f.m. on 28MHz?

In the December 1979 WoAR attention was drawn to the increasing use worldwide of narrow-band f.m. in the 28MHz band, particularly in "10kHz channels" between 29.3 to 29.5MHz, by both fixed and mobile stations and including, in the USA, a number of 28MHz repeaters with 100kHz spacing between input and output channels. A 29.67/29.57 repeater is also now operational in West Germany.

In the UK, a small group of amateurs, including J. D. Harris, G3LWM of Bishops' Stortford, has launched a campaign to persuade more British amateurs to use this band, particularly during the coming years of low sunspot activity when its use for long-distance operation will be limited. The danger of there being an apparently "deserted" band immediately adjacent to what may rapidly become the overcrowded channels of 27MHz c.b. is only one of the reasons for the group wishing to see more local activity on the band. It is felt, for example, that there is considerable scope for improvement in receiver sensitivity and the development of more efficient mobile aerials.

They point out that local and mobile working on 28MHz was pushed into the background when 144MHz became available to Class B licence holders. They urge the formation of local 28MHz activity groups to encourage band-activity and to monitor for intruders.

The high-percentage of Class B amateurs (144MHz and above, although they may soon be authorized to use 70MHz) may make it difficult to achieve substantial use of 28MHz for mobile and local working. But clearly this is an urgent requirement if the integrity of the band is to be preserved.

From all quarters

A 3540km s.s.b. contact on 144MHz between Mike Lee, G3VYF in Basildon and 4X4IX in Tel Aviv on June 11 is believed to have been brought about by a combination of Sporadic E and tropospheric ducting. Signal reports were 59+ both ways and the contact represented the culmination of some two years of preparation and study of the path. During a Sporadic E opening on June 7 many British amateurs worked stations in the USSR including White Russia (UC2) and the Ukraine (UB5) at distances approaching the 2500km limit for unassisted single-hop Sporadic E propagation.

What appears to have been the first 432MHz r.t.t.y. teleprinter contact with Norway was made on June 21 by Alec Fraser, G8PWX in Tynemouth. His contact with LA3EQ was over a distance of 660km. The first transatlantic contact by moonbounce on the 2.3GHz band has been made by the Dutch amateur PA0SSB (20ft dish aerial) and the Californian W6YFK (18ft dish).

BARTG reports that the use of the sophisticated AMTOR mode of r.t.t.y., developed by Peter Martinez, G3PLX, is now in use by amateurs in eight countries, including Oman and Pakistan. Long-distance contacts using AMTOR have been made from the UK with mobile-marine station G3RSP/MM in New Zealand and Australian waters. Mode A operation proved possible over the short path with its propagation delay of about 135 milliseconds, but on the long path (about 162 milliseconds delay) only Mode B operation proved possible.

In brief

The German society DARC recently organized a "fox hunt" for blind amateurs, equipped with simple portable d/f receivers developed by DJ10V. Five synchronized transmitters hidden along a 2km path were all located by the winner, Peter Ellinger, DJ0NJ in 36 minutes. The 11 participants were accompanied either by guides or guide dogs . . . Dr Trevor Wadley, inventor of the Wadley Loop triple-mixing tuning system for h.f. communications receivers and also of the Tellurometer system for accurately measuring distances by radio, died recently in Natal, South Africa at the age of 61. . . . The Scottish Amateur Radio Convention is being held at Glenrothes on September 12. . . . Mobile rallies include Torbay (ITT Social Centre, Brixham Road, Paignton) on August 30; Vange rally at Nicholas School, Basildon on September 6; Telford New Town Centre on September 13; and Peterborough at the new venue of Wirrina Sports Stadium on September 20.

PAT HAWKER, G3VA

Phase locked detector for double-sideband, diminished-carrier reception

Avoiding transient delays by locking to the transmitted carrier

by D. A. Tong, B.Sc., Ph.D. Datong Electronics

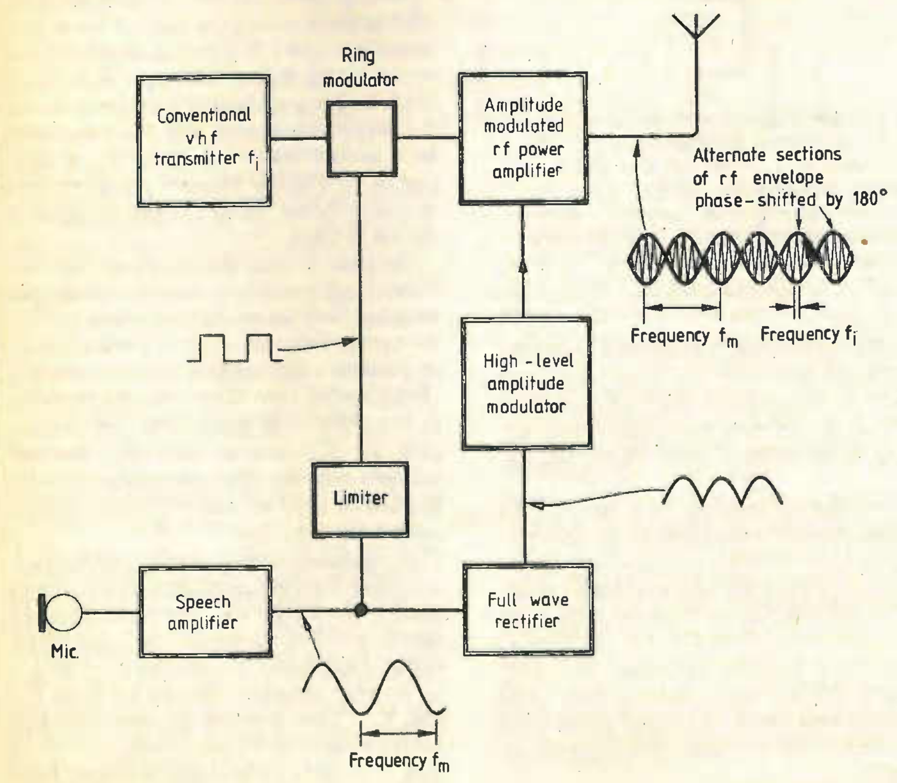
Previous methods of regenerating the carrier in a double-sideband, diminished-carrier receiver have suffered from delays, causing missed syllables at the start of transmission. In this design, a narrow-band, phase-locked loop is used to track the low-level carrier even in the absence of speech.

In the past few years it has been recognized that amplitude-modulation transmissions in which the carrier is either suppressed or diminished in amplitude have potentially significant advantages for equipment such as pocket v.h.f. transceivers, where one of the biggest limitations to range is the limited capacity of the battery power supply. Raven has pointed out[1] that double-sideband, suppressed-carrier (d.s.b.s.c.) transmissions can be generated very efficiently in terms of the utilization of primary power with the scheme shown in Fig. 1. More recently, Petrovic[2] has described a transmitter using these principles to generate double-sideband, diminished-carrier (d.s.b.d.c.) transmissions.

Provided that the carrier is reasonably suppressed relative to the average sideband level (−13dB is used in the system described in reference 1) both d.s.b.s.c. and d.s.b.d.c. transmissions have the characteristic that a negligibly small amount of power is consumed when the user is not actually uttering a syllable. Moreover no efficiency penalty is incurred by modulating at a level lower than the peak level allowed by the transmitter. This is in sharp contrast to conventional amplitude modulation (a.m.) where the carrier is constantly emitted at a high level. Since, for short phrases spoken without pauses, amplitude levels greater than 12% of the peak amplitude are exceeded for only 50% of the time, and since, in addition, there are many pauses in normal speech, large power savings are possible in a d.s.b.d.c. transmitter. Indeed Raven states[1] that personal radios with performance comparable to a 20W conventional a.m. transmitter become practicable.

Manuscript received in 1974.

Fig. 1. High efficiency, double-sideband suppressed-carrier scheme proposed by Raven. Amplitude and phase variations in the transmitted waveform are processed separately, allowing relatively inefficient linear r.f. power amplifiers to be eliminated. Ring-modulator is used as a voltage-controlled 180° phase filter.



The price which has to be paid for the above advantage is the increased complexity of the receiver. For good intelligibility in the audio output of a d.s.b.s.c. receiver, it is necessary to reinsert the carrier not only with the correct frequency, as in s.s.b., but also with the correct phase relative to the sideband components. Because of its symmetry, even a d.s.b.s.c. signal contains all the information required to specify the frequency and phase of the missing carrier, but the techniques used to replace it (principally either the "reciprocating detector"[3], the "2F method"[4,5]), or the phase-lock-loop method[6,7]) all suffer from the problem that they require a finite time to do the job of regenerating the carrier. This means that syllables of speech have their leading edges chopped off to an extent depending partly on the exact technique used, partly on the incoming signal-to-noise ratio, and partly on the initial degree of mistuning of the receiver. In the reciprocating detector, this delay in regenerating the carrier is apparently quite short, but long enough to give the detector a useful discrimination against impulsive interference.

With d.s.b.d.c., the low-level carrier can be used to define the regenerated carrier: any transient delays occur only once per transmission and are not a problem. In addition, two other worthwhile advantages are that (a) the carrier, although of reduced amplitude, can be used to reliably operate the squelch and also to control the gain of the receiver, and (b) the receiver is simpler.

The remainder of this article describes a demodulator which was built in 1974 by the author principally for experiments using d.s.b.d.c. but which also has advantages compared with the more conventional techniques for demodulating ordinary a.m. and f.m. It was intended for eventual inclusion in a pocket transceiver along the lines of the one already described by the author in *Wireless World*[8] but using d.s.b.d.c. modulation. Other constraints are therefore imposed on the design:

- the power consumption must be minimal.
- it should produce an indication (i.e.' a change in a logic level) that a genuine signal is being received despite the presence of interference and within as short a time as possible of applying the power supply to the circuit. This is so that an effective battery saving technique can be applied by pulsing the whole receiver on and off at a

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low duty cycle [8,9].
- incoming signals with a signal-to-noise ratio just inadequate for intelligibility should be able to provide a reliable "signal present" indication. This ensures that usable signals are never too weak to operate the squelch.
- stability of the squelch detector should be adequate to make a user-operated control unnecessary.

Circuit operation

The block diagram of a circuit to meet the above criteria is shown in Fig. 2. It is basically a phase-lock loop with a bandwidth narrow enough to allow it to lock onto signals which are buried in the receiver's noise. The loop comprises a balanced mixer M_2, operational amplifier A_4, and the voltage-controlled carrier-insertion oscillator. By choosing appropriate parameters for the loop filter (A_4 and associated components) an almost arbitrarily narrow bandwidth can be obtained, but at the expense of an increased lock-up time[10]. The phase-lock loop behaves, in effect as a narrow-band r.f. filter which tracks the frequency of an incoming signal.

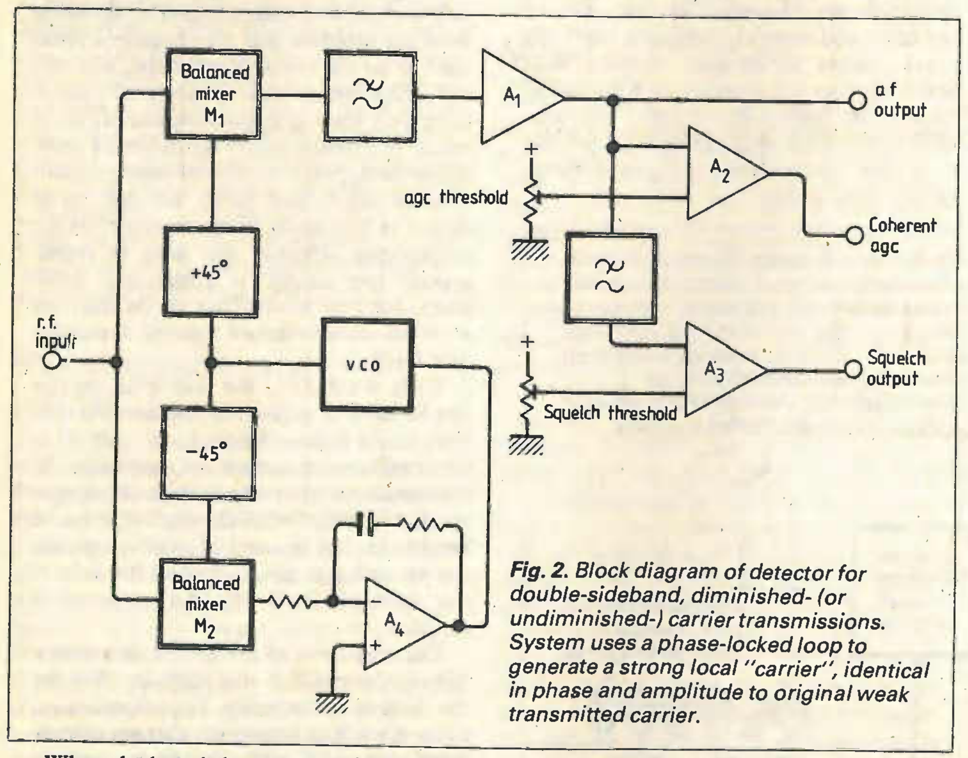


Fig. 2. Block diagram of detector for double-sideband, diminished- (or undiminished-) carrier transmissions. System uses a phase-locked loop to generate a strong local "carrier", identical in phase and amplitude to original weak transmitted carrier.

When the loop is locked it forces the two r.f. inputs to M_2 into a 90° phase difference, and the d.c. output component of M_2 is zero. A shift in relative phase of the two signals would tend to give a d.c. output component from M_2 whose sign and amplitude would depend on the sense and magnitude of the shift. Because the mixer is enclosed in a negative-feedback loop, however, any tendency to a phase shift is automatically cancelled by a shift in the instantaneous frequency of the carrier-insertion oscillator.

The local oscillation fed to M_1 is phase-shifted by 90° relative to that applied to M_2. When the system is locked, therefore, M_1 gives an output which is proportional to the amplitude of the incoming signal and which contains the demodulated audio signal, if any. The d.c. component is fed to A_2 and A_3 for the use as an a.g.c. source and to provide the "signal present" indication.

It is worth pointing out at this stage that a coherent detection system such as this has a number of advantages, even for ordinary a.m., over an envelope detector.
- The signal-to-noise ratio at the audio output is the same as that at the r.f. input. In contrast, an envelope detector has a threshold below which the output signal-to-noise ratio is worse than that at the input[7].
- An envelope detector gives a rectified output for noise-modulated r.f. voltages at any frequency. Thus, broad-band noise (that is, noise with a bandwidth greater than that of the desired signal) at the input adds in the output of an envelope detector to the noise which is present within the information bandwidth. In contrast, in a coherent detector broadband noise is heterodyned to appropriately higher frequencies (i.e., higher than the highest component of the wanted signal) and can easily be filtered out with a low-pass audio filter. This advantage has long been utilised in s.s.b. receivers using so-called "product detectors".
- Adjacent-channel interference is not demodulated properly but gives an output which is frequency-shifted like off-tune s.s.b. It is therefore more easily differentiated by the listener from the wanted signal.
- By adding a low-pass filter prior to the "signal-present" comparator, an arbitrarily small (say 10Hz) r.f. bandwidth can be achieved. Thus even very low carrier levels can be reliably filtered from the noise, and excellent squelch action obtained. Further, a squelch indication will only occur if the receiver is phase-locked. Any non-coherent input signal will not actuate the comparator and false squelch openings are rare.
- The output voltage from A_4 is related to the frequency of the incoming carrier. Therefore if the loop bandwidth is great enough, frequency modulation will also be demodulated and appear at the output of A_4.

Practical circuit

The block diagram could be implemented using commercially available phase-lock-loop integrated circuits were it not for the extra constraints mentioned earlier. The circuit finally developed is shown in Fig. 3 and is based mainly on c.m.o.s. logic devices because of their extremely low power consumption. A differential configuration was chosen to eliminate any constant voltage levels (in the absence of a signal) across the capacitor. This allows the circuit to respond as soon as the power is applied and without any delays caused by the time required to charge the capacitors. A differential system also removes most of the sources of d.c. drift and makes the squelch and a.g.c. thresholds independent of temperature and supply voltage.

Each of the two mixers is based on a pair of c.m.o.s. analogue switches controlled by square-wave switching waveforms at the frequency of the incoming carrier and in such a way that when, for example, $IC_{7(a)}$ is closed, $IC_{7(b)}$ is open, and vice versa. When open, the path through a gate behaves like a bidirectional resistor of about 300 ohms, whereas when closed its resistance is of the order of 10^9 ohms. When fed with good square waves, such a balanced mixer behaves very well indeed as a phase-sensitive detector and has the advantages that it can, if necessary, be bidirectional and that its quiescent output voltage is the same as its input voltage. Thus, no temperature-dependent offset voltages are introduced to upset the differential symmetry.

Switching waveforms for the four gates (two in each mixer) are derived from IC_5, which is a dual J-K flip-flop connected as a digital phase-shifter[11]. It requires an input clock frequency which is four times that of the output waveforms, and this is provided by a multivibrator based on IC_6 as described by Linsley Hood[12]. An alternative oscillator based on an LC tuned circuit is shown in Fig 4.

Because of the high gain of the 741 operational amplifier, the squelch output switches from its low limit of about +2V to its upper limit of $+(V_{cc}-1)$ volts for an extremely small output signal from M_1 ($IC_{7(a)}$ and $IC7_{(b)}$). With no input signal or in the absence of phase lock, the two inputs to IC_2 receive virtually identical voltages and the offset null potentiometer R_{30} can be used to ensure that the squelch output signal is "low"

The phase-lock loop uses IC_4 as the loop amplifier-filter but an addition to the basic system shown in Fig 3 is that when no signal is being detected the loop bandwidth is increased by opening gates $IC_{8(a), (b)}$ thereby shorting the two resistors R_{18} and R_{19}. This reduces the time required for the loop to lock by a large factor. When lock is achieved the squelch output goes high and the two gates are closed, thereby reducing the bandwidth of the loop to its normal working value, [10].

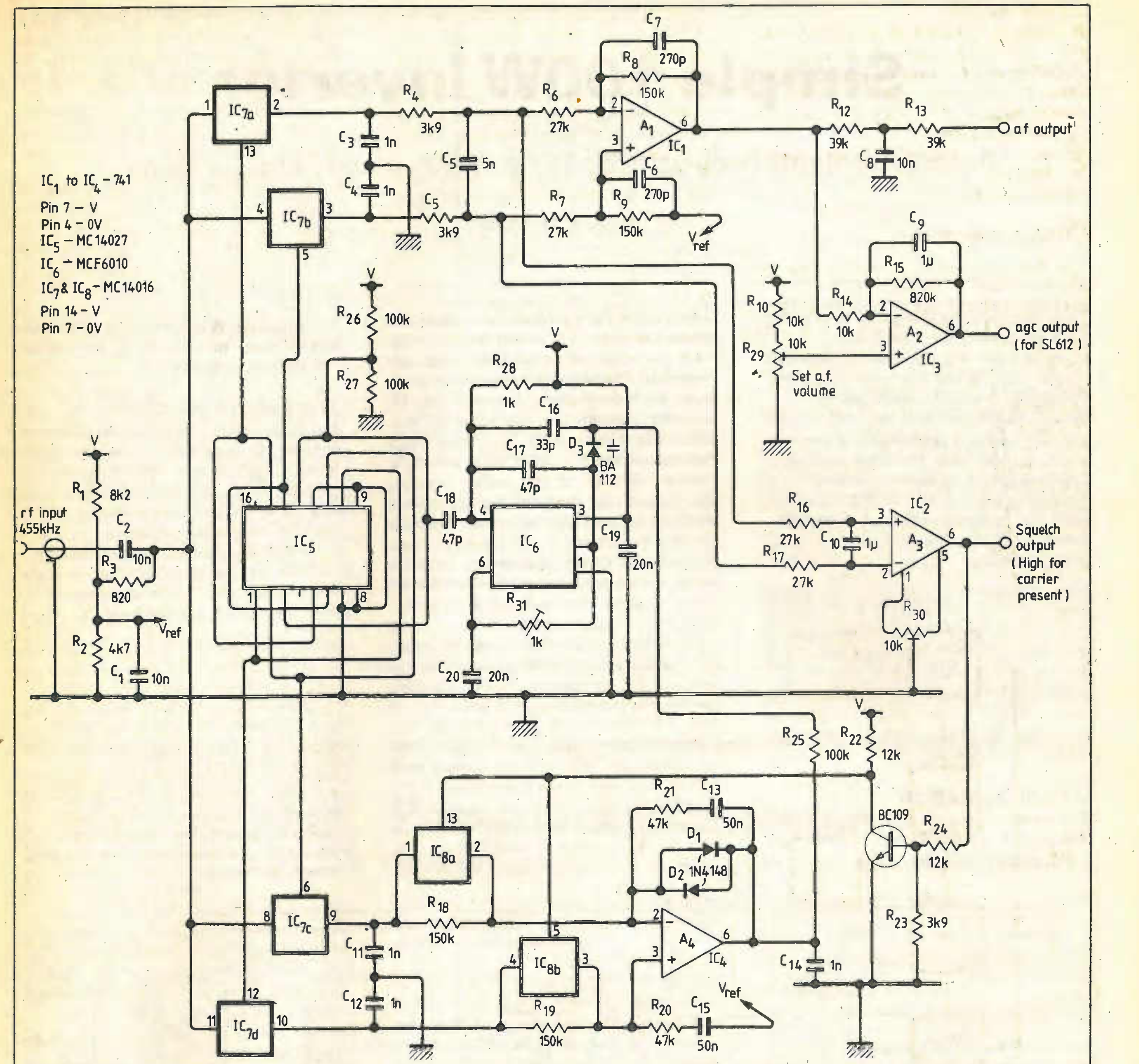


Fig. 3. Circuit of d.s.b.d.c. detector, operating at input frequencies of 455 kHz, suitable for adding to final i.f. amplifier of existing receiver. A.g.c. output is suitable for controlling Plessey SL610, 611 or 612 i.f. amplifier i.cs. R.f. input level required is about 200 mV peak-to-peak and supply voltage can vary from 6 to 15 volts (maximum). For best oscillator stability (as needed for d.s.b.d.c. but not a.m. or f.m.) supply to IC_6 should be stabilized.

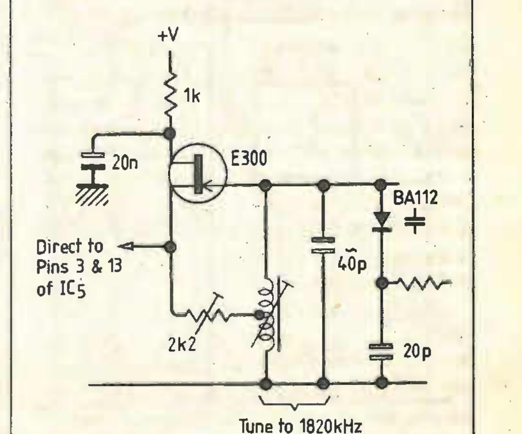
An a.g.c. voltage suitable for feeding Plessey SL600 i.f. amplifiers[13] is obtained by monitoring the amplified output of mixer M_1. IC_3 behaves as an amplifier for voltages from IC_1 which are more negative than that at the slider of R_{29}. The latter therefore sets the a.g.c. threshold in the phase-lock mode. Naturally, signals which do not cause phase-lock generate no coherent a.g.c. voltage and to avoid possible receiver overload on, for example, random noise inputs, some incoherent a.g.c., derived from a diode rectifier fed from the last i.f. amplifier, may also be required.

When the a.g.c. loop is operating, the volume of audio recovered from a d.s.b.d.c. input depends on the degree of carrier suppression, since IC_3 acts to maintain a constant rectified carrier level at the output of IC_1. Conventional a.m. would therefore emerge from this detector at a very low level unless R_{24} were readjusted to match the increased carrier level.

For minimum lock-up time on a signal which is close to the working threshold, it is essential that the carrier-insertion oscillator is close to the correct frequency (say within 100Hz). It is the function of D_1 and D_2 to limit the voltage swing at the output of IC_4 to a fairly narrow range; peaks of noise cannot then swing the v.c.o. fre-

Continued on page 83

Fig. 4. Simple alternative oscillator circuit for use as v.c.o. in Fig 3. The potentiometer is a skeleton preset and should be adjusted for an adequate but not excessive oscillation amplitude.



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Simple 100W inverter

Automatic mains back-up from 12V d.c. with battery charge mode

by A. K. H. Miller

This inverter was designed to provide back-up power for a desk-top computer during a period of frequent power cuts. While the normal mains voltage is available, the inverter circuit 'ticks over' and the 12V standby battery is charged. If the mains supply fails, the square-wave inverter starts up automatically providing up to 100W at 220V a.c. until the mains is restored. A simple overload protection circuit is incorporated.

Since the inverter provides a maximum power of about 100 watts, it is suitable for driving most small domestic loads such as television sets, hi-fi apparatus and central heating pumps. Although the inverter will power a tv load taken over from the normal mains supply, it may not be capable of providing the current peak required when the set is switched on.

Circuit operation

The complete circuit is shown in Fig. 1. When there is a likelihood of a power cut, a car battery and the mains supply are connected to the inputs of the inverter and the load to its output. Under these circumstances the mains input and output are connected together and the transformer keeps the battery charged through D_3, D_4 and the current limiting resistor, R_{14}. When the mains supply fails, relay RLA disconnects the live input from the high-voltage winding of the mains isolating transformer and connects its low-voltage windings to the collectors of the Darlington pair output stages, Tr_6 to Tr_9. These two pairs are driven in antiphase by 50Hz square waves produced in the drive circuit which operates from a 5 volt supply provided by a voltage regulator, IC_4.

Considering the circuit in more detail, IC_1 is a 555 timer connected as an astable multivibrator running at 200Hz. Variable resistor R_{15} is used to set the frequency. A dual J-K bistable, IC_2, divides the frequency of the square-wave from the timer by four to give 50Hz. Hence we now have two 50Hz square waves in antiphase at the Q and $\overline{Q}$ outputs of the second half of IC_2. These two signals, after being buffered by the emitter followers Tr_1 and Tr_2, are connected to the output stages, Tr_6 to Tr_9. Current is therefore switched alternately through the two halves of the low-voltage winding of the transformer.

Overload protection

The usual way of detecting an overload electronically is to place a low-value resistor in a high-current line and use the voltage drop across it to switch a transistor. In this design, the 0.7V required to switch an overload detection transistor would have resulted in a power loss in the detection resistor of some seven or eight watts, which would have significantly reduced the efficiency of the inverter.

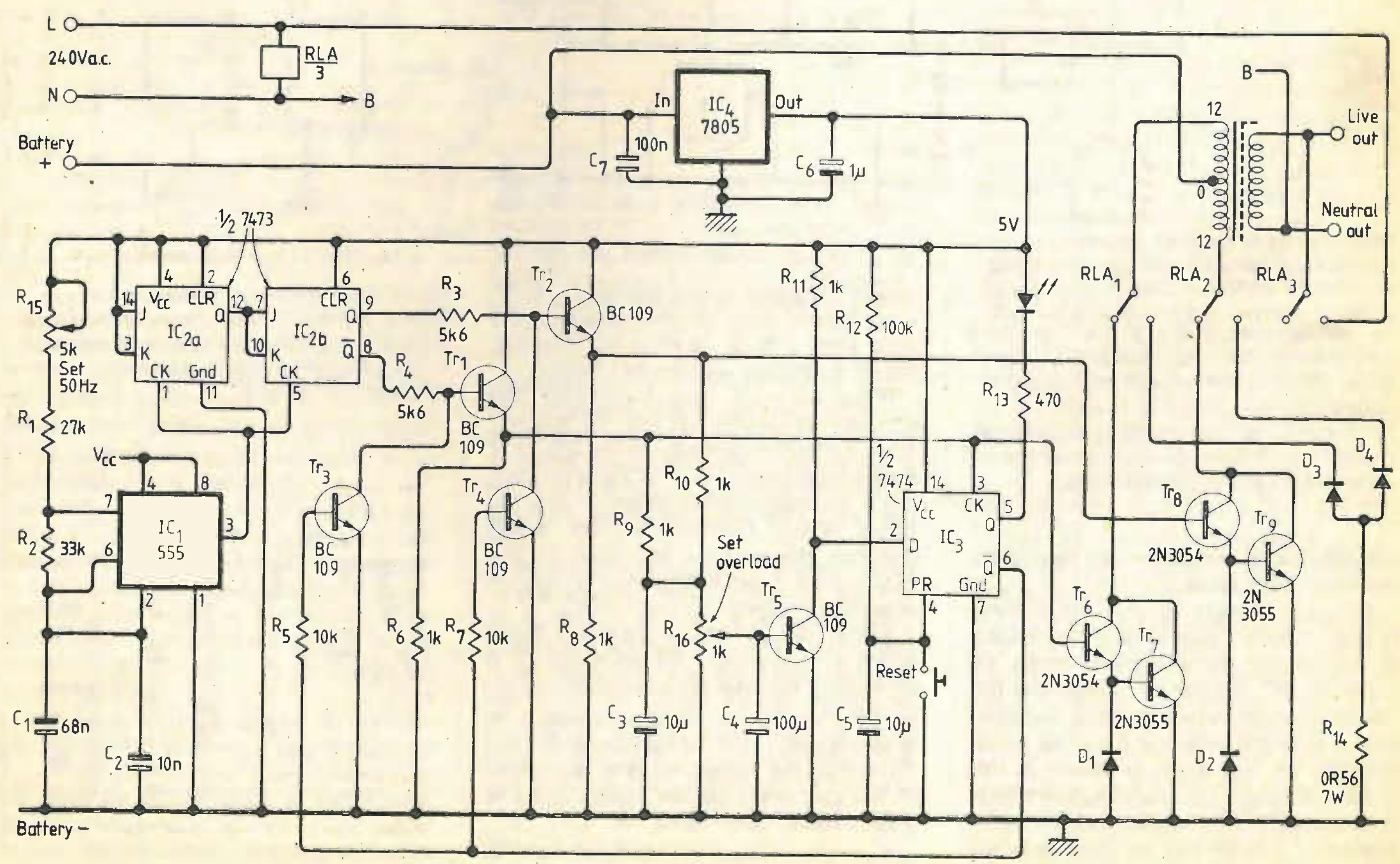

Fig. 1. Complete diagram of the inverter and battery charger circuits. Two antiphase 50Hz square waves from IC_1/IC_2 are buffered and used to drive two Darlington pairs connected to the output transformer. The relay coil is shown in its non-active state so the inverter is in operation. On mains input, the relay contacts switch and the battery charges.

The approach adopted, therefore, was to monitor the saturated base-emitter voltage of the output transistors, which rises proportionally with the collector current. Signals at the emitters of Tr_1 and Tr_2 are summed and smoothed and an adjustable proportion of the resulting voltage taken to the base of Tr_5. With normal loads, this voltage is low enough to ensure that the collector potential of Tr_5, and therefore the input potential of the D-type bistable IC_3, are close to the positive supply voltage. The Q and $\overline{Q}$ outputs are therefore high and low respectively.

As the current through the output stages increases there comes a point when Tr_5 starts to conduct, forcing the voltage at its collector towards zero. This point is set by R_{16}. On the next positive voltage transition at the emitter of Tr_1 the outputs of IC_3 change state, turning Tr_3 and Tr_4 on and inhibiting both the drive signals at the bases of the output transistors and the clock input of IC_3. Under these conditions the l.e.d. is lit. The inverter will remain disabled until the reset button is pressed. To avoid the overload circuit being activated when the inverter is switched on, R_{12} and C_5 have been included.

Construction

The transformer used in the prototype was a standard 240V primary/12-0-12V secondary type rated at 100VA, but a 200VA transformer was used in later versions because of its lower losses.

Transistors Tr_6 to Tr_9 must be mounted on a heat sink with a thermal resistance of between 1°C/W and 2°C/W. Diodes D_1 and D_2 are general purpose low-voltage silicon types, but D_3 and D_4 must be capable of carrying at least 4A without overheating. The latter two diodes are used to charge the battery.

The circuit diagram shows RLA in the non-energized state, i.e., with the mains input disconnected. This relay has three sets of changeover contacts; RLA_1 and RLA_2 should be rated at at least 10A. Resistor R_{14} has to dissipate several watts when a flat battery is being charged ($W=I^2R$), so it should not be mounted in contact with the circuit board. All other resistors are rated at 1/2W and all electrolytic capacitors at 10V d.c. It is important that a suitable grade of wire be used for the high-current carrying connections and that all conductors carrying mains voltage are well insulated.

When construction is completed connect the battery, but no load or mains supply, and check the current consumption of the circuit. Depending on the state of the battery, the current should be between 1A and 1.5A. Assuming this is satisfactory, adjust R_{16} so that its slider is at the 'earthy' end of the track and connect a load such as a 100W light bulb to the output. Adjust R_{16} until the overload protection circuit just fails to operate. Now make sure that the overload circuit operates when the output is shorted, exercising extreme caution as the output voltage is potentially lethal. Next, remove the short, connect the mains supply and check that the relay operates correctly and that the battery is being charged at not more than 4A. Finally, with the mains supply disconnected, adjust R_{15} to set the 50Hz frequency. In the absence of a frequency meter the easiest way to set the frequency is to use the inverter to drive a record player with a stroboscope type speed checking system. If the turntable speed remains the same when the mains is switched in and out then the frequency is correct. The lamp used to illuminate the stroboscope disc must, of course, be driven constantly by the mains.

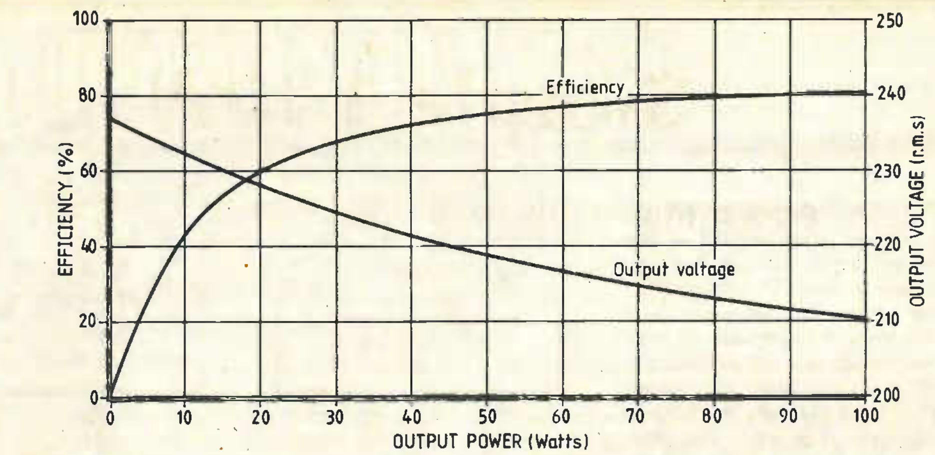

Fig. 2. Graph showing efficiency and output voltage variations due to loading. For most domestic loads the voltage regulation is sufficient so output/driver feedback was left out of the circuit to keep the design simple.

The graph shown in Fig. 2 summarizes the performance of the inverter. The efficiency is low at low output powers because of transformer losses. As the output power rises, however, the efficiency increases rapidly to about 80% at the rated output.

Voltage regulation is rather poor but the fall in r.m.s. output voltage from 237V to 210V at full load should be acceptable for all but the most demanding applications. Regulation could be improved at the expense of simplicity by including some form of feedback from the output to the drive stages. When measuring the output voltage, remember that for a square wave, r.m.s. and peak levels are the same.

Phase locked detector

Continued from page 81

quency a disproportionate distance from the correct value, thereby causing the system to lose lock.

With the circuit values shown in Fig. 3, the loop will lock onto an unmodulated carrier whose peak-to-peak amplitude is only one tenth of that of the associated random noise, which is itself at a level of about 500 mV peak-to-peak. A positive indication is obtained from the squelch output that such a weak signal is present within 50 ms of power being applied to the circuit. For larger input signals the lock-up time is much reduced, and this will always be the case when ordinary a.m. is being received. Moreover, for a.m. and f.m. reception, a much wider loop bandwidth can be used and there is then no need for gates $IC_{8(a),(b)}$. R_{18} and R_{19} can then be reduced to say, 1kΩ. Similarly, D_1 and D_2 can be removed and a much wider acquisition range obtained. If f.m. is received, the output is taken from pin 6 of IC_4. In all cases the squelch output comes from IC_2 and is independent of temperature and supply voltage from 6-15V.

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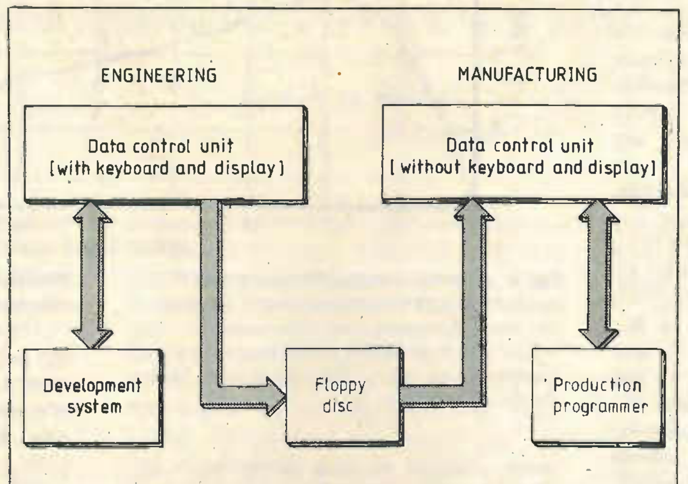
NEW PRODUCTS

P.r.o.m. programmer

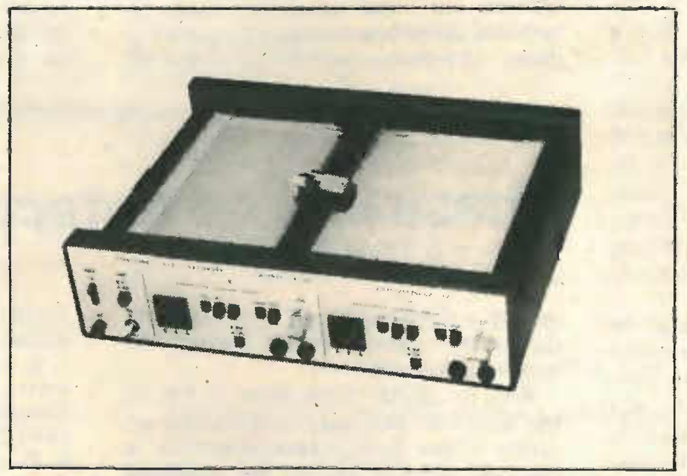
A p.r.o.m. programming system for production use has been developed by Data I/O. Availability of this product was announced as a 'stop press' at an introduction ceremony for the first two members of a family of 8 and 16-bit microprocessor software/hardware development aids from Millenium. The basic p.r.o.m. programming system, consisting of the Data Control Unit (DCU) and the Production Programmer, can be used to program memory devices on its own or as part of a general purpose microcomputer system. Programs are stored and transmitted to the programmer by the DCU in any of twenty three formats from floppy disc. The control unit is available with either one or two 82K-byte disc drives, each of which can store up to 41 different programs for a 2716 type e.p.r.o.m. An expanded version with keyboard and display can be controlled both from the programmer and from a terminal through an RS-232 link. The Production Programmer controls operations ranging from creating data files to programming memory devices in quantity. An alphanumeric display and keyboard, standard on this unit, give the operator instructions and provide a means of entering device part numbers. When the programmer is set up all the operator has to do to program p.r.o.ms is to press the start button. An optional foot switch is available so that the operator's hands are left free to insert and remove devices (makes programming p.r.o.ms as easy as stamping washers and probably as . . .). The programming unit also has an RS-232 communication link with 23 possible data formats. Both the development system mentioned earlier and the programmer are available through Microsystem Services, Duke St, High Wycombe, Bucks.

WW301

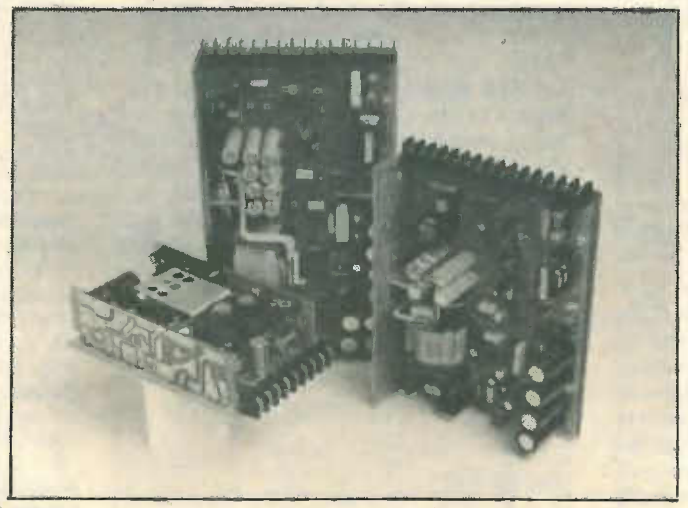


ONE APPLICATION OF THE PROGRAMMING SYSTEM

WW301



WW302



WW303

Portable x-y recorder

Pen speeds of the Model F-5B portable x-y recorder from Riken Denshi are 314mm/s on the x axis and 300mm/s on the y axis. This recorder weighs less than 3kg, measures 302×220×77mm overall and takes paper sizes of up to 220×150mm. Input sensitivity of both amplifiers is adjustable from 0.5mV/cm to 20V/cm and linearity and repeatability errors are ±0.25% and ±0.1% respectively. The input resistance of the amplifiers is 10MΩ on all attenuator settings. Common-mode noise rejection is 140dB for d.c. and 120dB for a.c. The origin of the pen with relation to the paper is adjustable over the writing area. Paper is held in place electrostatically. Balaton Products Ltd, Orchard House, Overton-on-Dee, Wrexham, Clwyd LL13 0HF.

WW302

Switched mode power supplies

Complementing their SMM series of multi-output switched mode units, Weir now offer the SMS series of single-output switching supplies. This open frame range comprises 30, 50 and 100 watt models, 5V 6A, 5V 10A and 5V 20A respectively. They are dimensionally similar to the firm's multi-rail models and use the same flyback converter technique. Line and load regulation is claimed to be better than 0.5% over a load range from 20 to 100% and line voltage swings of 196-264V and 98-132V. Ripple content in the output is typically 25mV peak, and output hold-up is better than a missing cycle on full load. The supplies incorporate over-voltage and overcurrent protection and remote sense. A triple output auxiliary giving ±12V, 0.5A and −5V, 0.1A may be specified for single board computer systems with memory expansion. They are designed to meet BS, IEC and VDE specifications for safety and r.f.i. and comply with BS5850 for office machines, harmonized with IEC 380. 100-up prices are £52.00, £65.00 and £85.50 for 5V 6A, 5V 10A and 5V 20A respectively. Weir Electronics Ltd, Durban Road, Bognor Regis, Sussex.

WW303

V.d.u. i.cs

Two i.cs for simplifying c.r.t. control in visual display units have been introduced by ITT Semiconductors. The TCA1001 video i.c. drives the picture-tube cathode directly from the character generator and with two potentiometers the brightness either of the whole screen or of a sector of the screen can be altered. This i.c. operates from a 55V supply and is housed in an 8pin d.i.l. package. The TCA1002 deflection i.c. comprises a sync separator, phase and frequency comparator, vertical pulse integrator, vertical oscillator, pulse shaper and a horizontal-output stage suitable for driving a Darlington pair deflection circuit. This i.c. is housed in an 18-pin d.i.l. package. ITT Semiconductors, Maidstone Rd, Sidcup, Kent DA14 5HT.

WW304

Digital/analogue multimeter

In an effort to combine the ease of reading of an analogue meter with the accuracy of a digital display, Bach-Simpson have used a 31/2 digit l.c.d. with integral bar-graph type indication in their latest multimeter. The Model 467 has a peak-holding facility, audible indication for continuity/logic checking and can detect and indicate pulses down to 50μs. Percentage modulation and signal-tracing measurements can be made. Basic measurement error (direct voltage) is 0.1%. Ranges covered by the 467 include 200mV to 1000V – d.c., 200mV to 750V r.m.s., 200Ω to 20MΩ and 200μA to 2A – d.c. and a.c. The multimeter is battery operated and portable. Bach-Simpson (UK) Ltd, Trenant Estate, Wadebridge, Cornwall PL27 6HD.

WW305

WW305

Supply decoupling d.i.p. sockets

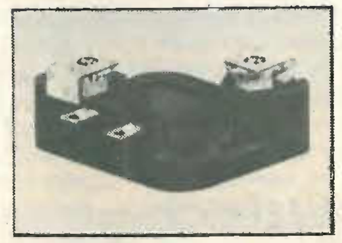
Assemblies comprising a dual-in-line socket and integral power-supply decoupling capacitor (often the only discrete component required with logic i.cs) can increase p.c.b. component packing density by 12% and cut the cost of decoupling by 50% in production applications, claims the manufacturer.

Mounting the capacitor inside the socket gives supply decoupling as close as possible to the i.c. pins and reduces board assembly time by eliminating insertion and soldering of a separate capacitor. Removing the need for an external decoupling capacitor gives extra board space, so the sockets can be assembled closer together than usual. These sockets, from a division of the Brand-Rex company called Garry, come in standard in-line spacings of 0.3, 0.4 or 0.6in with capacitors ranging from 0.01 to 0.1μF. Both wire-wrap and solder-pin versions of the 'Garry Quiet Socket' can be supplied. Hub Mail/ISA, 35 Morrissey Blvd., Boston, MA 02125, USA.

WW306

Power transistors

Expansions in Motorola's high-power transistor ranges have been made to accommodate what they call a 'large upcoming high-power control market'. Three n-p-n Darlingtons, the MJ10050, MJ10100 and MJ10200 with $I_{c(max)}$ ratings of 50, 100 and 200A and V_{ceo} ratings of 850, 450 and 250V respectively, are designed for six-step motor speed/torque control and low-frequency inverters. Maximum power dissipation of each device (see photo) is 500W. Two p-channel m.o.s.f.e.ts for 8A continuous maximum drain current are the



MTM814 and MTM815 in TO-3 packages with breakdown voltages of 80 and 100V respectively. These f.e.ts have an 'on' resistance of 0.4Ω at 4A and are designed for switching applications. Plastic-package versions are available. Lastly, two high-speed switch-mode Darlingtons are available with V_{ceo} ratings of 750V, the MJ10024, and 850V, the MJ10025. Both devices have collector current ratings of 20A and are designed for power control from 440V lines. The manufacturers plan to introduce more such power devices in the near future. Motorola Ltd, York House, Empire Way, Wembley, Middx HA9 0PR.

WW307

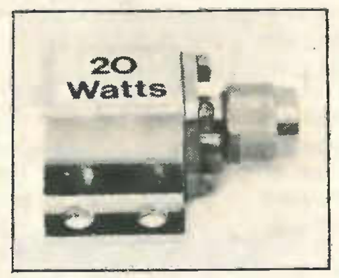
Schottky diodes

A number of high-power Schottky diodes have recently been announced by International Rectifier. First is the 85HQ series. These 85A diodes have DO-5 type packages, reverse leakage currents of 45mA maximum at 125°C and can handle up to 1300A peak on a single 50Hz cycle. Reverse working maximum voltages range from 30 to 45V. The 60HQ series diodes, similar in packaging and construction to the 85HQ types, are rated at 60A and can be obtained with reverse working-voltages from 60 to 100V. Three common-cathode dual diodes with current ratings of 12, 20 and 30A and a single diode with 10A rating complete the introductions. They are the 12CTQ, 20CTQ, 30CTQ and 10TQ respectively. These devices, all with TO-220 packages, can be supplied with reverse voltage ratings from 30 to 45V. International Rectifier, Hurst Green, Oxted, Surrey RH8 9BB.

WW308

Dummy load

Thin-film resistor techniques have been used by KDI Pyrofilm to produce a miniature coaxial dummy load with power dissipation ratings of 20W continuous, 200W peak at a maximum heat-sink temperature of 100°C. The PCX-050-



M-20, for frequencies from 0 to 18GHz, has an impedance of 50 ohms and a v.s.w.r. no greater than 1.35 over the bandwidth. A stainless-steel SMA connector to MIL-C-39012 specifications is used. Aspen Electronics Ltd, 2 Kildare Close, Eastcote, Ruislip, Middx HA4 9UR.

WW309

Fibre-optic evaluation kit

Fully assembled Fibre Optic Evaluation Modules comprising a p.c.b., the main element of which is a t.t.l. compatible transceiver, five metres of terminated fibre-optic cable and an information brochure are available from Fairchild. These kits, when connected to a single 5V supply, can be operated at data rates from 0 to 10Mbit/s. The brochure covers such topics as fibre-optic theory, fibre construction, transmission and coupling losses and, of course, the module's technical specifications. Each module costs £31.72 excluding v.a.t. Fairchild Camera and Instrument (UK) Ltd, 230 High St, Potters Bar, Herts EN6 5BU.

WW310

Pressure transducers

Five transducers covering pressure ranges from 100 to 5000lbf/in^2 make up the Vernitech Model 9000 series available through Computer Controls Ltd. These pressure transducers weigh under 90g each and have a three-terminal potentiometer type output so that a voltage can be obtained directly

which either increases or decreases with pressure rise. Potentiometer resistances of 1, 2, and 5kΩ are available, all capable of dissipating 1W and operating from −55° to +85°C. Linearity error and repeatability are quoted as 5% and 25% respectively regardless of temperature. Prices vary according to measuring range and resistance but average out at around £50 each in 25-off quantities. Computer Controls Ltd, 19 Buckingham St, London WC2

WW311

Speech loudspeaker

A small loudspeaker with mounting bracket and enclosure has been designed for speech reproduction by Telecommunications Accessories Ltd. Frequency response, maximum input power and input impedance of the CS100 are 500 to 3500Hz, 4W and 4Ω respectively. Dimensions of the unit are 6.8×6.8×4.3cm. Telecommunications Accessories Ltd, Thame Industrial Estate, Bandet Way, Thame, Oxon OX9 3SS.

WW312

www.americanradiohistory.com

WAVES

By Ariel

Why not some jam today?

The Bill to give birth to the Act that will cut the umbilical cord joining British Telecom to the rest of the Post Office is labouring its way through the normal Parliamentary processes.

But, even though, as far as I can make out, it does not as yet have an official identity, this lively youngster has already made its presence felt in more ways than one. Before we'd even had time to get used to the name or make sense of the new logo – part of which appears to be written in Hebrew – BT, under the approving eye of its proud parent, Peter Benton, got itself involved in what history may call The Great Yellow Paint Controversy. And if you know of a better way of arriving with a bang I'd like to hear about it.

BT's chairman, Sir George Jefferson, whom we can dub its putative grandfather, has played no mean role in putting his organization on the map of the public mind. In a number of weighty statements, supported by snowstorms of releases from the Press Offices, he has chronicled BT's past achievements, told us about what is under way now and lifted the lid off some of the goodies we can expect in the future. And he has reminded us, as a rider, that if we want a good service we're going to have to pay for it. Now, there's a surprise.

In fairness, however, even the most cynically critical will admit that BT is in many respects showing a vitality not usually associated with a public service. Planned expansion is certainly impressive, and the list of current and future innovations designed to help users get the best out of their telecommunications services – albeit at a price – shows a remarkable awareness of specialized customer needs. Much, for instance, is being done for the handicapped. The hard of hearing, the infirm, amputees, even those with sight defects can now enjoy the benefits of the telephone with comparative ease. The rest of us are promised better this, simpler that and more efficient the other. And, doubtless, these things will come to pass.

But, before BT gets too complacent about tomorrow's benefits, it should look for a moment at its shortcomings of today. It is, for instance, quite unacceptable that BT should be congratulating itself while waiting lists for the 'phone remain. It's ludicrous that we should be reminded we can dial direct to the Sultanate of Oman when establishing contact between London and Birmingham can sometimes be as fraught with difficulty as talking to the Moon. It is unsatisfactory that there should be such a high incidence of crossed lines, causing impatience and undermining telephone confidentiality. Above all, it is insulting to our intelligence that we should be exhorted, via the home screen, to make more use of the 'phone by an ill-conceived, unhealthy-looking, rough-tongued and utterly repellent bird.

All credit to Sir George, Mr Benton and his merry band of planners for having the courage to set their eyes on the stars. But please, gentlemen, don't forget there's still a lot down here on terra firma that needs to be done first – like shooting that foul fowl for a start.

A better break for Prestel

Meanwhile, back at the Post Office, the failure, in spite of intensive promotion, of Prestel to take off at the rate hoped for must be causing a fair bit of brow-furrowing.

Come to think of it, it furrows my brow as well. I would have thought that a facility for selecting, at the touch of a button, a five-star restaurant, not more than a mile off the M1, which features a full symphony orchestra for dancing on Saturday nights and serves truffles out of season, would have been snapped up like a pelican gulping down a sprat. One cannot help thinking that there is something wrong with a world whose inhabitants are reluctant to fork out a few hundred pounds for the pleasure of spending an evening playing battleships, being psychoanalysed or taking part in a spelling bee. But there I go, mocking again ......

Perhaps the trouble lies in the average Briton's inbuilt resistance to change. They laughed at Remington when he sat down at the typewriter. They tittered at Hargreaves when he gave his Jenny her first spin. Caxton's printing press was a case for a chuckle. But it wasn't amusement that caused these reactions: rather, it was a kind of defence mechanism, an instinctive manning of the ramparts against the imminent threat of something new that would dramatically alter the established way of doing things. But later, when the scoffers became convinced of the enormous advantages these innovations offered, they were welcomed with open arms.

The need for information has until now been met in two traditional ways: by talking to informed experts on the subject concerned, or by consulting standard reference works or other authoritative published data. What's the difference, then, between that technique and Prestel? Not all that much. One 'talks' to the computer and it 'answers' by displaying the information you're after. Of course, even with its library of hundreds of thousands of pages, Prestel's range of information is still relatively limited, compared with that found in a conventional library. But extension is only a matter of time.

This notable British achievement deserves a much more positive recognition than it is currently getting – especially from the business world which it is uniquely capable of serving.

New thinking on the news

Still on the subject of information technology, I see that there's good news from the teletext front. One major set manufacturer reports that, followingl the 1981 Spring trade shows, their sales of teletext receivers are up by 250 per cent on last year. A spokesman expressed the company's pleasure – which didn't seem to me to be all that startling a revelation – at this trend and added that the multiples have come to realise just how wide the scope of the telext market is.

When I was at school the law of economics held that an increase in the sales of a product should, all things being equal, be followed, as night follows day, by a cut in its price. Nowadays the trend is to up the price and then point out how much bigger the increase would have been if there had been no jump in sales. Nonetheless, if other setmakers have a similarly joyful tale to tell, the great British public will be looking for some movement in the price sector.

There is another angle to this. If teletext is now well and truly on the way to wider public acceptance, the broadcasters have a wonderful opportunity, if not a duty, to improve the service they give to viewers. This particularly applies to the updating of general news.

Recently, being of an investigative, scientific turn of mind, I conducted a modest experiment. In our home, being the only male, I tend to rise early in order to achieve at least a brief occupancy of the bathroom before it is taken over by the female squatters with whom it is my lot to reside. This means that I can also listen to the 7 o'clock news in comfortable silence. Every day for a week I carefully made a note of the bulletin headlines. Then, five hours later at midday, I switched on the office teletext set to see what more had happened in the great big world outside in the interim. On practically every one of those five days it was still virtually 7 a.m. as far as the transmitting end was concerned.

This is hardly a good advertisement for a service whose prime advantage is professed to be the instant transmission of news as it is made. And as the number of teletext viewers grows, there is going to be an insistent demand for a far better service than that. Now seems to be a good time for the broadcasters to start providing it.

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SEC: 0 12V 0V 12V

TYPE	AMPS 12v	AMPS 24v	PRICE £	P/P £
242	0.3	0.15	1.70	0.40
213	10.50		2.65	0.87
71	2	1	2.77	1.10
18	4	2	3.98	1.43
68	3	1.5	3.46	1.43
85	5	2.5	6.06	1.43
70	6	3	6.67	1.43
108	8	4	8.03	1.43
72			8.66	1.73
116	12	6	9.31	1.90
17	16	8	11.46	2.05
115	20.10		13.69	2.05
187	30.15		19.23	2.35
232	40	20	27.61	4.50
226	60	30	35.35	4.00

15/30V RANGE PRI 220/240V
SEC: 0V 12V 15V 0V 5V 9V 15V
VOLTS AVAILABLE 3 ⟹ 15 — 0 — 15

TYPE	AMPS 15v	AMPS 30v	PRICE £	P/P £
112	1	0.50	2.84	1.10
79	2	1.0	3.29	1.10
3	4	2	6.18	1.43
20	6	3	7.19	1.73
21	8	4	8.52	1.73
51	10	5	10.57	1.90
117	12	6	11.94	2.05
88	16	8	16.14	2.20
89	20	10	18.54	2.35
90	24	12	20.57	2.55
91	30	15	23.63	2.65
92	40	20	33.21	4.50

25/50V RANGE PRI 120/220/240V
SEC: 0V 20V 25V 0V 8V 15V 25V
VOLTS OUT 5 ⟹ 25 — 0 — 25

TYPE	AMPS 25v	AMPS 50v	PRICE £	P/P £
102	1	0.50	3.29	1.43
103	2	1.0	4.09	1.43
104	4	2	7.65	1.73
105	6	3	9.09	1.90
106	8	4	12.24	1.90
107	12	6	16.15	2.20
118	16	8	22.46	2.55
119	20	10	27.05	2.55
109	24	12	32.44	4.50

30/60V RANGE PRI 120/220/240V
SEC: 0V 24V 30V 0V 10V 18V 30V
VOLTS 6 ⟹ 30 — 0 — 30

TYPE	AMPS 30v	AMPS 60v	PRICE £	P/P £
124	1	0.5	3.30	1.43
126	2	1	6.36	1.43
127	4	2	7.86	1.73
125	6	3	11.78	1.90
123	8	4	14.72	2.20
40	10	5	17.10	2.20
120	12	6	19.44	2.35
121	16	8	27.70	2.65
122	20	10	32.05	4.00
189	24	12	37.02	5.00

48/96V RANGE PRI 120/220/240V
SEC: 0V 36V 48V 0V 36V 48V
VOLTS 12 ⟹ 48 — 0 — 48

TYPE	AMPS 48v	AMPS 96v	PRICE £	P/P £
430	1	0.5	4.69	1.43
431	2	1	7.84	1.43
432	4	2	12.94	2.05
433	6	3	14.62	2.20
434	8	4	20.04	2.45
435	10	5	28.75	2.65
436	12	6	36.16	4.00
437	16	8	39.47	5.00

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0V 115V 220V 240V

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64	80	4.82	1.10
4	150	6.21	1.43
69	250	7.54	1.43
53	350	9.73	1.90
67	500	11.70	2.20
83	750	13.51	2.05
84	1000	18.31	2.35
95	2KVA	34.36	5.00
73	3	64.74	5.00
57	5	97.85	6.50
101	10	179.05	10.00

CASED AUTOTRANSFORMERS
240V LEAD IN 115V 2PIN SOCKET OUT

TYPE	VA	PRICE £	P/P £
56W	20	6.60	0.87
64W	80	8.43	1.43
4W	150	10.86	1.73
69W	250	13.17	1.90
67W	500	20.46	2.20
84W	1000	30.24	2.55
95W	2000	54.83	5.00
73W	3000	78.67	6.50

LINE ADJUSTMENT AUTOTRANSFORMERS
0 200 210 220 230 240 250

TYPE	VA	PRICE £	P/P £
415C	50	2.31	0.87
416C	100	3.46	0.87
417C	200	4.00	1.10
418F	350	6.26	1.43
419F	500	6.74	1.73
420E	750	8.33	1.90
421F	1000	11.64	2.05

MAINS ISOLATORS (SAFETY SCREEN)
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TYPE	VA	PRICE £	P/P £
149F	60	8.40	1.73
150F	100	9.71	1.73
151F	200	13.84	2.05
152F	250	16.69	2.20
153F	350	20.77	2.55
154F	500	26.03	2.65
155F	750	36.75	5.00
156F	1000	47.42	6.00

MAINS ISOLATORS (SAFETY SCREEN)
PRI 380/415/460V SEC 60V 55V 0V 55V 60V 60V 55V 0V 55V 60V

TYPE	VA	PRICE £	P/P £
243F	60	8.40	1.43
244F	100	9.76	1.73
245F	200	13.93	2.05
246F	250	16.69	2.20
247F	350	20.77	2.55
248F	500	26.03	2.65
249F	750	36.75	5.00
250F	1000	47.42	6.00

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Inv. 2	Open	30.95	2.65

P.C.B.
120/220/240V
0–12–0–12V

		PRICE £	P/P £
6VA	467 PCB	1.89	0.58
9VA	468 PCB	2.24	0.58
12VA	470 PCB	2.39	0.58
25VA	471 PCB	2.52	0.87
50VA	472 PCB	4.63	1.43

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2114 450ns Low power	1.25	1.15	1.05
4118 250ns	3.95	3.25	2.95
6116 150ns CMOS	8.75	8.25	7.95
2708 450ns	2.40	2.25	2.15
2716 450ns 5 volt	2.65	2.40	2.20
2716 450ns three rail	7.40	7.00	6.75
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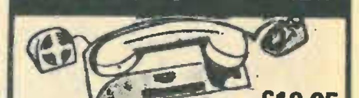

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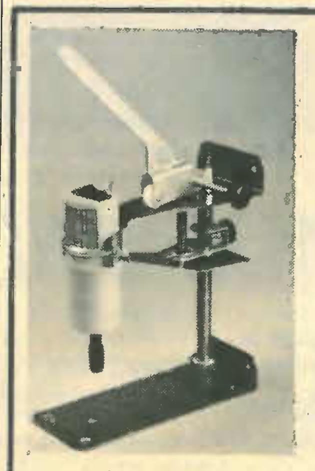

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				BC207	0.09	BC408	0.11	BD239	0.30	BF259	0.27	BU500	2.00	2N3053	0.28
AC125	0.20	BC117	0.17	BC208	0.09	BC409	0.11	BD240	0.32	BF271	0.24	BUY69A	1.75	2N3054	0.60
AC126	0.20	BC119	0.18	BC209	0.09	BC413	0.11	BD241A	0.30	BF273	0.12	C106D1	0.24	2N3055	0.45
AC127	0.15	BC125	0.11	BC212	0.08	BC417	0.11	BC241B	0.30	BF308	0.30	OC28	1.00	2N3442	1.20
AC128	0.18	BC126	0.11	BC212L	0.08	BC418	0.11	BD241C	0.30	BF336	0.32	OC35	1.00	2N3553	2.20
AC127K	0.20	BC140	0.19	BC212LB	0.08	BC427	0.11	BC433	0.50	BF337	0.27	R2008B	1.50	2N3565	0.20
AC128K	0.27	BC141	0.19	BC213	0.08	BC440	0.22	BC434	0.50	BF338	0.27	R2010B	1.50	2N3702	0.10
AC141	0.20	BC142	0.20	BC213L	0.08	BC441	0.22	BC435	0.50	BF355	0.37	R1038	1.00	2N3703	0.10
AC141K	0.27	BC143	0.20	BC213LB	0.08	BC460	0.30	BC436	0.50	BF380	0.30	R1039	1.50	2N3704	0.10
AC142	0.20	BC147	0.07	BC214	0.08	BC461	0.30	BC437	0.50	BF451	0.10	R2029	1.50	2N3705	0.10
AC142K	0.27	BC147A	0.07	BC214L	0.08	BC477	0.20	BC438	0.50	BF457	0.30	R2322	1.00	2N3706	0.10
AC151	0.20	BC147B	0.07	BC214LB	0.08	BC478	0.20	BC439	0.50	BF458	0.30	R2773	0.50	2N3707	0.10
AC153	0.20	BC147C	0.07	BC237	0.08	BC537	0.09	BC517	0.55	BF459	0.30	TIP29	0.35	2N3708	0.10
AC176	0.20	BC148	0.07	BC237A	0.08	BC547	0.09	BC518	0.55	BF523	0.15	TIP29A	0.35	2N3711	0.10
AC176K	0.27	BC148A	0.07	BC237B	0.08	BC548	0.09	BC519	0.55	BF594	0.20	TIP29B	0.35	2N3773	3.00
AC187	0.20	BC148B	0.07	BC237C	0.08	BC548B	0.09	BC937	0.40	BF595	0.20	TIP29C	0.35	2N3819	0.20
AC188	0.20	BC148C	0.07	BC238	0.08	BC548C	0.09	BC945	0.40	BF596	0.20	TIP30	0.35	2N3866	0.60
AC187K	0.27	BC149	0.07	BC238A	0.08	BC549	0.07	BC950	0.40	BFR40	0.22	TIP30A	0.35	2N3903	0.15
AC188K	0.27	BC149A	0.07	BC238B	0.08	BC549A	0.07	BDX32	1.20	BFR91	1.20	TIP30B	0.35	2N3904	0.15
AD140	0.40	BC149B	0.07	BC238C	0.08	BC549B	0.07	BF115	0.20	BFX29	0.25	TIP30C	0.35	2N3905	0.18
AD141	0.60	BC149C	0.07	BC251A	0.09	BC549C	0.07	BF121	0.18	BFX37	0.20	TIP31A	0.35	2N3906	0.18
AD142	0.70	BC157	0.08	BC251B	0.09	BC550	0.07	BF123	0.18	BFX48	0.40	TIP31B	0.35	2N4037	0.60
AD143	0.70	BC158	0.08	BC252A	0.09	BC557	0.06	BF127	0.18	BFX84	0.24	TIP31C	0.35	2N4058	0.11
AD149	0.48	BC159	0.08	BC252B	0.09	BC558	0.07	BF137	0.30	BFX86	0.20	TIP32	0.40	2N4061	0.16
AD161	0.22	BC160	0.26	BC257	0.09	BC559	0.07	BF152	0.09	BFX87	0.22	TIP32B	0.40	2N4062	0.16
AD162	0.22	BC161	0.26	BC258	0.10	BCY56	0.25	BF157	0.30	BFX88	0.22	TIP32C	0.42	2N4125	0.20
AD161/		BC167	0.09	BC260	0.15	BCY58	0.25	BF160	0.20	BFX89	0.38	TIP33B	0.55	2N4143	0.20
162	.45	BC168	0.09	BC261A	0.15	BCY70	0.15	BF167	0.20	BFY34	0.40	TIP34	0.80	2N4250	0.18
ACY39	0.30	BC169	0.09	BC261B	0.16	BCY71	0.15	BF173	0.20	BFY50	0.20	TIP35	1.50	2N4400	0.10
ACY40	0.20	BC170A	0.05	BC262B	0.16	BCY72	0.15	BF177	0.26	BFY51	0.20	TIP36	1.00	2N4402	0.10
ACY44	0.20	BC170B	0.05	BC263	0.14	BD115	0.24	BF178	0.26	BFY52	0.20	TIP41C	0.40	2N4403	0.12
AF106	0.28	BC170C	0.05	BC264	0.20	BD124P	0.56	BF179	0.26	BFY56	0.40	TIP42C	0.40	2N4416	0.50
AF109	0.28	BC171	0.07	BC268	0.20	BD131	0.30	BF180	0.20	BFY90	0.50	TIP47	0.60	2N4441	1.00
AF124	0.20	BC171A	0.07	BC300	0.28	BD132	0.30	BF181	0.20	BR100	0.19	TIP2955	0.80	2N4443	1.10
AF125	0.20	BC171B	0.07	BC301	0.28	BD133	0.37	BF182	0.20	BR101	0.28	TIP3055	0.60	2N4900	1.50
AF126	0.20	BC172	0.07	BC302	0.28	BD135	0.24	BF183	0.20	BRC4443	0.80	2N696	0.25	2N4922	0.50
AF127	0.20	BC172A	0.07	BC303	0.26	BD136	0.24	BF184	0.26	BRY39	0.30	2N697	0.23	2N5060	0.20
AF139	0.30	BC172B	0.07	BC304	0.28	BD137	0.24	BF185	0.26	BSX52	0.20	2N698	0.35	2N5088	0.20
AF239	0.32	BC172C	0.07	BC307	0.08	BD138	0.24	BF194	0.11	BSY84	0.20	2N706A	0.28	2N5105	0.50
AU106	1.90	BC173B	0.09	BC308	0.08	BD139	0.24	BF195	0.11	BSY95A	0.20	2N708	0.28	2N5195	0.40
AU107	1.30	BC174	0.08	BC309	0.08	BD140	0.24	BF196	0.08	BT106	1.00	2N918	0.35	2N5298	0.50
AU110	1.40	BC177	0.15	BC313	0.20	BD150	0.40	BF197	0.09	BT119	1.00	2N930	0.18	2N5447	0.09
AU113	1.80	BC177B	0.15	BC315	0.20	BD159	0.40	BF198	0.08	BT120	1.00	2N1131	0.35	2N5449	0.09
BC107	0.09	BC178	0.15	BC317	0.15	BD175	0.30	BF199	0.08	BT116	1.20	2N1132	0.35	2N5458	0.30
BC107A	0.09	BC179	0.15	BC318	0.15	BD176	0.30	BF200	0.20	BU105	1.10	2N1613	0.23	2N5485	0.34
BC107B	0.09	BC182	0.07	BC319	0.12	BD182	0.65	BF224	0.15	BU108	1.40	2N1711	0.23	2N5486	0.30
BC108	0.09	BC182B	0.07	BC320	0.12	BD201	0.50	BF240	0.12	BU124	1.00	2N2102	0.65	2N5490	0.50
BC108A	0.09	BC182L	0.07	BC322	0.12	BD202	0.50	BF241	0.12	BU126	0.90	2N2160	3.50	2N5496	0.70
BC108B	0.09	BC182LB	0.09	BC323	2.00	BD203	0.50	BF243	0.26	BU133	0.98	2N2219A	0.22	2N5551	0.15
BC108C	0.09	BC183	0.08	BC327	0.09	BD204	0.50	BF244B	0.20	BU204	1.30	2N2222A	0.22	2N6109	0.44
BC109	0.09	BC183L	0.08	BC328	0.09	BD223	0.40	BF245	0.20	BU205	1.10	2N2369	0.20	2N6123	0.40
BC109A	0.09	BC183LB	0.08	BC337	0.09	BD224	0.40	BF245A	0.22	BU207	0.70	2N2484	0.28	2N6386	0.90
BC109B	0.09	BC184	0.08	BC338	0.09	BD233	0.30	BF245C	0.24	BU208	1.00	2N2646	0.38	2SC1172	1.50
BC109C	0.09	BC184L	0.08	BC347	0.09	BD234	0.30	BF254	0.09	BU208A	1.20	2N2904	0.28	2SC1306	1.00
BC113	0.10	BC184LB	0.08	BC348	0.09	BD235	0.30	BF255	0.09	BU208/02	1.80	2N2905	0.28	2SC2028	1.00
BC114	0.10	BC204	0.09	BC350	0.09	BD236	0.30	BF256	0.22	BU326A	1.30	2N2906A	0.28	2SC2029	2.00
BC115	0.10	BC205	0.09	BC351	0.09	BD237	0.30	BF257	0.27	BU406	1.00	2N2907A	0.28	2SC2078	1.70
BC116A	0.11	BC206	0.09	BC407	0.09	BD238	0.30	BF258	0.27	BU407	1.00	2N2926	0.09		

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AA119	0.06
BY127	0.10
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OA81	0.10
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OA90	0.07
OA91	0.07
OA95	0.07
OA200	0.09
OA202	0.09
1N914	0.35
1N4148	0.03
1N4001	0.04
1N4002	0.06
1N4003	0.06
1N4004	0.06
1N4005	0.05
1N4006	0.05
1N4007	0.06
1N5401	0.14
1N5402	0.14
1N5403	0.14
1N5404	0.14
1N5405	0.14
1N5406	0.14
1N5407	0.14
1N5408	0.14

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LM340T12	0.70	SN76023N	1.10	TBA530	0.90	TBA990	1.30	TDA2523	1.50
LM348	1.00	SN76110N	0.70	TBA530Q	0.90	TBA990Q	1.30	TDA2530	1.40
MC1307P	1.00	SN76227N	1.00	TBA540	0.90	TCA270	0.60	TDA2532	2.00
MC1310P	1.00	SN76660	0.50	TBA540Q	0.90	TCA270SQ	1.00	TDA2540	1.50
MC1327P	0.90	TAA550B	0.20	TBA550	1.20	TCA800	1.20	TDA2541	2.00
MC1330	1.00	TAA621AX1	0.70	TBA550Q	1.20	TDA440	1.75	TDA2560	2.00
MC1355	1.00	TAA661A	2.00	TBA560Q	1.20	TDA1004A	1.70	TDA2581	1.20
MC231B	1.50	TAA661B	0.90	TBA570	1.00	TDA1170	1.80	TDA2593	2.40
ML232B	1.50	TBA120B	0.60	TBA750AQ	1.70	TDA1190	2.00	TDA2600	2.90
SAS560S	1.50	TBA120SB	0.60	TBA800	0.60	TDA1327	1.20	TDA2640	2.40
SAS570S	1.50	TBA120S	0.60	TBA810S	1.00	TDA1352	1.20	TDA3950	2.00
SAS580S	2.20	TBA120AS	0.60	TBA810AS	1.00	TDA1412	0.80		
SAS590S	2.20	TBA520	0.90	TBA820	1.00	TDA2020	2.00		

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DAWN OF A NEW ERA

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POWER UP TO 480 WATTS RMS SINGLE CHANNEL

Which amplifier?

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

AMPLIFIER WITH HEAT SINK

BIPOLAR Standard, with heatsinks

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

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

HEAVY DUTY with heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	DISTORTION T.H.D. Typ at 1kHz	DISTORTION I.M.D. 60HZ/7kHz 4:1	SUPPLY VOLTAGE TYP/MAX	SIZE mm	WT gms	PRICE	VAT	Without heatsinks: MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
HD120	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x50	515	£22.48	£3.37	HD120P	120x26x50	265	£19.84	£2.98
HD200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x60	620	£27.38	£4.11	HD200P	120x26x50	265	£23.63	£3.54
HD400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£38.63	£5.79	HD400P	120x26x70	375	£34.28	£5.14

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

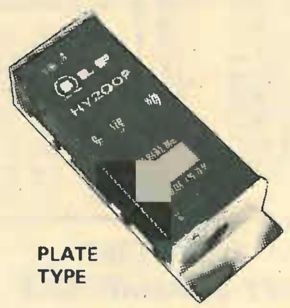

PLATE TYPE

MOSFET Ultra-Fi, with heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	DISTORTION T.H.D. Typ at 1kHz	DISTORTION I.M.D. 60HZ/7kHz 4:1	SUPPLY VOLTAGE TYP/MAX	SIZE mm	WT gms	PRICE	VAT	Without heatsinks: MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
MOS120	60w/4-8Ω	<0.005%	<0.006%	±45±50	120x78x40	420	£25.88	£3.88	MOS120P	120x26x40	215	£23.32	£3.50
MOS200	120w/4-8Ω	<0.005%	<0.006%	±55±60	120x78x80	850	£33.46	£5.02	MOS200P	120x26x80	420	£28.53	£4.28
MOS400	240w/4Ω	<0.005%	<0.006%	±55±60	120x78x100	1025	£45.39	£6.81	MOS400P	120x26x100	525	£38.91	£5.84

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

PSU

POWER SUPPLY UNITS

MODEL NO.	FOR USE WITH	PRICE	VAT
PSU30	± 15V combinations of HY6/66 series to a maximum of 100mA or *one* HY67	£4.50	£0.68
	The following will also drive the HY6/66 series except HY67 which requires the PSU30.		
PSU36	1 or 2 HY30	£8.10	£1.22
PSU50	1 or 2 HY60	£10.94	£1.64
PSU60	1 x HY120/HY120P/HD120/HD120P	£13.04	£1.96
PSU65	1 x MOS120/1 x MOS120P	£13.32	£2.00
PSU70	1 or 2 HY120/HY120P/HD120/HD120P	£15.92	£2.39
PSU75	1 or 2 MOS120/MOS120P	£16.20	£2.43
PSU90	1 x HY200/HY200P/HD200/HD200P	£16.20	£2.43
PSU95	1 x MOS200/MOS200P	£16.32	£2.45
PSU180	2 x HY200/HY200P/HD200/HD200P or 1 x HY400/1 x HY400P/HD400/HD400P	£21.34	£3.20
PSU185	1 or 2 MOS200/MOS200P/1 x MOS400/ 1 x MOS400P	£21.46	£3,22

All models except PSU30 and PSU36 incorporate our own toroidal transformers.

FP480

BRIDGING UNIT FOR DOUBLING POWER

Designed specially by I.L.P. for use with any two power amplifiers of the same type to double the power output obtained and will function with any I.L.P. power supply. In totally sealed case, size 45 x 50 x 20mm, with edge connector. It thus becomes possible to obtain 480 watts rms (single channel) into 8Ω. Contributory distortion less than 0.005%.
Price: £4.79 + 72p. V.A.T.

Which modules?

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

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

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

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

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

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

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

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WW – 062 FOR FURTHER DETAILS

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Eddystone

WW – 082 FOR FURTHER DETAILS

ADV 030

ADV 025

Model No.	ADV 030	ADV 025
Output Current	5 Amp	10 Amp
Output Volts	2.30 DC	0.25 DC
Input Volts	115-230-250 A/C	115-230-250 A/C
Tolerated Mains Variation	15%	15%
Ripple On Load	.05%	.05%
Load Regulation Better Than	.5%	.5%
Protection	Both Models. Internal Fold Back. Overload. Thermal and short circuit Protected.	
Guarantee	Both Models. 2 years	
Dimensions	Height. 130 M/M mm	177 mm
	Width. 250 M/M mm	335 mm including
	Depth. 170 M/M mm	294 mm handles

SOUTHERN ELECTRONICS

6 WESTCLIFF ARCADE, RAMSGATE, KENT TEL. THANET (0843) 57888

WW – 023 FOR FURTHER DETAILS

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Axial or vertical mounting
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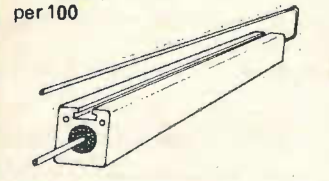

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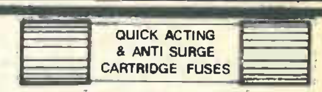

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WW – 021 FOR FURTHER DETAILS

Decade Resistance Box 8000 £99
- 0.1% ACCURACY
- 1Ω TO 100MΩ
- COLOUR CODED DIGITS

NEW

Low Ohm Resistance Box 1051 £108
- 0.0Ω TO 1M
- IN LINE READ-OUT
- 1 WATT POWER RATING

Decade Resistance Boxes Type 1061/1062 £58

- IN LINE READ-OUT
- PRECISE
- MECHANICALLY AND ELECTRICALLY ROBUST
- STABLE–(METAL FILM RESISTORS)
- FULLY SCREENED
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- 10Ω to 12MΩ (1062)

The 1061/1062 Decade Resistance boxes are designed to meet the standard required in both educational and industrial applications. Metal film resistors, with the advantages of stability and low temperature coefficient, are used throughout. The case provides complete electrostatic screening.

NEW

Decade Capacitance Box 1071 £127
- 1% ACCURACY
- 10 pF-100 µF
- COLOUR CODED DIGITS

A compact 7 decade capacitance box. Coloured digits give nF in white, pF in yellow and µF in red. All contacts are gold plated.

NEW

Microcal 1030 £93
- VOLTAGE/CURRENT RANGES
- BATTERY OPERATION
- 0.1% ACCURACY

A compact low cost voltage and current source for general use. Outputs are 10 µV to 1 V and 10 µA to 100 mA.

TIME ELECTRONICS LTD, Botany Industrial Est., Tonbridge, Kent, England TN9 1RS. Tel: (0732) 355993. Telex: 95481

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7411	20p	74LS08	18p	4041	70p
7412	20p	74LS09	20p	4042	55p
7413	25p	74LS10	17p	4043	60p
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7421	30p	74LS27	20p	4050	30p
7422	22p	74LS30	17p	4051	60p
7423	25p	74LS32	27p	4052	80p
7425	30p	74LS37	20p	4053	60p
7426	30p	74LS38	20p	4054	130p
7427	25p	74LS42	50p	4055	125p
7428	30p	74LS47	50p	4056	120p
7430	17p	74LS51	24p	4059	500p
7432	30p	74LS55	30p	4060	90p
7433	30p	74LS73	25p	4063	100p
7437	30p	74LS74	24p	4066	35p
7438	30p	74LS75	28p	4067	400p
7440	17p	74LS76	20p	4068	18p
7441	70p	74LS83	50p	4069	20p
7442A	50p	74LS85	70p	4070	20p
7443	112p	74LS86	36p	4071	20p
7444	112p	74LS90	35p	4072	20p
7445	80p	74LS92	40p	4073	20p
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74132	45p	74LS195	50p	4536	300p
74136	32p	74LS196	60p	4538	120p
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74196	70p	4008	60p	75154	150p
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LM2917	200p	TL170	50p
LM3302	100p	UAA170	175p
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LM723	37p	79HGKC	600p
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LEDS			
0.125″		0.2″	
TIL32	55p	TIL220 Red	16p
TIL209 Red	13p	TIL222 Gr	18p
TIL211 Gr	20p	TIL228 Red	22p
TIL212 Ye	25p	Rectangular LEDs (R, G, Y)	30p
TIL216 Red	18p	NSB5881	570p
DISPLAYS		TIL311	600p
3015F	200p	TIL312/3	110p
DL704	140p	TIL321/2	130p
DL707 Red	140p	TIL330	140p
FND357	120p	7750/60	200p
FND500	110p	**DRIVERS**	
FND507	110p	9368	250p
MAN3640	175p	9370	300p
MAN4640	200p	UDN6118	320p
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AC126	25p	BFR41	25p	TIP30C	60p	2N3442	140p
AC127/8	20p	BFR79	25p	TIP31A	58p	2N3553	240p
AC176	25p	BFR80	25p	TIP31C	62p	2N3565	30p
AC187/8	25p	BFR81	25p	TIP32A	68p	2N3584	250p
AF116	50p	BFX29	40p	TIP32C	82p	2N3643/4	48p
AD149	70p	BFX30	34p	TIP33A	90p	2N3702/3	12p
AD161/2	45p	BFX84/5	40p	TIP33C	114p	2N3704/5	12p
AU107	200p	BFX86/7	30p	TIP34A	115p	2N3706/7	14p
BC107/8	11p	BFX88	30p	TIP34C	160p	2N3708/9	12p
BC109	11p	BFW10	90p	TIP35A	225p	2N3773	300p
BC117	20p	BFY50	30p	TIP35C	290p	2N3819	25p
BC147/8	9p	BFY51/2	30p	TIP36A	270p	2N3820	50p
BC149	10p	BFY56	33p	TIP36C	340p	2N3823	70p
BC157/8	10p	BFY90	90p	TIP41A	65p	2N3866	90p
BC159	11p	BRY39	45p	TIP41C	78p	2N3902	700p
BC169C	12p	BSX19/20	24p	TIP42A	70p	2N3903/4	18p
BC172	12p	BU104	225p	TIP42C	82p	2N3905/6	20p
BC177/8	17p	BU105	190p	TIP54	160p	2N4037	65p
BC179	18p	BU108	250p	TIP120	120p	2N4061/2	18p
BC182/3	10p	BU109	225p	TIP122	130p	2N4123/4	27p
BC184	11p	BU126	150p	TIP142	130p	2N4125/6	27p
BC187	30p	BU180A	120p	TIP147	130p	2N4401/3	27p
BC212/3	11p	BU205	200p	TIP2955	78p	2N4427	90p
BC214	12p	BU208	200p	TIP4055	70p	2N4871	60p
BC237	15p	BU406	145p	TIS43	48p	2N5087	27p
BC327	16p	E300	50p	TIS93	30p	2N5089	27p
BC337	16p	E308	50p	ZTX108	12p	2N5172	27p
BC338	16p	E310	50p	ZTX300	13p	2N5179	90p
BC461	36p	MJ2501	225p	ZTX500	15p	2N5191	90p
BC477/8	30p	MJ2955	90p	ZTX502	18p	2N5194	90p
BC516/7	40p	MJ3001	225p	ZTX504	30p	2N5245	40p
BC547B	16p	MJE340	60p	2N457A	250p	2N5296	55p
BC548C	9p	MJE2955	100p	2N696	35p	2N5401	50p
BC549C	18p	MJE3055	70p	2N697	25p	2N5457/8	40p
BC557B	16p	MPF102	45p	2N698	45p	2N5459	40p
BC559C	18p	MPF103/4	40p	2N706A	30p	2N5460	60p
BCY70	18p	MPF105/6	40p	2N708	30p	2N5485	44p
BCY71/2	22p	MPS6531	50p	2N918	45p	2N5875	250p
BD131/2	50p	MPS6534	50p	2N930	18p	2N6027	48p
BD135/6	54p	MPSA06	30p	2N1131/2	36p	2N6041	160p
BD139	56p	MPSA12	50p	2N1613	25p	2N6044	160p
BD140	60p	MPSA13	50p	2N1711	25p	2N6052	300p
BD189	60p	MPSA20	50p	2N2102	70p	2N6059	325p
BD232	95p	MPSA42	50p	2N2160	350p	2N6107	65p
BD233	75p	MPSA43	50p	2N2219A	30p	2N6247	190p
BD235	85p	MPSA56	32p	2N2222A	30p	2N6254	130p
BD241	70p	MPSA70	50p	2N2369A	25p	2N6290	65p
BD242	70p	MPSU06	63p	2N2484	30p	2N6292	65p
BDY56	200p	MPSU07	60p	2N2646	45p	2SC1172	150p
BF200	32p	MPSU45	90p	2N2904/5	30p	2SC1306	150p
BF244B	35p	MPSU65	78p	2N2906A	30p	2SC1969	200p
BF256B	70p	OC28	130p	2N2907A	30p	2SC2028	120p
BF257/8	32p	OC35	130p	2N2926	9p	2SC2029	250p
BF259	36p	TIP29A	40p	2N3053	30p	2SC2078	200p
BFR39	25p	TIP29C	55p	2N3054	65p	3N128	120p

3N140	120p
3N141	110p
3N201	110p
3N204	120p
40290	250p
40361/2	75p
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8212	200p		
8216	200p		
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(WITH 5X MAG.) 1 mV ~ 2V/DIV (within ± 5%)
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(WITH 5X MAG.) DC (AC: 2Hz) ~ 10MHz (–3 dB, 8 DIV)
RISE TIME Approx 17.5n sec (20MHz) Approx 35n sec (10MHz)
INPUT IMPEDANCE 1M Ω ± 2%, 30pF ± 2pF
INPUT COUPLING AC, DC or GND
OPERATION MODE CH1, CH2, DUAL X-Y (DUAL: automatic switching ALT and CHOP)
CHOP FREQUENCY Approx. 200 kHZ
★HORIZONTAL AXIS 1-2-5 sequence, 20 ranges
SWEEP TIME 0.4μsec 0.5 sec/DIV (within ± 5%)
(WITH 5X MAG.) 0.04μsec 0.1 sec/DIV (within ± 5%)
SWEEP STOP Sweep stops and trace becomes a spot.
★EXTERNAL SWEEP MODE X-Y mode (CH1: X axis)
SENSITIVITY 5mV ~ 10V/DIV
FREQUENCY RESPONSE DC (AC: 2Hz) ~ 1MHz
INPUT IMPEDANCE 1 MΩ ± 2%, 30pF ± 2pF
X-Y PHASE DIFFERENCE within 3° at 50kHZ
★ TRIGGERING
TRIGGER MODE AUTO, NORM, SINGLE, TV
TRIGGER SOURCE INT. EXT.
COUPLING AC and DC
POLARITY "±" and "–"
★Z AXIS
SENSITIVITY 3 Vp-p (Trace becomes brighter with negative input signal)
FREQUENCY RESPONSE DC ~ 5MHz
INPUT RESISTANCE Approx. 10kΩ
★CALIBRATION VOLTAGE
WAVEFORM Square wave. Approx. 1kHz
OUTPUT VOLTAGE 1Vp-p. ± 3%
★ CRT
TYPE 5-inch round-type
PHOSPHOR B31 (Green)
ACCELERATION VOLTAGE Approx. 2kV
EFFECTIVE AREA 8 DIV × 10 DIV (1DIV = 9.5mm)
GRATICULE ILLUMINATION Brightness is continuously variable
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AC LINE VOLTAGE 100V, 110V, 120V, 220V, 230V, 240V, ± 10%
FREQUENCY 50/60 Hz
POWER CONSUMPTION Approx. 40VA
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MAXIMUM DIMENSIONS 250W × 210H × 435D mm
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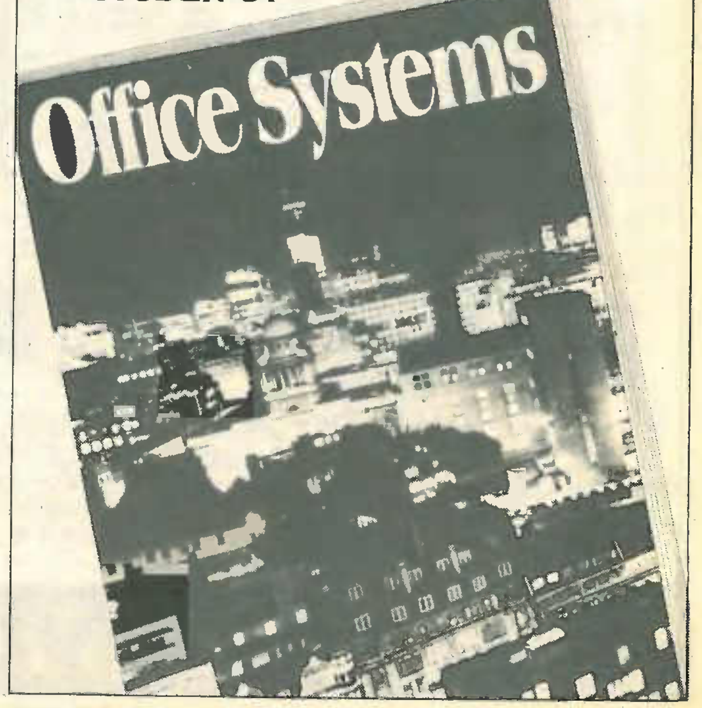
FIRST ISSUE: OCTOBER '81



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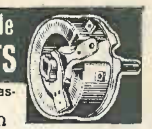

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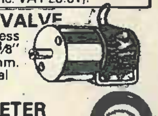

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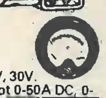

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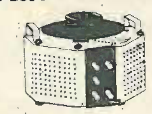

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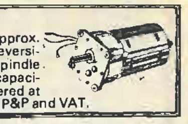

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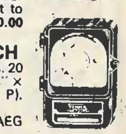

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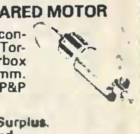

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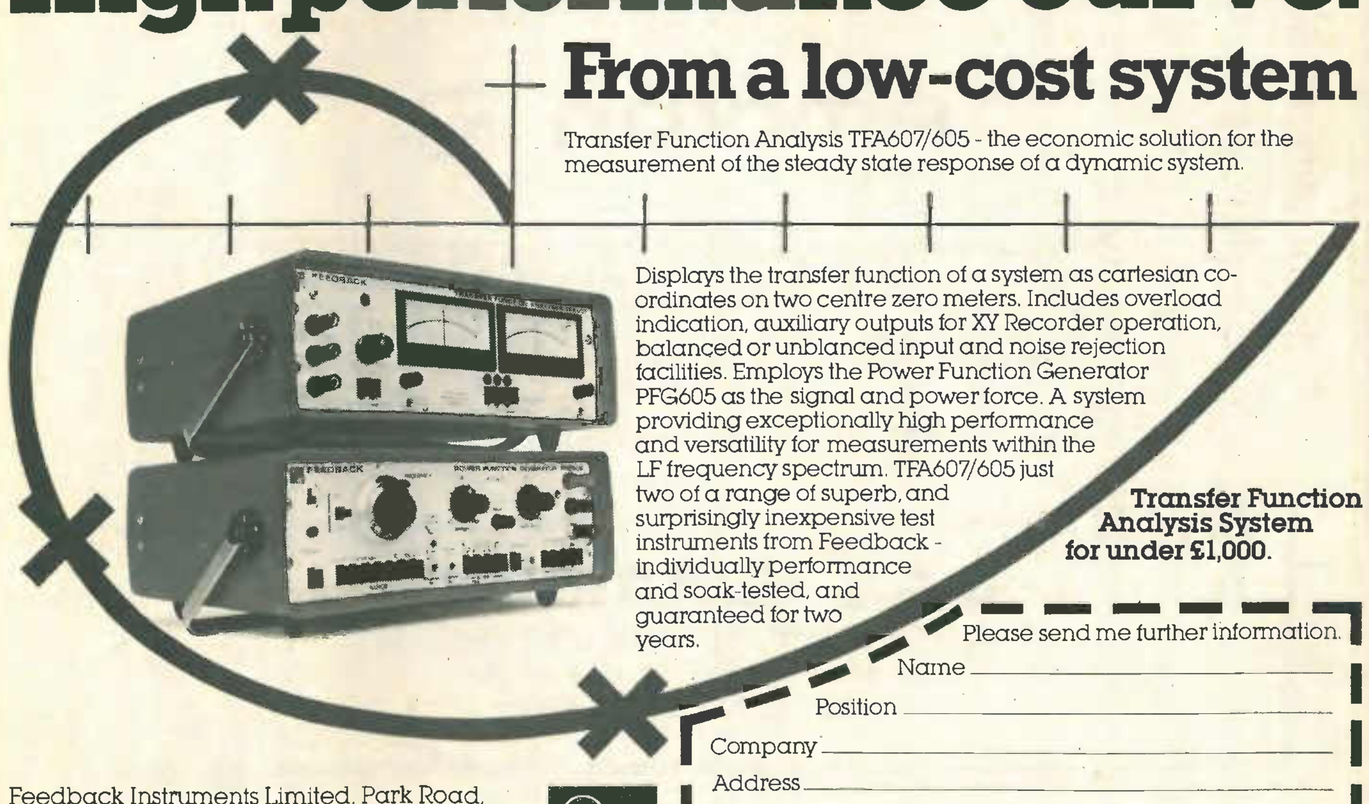

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AC125	0.29
AC126	0.29
AC127	0.29
AC128	0.35
AC141	0.32
AC141K	0.40
AC142	0.32
AC142K	0.40
AC176	0.35
AC187	0.32
AC188	0.32
ACY17	1.50
ACY18	1.32
ACY19	1.27
ACY20	1.27
ACY21	1.32
ACY39	2.88
AD149	0.86
AD161	0.40
AD162	0.40
AF106	0.40
AF114	0.86
AF115	0.86
AF116	0.86
AF117	0.86
AF139	0.38
AF186	1.15
AF239	0.45
AFZ11	4.60
AFZ12	4.60
ASY26	1.61
ASY27	1.04

ASZ15	1.38
ASZ16	1.27
ASZ17	1.15
ASZ20	2.64
ASZ21	2.88
AU113	2.88
AUY10	3.45
AU110	2.88
BA145	0.15
BA148	0.17
BA154	0.12
BA155	0.13
BA156	0.12
BAW62	0.06
BAX13	0.07
BAX16	0.07
BC107	0.18
BC108	0.18
BC109	0.18
BC113	0.17
BC114	0.17
BC115	0.21
BC116	0.22
BC117	0.26
BC118	0.21
BC125	0.21
BC126	0.21
BC135	0.17
BC136	0.22
BC137	0.22
BC147	0.14
BC148	0.14
BC149	0.15
BC157	0.15
BC158	0.15
BC159	0.15
BC167	0.13
BC170	0.13
BC171	0.12

BC172	0.13
BC173	0.13
BC177	0.32
BC178	0.16
BC179	0.32
BC182	0.35
BC183	0.13
BC184	0.13
BC212	0.13
BC213	0.13
BC214	0.13
BC237	0.13
BC238	0.13
BC301	0.38
BC303	0.39
BC307	0.13
BC308	0.13
BC327	0.14
BC328	0.14
BC337	0.14
BC338	0.14
BCY30	1.44
BCY31	1.73
BCY32	1.73
BCY33	1.27
BCY34	1.15
BCY39	3.91
BCY40	3.22
BCY42	0.35
BCY43	0.35
BCY58	0.22
BCY70	0.20
BCY71	0.21
BCY72	0.20
BCZ11	2.01
BD115	0.48
BD121	1.96
BD123	3.22
BD124	2.30

BD131	0.51
BD132	0.55
BD135	0.46
BD136	0.46
BD137	0.46
BD138	0.55
BD139	0.55
BD140	0.58
BD144	2.30
BD181	1.38
BD182	1.36
BD137	0.62
BD238	0.62
BDX10	1.05
BDX32	2.30
BDY20	1.73
BDY60	3.16
BF115	0.40
BF152	0.18
BF153	0.18
BF154	0.20
BF159	0.20
BF160	0.20
BF167	0.28
BF173	0.35
BF177	0.40
BF178	0.40
BF179	0.40
BF180	0.32
BF181	0.32
BF182	0.35
BF183	0.32
BF184	0.32
BF185	0.35
BF194	0.16
BF195	0.14
BF196	0.15
BF197	0.16
BF200	0.46
BF224	0.29
BF244	0.32

BF257	0.31
BF258	0.31
BF259	0.32
BF336	0.39
BF337	0.38
BF338	0.41
BFS21	4.60
BFS28	2.58
BFS61	0.23
BFS98	0.23
BFW10	1.12
BFW11	1.10
BFX84	0.35
BFX85	0.35
BFX87	0.35
BFX88	0.35
BFY50	0.29
BFY51	0.29
BFY52	0.29
BFY64	0.35
BFY90	1.09
BSX19	0.31
BSX20	0.31
BSX21	0.33
BT106	1.38
BTY79/400R	2.30
BU205	1.50
BU206	1.73
BU208	2.30
BY100	0.46
BY126	0.15
BY127	0.16
BZX61	0.20
Series	
BZY88	0.12
Series	
CRS1/40	0.69
CRS3/06	0.52
CRS3/40	0.86

CRS3/60	1.04
GEX66	1.73
GEX541	5.75
GJ3M	1.73
GM0378A	2.02
KS100A	0.52
MJE340	0.69
MJE370	0.84
MJE371	0.82
MJE520	0.54
MJE521	0.84
MJE2955	1.50
MJE3055	1.27
MPF102	0.40
MPF103	0.40
MPF104	0.40
MPF105	0.40
MPSA06	0.30
MPSA56	0.32
MPSU01	0.61
MPSU06	0.75
MPSU56	0.79
NE555	0.52
NKT401	4.03
NKT403	2.88
NKT404	2.53
OA5	1.38
OA7	0.69
OA10	0.63
OA47	0.14
OA70	0.29
OA79	0.14
OA81	0.20
OA85	0.20
OA90	0.09
OA91	0.09
OA95	0.09
OA200	0.17
OA202	0.17
OA211	1.73
OAZ200	1.73

OAZ201	1.73
OAZ206	1.73
OAZ207	1.73
OC16	2.88
OC20	2.88
OC22	2.88
OC23	4.60
OC24	3.45
OC25	1.15
OC26	1.73
OC28	2.30
OC29	2.30
OC35	1.73
OC36	1.73
OC41	1.04
OC42	1.04
OC43	1.73
OC44	0.98
OC45	0.75
OC71	0.63
OC72	1.15
OC73	1.15
OC74	0.81
OC75	0.75
OC76	1.15
OC77	1.15
OC81	0.75
OC81Z	1.38
OC82	1.04
OC83	0.92
OC84	0.92
OC122	3.16
OC123	2.30
OC139	3.45
OC140	4.60
OC141	4.93
OC170	1.44
OC171	1.44
OC200	1.73
OC201	2.88
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OC203	3.45
OC204	3.45
OC205	3.16
OC206	3.16
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OCP71	2.30
ORP12	1.15
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R2009	2.59
R2010B	2.30
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T1C226D	1.38
TIL209	0.18
T1P29A	0.49
T1P30A	0.52
T1P31A	0.38
T1P32A	0.41
T1P33A	0.62
T1P34A	0.77
T1P41A	0.51
T1P42A	0.48
T1P2955	0.81
T1P3055	0.64
T1S43	0.49
ZS140	0.29
ZS170	0.24
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ZS271	0.26
ZS278	0.65
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ZTX108	0.14
ZTX109	0.14
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ZTX311	0.15
ZTX314	0.29
ZTX500	0.16
ZTX501	0.16

ZTX502	0.21
ZTX503	0.22
ZTX504	0.24
ZTX531	0.28
ZTX550	0.29
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1N916	0.10
1N4001	0.07
1N4002	0.07
1N4003	0.07
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1N4006	0.13
1N4007	0.14
1N4009	0.08
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1N5400	0.15
1N5401	0.15
1S44	0.05
1S920	0.09
1S921	0.10
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2G302	1.15
2G306	1.15
2N404	1.50
2N696	0.37
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2N705	1.44
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2N930	0.29
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2N2222	0.23
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2N2369A	0.29
2N2484	0.29
2N2646	0.58
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2N3820	0.45
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2S017	11.50
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2S026	28.75
2S103	1.73
2S302	2.30
2S303	1.73
2S322	4.03
2S324	4.03
2S701	2.30
2S745A	1.09
2S746A	1.09

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A1834	10.35
A2087	13.58
A2134	20.13
A2293	8.62
A2426	17.63
A2521	24.38
A2900	14.43
A3343	25.56
AZ31	1.26
AZ41	1.32
BK448	110.27
BK484	149.09
BS90	52.27
BS810	35.24
BT5	58.13
BT17	106.89
BT19	36.17
BT29	327.69
BT69	333.50
BT75	102.46
BT95	127.02
CBL31	2.30
CL33	2.30
CY31	1.15
C1K	21.30
C3A	11.50
C3JA	23.23
DA41	21.50
DA42	12.30
DA100	112.62
DAF91	0.46
DAF96	1.15
DET22	32.78
DET24	52.90
DF91	0.46
DF96	1.15
DK91	1.21
DK92	1.44
DK96	1.26
DL92	1.26
DL94	1.38
DL96	1.26
DLS10	9.48
DLS15	12.37
DLS16	12.37
DLS19	12.37
DM70	1.44
DM71	1.44
DM160	3.96
DY87	0.74
DY802	0.96
E55L	25.17
E80CC	10.13
E80CF	12.96
E80F	14.19
E80L	13.98
E81CC	6.62
E81L	14.06
E82CC	7.03
E83CC	7.16
E86C	12.48
E88C	7.12
E88CC	3.86
E90CC	9.90
E90F	10.38
E91H	5.34
E92CC	9.40
E99F	10.16

E130L	19.39
E180CC	8.86
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E182CC	9.90
E186F	12.58
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EAF42	1.44
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EB91	1.01
EBC33	2.02
EBC41	1.44
EBC81	1.26
EBC90	0.97
EBF80	0.58
EBF83	1.44
EBF89	0.97
EBL31	2.88
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EC91	8.69
EC92	1.44
EC157	310.50
ECC33	4.02
ECC35	4.02
ECC40	2.30
ECC81	1.01
ECC82	0.82
ECC83	1.01
ECC84	1.36
ECC85	1.38
ECC86	2.30
ECC88	2.07
ECC89	1.88
ECC91	10.27
ECC189	1.90
ECC807	2.02
ECC808	2.59
ECF80	1.24
ECF82	1.38
ECF86	1.73
ECH35	2.30
ECH42	1.32
ECH81	1.38
ECH83	1.44
ECH84	1.47
ECL80	1.15
ECL81	1.73
ECL82	1.15
ECL83	1.73
ECL84	1.61
ECL85	1.28
ECL86	1.38
EF37A	4.02
EF39	3.16
EF40	3.45
EF41	2.30
EF42	2.30
EF50	1.73
EF54	5.75
EF55	2.88
EF80	0.92
EF83	4.03
EF85	0.92

EF86	1.74
EF89	1.84
EF91	2.07
EF92	6.68
EF93	1.15
EF94	1.24
EF95	6.27
EF98	1.44
EF183	0.92
EF184	0.96
EF804S	12.65
EF805S	12.65
EH90	1.61
EK90	1.24
EL32	1.73
EL33	4.02
EL34TH	2.53
EL34MUI	3.16
EL36	1.84
EL41	1.44
EL42	2.02
EL81	4.03
EL83	4.03
EL84	1.15
EL86	2.88
EL90	1.10
EL91	8.21
EL95	1.51
EL156	27.60
EL360	9.77
EL500/504	2.16
EL509	3.63
EL821	11.46
EL822	12.55
EM34	5.75
EM80	1.26
EM81	1.15
EM84	1.15
EM85	1.44
EM87	1.73
EN32	16.28
EN91	2.94
EN92	6.18
EY51	2.02
EY81	1.89
EY83	2.02
EY84	10.57
EY86	0.96
EY88	2.02
EY500A	2.23
EY802	94
EZ35	97
EZ40	1.44
EZ41	1.44
EZ80	0.96
EZ81	0.96
EZ90	1.38
FW4-500	2.88
FW4-800	2.88
G1.371K	41.40
G551K	12.65
G180.2M	18.42
G240.2D	12.85
G400.1K	19.28
GN4	8.62
GN4A	8.62
GS16	10.35
GT1C	14.38
GU50	14.31
GU51	13.62

GXU1	16.10
GXU2	28.43
GXU3	30.49
GXU4	32.77
GXU50	17.25
GY501	3.16
GZ32	1.44
GZ33	4.60
GZ34	2.88
GZ37	4.60
KT61	4.02
KT66	11.50
KT88	13.80
KTW61	2.02
KTW62	2.02
KTW63	2.02
M8079	12.29
M8080	9.49
M8081	11.30
M8082	9.87
M8083	8.54
M8091	11.99
M8096	4.31
M8097	4.09
M8098	5.50
M8099	5.98
M8100	9.49
M8136	9.75
M8137	9.73
M8140	5.17
M8141	5.52
M8142	7.77
M8144	4.31
M8149	5.86
M8161	9.11
M8162	10.36
M8163	5.17
M8190	5.29
M8195	4.25
M8196	7.47
M8204	6.57
M8212	12.47
M8223	3.80
M8224	4.66
M8225	2.99
M8248	13.32
MU14	1.73
MX119	58.65
MX123	67.85
MX145	58.65
MX151	17.25
MX152	135.70
MX161	166.75
MX163	23.11
MX164	25.88
MX166	142.60
MX168	48.30
N78	10.35
OA2	2.36
OA3	5.69
OA4	4.02
OB2	1.44
OB3	2.20
OC2	3.04
OC3	2.20
OD3	2.20
OZ4	1.84
PC86	1.61
PC88	1.61
PC95	1.49

PC97	1.38
PC900	1.38
PCC84	1.15
PCC85	1.38
PCC88	1.38
PCC89	1.56
PCC189	1.61
PCC805	1.51
PCC806	2.07
PCE82	2.07
PCF80	1.15
PCF82	1.15
PCF86	1.84
PCF87	1.84
PCF200	3.74
PCF201	2.45
PCF801	1.84
PCF802	2.19
PCF805	1.84
PCF806	1.84
PCF808	1.84
PCL82	1.15
PCL83	2.30
PCL84	1.15
PCL85	1.24
PCL86	1.24
PCL805/85	1.24
PD500	4.14
PE06-40N	31.40
PFL200	2.07
PL36	1.38
PL81	1.38
PL81A	1.38
PL82	1.38
PL83	2.55
PL84	1.24
PL504/5	1.61
PL508	2.07
PL509	3.73
PL519	3.73
PL801	1.27
PL802	3.40
PY33	1.27
PY81	0.97
PY82	0.92
PY83	0.81
PY88	1.01
PY500A	2.07
PY800	0.97
PY801	0.97
QQV02-6	14.44
QQV03-20A	20.13
QQV06-40A	47.15
QQV07-50	60.66
QQZ03-20A	59.80
QQZ06-40A	55.10
QU37	14.38
QV03-12	5.13
QV04-7	2.88
QV08-100	122.26
QY3-65	57.06
QY3-125	61.02
QY4-250	70.16
QY4-400	80.44
QY5-500	168.83

QY5-3000A	333.91
QZ06-20	30.48
R10	5.75
R17	1.89
R18	4.89
R19	1.38
R20	1.66
RG3-250	35.77
RG3-250A	37.49
RG3-1250	36.23
RG4-1250	43.93
RG4-3000	89.64
RR3-250	53.54
RR3-1250	94.83
S11E12	40.25
S130	3.45
S130P	4.03
STV280-40	11.50
STV280-80	24.15
SU41	2.88
SU42	10.35
TD03-10	32.78
TD03-10E	32.78
TD03-29F	33.93
TT15	34.50
TT21	14.16
TT22	18.98
TT100	59.51
TY2-125	69.01
TW4-400	74.07
TY4-500	101.44
TY5-500	178.25
TY6-800	181.70
TY6-5000A	337.51
TY6-5000B	264.50
TY6-5000W	290.98
TY7-6000A	357.49
TY7-6000W	286.33
TZ40	17.25
U18-20	2.88
U19	15.81
U25	1.33
U26	1.66
U37	10.35
UABC80	1.44
UAF42	1.44
UB41	1.44
UBC41	1.73
UBF89	1.38
UCC84	1.26
UCC85	1.38
UCF80	1.32
UCH42	1.38
UCH81	2.67
UCL82	1.20
UCL83	1.66
UF41	1.15
UF42	1.44
UF80	1.66
UF85	1.66
UF89	1.66
UL41	2.88

UL84	1.38
UM80	1.15
UY41	1.44
UY85	1.20
VLS631	15.24
XG1-2500	42.04
XG2-6400	113.50
XG5-500	28.52
XG2-6400	106.15
XR1-1600A	38.53
XR1-3200	93.15
XR1-3200A	93.15
XR1-6400	102.01
XR1-6400A	164.23
YD1120	264.50
YD1240	366.62
Z759	19.32
ZM1000	6.03
ZM1001	6.19
ZM1020	10.83
ZM1021	10.17
ZM1022	10.60
ZM1023	8.81
ZM1040	22.26
ZM1041	19.16
ZM1042	20.44
ZM1051	100.05
1B3GT	2.58
1B24	11.50
1B35A	28.75
1B63	57.50
1R5	1.21
1S5	0.46
1T4	0.46
2AS15	11.50
2C39A	21.85
2C43	20.70
2D21	2.94
2E26	15.34
2J42	89.70
2J55	239.97
2J70A	270.25
2J70B	418.34
2K25	40.25
3-400Z	57.50
3-500Z	63.25
3A5	2.70
3B24	9.20
3B28	16.50
3B29	11.50
3B240M	17.25
3B241M	17.25
3C23	18.73
3C45	28.18
3CX100A5	23.00
3E29	29.67
3S4	1.26
3V4	1.38
465A	29.15
4-125A	41.99
4-250A	41.99
4-400A	52.05

4B32	29.16
4C35	74.75
4CX250B	31.63
4CX350A	48.88
4X150A	24.41
4X150D	28.75
5B254M	23.12
5B255M	23.12
5C22	74.75
5J180E	1380.00
5R4GY	4.03
5U4G	3.86
5U4GB	2.90
5V4G	1.75
5Y3GT	0.98
5Z3	1.73
5Z4G	1.75
5Z4GT	1.75
6-30L2	1.79
6AB4	1.44
6AB7	1.73
6AC7	1.61
6AF4A	1.84
6AG7	2.30
6AH6	5.52
6AK5	4.15
6AK6	2.81
6AL5	1.01
6AM4	2.65
6AM5	8.21
6AM6	2.07
6AN5	4.45
6AN8A	3.97
6AQ5	1.10
6AS6	5.73
6AS7G	9.49
6AT6	0.98
6AU5GT	4.97
6AU6	1.24
6AV5GA	4.52
6AV6	0.98
6AX5GT	3.57
6B7	1.73
6B8	2.02
6BA6	1.15
6BA7	5.89
6BA8A	4.31
6BC4	4.27
6BE6	1.24
6BH6	1.75
6BJ6	1.24
6BK4	4.84
6BL6	97.75
6BL7GT	4.44
6BM6	97.75
6BN6	1.89
6BQ7A	4.28
6BR7	4.60
6BR8	2.02
6BS7	4.60
6BW6	4.60
6BW7	1.75
6BX7GT	5.70
6BZ6	2.73
6C4	1.01
CB6A	2.86
6CD6GA	5.83
6CG7	2.62
6CH6	9.78
6CL6	4.12

6CW4	8.83
6D2	1.01
6DK6	3.00
6DQ6B	4.69
6EA8	3.38
6EB8	2.44
6EW6	1.73
6F6	2.02
6F23	1.84
6F28	1.33
6F33	29.90
6H1	14.38
6H2N	1.21
6H3N	1.21
6H6	1.73
6J4	6.10
6J6	6.21
6J7	8.07
6K4N	1.44
6K6GT	1.50
6K7	1.73
6K8	2.02
6KD6	7.31
6L6G	2.88
6L6GA	1.73
6L6GT	2.24
6L6GC	2.88
6L7	2.30
6N2P	1.21
6N3P	1.21
6N7	1.73
6P25	4.14
6Q7	2.53
6R7	2.07
6SA7	1.67
6SC7	1.73
6SF7	1.84
6SH7	1.73
6SJ7	1.84
6SK7	1.50
6SK7GT	3.08
6SN7GT	1.84
6SQ7	1.50
6SR7	1.73
6SS7	2.07
6U5G	2.30
6U8	0.92
6U8A	3.38
6V6GT	1.84
6X4	1.38
6X5GT	0.97
7B7	1.96
7C5	3.40
7C6	2.60
7H7	2.30
7R7	1.73
7S7	2.59
7Y4	1.84
7Z4	2.13
11E3	60.82
12AT6	1.38
12AT7	1.01
12AU6	2.97
12AU7	0.83
12AV6	2.55
12AV7	4.00
12AX7	1.01
12AY7	4.69
12B4A	3.62
12BA6	2.52

12BE6	2.79
12BH7	1.29
12BY7	3.11
12E1	19.67
12E11TT	19.26
12E14	34.50
13E1	123.05
19H4	28.75
19H5	40.25
24B9	55.20
30C15	1.84
30C17	1.84
30C18	1.84
30F5	1.93
30FL1/2	1.28
30FL12	2.07
30FL14	1.84
30L1	1.15
30L15	2.07
30L17	2.07
30P4	1.06
30P19	1.38
30PL1	2.88
30PL14	1.93
30PL15	2.07
35W4	0.69
50C5	0.81
75B1	5.38
75C1	2.70
85A1	8.63
85A2	2.75
90AG	14.90
90AV	14.90
90C1	2.81
90CG	16.72
90CV	17.50
92AG	14.90
92AV	14.90
95A1	7.48
150B2	3.47
150B3	6.39
150C2	2.21
150C4	2.75
211	21.85
723AB	40.25
803	11.50
805	23.00
807	4.31
811A	18.32
812A	18.26
813	85.87
833A	128.80
866A	15.23
872A	21.47
922	5.01
931A	16.97
1624	2.59
1625	1.96
2050	8.00
4212E	304.75
4212H	304.75
5544	62.10
5545	67.85
5551A	106.03
5552A	143.35
5553A	259.10
5642	6.45
5654	3.93
5651	2.65

5670	5.18
5675	19.91
5687	6.31
5696	4.35
5718	7.87
5725	5.62
5726	3.62
5727	5.42
5749	5.14
5751	4.80
5763	4.66
5814A	4.28
5840	5.06
5842	13.90
5876A	19.55
5879	5.38
5886	12.08
5963	3.38
5965	4.00
6005	5.62
6021	5.13
6057	4.02
6058	12.47
6059	4.60
6061	4.89
6062	4.31
6063	4.20
6064	8.54
6067	4.02
6072	5.80
6080	7.88
6097AxBxC	46.00
6146A	10.30
6146B	8.12
6159B	17.27
6189	10.03
6201	5.28
6442	17.25
6883B	12.77
6973	4.38
7025	2.73
7551	6.45
7586	11.66
7587	20.11
7609	36.57
7868	5.04
7895	13.25
8005	75.03
8068	6.33
8122	60.11
8136	2.48
8417	6.76
18042	8.63
18045	12.06

Tested Ex-Equipment

4CX250B	5.75

BASES

B7G unskirted	0.25
B7G skirted	0.35
B9A unskirted	0.25
B9A skirted	0.35
Int Octal	0.40
Loctal	0.63
Nuvistor base	0.86
8 pin DIL	0.17
14 pin DIL	0.17
16 pin DIL	0.20
Valve screening cans all sizes	0.35

CRTs

2AP1	9.78
2BP1	10.35
3BP1	11.50
3DP1	5.75
3EG1	8.05
3FP7	6.90
3GP1	6.90
3JP1	9.20
3JP2	9.20
3JP7	11.50
3KP1	17.25
3RP1	40.25
3WP1	23.00

5ADP1	40.25
5BP1	11.50
5CP1	11.50
5CP1A	46.00
5FP15A	17.25
5UP7	28.75
DG7-5	72.82
DG7-31	66.78
DG7-32	66.78
DH3-91	67.65
DH7-11	130.09
VCR97	13.80
VCR138	11.50

VCR138A	14.38
VCR139A	9.20
VCR517A	11.50
VCR517B	11.50
VCR517C	11.50

Tube Bases Prices on application

INTEGRATED CIRCUITS

7400	0.18
7401	0.20
7402	0.20
7403	0.20
7404	0.21
7405	0.21
7406	0.49
7407	0.49
7408	0.23
7409	0.23
7410	0.20
7412	0.33
7413	0.37
7416	0.37
7417	0.37
7420	0.21
7422	0.23

7423	0.38
7425	0.35
7427	0.35
7428	0.50
7430	0.20
7432	0.35
7433	0.46
7437	0.37
7438	0.37
7440	0.37
7441	1.04
7442	0.83
7447AN	1.35
7450	0.21
7451	0.21
7453	0.21
7454	0.21

7460	0.21
7470	0.44
7472	0.38
7473	0.44
7474	0.44
7475	0.62
7476	0.48
7480	0.64
7482	0.86
7483	1.15
7484	1.21
7486	0.45
7490	0.69
7491	0.94
7492	0.69
7493	0.69
7494	0.94

7495	0.84
7496	0.94
7497	3.62
74100	1.77
74107	0.52
74109	0.84
74110	0.59
74111	0.82
74116	2.13
74118	1.15
74119	1.77
74120	0.95
74121	0.49
74122	0.71
74123	1.36
74125	0.67
74126	0.67
74128	0.72
74132	0.83

74136	0.59
74141	1.02
74142	2.64
74143	2.99
74144	2.99
74145	1.15
74147	2.30
74148	2.02
74150	2.07
74151	1.08
74154	2.07
74155	1.04
74156	1.04
74157	0.86
74159	2.53
74170	2.76
74172	5.06
74173	1.63
74174	1.84

74175	1.17
74176	1.33
74178	1.56
74179	1.56
74180	1.38
74190	2.19
74191	2.19
74192	2.19
74193	2.19
74194	1.44
74195	1.38
74196	1.55
74197	1.55
74198	3.11
74199	2.64
76013N	2.02
TAA570	2.65
TAA630S	4.02
TAA700	4.50

TBA480Q	2.12
TBA520Q	2.65
TBA530	2.28
TBA540Q	2.65
TBA550Q	3.70
TBA560CQ	3.70
TBA673	2.52
TBA700	1.75
TBA720Q	2.65
TBA750Q	2.38
TBA800	1.38
TBA920	3.34
TBA920Q	3.34
TBA990Q	3.34
TCA270Q	3.34
TCA760A	1.59

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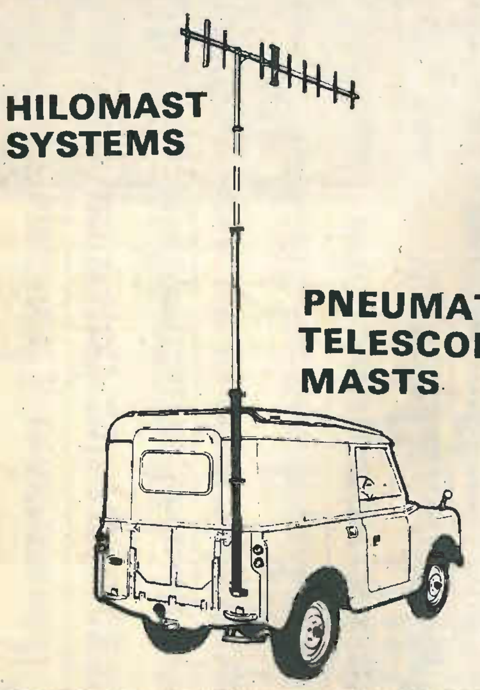

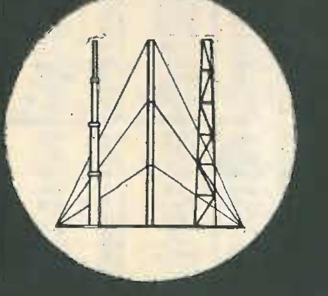

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TM353 .. £84.00 TM354 .. £39.95
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TF200 £145.00
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OSCILLOSCOPE: SC110 .... £139.00
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FUNCTION GENERATORS:
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PDM35, TM354, PFM200 .... £3.00
TM351, TM353, TF040, TG102,
TF200, TG105, TG100 .... £5.95
TM352 ... £3.00 SC110 ..... £7.70

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.... £7.50
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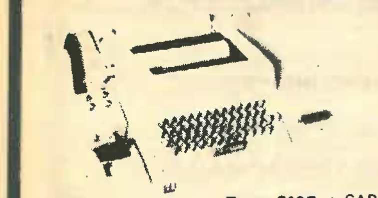

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Sound proof enclosure £25.00 + VAT

ICL TERMIPRINTER 300 BAUD TERMINALS

PRICES REDUCED
ONLY £295 + CAR + VAT

Made under licence from the world famous GE Co. The ICL Termiprinter is a small attractive unit with so many features it is impossible to list them in the space available! Brief spec. as follows; RS232 serial interface, switchable baud rates 110, 150, 300, (30 cps), upper and lower case correspondence type face, standard paper, almost silent running, form feed, electronic tab settings, suited for word processor applications plus many more features. Supplied in good condition and in working order. Limited quantity.

MPU EXPERIMENTORS +5v+12v-12v+24v POWER SUPPLY

Once again we are very pleased to offer this superb Power Supply Unit, and hope to satisfy most of our previous customers who were disappointed when we sold out due to demand last time they were advertised!!! These units may just have well been made for your lab., they consist of a semi-enclosed chassis measuring 160mm x 120mm x 350mm containing all silicon electronics to give the following fully regulated and short circuit proof outputs of:
+5v @ 2 amps DC + 12v @ 800 ma DC
-12v @ 800 ma DC + 24v @ 350 ma DC
and if that's not enough a fully floating 5v output @ 50 ma DC which may be seriesed to give a host of other voltages. All outputs are brought out to the front panel via miniature jack sockets and are also duplicated at the rear on short flying leads. Units accept standard 340v AC mains input. They are ex GPO and may have minor scratches on the front panels, they are sold untested but in good internal condition. £16.50 each + £2.50 p+p complete with circuit and component list. Transformer guaranteed. HURRY WHILE STOCKS LAST!!

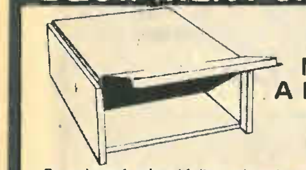
HIGH SPEED DATA MODEMS

A superb piece of engineering made by SE Labs Ltd. to a "no cost spared" spec for the GPO, the Modem 12 is a synchronous Modem for use on DATEL 2412 services, or other data links. Many features include switchable V26 modulation, 2400 baud full duplex 600/1200 standby, auto answer, 4 wire or 2 wire operation. Self test, LED status indication, CMOS technology, modular construction, original cost over £700 each. Believed brand new, supplied complete with PSU etc.
£185.00 + £9.50 carriage + VAT.
*Permission may be required for connection to PO lines.

PERTEC

PERTEC TAPE DRIVES
7 track 6840 — 75-25 £175.00 + VAT
9 track 6840 — 9-25 £295.00 + VAT
Phone for more details

EQUIPMENT CASES

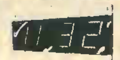


GIVE YOUR M.P.U. A HOME
ONLY £9.95 + 1.85 pp

Superb professional fully enclosed, made for the G.P.O. to the highest standard, offered at a fraction of their original cost they feature aluminium sides, hinged removable front panel, which can be secured by 2 screws to prevent prying fingers. All are finished in two tone G.P.O. grey and although believed brand new may have minor scuff marks/scratches due to bad storage. Dimensions 16"D × 6½"H × 14¾"W

NATIONAL MA1012 LED CLOCK MODULE

★ 12 HOUR
★ ALARM
★ 50/60 HZ



The same module as used in most ALARM/CLOCK radios today, the only difference is our price! All electronics are mounted on a PCB measuring only 3" × 1½" and by addition of a few switches and 5/16 volts AC you have a multi function alarm clock at a fraction of cost. Other features include snooze timer, am pm, alarm set, power fail indicator, flashing seconds cursor, modulated alarm output etc.
Supplied brand new with full data only
Suitable transformer £1.75. £5.25

SAVE OVER £1400

THE PRINTER SCOOP OF THE YEAR
THE LOGABAX Z80 MICROPROCESSOR CONTROLLED LX180L MATRIX PRINTER

A massive bulk purchase enables us to offer you this superb professional printer at a fraction of its recent cost of over £2000. Utilising the very latest in microprocessor technology, it features a host of facilities with all electronics on one plug in P.C.B. Just study the specification and you will instantly realise it meets all the requirements of the most exacting professional or hobbyist user.
STANDARD FUNCTIONS ★ Full ASCII character set ★ Standard ink ribbon ★ RS232/V24 serial interface – 7 xtal controlled baud rates up to 9600 ★ 194 characters per line ★ Parallel interface ★ Handshakes on serial and parallel ports ★ 4 Type fonts, italic script, double width, italic large, standard ★ Internal buffer ★ Internal self test ★ 170 CPS ★ Variable paper tractor up to 17.5" wide ★ Solid steel construction ★ All software in 2708 eproms easily reconfigured for custom fonts etc.

All this and more, not refurbished but BRAND NEW At Only £525 + VAT
+ carriage and ins. £18.00 + VAT

OPTIONAL EXTRAS ★ Lower case £25.00 ★ 16K buffer £30.00 ★ Second tractor for simultaneous dual forms £85.00 ★ Logabax maintenance. P.O.A.

EX STOCK SOFTY

EPROM BLOWER

Software development system invaluable tool for designers, hobbyists, etc. Enables open heart surgery on 2716, 2708 etc. Blows, copies, reads EPROMS or emulates EPROM/ROM/RAM in situ whilst displaying contents on domestic TV receiver. Many other features. £115 + carr. + VAT. Optional 2716, 2716 Function Card £40 + VAT. PSU £20 + £1.50 carr. + VAT.
Write of phone for more details.

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Ex-equipment 9" Motorola Video Monitors 75 Ω composite input, tested but unguaranteed. £39.99 + £7.50 carriage + VAT. Complete with circuit.

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Mixed Semis amazing value contents include transistors, digital, linear, I.C.'s, triacs, diodes, bridge recs., etc. etc. All devices guaranteed brand new full spec with manufactures markings, fully guaranteed 50+ bag £2.95 100+ bag £5.15
TTL 74 Series
A gigantic purchase of an "across the board" range of 74 TTL series I.C.'s enables us to offer our 100+ mixed "mostly TTL" grab bags at a price which two or three chips in the bag would normally cost to buy, fully guaranteed all I.C.'s full spec. 100+ £6.90 200+ £12 30 300+ £19.50

MAJOR SAVINGS HARD DISK DRIVES

Another major purchase allows us to bring you the professional technology of hard disk drives at a price you can now afford. Just imagine absolutely masses of correct data transferred or saved on your system by the time your finger leaves the carriage return key!! All drives offered are made to the highest professional standard by the DRE Co., perhaps the largest of UK OEM peripheral manufacturers. All components are batch selected to obtain the utmost reliability and after having run two series 30 and a 4000 drive continuously 24 hours a day for over a year without a single read/write error we can most certainly vouch for the quality.
DIABLO/DRE series 30. Fully refurbished this 2.5 MB drive accepts 2315 exchangable (via removing top cover) disk cartridges. Sectoring is a feature of the disk pack and may range from 8-48. Fully DEC RK05, Nova, Texas, system compatable. Requires + & —15v DC Supply.
Series 30 Drive £475 + VAT Series 30 Front Loader £695 + VAT
DC Power Supply for 2 series 30's £125 + VAT
DRE 4000 B Series. Model 4044. Technology at its finest, this drive currently manufactured by DRE features 10 MB's of on line storage split into two disk plattens. 1, 5 MB fixed and 1 top load 5 MB type 5440 exchangable cartridge. Features, DC drive motor, built in air conditioning system, write protect, mains powered, etc. Supplied Brand New and Boxed complete with Manual and Rack Slides.
Fully Ampex, Hawk, Wango, Nova compatible.
Manufacturers current price £3100, our price £1495 — VAT.

*For DEC compatability or alternate sectoring please enquire, Xylogics DEC LSI 11 controller for 4 S30 or 2 4000 drives £850 + VAT Newton Labs S100 controller for 4 S30 or 2 4000 £625 + VAT Controller for TRS80, PET, APPLE, price to be announced.
NEW 2315 12 sector disk packs £40 + VAT
NEW 5440 any sector packs £48 + VAT
ORDER NOW!! These prices may never be repeated. Specialist carriage S30 £15.00 + VAT 4000 £20 + VAT.

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IDEAL – TANGERINE, OHIO ETC,

Straight from the U.S.A. made by the world famous R.C.A. Co., the VP600 Series of cased freestanding keyboards meet all requirements of the most exacting user, right down to the price! Utilising the latest in switch technology. Guaranteed in excess of 5 million operations. The keyboard has a host of other features including full ASCII 128 character set, user definable keys, upper/lower case, rollover protection, single 5V rail, keyboard impervious to liquids and dust, TTL or CMOS outputs, even an on-board tone generator for keypress feedback, and a 1 year full R.C.A. backed guarantee.

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Professional type mains filters as used by "Main Frame Manufacturers" ideal for curing those unnerving hang ups and data glitches, fit one now and cure your problems!
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Keep your equipment Cool and Reliable with our tested ex-equipment "Muffin Fans" almost silent running and easily mounted. Available in two voltages. 110 V.A.C. £5.05 + pp 90p OR 240v A.C. £6.15 + pp 90p DIMENSIONS 4¾" x 4¾" x 1½".

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Due to our massive bulk purchasing programme which enables us to bring you the best possible bargains, we have thousands of I.C.'s, Transistors, Relays, Cap's., P.C.B.'s, Sub-assemblies, Switches, etc. etc. surplus to our requirements. Because we don't have sufficient stocks of any one item to include in our ads., we are packing all these items into the "BARGAIN PARCEL OF A LIFETIME" Thousands of components at giveaway prices! Guaranteed to be worth at least *3 times* what you pay plus we always include something from our ads. for unbeatable value!! Sold by weight

2.5kls £ 4.75 + pp £1.25 5kls £ 6.75 + pp £1.80
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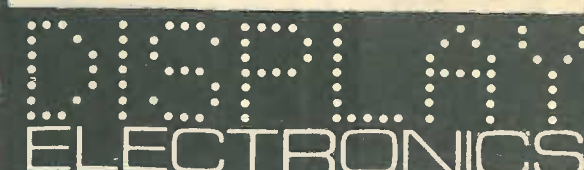
Following the recent "SELL OUT" demand for our 5v 3 amp P.S.U. we have managed to secure a large quantity of ex-computer systems P.S.U.'s with the following spec.; 240 or 110v A.C. input. Outputs of 5v @ 3-4 amps, 7.2v @ 3 amps and 6.5v @ 1 amp. The 5v and 7.2v outputs are fully regulated and adjustable with variable current limiting on the 5v supply. Unit is self contained on a P.C.B. measuring only 12" x 5" x 3". The 7.2v output is ideal for feeding "on board" regulators or a further 3 amp LM323K regulator to give an effective 5v @ 7 amp supply.
Supplied complete with circuit at only £10.95 + £1.75pp.
Believed working but untested, unguaranteed.



Dept. W.W. 64-66 Melfort Rd., Thornton Heath, Croydon, Surrey. Tel: 01-689 7702 or 01-689 6800

MAIL ORDER INFORMATION
Unless otherwise stated all prices inclusive of V.A.T. Cash with order. Minimum order value £2.00 Prices and Postage quoted for UK only. Where post and packing not indicated please add 80p per order. Bona Fida account orders minimum £20.00. Export and trade enquiries welcome. Orders despatched same day where possible. 3% surcharge on Access and Barclaycard orders.

WW – 083 FOR FURTHER DETAILS

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Minimum Order £1

VALVES VAT IS INCLUDED

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DK96	1.20
DH76	0.75
DL92	0.60
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DY802	0.70
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E88CC/01	3.10
E92CC	1.20
E180CC	2.80
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EA76	2.25
EABC80	0.60
EB91	0.60
EBC33	1.15
EBC90	0.90
EBF80	0.60
EBF83	0.60
EBF89	0.80
EC52	0.65
EC91	3.40
EC92	0.85
ECC81	0.65
ECC82	0.60
ECC83	0.65
ECC84	0.60
ECC85	0.60
ECC86	1.70
ECC88	0.80
ECC189	0.95
ECC804	0.90
ECF80	0.85
ECF82	0.65
ECF801	1.05
ECH34	2.25
ECH35	1.70
ECH42	1.20
ECH81	0.70
ECH84	0.80
ECL80	0.70
ECL82	0.75
ECL83	1.40
ECL85	0.80
ECL86	0.90
EF37A	2.15
EF39	1.80
EF80	0.65
EF83	1.75
EF85	0.60
EF86	0.75
EF89	1.05
EF91	1.50
EF92	2.90
EF95	0.65
EF96	0.60
EF183	0.80
EF184	0.80
EF804	4.95
EF812	0.75
EFL200	1.85
EH90	0.85
EL32	1.10
EL34	1.80
	2.90*
EL37	4.40
EL81	2.45
EL82	0.70
EL84	0.80
EL86	0.95
EL90	1.00
EL91	4.20
EL95	0.80
EL504	1.70
EL803	5.90

EL509	2.70
EL802	1.70
EL821	8.20
EL822	9.95
EM31	1.60
EM80	0.85
EM81	0.85
EM84	0.85
EM87	1.30
EY51	0.95
EY81	0.65
EY86/87	0.60
EY88	0.65
EZ80	0.70
EZ81	0.70
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GY501	1.30
GZ32	1.05
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GZ34	2.75
GZ37	3.95
KT66	6.30
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MH4	2.50
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MX10/01	21.50
N78	9.90
OA2	0.70
OB2	0.80
PABC80	0.60
PC85	0.75
PC86	0.95
PC88	0.95
PC97	1.50
PC900	1.15
PCC84	0.50
PCC89	0.85
PCC189	1.05
PCF80	0.80
PCF82	0.70
PCF84	0.75
PCF86	1.50
PCF87	0.50
PCF200	1.60
PCF201	1.65
PCF800	0.50
PCF801	1.75
PCF802	0.85
PCF805	2.45
PCF806	1.20
PCF808	2.75
PCH200	1.35
PCL81	0.75
PCL82	0.95
PCL84	0.90
PCL86	1.05
PCL805/85	1.25
PD500/510	4.30
PFL200	1.10
	2.80
PL36	1.25
PL81	0.85
PL82	0.70
PL83	0.60
PL84	0.95
PL504	1.45
PL508	1.95
PL509	2.90
PL519	3.20
PL802	3.20
PY33	0.70
PY80	0.70
PY81/800	0.85
PY82	0.65
PY83	0.80
PY88	0.85
PY500	1.70
PY809	6.45
PY801	0.80
QQV03/10	2.85
QQV03-20A	14.40
QQV03-25A	21.20

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QV03-12	4.20
SC1/400	4.50
SC1/600	4.50
SP61	1.80
TT21	16.50
U25	1.15
U26	1.15
U27	1.15
U191	0.85
U281	0.70
U301	0.65
U600	11.50
U801	0.90
UBC41	1.20
UABC80	0.75
UAF42	1.20
UBF80	0.70
UBF89	0.70
UBL21	1.75
UCC84	0.85
UCC85	0.70
UCF80	1.30
UCH42	1.65
UCH81	0.75
UCL82	0.95
UF41	1.35
UF80	0.95
UF85	0.95
UL41	2.30
UL84	0.95
UM80	0.90
UM84	0.70
UY82	0.70
UY85	0.85
VR105/30	1.25
VR150/30	1.35
X66	0.95
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Z759	19.00
Z749	0.75
Z800U	3.45
Z801U	3.75
Z803U	16.00
Z900T	2.45
1A3	0.85
1L4	0.50
1R5	0.60
1S4	0.45
1S5	0.45
1T4	0.45
1U4	0.80
1X2B	1.40
2D21	1.10
	1.85*
2K25	11.90
2X2	1.15
3A4	0.70
3AT2	2.40
3D6	0.50
3D22	23.00
3E29	19.00
3S4	0.60
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5C22	29.90
5R4GY	1.80
5U4G	0.75
5V4G	0.75
5Y3GT	0.80
5Z3	1.50
5Z4G	0.75
5Z4GT	1.05
6/30L2	0.90
6AB7	0.70
6AC7	1.15
6AG5	0.60
6AH6	1.15
6AK5	0.65
6AK8	0.60

6AL5	0.60
6AL5W	0.85
6AM5	4.20
6AM6	1.50
6AN8A	2.50
6AQ4	3.40
6AQ5	1.00
6AQ5W	1.80
6AS6	1.15
6AT6	0.90
6AU6	0.60
6AV6	0.85
6AX4GT	1.30
6AX5GT	1.30
6BA6	0.55
6BE6	0.60
6BG6G	1.60
6BJ6	1.30
6BQ7A	0.85
6BR7	4.80
6BW6	6.20
6BW7	0.90
6C4	0.50
6C6	0.55
6CH6	8.20
6CL6	1.70
6CX8	3.80
6CY5	1.15
6D6	0.70
6EA8	3.20
6F6	1.60
6F6GB	1.10
6F7	2.80
6F8G	0.85
6F12	1.50
6F14	1.15
6F15	1.30
6F17	1.15
6F23	0.75
6F24	1.75
6F33	10.50
6FH8	4.20
6GA8	0.90
6GH8A	0.95
6H6	1.60
6J4	1.35
6J4WA	2.00
6J5	2.30
6J5GT	0.90
6J6	0.65
6J6W	0.90
6JE6C	2.95
6JS6C	2.95
6K7	0.80
6L6M	2.80
6L6G	2.50
6L6GC	2.10
6L6GT	1.25
6L7G	0.65
6L18	0.70
6LQ6	2.95
6LD20	0.70
6KG6A	2.70
6Q7G	1.30
6SA7	1.00
6SG7	1.15
6SJ7	1.05
6SK7	0.95
6SL7GT	0.85
6SN7GT	0.80
6SR7	1.10
6SQ7	0.95
6V6G	1.50
6V6GT	0.95
6X4	0.75
6X4WA	2.10
6X5GT	0.65
6Y6G	0.90
6Z4	0.70
7B7	1.75
7Y4	1.25
9D2	0.70
9D6	2.90
10C2	0.85
10F18	0.70
10P13	1.50

11E2	19.50
12A6	0.70
12AT6	0.70
12AT7	0.65
12AU7	0.60
12AV6	0.95
12AX7	0.65
12BA6	0.90
12BE6	1.25
12BH7	1.10
12C8	0.65
12E1	18.95
12J5GT	0.55
12K7GT	0.70
12K8GT	0.80
12Q7GT	0.60
12SC7	0.65
12SH7	0.65
12SJ7	0.70
12SQ7	1.45
12SQ7GT	0.85
12Y4	0.70
13D3	0.70
13D5	0.90
13D6	0.80
14S7	1.15
19AQ5	0.85
19G3	11.50
19G6	8.50
19H5	39.55
20D1	0.80
20F2	0.85
20E1	1.30
20P1	0.65
20P3	0.75
20P4	1.25
20P5	1.35
25L6GT	0.95
25Z4G	0.75
30C15	0.50
30C17	0.50
30C18	2.45
30F5	1.15
30FL2	1.40
30FL12	1.25
30FL14	2.15
30L15	1.10
30L17	1.10
30P12	1.15
30PL13	1.25
30PL14	2.45
35L6GT	1.40
35W4	0.80
35Z4GT	0.80
40KD6	3.15
50C5	1.15
50CD6G	1.35
75B1	1.25
75C1	1.70
76	0.95
78	0.95
80	1.70
85A2	1.40
	2.55*
723A/B	11.90
807	1.25
813	14.80
829B	14.00
832A	8.90
866A	3.80
866E	6.25
931A	13.80
954	0.60
955	0.70
956	0.60
957	1.05
1625	1.80
1629	1.85
2051	2.90
5763	4.20
5842	7.50
5881	3.40
5933	6.90
6057	2.20
6060	1.95

6064	2.30
6065	3.20
6067	2.30
6080	5.30
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* spec. Q

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YL1430
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CV2116
BR 189
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GMU 2
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MIL 5948/1754

IC

SN5402N	0.28
SN5410F	0.32
SN5470F	0.48
SN54196J	1.20
SN7407N	0.29
SN7408N	0.18
SN7445P	0.85
SN74453P	1.10
SN7453N	0.18
SN74L73N	0.38
SN7474N	0.30
SN7485N	0.95
SN74L85N	1.10
SN7491AN	0.32
SN74123N	0.42
DM74123N	0.38
SN15836N	0.26
SN76013N	1.80
SN76003N	1.60
SN76033N	1.95
MC6800P	5.80
MC68B00P	6.40
MC14511BA1	2.20
B1702AL	3.30
MM6300-1J	3.80
MCM6810AP	3.40
6340-1J	3.60
MIC945-5D	0.28
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PRICES MAY VARY

TEST SET FT2 FOR TESTING Transceivers A40, A41, A42 and CPRC26.
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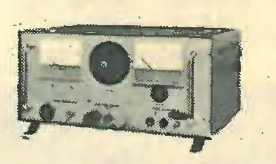

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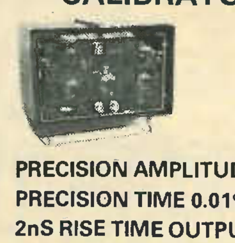

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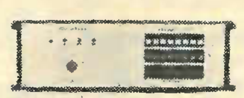

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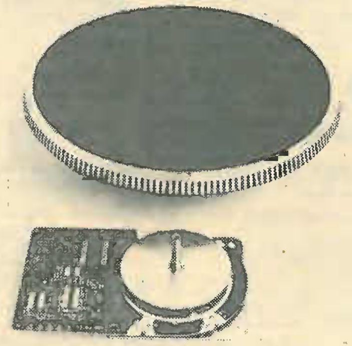

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151	200	12.28	1.72
152	250	14.61	2.04
153	350	18.07	2.12
154	500	22.52	2.20
155	750	32.03	OA
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18	4.0	2.0	4.46	1.20
85	5.0	2.5	6.16	1.20
70	6.0	3.0	6.99	1.20
108	8.0	4.0	8.16	1.44
72	10.0	5.0	8.93	1.60
116	12.0	6.0	9.89	1.60
17	16.0	8.0	11.79	1.72
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Ref.	Amps 50v	25v	£	P&P
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103	1	2	4.57	1.20
104	2	4	7.88	1.44
105	3	6	9.42	1.60
106	4	8	12.82	1.72
107	6	12	16.37	1.84
118	8	16	22.29	2.20
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Ref.	Amps 30v	15v	£	P&P
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79	1	2	3.93	1.00
3	2	4	6.35	1.20
20	3	6	7.39	1.44
21	4	8	8.79	1.60
51	5	10	10.86	1.60
117	6	12	12.29	1.72
88	8	16	16.45	1.96
89	10	20	18.98	1.84
90	12	24	21.09	OA
91	15	30	24.18	OA
92	20	40	32.40	OA

60 VOLT RANGE

Pri 220-240V (Split Sec)
Voltages available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V, or 24V-0-24V or 30V-0-30V

Ref.	Amps 60v	30v	£	P&P
124	.5	1	4.27	1.20
126	1	2	6.50	1.20
127	2	4	8.36	1.60
125	3	6	12.10	1.72
123	4	8	13.77	1.96
40	5	10	17.42	1.84
120	6	12	19.87	2.04
121	8	16	27.92	OA
122	10	20	32.51	OA
189	12	24	37.47	OA

SCREENED MINIATURES Pri 240V

Ref.	mA	Sec Volts	£	P&P
238	200	3-0-3	2.83	.50
212	1A, 1A	0-6, 0-6	3.14	1.00
13	100	9-0-9	2.35	.50
235	330, 330	0-9, 0-9	2.19	.60
207	500, 500	0-8-9, 0-8-9	3.05	.95
208	1A, 1A	0-8-9, 0-8-9	3.88	1.20
236	200,200	0-15, 0-15	2.19	.60
239	50MA	12-0-12	2.88	.50
214	300, 300	0-20, 0-20	3.08	1.00
221	700 (DC)	20-12-0-12-20	3.75	1.00
206	1A, 1A	0-15-20, 0-15-20	5.09	1.20
203	500, 500	0-15-27, 0-15-27	4.39	1.20
204	1A, 1A	0-15-27, 0-15-27	6.64	1.20

400/440V ISOLATORS

400/440 to 200/240

VA	Ref.	£	P&P
60	243	7.37	1.20
250	246	4.61	2.04
350	247	18.07	2.04
500	248	22.52	OA
1000	250	45.94	OA
2000	252	67.99	OA
3000	253	95.32	OA
6000	254	189.02	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	0-115-210-240V	2.77	1.00
64	80	0-115-210-240V	4.41	1.20
4	150	0-115-200-220-240V	5.89	1.20
67	500	0-115-200-220-240V	12.09	1.84
84	1000	0-115-200-220-240V	20.64	2.20
93	1500	0-115-200-220-240V	25.61	OA
95	2000	0-115-200-220-240V	38.31	OA
73	3000	0-115-200-220-240V	65.13	OA
80s	4000	0-115-200-220-240V	84.55	OA
57s	5000	0-115-200-220-240V	98.45	OA

CASED AUTOS

240V cable input USA 115V outlets

VA	Price	P&P	Ref
20	£6.55	.95	56W
75	£8.50	1.20	64W
150	£11.00	1.44	4W
200	£12.02	1.44	65W
250	£13.38	1.44	69W
500	£20.13	2.04	67W
1000	£30.67	2.20	84W
2000	£54.97	OA	95W

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171	500MA	2.30	.52
172	1A	3.26	.90
173	2A	3.95	.90
174	3A	4.13	.99
175	4A	6.30	1.10

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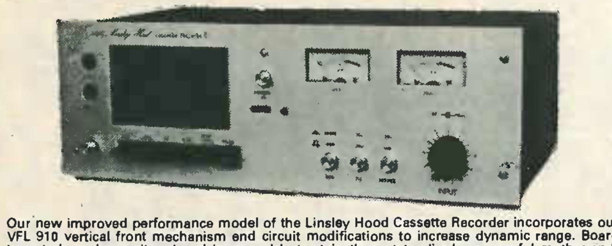
LINSLEY HOOD CASSETTE RECORDER 2



Our new improved performance model of the Linsley Hood Cassette Recorder incorporates our VFL 910 vertical front mechanism end circuit modifications to increase dynamic range. Board layouts have been altered and improved but retain the outstandingly successful mother-and-daughter arrangement used on our Linsley-Hood Cassette Recorder 1.
This latest version has the following extra features: Ultra low wow-and-flutter of .09% – easily meets DIN Hi-Fi spec. Deck controls latch in rewind modes and do not have to be held. Full Auto-stop on all modes. Tape counter with memory rewind. Oil damped cassette door. Latching record button for level setting. Dual concentric input level controls. Phone output. Microphone input facility if required. Record interlock prevents rerecording on valued cassettes. Frequency generating feedback servo drive motor with built-in speed control for thermal stability. All these desirable and useful features added to the excellent design of the Linsley-Hood circuits and the quality of the components used makes this new kit comparable with built-up units of much higher cost than the modest, **£94.90** + V.A.T. we ask for the complete kit.

LINSLEY-HOOD CASSETTE RECORDER 1

We are the Designer Approved suppliers of kits for this excellent design. The Author's reputation tells all you need to know about the circuitry and Hart expertise and experience guarantees the engineering design of the kit. Advanced features include: High-quality separate VU meters with excellent ballistics. Controls, switches and sockets mounted on PCB to eliminate difficult wiring. Proper moulded escutcheon for cassette aperture improves appearance and removes the need for the cassette transport to be set back behind a narrow finger trapping slot. Easy to use, robust Lenco mechanism. Switched bias and equalisation for different tape formulations. All wiring is terminated with plugs and sockets for easy assembly and test. Sophisticated modular PCB system gives a spacious, easily-built and tested layout. All these features added to the high-quality metalwork make this a most satisfying kit to build. Also included at no extra cost is our latest HS 16 Sendus Alloy super head, available separately at **£8.20** but included free with the complete kit at **£75** plus VAT.
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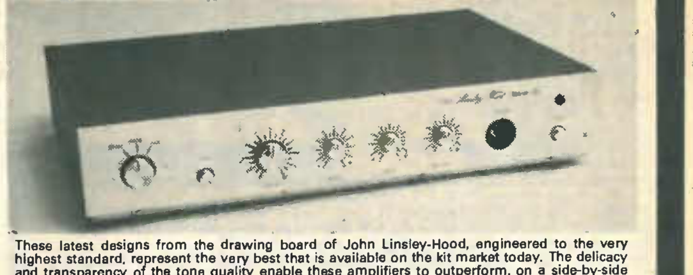

These latest designs from the drawing board of John Linsley-Hood, engineered to the very highest standard, represent the very best that is available on the kit market today. The delicacy and transparency of the tone quality enable these amplifiers to outperform, on a side-by-side comparison, the bulk of amplifiers in the commercial market-place and even exceed the high standard set by his earlier 75-watt design.
Three versions are offered, a 30-watt with Darlington output transistors, and a 35- and 45-watt, both with Mosfet output devices. All are of identical outside appearance which is designed to match and stack with our Linsley-Hood cassette recorder 2.
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AC141K	0.34	BC117	0.19	BC214	0.09	BD182	0.70	BF199	0.14	BT106	1.00	TIS91	0.20
AC142K	0.30	BC119	0.24	BC214L	0.09	BD201	0.83	BF200	0.30	BT108	1.22	2N2219	0.28
AC176	0.22	BC125	0.12	BC237	0.09	BD202	0.65	BF241	0.15	BT116	1.20	2N2905	0.40
AC176K	0.31	BC140	0.31	BC238	0.09	BD203	0.78	BF256	0.28	BU105	1.22	2N3054	0.59
AC187	0.26	BC141	0.25	BC251a	0.12	BD204	0.70	BF256/LC	0.28	BU108	1.69	2N3055	0.59
AC187K	0.28	BC142	0.21	BC252A	0.15	BD222	0.46	BF257	0.28	BU124	1.00	2N3702	0.12
AC188	0.22	BC143	0.24	BC258A	0.39	BD223	0.48	BF258	0.25	BU126	1.22	2N3703	0.12
AC188K	0.37	BC147	0.09	BC300	0.30	BD225	0.46	BF259	0.26	BU204	1.55	2N3704	0.12
AD142	0.90	BC148A	0.09	BC301	0.30	BD233	0.35	BF271	0.26	BU205	1.30	2N3705	0.12
AD143	0.82	BC148B	0.09	BC303	0.26	BD234	0.35	BF273	0.13	BU208	1.39	2N3706	0.12
AD149	0.70	BC149	0.09	BC307	0.09	BD236	0.45	BF336	0.34	BU208A	1.52	2N3708	0.12
AD161	0.39	BC157	0.10	BC327	0.10	BD237	0.30	BF337	0.29	BU208/02	1.89	2N5294	0.38
AD162	0.39	BC158	0.09	BC337	0.10	BD238	0.33	BF338	0.32	BU326A	1.42	2N5296	0.48
AD161/2	1.04	BC159	0.09	BC338	0.09	BD410	0.55	BF355	0.37	BU407	1.24	2N5298	0.52
AF124	0.34	BC160	0.28	BC461	0.30	BD434	0.55	BF362	0.38	BU500	1.75	2N5496	0.66
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AF126	0.32	BC170B	0.10	BC547	0.10	BD517	0.60	BF371	0.20	MJE340	0.40	2SC495	0.80
AF127	0.32	BC171	0.08	BC548	0.10	BD520	0.65	BF394	0.19	MJE520	0.48	2SC496	0.80
AF139	0.42	BC171A	0.10	BC549A	0.08	BDX32	1.50	BF457	0.23	MRF450A	11.50	2SC1096	0.80
AF150	0.42	BC171B	0.10	BC550	0.07	BF115	0.35	BF458	0.23	MRF477	10.00	2SC1173	1.15
AF239	0.42	BC172	0.09	BC550B	0.07	BF127	0.24	BF459	0.36	MRF475	2.50	2SC1449	0.80
AU106	2.08	BC172B	0.10	BC557	0.07	BF158	0.18	BF595	0.23	R2008B	1.70	2SC1678	1.25
AU107	1.75	BC172C	0.10	BC557B	0.07	BF160	0.27	BF597	0.25	R2010B	1.70	2SC1953	0.95
AU110	2.00	BC173B	0.10	BC558	0.07	BF167	0.24	BFR39	0.23	R2322	0.58	2SC2028	1.15
AU113	1.48	BC174	0.09	BD115	0.30	BF173	0.22	BFR41	0.28	R2323	0.66	2SC2029	1.60
BC107	0.10	BC174A	0.09	BD116	0.52	BF177	0.38	BFT42	0.28	R2540	2.48	2SC2078	1.45
BC107A	0.10	BC182	0.09	BD124P	0.56	BF178	0.26	BFW92	0.85	RCA16334	0.90	2SC2091	0.85
BC107B	0.10	BC182LB	0.10	BD131	0.32	BF179	0.34	BFX29	0.30	RCA16335	0.80	2SC1172Y	2.20
BC108	0.10	BC183	0.12	BD132	0.35	BF180	0.29	BFX84	0.26	TIP29	0.40	2SC1306	1.25
BC108A	0.10	BC183L	0.09	BD133	0.40	BF181	0.29	BFX85	0.28	TIP29C	0.42	2SC1307	1.85
BC108B	0.10	BC184LB	0.09	BD135	0.30	BF182	0.29	BFX86	0.30	TIP30C	0.43		
BC108C	0.10	BC204	0.10	BD136	0.30	BF183	0.29	BFX88	0.25	TIP31C	0.42		
BC109	0.10	BC208B	0.13	BD137	0.28	BF184	0.28	BFY50	0.21	TIP32C	0.42		
				BD138	0.30	BF185	0.28	BFY51	0.21	TIP33B	0.55		
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A2293	7.20	E180F	5.25	ECL82	0.58	EM85	0.85	OC3	1.05	QQZ06-40A	45.25	UF41	1.15	3B28	5.00	6BW7	0.75	7B7	1.40	31JS6A	2.95
A2900	10.90	E186F	7.95	ECL83	1.13	EM87	1.10	OD3	1.15	QS150/45	7.00	UF42	1.15	3D6	0.50	6BW8	4.00	7D6	1.40	35A5	1.20
ACP	3.00	E182CC	4.50	ECL84	0.74	EMM803	2.50	OM4	1.00	QS1200	3.95	UF80	0.80	3W4GT	2.50	6BX7GT	2.00	7H7	1.50	35L6GT	2.00
AC/HL/DD	3.00	E235L	14.00	ECL85	0.74	EN32	14.00	OM5B	3.60	QS1209	1.50	UF86	1.10	4-125A	35.00	6BZ6	2.00	7S7	2.00	35W4	0.70
AC/PEN	3.50	E280F	19.50	ECL86	0.74	EN91	0.95	OM6	2.00	QS1212	3 20	UF89	1.10	4-250A	38.00	6BZ8	0.95	7Y4	1.00	35Z3	1.85
AC/SP3	4.50	E283CC	8.25	ECLL800	13.50	EN92	4.00	PABC80	0.50	QV03-12	3.50	UL84	0.78	4-400A	40.00	6C4	0.45	8D8	2.75	40KD6	2.80
ACVP1	3.50	E810F	8.25	EF22	2.50	ES1500	115.00	PC86	0.80	QV05-25	1.75	UU5	1.50	4CX250B	26.60	6C6	0.50	8FQ7	0.75	41	0.80
ACVP2	1.50	EA50	1.00	EF37A	3.60	EY51	0.80	PC88	0.80	QY3-125	30.50	UU6	3.50	4CX350A	39.00	6C8G	1.25	9BW6	1.20	431U	1.25
AR8	0.70	EAA91	0.60	EF39	2.00	EY83	1.50	PC92	0.85	QY4-250	52.15	UU7	3.75	5A-170K	5.25	6C11	2.50	10C1	5.50	50C5	0.95
ARP12	0.70	EABC80	0.56	EF40	1.20	EY84	8.00	PC97	0.95	QY4-400	60.85	UU8	3.75	5A/206K	9.00	6C15	2.50	10C2	0.70	50CD6G	1.15
ARP34	2.00	EAC91	0.90	EF41	1.25	EY86/87	0.50	PC900	0.85	QY5-500	99.00	UY1N	0.90	5B-254M	14.50	6C18	2.50	10D2	1.25	52KU	0.85
ARP35	1.50	EAF42	1.40	EF42	1.95	EY88	0.60	PCC84	0.45	R1	1.50	UY85	0.70	5B-255M	14.50	6C31	1.50	10F1	0.75	57	0.85
ARP37	1.00	EB41	2.30	EF50	1.50	EY500A	1.50	PCC85	0.54	R2	1.50	VLS631	13.00	5D6	4.00	6CB5	1.50	10F9	0.75	75C1	1.20
B36	1.85	EB91	0.52	EF55	2.25	EZ41	1.20	PCC88	0.80	R3	1.50	VP41	1.50	5D21	15.50	6CB6	1.50	10F18	0.60	80	1.40
B729	1.20	EBC33	1.00	EF71	1.50	EZ80	0.56	PCC89	0.80	R10	4.00	VP133	2.00	5D22	38.00	6CD6GA	4.00	10GK6	1.95	83AI	7.00
BT17A	95.00	EBC41	0.85	EF80	0.48	EZ81	0.56	PCC189	0.80	R12	0.80	VR75/30	3.00	5R4GB	2.00	6CF6	1.50	10P14	2.50	84	0.85
CBL31	2.00	EBC81	0.85	EF83	3.50	EZ90	0.96	PCC806	0.80	R16	12.00	VR101	1.50	5U4G	0.85	6CG8A	1.00	11E2	15.50	85A1	5.40
C1K	14.00	EBC89	0.85	EF85	0.48	G1/371K	30.00	PCE82	0.80	R17	2.00	VR102	1.50	5U4GB	1.50	6CH6	7.00	12A4	2.50	85A2	1.20
C3JA	10.00	EBC90	0.75	EF86	0.70	G55/1K	8.00	PCF80	0.70	R18	8.00	VR105/30	1.05	5V4G	0.85	6CL6	1.50	12AC6	0.80	89	1.20
D3A	30.00	EBC91	0.75	EF89	0.75	G120/1B	8.00	PCF82	0.60	R19	1.20	VR150/30	1.15	5Y3GT	0.85	6CZ5	2.00	12AD6	0.80	90C1	1.69
DAC32	1.20	EBF80	0.55	EF91	1.22	G150/2D	4.00	PCF84	0.65	R20	1.20	VT25	5.00	5Z4G	0.85	6DC6	2.00	12AE6	0.85	90CG	10.85
DAF91	0.45	EBF89	0.70	EF92	2.50	G180/2M	7.00	PCF86	1.20	RG1-125	3.50	VT120	1.15	6/30L2	0.70	6DW4	1.20	12AG8	1.50	92AG	9.00
DAF96	0.65	EBL1	1.50	EF93	0.65	G400/1K	14.00	PCF87	0.40	RG1-240A	11.75	VT138	4.25	6A/203K	9.00	6EA8	0.80	12AH7GT	0.85	92AV	9.00
DC90	1.20	EBL21	2.00	EF94	0.55	GC10B	9.00	PCF200	1.35	RG3-250A	11.75	VU39	1.50	6A6	1.50	6F1	2.00	12AH8	5.50	150B2	3.50
DCX4/1000	5.00	EC52	0.70	EF95	0.78	GC10D	9.00	PCF201	1.35	RG4-1000	10.00	VX6120	5.00	6A8G	1.50	6F6G	2.00	12AT6	0.59	150B3	3.90
DD620	1.20	EC86	1.00	EF96	0.65	GC104B	9.00	PCF800	0.40	RK-20A	12.00	VX9133	5.00	6AB7	0.60	6F8G	1.50	12AT7	0.55	150C4	1.50
DET10	6.00	EC88	1.00	EF97	0.95	GN4	4.00	PCF801	0.92	RPL16	12.00	X65	0.85	6AB8	0.66	6F12	1.30	12AT7WA	1.50	155UG	25.00
DF33	1.20	EC90	0.45	EF183	0.56	GN10	15.00	PCF802	0.72	RR3-1250	65.00	X66	0.85	6AC7	1.00	6F14	1.00	12AU6	0.60	185BT	1.50
DF91	0.45	EC91	3.00	EF184	0.56	GN24	1.50	PCF805	1.80	S11A	1.50	X719	0.58	6AF4A	1.20	6F22	0.70	12AU7	0.55	257A	6.00
DF92	0.60	EC92	0.80	EF731	1.80	GRD7	9.00	PCF806	0.60	S130	2.50	XG5-500	19.50	6AG7	1.20	6F23	0.48	12AV6	0.80	408A	4.00
DF96	0.65	EC93	0.80	EH90	0.65	GS10C	12.00	PCF808	1.48	S130P	3.00	XR1-1600A	29.00	6AH6	1.00	6F24	1.25	12AX7	0.55	708A	5.00
DF97	1.50	ECC33	4.00	EK90	0.65	GT1C	13.50	PCH200	1.10	SP41	4.00	XR1-6400A	128.00	6AJ7	1.00	6F25	1.25	12AX7WA	1.50	715A	6.00
DH63	2.20	ECC40	2.30	EL32	0.95	GU50	11.50	PCL82	0.74	SP42	2.50	YL1020	29.00	6AK5	0.60	6F26	0.48	12AY7	4.00	715C	15.50
DH77	0.90	ECC81	0.55	EL33	2.50	GXU1	13.50	PCL83	2.00	STV280/40	8.00	YL1060	15.00	6AK6	2.00	6F28	1.25	12AZ7A	1.50	717A	1.50
DK91	0.90	ECC82	0.55	EL34	1.54	GXU50	12.50	PCL84	0.76	STV280/80	23.00	Z63	1.00	6AL5	0.52	6F33	8.50	12B4A	1.60	801A	2.00
DK92	1.20	ECC83	0.60	EL34 Mullard	2.45	GY501	1.20	PCL85	0.80	T41	2.00	Z77	1.20	6AM4	2.50	6FG5	1.50	12BA6	0.75	803	16.00
DK96	1.00	ECC84	0.60	EL36	1.60	GZ30	0.85	PCL86	0.76	TP25	1.50	Z303C	9.00	6AM5	6.00	6FH5	1.50	12BE6	1.05	807	1.50
DL92	0.60	ECC85	0.60	EL37	9.00	GZ32	0.85	PCL200	1.60	TT11	1.50	Z502C	12.00	6AM6	1.30	6FN5	1.50	12BH7	0.95	808	3.00
DL94	1.20	ECC88	0.65	EL38	4.50	GZ33	3.25	PCL805	0.80	TT21	14.50	Z504S	13.50	6AN5	2.00	6FL2	1.50	12BL6	0.70	811A	9.00
DL96	1.00	ECC91	0.65	EL41	1.50	GZ34	2.00	PD500	2.95	TY2-125A	45.00	Z700U	1.00	6AN8A	2.50	6GH8A	0.80	12C8GT	0.70	813	11.30
DLS10	9.00	ECC189	0.78	EL81	2.05	GZ37	4.00	PEN4DD	1.50	TY4-350	90.00	Z749	0.48	6AQ5	0.82	6GK5	1.00	12E1	16.50	833A	47.85
DLS16	10.00	ECC803S	1.50	EL82	0.58	HL41	1.50	PEN25	1.50	TY4-500A	41.50	Z759	9.00	6AS5	1.50	6GK6	1.00	12GN7	3.25	845	8.00
DM70	1.10	ECC804	0.40	EL84	0.60	HL42DD	2.00	PEN45	3.50	U10	1.50	Z803U	12.50	6AS6	3.50	6H2N	0.70	12HG7A	3.25	866A	3.00
DM160	2.50	ECC807	1.30	EL85	3.85	HL92	1.50	PEN46	1.50	U15	1.50	ZC1040	8.00	6AS7G	4.50	6H3N	0.70	12J5GT	0.48	868	5.00
DY80	1.20	ECC808	2.00	EL86	0.80	HL133/DD	1.50	PENA4	2.50	U17	1.50	ZM1001	5.00	6AT6	0.80	6H6	1.00	12J7GT	0.70	885	2.00
DY86/87	0.55	ECF80	0.65	EL90	0.82	HP6	1.50	PFL200	1.13	U18-20	2.00	ZM1020	4.00	6AV5GTA	1.50	6HF5	4.50	12K5	1.00	954	0.50
DY802	0.60	ECF82	0.60	EL91	6.00	HY90	1.00	PL33	0.75	U19	11.95	1AC6	1.20	6AU6	0.55	6HG8	1.50	12K7GT	0.60	955	0.60
E55L	14.00	ECF86	1.50	EL95	0.70	KT61	3.50	PL36	1.05	U22	1.00	1B22	10.00	6AV6	0.72	6HZ6	1.00	12Q7GT	0.50	958A	0.90
E80CC	4.75	ECF802	1.20	EL360	9.00	KT66 USA	4.95	PL81A	0.74	U25	0.68	1B3GT	1.00	6AW8A	2.50	6J5GT	0.75	12SA7GT	1.00	1299A	0.60
E80F	6.25	ECF804	6.00	EL504	1.40	KT66 UK	9.00	PL82	0.60	U26	0.90	1B22	10.00	6AZ8	1.80	6J6	0.55	12SJ7	0.60	2050	6.00
E81CC	3.90	ECF812	1.20	EL509	2.60	KT77	5.00	PL83	0.52	U37	12.00	1B5	2.50	6B10	2.50	6J7	0.70	12SL7	1.50	4212E	230.00
E82CC	1.50	ECH3	2.50	EL821	7.00	KT88 USA	6.00	PL84	0.65	U41	0.70	1D5	1.00	6BA6	0.50	6J7GT	1.00	12SN7GT	1.85	5557	19.50
E83CC	1.50	ECH4	3.00	EL822	8.25	KT88 UK	11.50	PL95	1.00	U191	0.70	15G	1.00	6BA7	3.75	6JE6	2.10	12SR7	0.70	5636	3.00
E83F	2.50	ECH35	1.50	EM1	4.00	KTW61	1.50	PL500	1.12	U193	0.65	1L6	1.50	6BA8A	3.50	6JS6C	2.55	12U7	1.50	5642	5.00
E86C	6.00	ECH42	1.00	EM4	4.00	L63	1.00	PL504	1.20	U281	1.00	1LA6	1.00	6BD6	1.00	6K4N	1.00	12Y4	0.60	5651	1.75
		ECH81	0.58			L120/2K	12.00	PL508	1.48	U282	1.00	1U5	1.00	6BE6	0.50	6K7	0.70	13D3	3.20	5654	1.95
						M8079	6.00	PL509	2.30	U291	0.60	1X2B	1.15	6BH6	1.60	6KD6	3.95	13D7	3.20	5670	3.50
						M8083	3.25	PL519	2.60	U301	0.60	2A3	3.00	6BJ6	1.05	6L1	2.50	13D8	3.20	5687	8.15
						M8100	2.85	PL802	2.50	U309	0.60	2AS15A	11.00	6BK4	2.75	6L6GC	1.75	14S7	1.00	5696	2.55
						M8137	2.85	PL820	3.00	U801	0.80	2C39A	19.00	6BN4	1.25	6L6GT	1.10	15D2	1.00	5718	3.50
						M8162	3.85	PT4	4.00	UABC80	0.65	2C21	1.00	6BN6	1.30	6L7	0.55	17JZ8	1.60	5725	3.50
						M8196	3.25	PT15	4.50	UAF42	1.00	2C42	4.00	6BN7	3.50	6L15	1.50	18D3	1.60	5726	1.50
						M8225	1.20	PY31	0.60	UBC81	1.00	2C51	0.75	6BN8	0.85	6L17	1.50	19AQ5	0.70	5727	2.00
						ME1400	4.00	PY32	0.60	UBF80	0.60	2B7	1.50	6BQ5	0.60	6L18	0.60	20A2	4.00	5749	2.00
						ME1402	4.50	PY33	0.60	UBF89	0.60	2D21	0.95	6BQ6GA	2.00	6LD3	0.85	20D1	0.70	5751	1.50
						ME1403	10.00	PY81	0.65	UBL21	1.20	2D21W	2.00	6BQ7A	0.72	6LD20	0.60	20D4	1.75	5763	3.20
						ME1501	14.00	PY82	0.55	UC92	0.80	2K25	10.00	6BL8	0.65	6P1	0.60	20F2	0.75	5814A	2.75
						MH4	2.10	PY83	0.70	UCC84	0.70	3A/147J	7.50	6BR7	3.75	6P15	0.60	20L1	0.95	5842	6.50
						MH41	2.10	PY88	0.74	UCC85	0.60	3A/167M	10.00	6BR8A	1.20	6P25	2.50	20P1	0.55	6080	4.20
						MS4B	5.00	PY500A	1.35	UCH21	1.20	3A2	3.00	6BS7	3.30	6P28	2.00	20P3	0.60	6080WA	6.00
						MU12	1.50	PY800	0.65	UCH41	1.20			6BS8	1.88	6SA7GT	1.00	20P4	1.05	6146	4.20
						MU14	1.50	PY801	0.65					6BU6	2.00	6SH7	1.50	20P5	1.15	6146A	4.45
						N18	1.00	PZ30	0.60							6SK7	0.80	30	2.85	6146B	4.45
						N78	8.90	QB3-300	30.50							6SL7GT	0.72	30C15	0.40	7360	7.50
						NR14	9.00	QE03-10	3.20							6SN7GT	0.69	30C17	0.40		
						NR73	3.50	QP25	1.00							6SS7	1.50	30F5	0.95		
						NU3	1.50	QQE06-40	13.95							6U56	1.60	30FL1	0.95		
						NU17	1.50	QQV02-6	10.50							6U8	0.60	30FL2	0.95		
						NU18	1.50									6V6GT	0.90	30FL12	1.10		

ZENER DIODES

BZX61 0.15

6V2 7V5 8V2 9V1 10V 11V 12V 13V 15V 16V 18V 20V 22V 24V 27V 30V 33V 36V 39V 47V

BZY88 0.07

2V7 3V 3V3 3V6 3V9 4V3 4V7 5V1 5V6 6V2 6V8 7V5 8V2 9V1 10V 11V 12V 13V 15V 18V 24V 27V

BASES

B7G	0.15
B7G Skirted	0.30
B8G	0.70
B9A	0.15
B9A Skirted	0.30
B10B	0.16
B13B	0.50
8 Pin DIL	0.20
14 Pin DIL	0.22
14 Pin DIL/Q	0.30
16 Pin DIL	0.30
VALVE SCREENING CANS	0.27

DIODES

AA119	0.08	BY176	0.85	OA95	0.06	IN5406	0.13
BA102	0.17	BY179	0.63	OA202	0.11	IN5407	0.16
BA115	0.13	BY199	0.28	IN914	0.03	IN5408	0.16
BA145	0.17	BY206	0.14	IN4001	0.04	ITT44	0.04
BA148	0.17	BY208.800	0.33	IN4002	0.04	ITT2002	0.11
BA154	0.06	BY210.800	0.33	IN4003	0.04		
BA155	0.13	BY223	0.90	IN4004	0.05		
BA156	0.15	BY298.400	0.22	IN4005	0.05		
BAX13	0.04	BY299-800	0.22	IN4006	0.05		
BAX16	0.06	BYX10	0.20	IN4007	0.06		
BB105B	0.30	BYX55/600	0.30	IN4148	0.02		
BB105G	0.30	BYX71/600	0.60	IN4448	0.10		
BY126	0.10	OA47	0.09	IN5401	0.12		
BY127	0.11	OA90	0.05	IN5402	0.14		
BY133	0.15	OA91	0.06	IN5403	0.12		
BY164	0.45			IN5404	0.12		
				IN5405	0.13		

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	10K	0.22
7 Watt		
	R47-4K7	0.14
	5K6-12K	0.15
	15K-22K	0.18
11 Watt		
	1R-10K	0.18
	15K	0.21
17 Watt		
	1R-10K	0.24
	15K-22K	0.25

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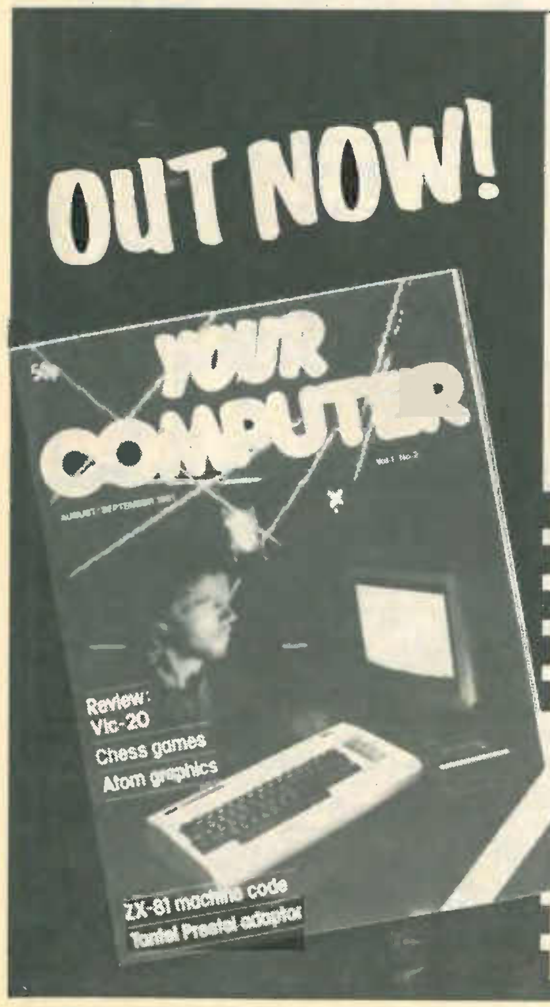

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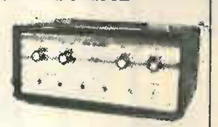

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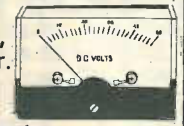

50μa 100μa 500μa,
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Facia 2⅜ × 1¾ × 1½in.
Fixing hole 1½in. dia.
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Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel. Suitable for home or disco. **£15** Easy to build. Full instructions supplied. Cabinet **£4.50** extra. Will operate from 200MV to 100 watt signal. Post 95p
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12V, 100mA	£1.30	80p	20V, 40V, 60V, 1a	£4.00	£2
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30V, 5a and			2 of 28 volt 1a	£5.00	£2
17-0-17V 2a	£4.00	£2	20V, 1a	£3.00	£1
0.5, 8, 10, 16V, ½a	£2.50	80p	20V-0-20V, 1a	£3.50	£1
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25-0-25V 2a	£4.50	£1	2 of 18V, 6a	£11.00	£2
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6V ½a	£2.00	£1	9V, ¼a	£1.50	80p
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6-12 volt 4a	£6.50+£2	6-12 volt 4a	£2.00+80p

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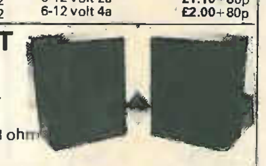

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TEAK VENEERED CABINET
11×8½×7in 15 watts
50 to 14,000 cps. 4 ohm or 8 ohm
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2500mF 50V **70p**; 3000mF 50V **65p**; 2000mF 100V **£1.**
4500mF 64V **£2.** 4700mF 63V **£1.20.** 2700mF/76V **£1.**

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8/450V	45p	8+8/450V	75p	32+32+16/350V	90p
8/800V	£1.20	8+16/450V	75p	100+100/275V	65p
16/350V	45p	20+20/450V	75p	150+200/275V	70p
32/500V	75p	32+32/350V	50p	220/450V	95p
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DELUXE MK II	12	8-16	15	HI-FI	£14
SUPERB	12	8-16	30	HI-FI	£24
AUDITORIUM	12	8-16	45	HI-FI	£22
AUDITORIUM	15	8-16	80	HI-FI	£34
GROUP 45	12	4-8-16	45	PA	£14
GROUP 75	12	4-8-16	75	PA	£22
GROUP 100	12	8-16	100	PA	£24
GROUP 100	15	8-16	100	PA	£32
DISCO 100	12	8-16	100	DISCO	£24
DISCO 100	15	8-16	100	DISCO	£34

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GOODMANS	TWEETER	3½in	25	8	£4.00
AUDAX	TWEETER	3¾in	60	8	£10.50
SEAS	MID-RANGE	4in	50	8	£7.50
SEAS	MID-RANGE	5in	80	8	£12.00
SEAS	MID-RANGE	4½in	100	8	£12.50
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GOODMANS	FULL-RANGE	8in	30	8	£9.50
GOODMANS	AUDIOM 8p	8in	15	15	£8.50
SEAS	WOOFER	8in	30	8	£14.00
CELESTION	DISCO	10in	20	8/16	£11.50
CELESTION	DISCO	10in	60	8/16	£21.50
RIGONDA	GENERAL	10in	15	8	£6.50
GOODMANS	AUDIOM PG	12in	60	8	£20.00
GOODMANS	PP12	12in	75	8/15	£24.50
GOODMANS	AUDIOM P	12in	50	8/15	£20.00
GOODMANS	GR12	12in	90	8/15	£27.50
EMI	HI-FI	13x8	10	3/8	£9.50

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2650A	10.00
2651	10.90
2652	18.35
2653	9.00
2661–1	12.00
6100 FAMILY	
6100	9.25
6101	6.40
6102	17.75
6103	6.75
6402	3.80
6403	6.50
6800 FAMILY	
6800	3.80
6802	5.75
6808	4.45
6810	2.17
6821	2.52
6840	5.50
6850	2.00
6852	2.47
6854	4.60
68047	5.64
68488	5.43

DEVICE	PRICE
8080 FAMILY	
8080A	3.50
8085A	8.00
8155	8.75
8156	8.75
8212	1.95
8216	1.80
8224	2.25
8226	1.80
8228	5.50
8238	5.50
8251	3.85
8253	9.00
8255A	3.55
8257	7.95
8279	10.50
TMS5501	15.00
Z80 FAMILY	
Z80 CPU	4.10
Z80A CPU	6.25
Z80 CTC	4.40
Z80A CTC	5.25
Z80 PIO	4.25
Z80A PIO	4.95
Z80 SIO-0	17.50

DEVICE	PRICE
Z80 SIO-1	17.50
Z80 SIO-2	17.50
Z80 SIO-9	11.50
Z80A SIO-0	23.50
Z80A SIO-1	23.50
Z80A SIO-2	23.50
Z80A SIO-9	15.50
9900 FAMILY	
9900	32.50
9980A	20.00
9981	29.30
9901	9.94
9902	8.52
9903	25.55
9911	28.46
9914	19.29
9927	27.39
MEMORIES	
2101	1.15
2102	1.15
2111	1.25
2112	1.35
2114	3.25
2708	3.45
2708–4	1.50

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74LS00	0.14	74LS112	0.25	74LS243	0.85
74LS01	0.15	74LS113	0.25	74LS244	1.10
74LS02	0.14	74LS114	0.25	74LS245	1.60
74LS03	0.15	74LS122	0.42	74LS247	0.80
74LS04	0.15	74LS123	0.59	74LS251	0.45
74LS08	0.15	74LS124	1.15	74LS253	0.45
74LS09	0.15	74LS125	0.30	74LS257	0.50
74LS10	0.14	74LS126	0.30	74LS258	0.50
74LS11	0.15	74LS132	0.50	74LS261	1.98
74LS12	0.15	74LS136	0.27	74LS266	0.25
74LS13	0.30	74LS137	0.75	74LS273	1.10
74LS14	0.50	74LS138	0.40	74LS279	0.42
74LS15	0.15	74LS139	0.40	74LS280	2.15
74LS20	0.14	74LS145	0.80	74LS283	0.70
74LS21	0.15	74LS147	1.20	74LS290	0.60
74LS22	0.15	74LS148	1.08	74LS293	0.60
74LS27	0.15	74LS151	0.42	74LS295	1.05
74LS28	0.20	74LS153	0.42	74LS298	1.05
74LS30	0.15	74LS155	0.55	74LS299	2.50
74LS32	0.15	74LS156	0.55	74LS365	0.39
74LS33	0.17	74LS157	0.38	74LS366	0.39
74LS37	0.18	74LS158	0.38	74LS367	0.39
74LS38	0.18	74LS160	0.45	74LS368	0.39
74LS40	0.15	74LS161	0.45	74LS373	1.05
74LS42	0.45	74LS162	0.45	74LS374	1.05
74LS43	0.50	74LS163	0.45	74LS377	1.05
74LS44	0.50	74LS164	0.62	74LS378	0.75
74LS47	0.55	74LS165	0.95	74LS379	0.95
74LS51	0.15	74LS166	1.40	74LS386	0.27
74LS54	0.15	74LS170	1.50	74LS393	0.75
74LS55	0.15	74LS174	0.72	74LS395	1.15
74LS73	0.25	74LS175	0.71	74LS668	0.67
74LS74	0.20	74LS181	1.45	74LS669	0.67
74LS75	0.30	74LS183	1.96	74LS670	1.65
74LS76	0.25	74LS190	0.60	81LS95	1.32
74LS78	0.30	74LS191	0.60	81LS96	1.32
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20 pin	.14	.126	.113	.12	.10	.092
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24 pin	.15	.135	.12	.146	.132	.116
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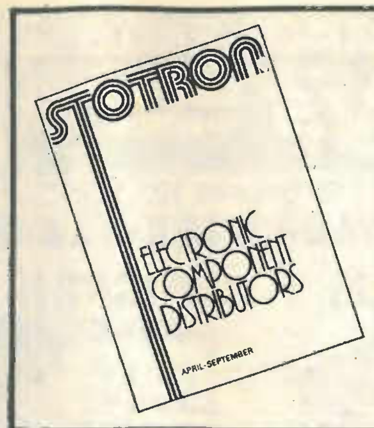

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	1X013	15 + 15	1.00	
	1X014	18 + 18	0.83	
	1X015	22 + 22	0.68	
	1X016	25 + 25	0.60	
	1X017	30 + 30	0.50	
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	2X012	12 + 12	2.08	
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	2X014	18 + 18	1.38	
	2X015	22 + 22	1.13	
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	2X017	30 + 30	0.83	
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	2X029	220	0.22	
	2X030	240	0.20	
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	3X013	15 + 15	2.66	
	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	
120VA 90 × 40mm 1.2 Kg Regulation 11%	4X010	6 + 6	10.00	**£6.38** + £1.43 P/P + £1.17 VAT
	4X011	9 + 9	6.66	
	4X012	12 + 12	5.00	
	4X013	15 + 15	4.00	
	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	
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	5X016	25 + 25	3.20	
	5X017	30 + 30	2.66	
	5X018	35 + 35	2.28	
	5X026	40 + 40	2.00	
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	5X030	240	0.66	

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	6X017	30 + 30	3.75	
	6X018	35 + 35	3.21	
	6X026	40 + 40	2.81	
	6X025	45 + 45	2.50	
	6X028	110	2.04	
	6X029	220	1.02	
	6X030	240	0.93	
300VA 110 × 50mm 2.6 Kg. Regulation 6%	7X014	18 + 18	8.33	**£11.66** + £1.73 P/P + £2.01 VAT
	7X015	22 + 22	6.82	
	7X016	25 + 25	6.00	
	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	
500VA 140 × 60mm 4 Kg. Regulation 4%	8X017	30 + 30	8.33	**£15.53** + £2.05 P/P + £2.64 VAT
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	8X026	40 + 40	6.25	
	8X025	45 + 45	5.55	
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	8X042	55 + 55	4.54	
	8X028	110	4.54	
	8X029	220	2.27	
	8X030	240	2.08	
625VA 140 × 75mm 5.0 Kg. Regulation 4%	9X017	30 + 30	10.41	**£21.54** + £2.20 P/P + £3.56 VAT
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	9X026	40 + 40	7.81	
	9X025	45 + 45	6.94	
	9X033	50 + 50	6.25	
	9X042	55 + 55	5.68	
	9X028	110	5.68	
	9X029	220	2.84	
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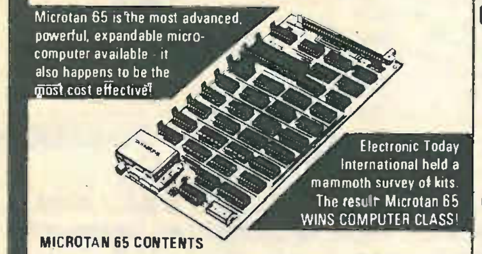

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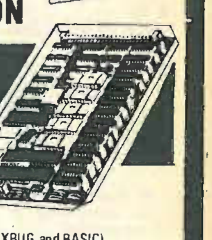

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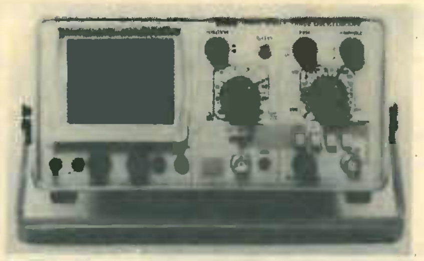

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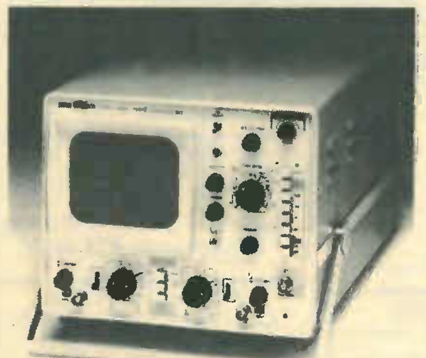

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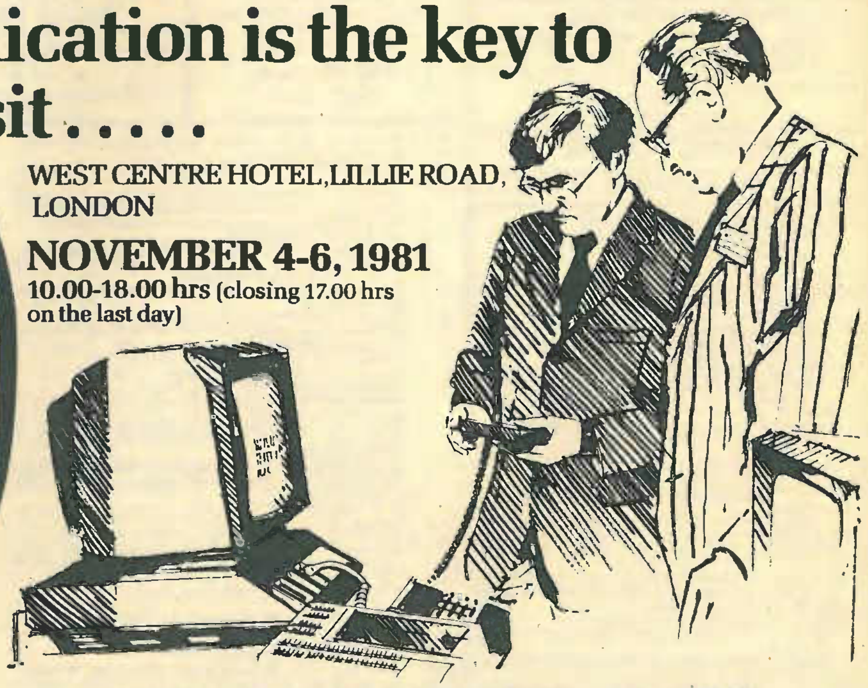

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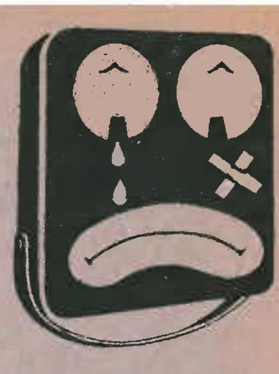

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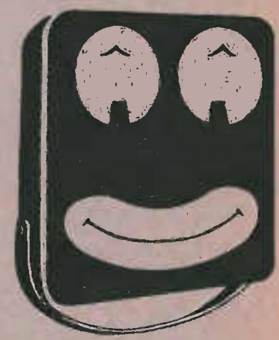

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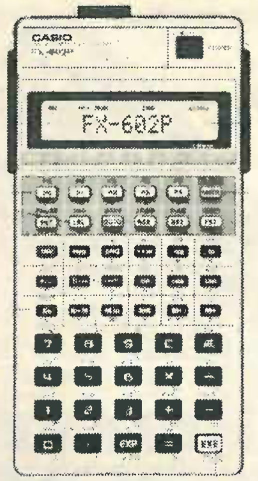

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CE1008	65	—	CPS150	HS50/100	30VuS	110dB	775mV	0.0035%	1.5Hz—50KHz	80—120—25
CE1704	85	121	CPS250	HS100/150/FM1	30VuS	110dB	775mV	0.0035%	1.5Hz—50KHz	80—120—25
CE1708	125	—	CPS250	HS100/150/FM1	30VuS	110dB	775mV	0.0035%	1.5Hz—50KHz	80—120—25
CE3004	170	250	CPS250	HS150/FM2	30VuS	110dB	775mV	0.008 %	1.5Hz—50KHz	161—102—35
CPR1X	output	775mV	REG1	—	3VuS	70dB	2.8mV	0.008 %	10Hz —50KHz	138— 80—35
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Applications are invited for the above post established by Shell Research Limited for 5 years, with possibility for renewal to an established grade 1A post, to provide instrumentation services to the Inorganic Chemistry Laboratory. The instrumental needs of the department involve maintenance, calibration and alignment, design and development, and computer interfacing of an increasing variety of instruments that include high-resolution n.m.r., e.s.r., mass spectrometry, p.e.s., and magnetometers. Knowledge of modern electronics, computer technology, vacuum technology, electron guns and ion sources, magnetometers, and the techniques of high temperature and high pressure are all relevant. The post offers participation in the development of modern instrumentation in a department active in research in solid-state, molecular-complexes, organometallic, bioinorganic, electro-, photo-, photoelectro-, and surface chemistry utilizing a wide range of techniques. The scope of the post will be defined by the measure of the person who occupies it. A background in electronic engineering, physics, or physical chemistry would be appropriate. Salary in the range £6,070 to £10,575.

Applications stating age, qualifications, present salary, and experience along with the names and addresses of two referees should be sent to the Administrator, Inorganic Chemistry Laboratory, South Parks Road, Oxford OX1 3QR before 1 October 1981.

(1272)

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(861)

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(321)

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(1258)

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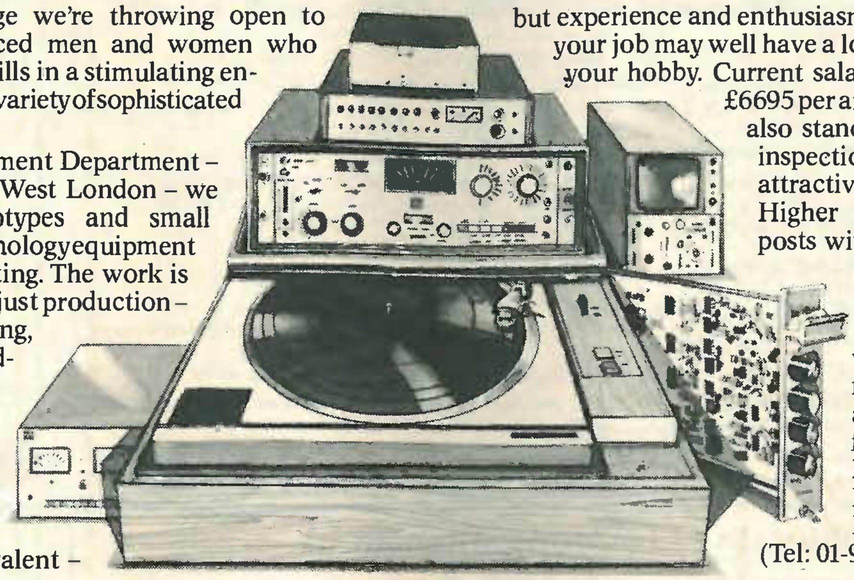

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You will be required to assist in the preparation of specifications for transmitter and associated equipment including the subsequent analysis and evaluation of tenders.
You will also assist in the installation and commissioning at site and will also be involved in the evaluation of new designs of equipment. Some design work will be involved, therefore, ideally you should have a good knowledge of microprocessors and software based systems.
You should be qualified to degree level in Electrical/Electronic Engineering and have had formal engineering training in broadcasting technology or a related field. You should also have several years post training experience in industry or broadcasting engineering on transmitters and associated equipment. A current driving licence is essential as the post involves travel away from base.
The commencing salary (depending upon qualifications and experience) will be on a range which rises to £9,855 per annum. Salaries are currently under review. Relocation expenses will be paid where applicable.

IBA INDEPENDENT BROADCASTING AUTHORITY

Please write or telephone for an application form quoting reference number WW/624cc, to Christine Gossling, IBA, Crawley Court, Winchester, Hampshire, S021 2QA. Telephone 822270.

(1275)

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Candidates must have a degree in electrical or electronic engineering or a pass in the Council of Engineering Institutions Part 2 examination in appropriate subjects or an equivalent qualification. They should preferably have achieved Corporate membership of an appropriate professional institution or be well experienced in telecommunications engineering; and must have several years' professional experience in at least one of the following fields: land mobile radio, link-planning, data communications, CCTV, line communications PABXs or frequency planning.

Starting salary (under review) £9,615-£11,215 according to qualifications and experience. Promotion prospects.

For further details and an application form (to be returned by September 10, 1981) write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). **Please quote Ref: T/5620.**

Home Office

(1287)

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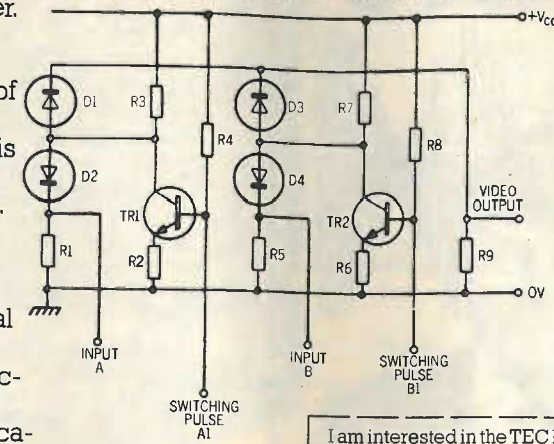

Diagram by courtesy of the City & Guilds of London Institute

I am interested in the TEC Higher Certificate in Electrical Engineering.

Name

Address 6/62/53

Tel

TOPS TRAINING OPPORTUNITIES SCHEME Manpower Services Commission MSC

*This course is open to people who are looking for a job or prepared to leave their present one to take up training. They should also have been out of full-time education for two years, not have been on a TOPS course in the last three years and be resident in Great Britain at the time of application.

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Why not contact Lynn Osborne at Pye TVT Ltd., Coldham's Lane, Cambridge CB1 3JU, telephone (0223) 45115 for an application form and further details? She will be pleased to hear from you.

Pye TVT Limited
The Broadcast Company of Philips

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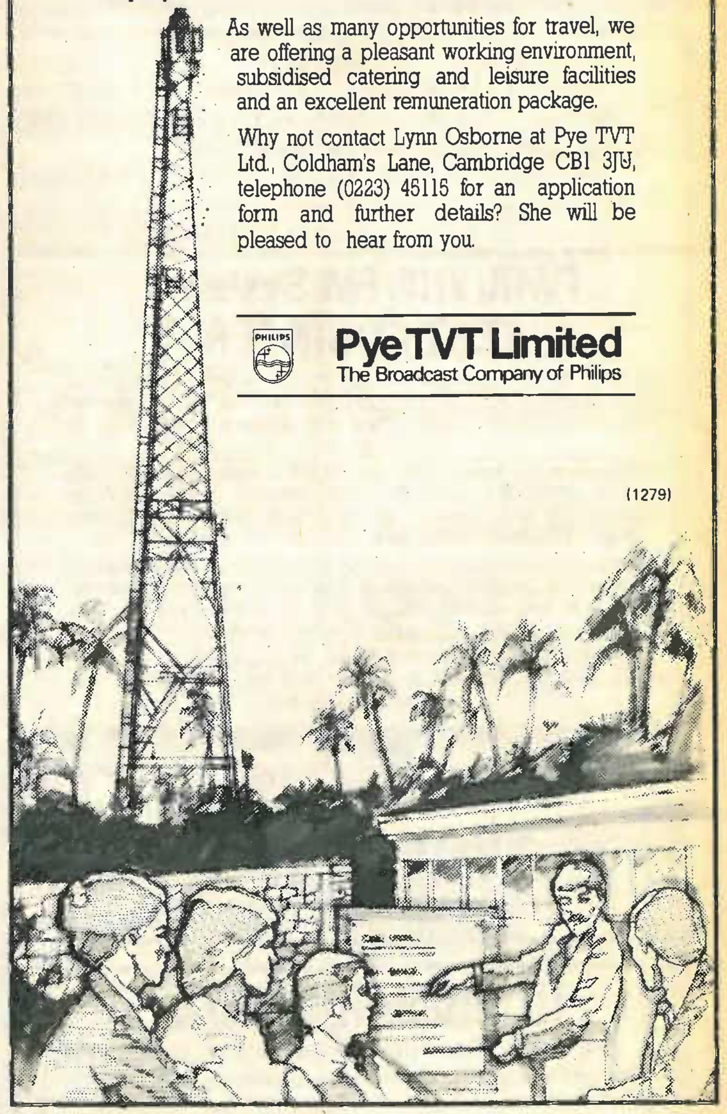

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Foreign and Commonwealth Office

(1270)

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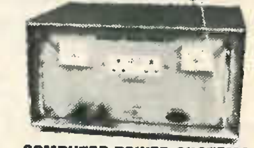

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